Reclaiming Cities:

A Socioecological Analysis of Urban Highway Removal

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Author Note

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Abstract

This research paper examines the socioecological impacts of urban highway removal, arguing that highways actively shape inequality, environmental conditions, and urban form. Historically, highway construction improved regional mobility while producing displacement, segregation, and community fragmentation.

Using a comparative case study approach, the research analyzes four projects: Cheonggyecheon (Seoul), Madrid Río (Madrid), the Embarcadero (San Francisco), and Harbor Drive (Portland). Findings show that transportation systems are adaptable, with highway removal rarely causing severe congestion. These projects also generate environmental improvements and economic gains.

However, benefits are unevenly distributed, often contributing to rising property values and displacement. The study concludes that outcomes depend primarily on governance and policy, emphasizing that equitable benefits require integrating infrastructure transformation with broader strategies focused on sustainability and social justice.

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Executive Summary

This research paper examines the impacts of urban highway removal, arguing that highways are not neutral infrastructure but systems that shape inequality, environmental conditions, and urban form. Historically, urban highways improved regional mobility but caused widespread displacement, segregation, and community fragmentation. As cities reconsider these systems, highway removal has emerged as a strategy for urban transformation.

Through a comparative analysis of four cases—Seoul (Cheonggyecheon), Madrid (Madrid Río), San Francisco (Embarcadero), and Portland (Harbor Drive)—the study evaluates outcomes across transportation, environmental, economic, and equity dimensions. Findings show that transportation systems are highly adaptable: removing highways rarely produces severe congestion, as traffic redistributes or declines. At the same time, all cases generated environmental improvements and increased land values.

However, benefits were unevenly distributed. Rising property values often led to displacement, highlighting the risk of environmental gentrification. The research finds that outcomes depend less on physical design and more on governance and policy. Projects that include public investment, community engagement, and anti-displacement measures produce more equitable results.

Ultimately, highway removal presents a significant opportunity to improve cities, but equitable outcomes require intentional integration with broader planning and policy frameworks.

Introduction

Background and Problem Statement

The construction of urban highway systems represents one of the most consequential spatial transformations of the twentieth century. Across the United States and many cities worldwide, highways emerged as central components of a modernist planning paradigm that prioritized speed, efficiency, and regional connectivity. Elevated expressways and high-capacity roadways were designed to facilitate the rapid movement of automobiles, reflecting both technological optimism and the increasing dominance of private vehicle ownership in shaping urban life.

These infrastructures were frequently inserted into dense urban cores, fundamentally altering the spatial and social organization of cities. While they contributed to suburban expansion and improved regional accessibility, their localized impacts were often severe. Neighborhoods were divided or demolished outright, with disproportionate effects on low-income and marginalized populations. The physical presence of elevated highways created barriers to movement, fragmented urban fabric, and diminished access to public space. Environmental impacts compounded these effects, as increased exposure to air pollution, noise, and heat reshaped the lived experience of communities situated along these corridors. This growing interest is also tied to the recognition that many mid-twentieth-century highway systems are reaching the end of their functional and structural lifecycles, positioning removal not only as a corrective strategy but as a necessary phase of infrastructure transition (Mohl, 2008; Napolitan & Zegras, 2008).

By the late twentieth century, many of these systems were no longer seen as unqualified symbols of progress. Aging infrastructure, changing economic conditions, and mounting public criticism prompted a reevaluation of their role within the city. Increasingly, urban highways came to be viewed as incompatible with emerging priorities centered on environmental sustainability, public health, and urban livability. In response, some cities began to explore alternatives to reconstruction, including the removal, burial, or transformation of major highway corridors. What had once seemed unthinkable began to emerge as a plausible and, in some cases, desirable planning strategy.

Research Focus and Significance

This research paper examines the socioecological impacts of urban highway removal, situating these projects within a broader understanding of cities as integrated systems in which infrastructure, environment, and social life are deeply intertwined. Rather than treating highways solely as technical solutions for mobility, this study approaches them as infrastructures that organize patterns of land use, environmental exposure, economic activity, and everyday behavior. Their removal therefore represents a form of systemic transformation rather than a singular intervention.

The growing relevance of this topic is closely tied to contemporary urban challenges. Cities are increasingly confronted with the need to reduce greenhouse gas emissions, mitigate climate-related risks, and improve public health outcomes, all of which intersect with transportation systems. At the same time, renewed attention to spatial inequality and environmental justice has brought greater scrutiny to the legacy of infrastructure investments that have historically concentrated burdens in disadvantaged communities. In this context, highway removal appears to offer a potential pathway toward more equitable and sustainable urban futures.

Yet the outcomes of such interventions remain uneven and context-dependent. In some cases, highway removal has produced significant improvements in environmental quality, economic vitality, and public space. In others, it has triggered rising property values, displacement pressures, or limited shifts in travel behavior. These varied outcomes highlight the need for a more comprehensive and comparative understanding of how highway removal reshapes urban systems and under what conditions it contributes to broader socioecological goals.

Research Questions

This research paper is guided by a central question concerning the relationship between infrastructure transformation and urban socioecological change. Specifically, it asks how the removal or transformation of urban highways reshapes socioecological conditions in cities and under what circumstances these interventions produce outcomes that can be understood as both sustainable and

equitable. In addition to evaluating the benefits of highway removal, this study also considers the conditions under which such projects may produce limited or uneven outcomes, particularly in relation to equity and long-term transportation change.

Addressing this overarching question requires examining several interrelated dimensions of change. Subsequent research has shown that highway expansion often generated additional traffic rather than alleviating congestion, a phenomenon known as induced demand (Lopez, 2012). The analysis considers how highway removal affects transportation system performance and travel behavior, paying particular attention to debates surrounding induced demand and traffic evaporation. It also investigates the economic consequences of these projects, including their influence on land values and development patterns. Environmental outcomes, such as changes in air quality, temperature regulation, and the availability of public and green space, form another key area of inquiry. In addition, the study explores how highway removal reshapes social and spatial relationships, including issues of connectivity, displacement, and environmental justice. Finally, it examines the governance structures and political processes that shape both the implementation and long-term impacts of these interventions.

Taken together, these lines of inquiry position highway removal as a multidimensional phenomenon that engages core concerns in urban planning, geography, and environmental studies.

Analytical Approach and Conceptual Framework

This study adopts an interdisciplinary analytical approach grounded in the concept of infrastructure as a socioecological system. From this perspective, urban highways are understood not merely as transportation facilities, but as complex assemblages that organize flows of people, energy, capital, and environmental effects. Their presence structures how cities function, shaping both material conditions and social practices.

The removal or transformation of such infrastructure thus represents a reconfiguration of what can be described as urban metabolism—the processes through which resources, mobility, and environmental

impacts circulate within the city. Changes to highway systems can redirect these flows, producing shifts in travel behavior, land markets, ecological conditions, and social interaction.

To examine these processes systematically, this research paper employs a multidimensional framework that considers transportation performance, economic and land-value effects, environmental and quality-of-life outcomes, social and spatial dynamics, and governance structures as interconnected aspects of a single transformation. By analyzing these dimensions in relation to one another rather than in isolation, the study can capture both the synergies and tensions that characterize highway removal projects. This approach also makes it possible to identify trade-offs, uneven outcomes, and context-specific variations that might otherwise be obscured.

Case Study Overview

The empirical foundation of this research paper is built upon four internationally recognized cases of urban highway removal or transformation, each of which represents a distinct approach to reconfiguring transportation infrastructure. The restoration of the Cheonggyecheon corridor in Seoul involved the demolition of an elevated freeway and the reintroduction of a linear waterway and public space, exemplifying large-scale ecological and spatial transformation under centralized political leadership. In Madrid, the Río project pursued a hybrid strategy, relocating a major ring road underground while converting the surface into an extensive linear park, thereby achieving substantial spatial and environmental improvements without eliminating vehicular capacity.

In the United States, the removal of the Embarcadero Freeway in San Francisco followed the structural failure caused by the 1989 Loma Prieta earthquake, illustrating how crisis can create opportunities for long-term urban transformation. The case of Harbor Drive in Portland represents one of the earliest proactive highway removals, in which sustained civic advocacy and political leadership led to the conversion of a waterfront highway into a major public park.

These cases were selected to capture variation in infrastructure strategy, governance context, and geographic setting. By examining projects that differ in terms of their technical approach, political

conditions, and urban environments, the research paper develops a comparative perspective that highlights both common patterns and context-dependent outcomes.

Contribution of the Research paper

This research paper contributes to ongoing scholarly and planning debates by reframing highway removal as a socioecological process rather than a purely technical or transportation-focused intervention. In doing so, it advances a more integrated understanding of how infrastructure shapes and reshapes urban systems.

In addition to its conceptual contribution, the study provides comparative insights derived from the analysis of diverse international cases. This approach allows for the identification of generalizable patterns while also recognizing the importance of local context in shaping outcomes. Such a perspective is particularly valuable in a field where much of the existing literature remains focused on single-case studies.

The research paper also offers practical relevance for urban planning and policy. By identifying the conditions under which highway removal produces desirable outcomes, as well as the risks and trade-offs associated with these interventions, it provides guidance for cities considering similar transformations. In this sense, the study seeks to bridge the gap between academic inquiry and applied planning practice.

Structure of the Paper

The structure of the research paper reflects the progression from historical context and theoretical framing to empirical analysis and broader synthesis. The following chapters examine the literature and historical development of urban highway systems, tracing their origins within mid-twentieth century planning paradigms, and analyzing their social and environmental consequences. This historical foundation provides an essential context for understanding the significance of contemporary removal efforts.

Subsequent chapters develop the theoretical framework, outline the research methodology, and present detailed case study analyses. These chapters are followed by a comparative synthesis that draws out key patterns and differences across cases. The latter portion of the research paper focuses on broader thematic issues, including equity, environmental justice, climate change, and governance, before

concluding with a synthesis of findings and reflections on the implications of highway removal for the future of urban planning.

Literature Review

Scholarly research on the Interstate Highway System and urban redevelopment consistently demonstrates that infrastructure projects are deeply intertwined with broader social, economic, and political dynamics rather than functioning as neutral instruments of progress. While highways have historically been celebrated for improving mobility and fostering economic growth, a substantial body of literature reveals that these projects have also contributed to patterns of racialized displacement, spatial segregation, and long-term social fragmentation.

At the same time, more recent scholarship has begun to explore the removal or redesign of highways as a potential corrective strategy, raising important questions about whether such interventions can address historical inequities or simply reproduce them in new forms. This chapter synthesizes existing research across these themes, situating highways within a continuum of urban policy that has both shaped and been shaped by inequality, while also examining emerging efforts to reimagine infrastructure in more equitable and sustainable ways. Recent scholarship further emphasizes that environmental improvements are frequently capitalized into land markets, a process through which ecological and amenity gains are translated into rising property values and rents (Brinkman & Lin, 2024; Patterson & Harley, 2019).

Highways, Urban Renewal, and Racialized Displacement

A central theme in the literature is the close relationship between highway construction and mid-twentieth-century urban renewal policies, which collectively facilitated the large-scale displacement of Black communities in American cities. Scholars argue that these processes were not simply the byproduct of modernization but were actively embedded within planning decisions that prioritized economic development over the well-being of marginalized populations. Urban renewal programs between 1949 and 1968 resulted in the demolition of approximately 425,000 housing units while constructing only 122,000 replacement units, most of which were unaffordable to displaced residents (Lopez, 2012). By the early 1970s, federal urban renewal and related programs were projected to displace as many as 4 million people nationwide (Lopez, 2012).

Daniels (2018) explicitly characterizes urban renewal and highway construction as forms of "Negro Removal," emphasizing that these projects disproportionately targeted Black neighborhoods and dismantled long-standing centers of economic, cultural, and political life. Lopez backs this up, stating estimates indicated that approximately 80 percent of those displaced by urban renewal were African American, leading to widespread critiques of these programs as forms of "Negro removal" (Lopez, 2012).

This interpretation is reinforced by more recent empirical research, which demonstrates that highway placement often reflects and reinforces existing patterns of racial inequality. Aiello et al. (2025) highlight that infrastructure projects were frequently used as tools to isolate or disrupt Black communities, aligning with broader practices of segregation found in housing and urban policy.

Importantly, this body of literature challenges narratives that frame displacement as an unintended consequence of development. Instead, scholars such as Kraft-Klehm (2015) argue that highway expansion actively contributed to the redistribution of populations and resources, accelerating suburbanization while simultaneously undermining urban cores. This dual process, in which highways facilitated outward growth while destabilizing inner-city neighborhoods, underscores the extent to which infrastructure served as a mechanism for restructuring urban space along racial and economic lines. As such, displacement must be understood not as incidental but as a predictable outcome of policy decisions rooted in unequal power dynamics.

Spatial Segregation and the Built Environment

In addition to displacement, researchers emphasize that highways have played a significant role in producing and maintaining spatial segregation within cities. Rather than merely reflecting preexisting divisions, infrastructure has been shown to actively shape patterns of separation by creating physical barriers that limit interaction between communities. Aiello et al. (2025) provide compelling quantitative evidence for this argument, demonstrating that highways significantly reduce social connectivity between neighborhoods, particularly at short distances where everyday interactions are most likely to occur. Their

concept of the "barrier effect" highlights how even small distances can become socially meaningful when they are divided by major infrastructure, effectively fragmenting urban space.

This perspective is further supported by economic analyses that examine the localized impacts of highway proximity. Brinkman and Lin (2024) show that highways generate substantial disamenities, including noise, pollution, and restricted pedestrian mobility, all of which contribute to declining neighborhood desirability. Their findings indicate that these negative effects are particularly pronounced in central-city neighborhoods, where residents experience the costs of infrastructure without receiving equivalent benefits in accessibility. Together, these studies illustrate how highways function as both physical and social boundaries, reinforcing patterns of segregation by limiting access to shared resources and opportunities.

By situating highways within the broader context of the built environment, this literature demonstrates that infrastructure decisions have long-term implications for how cities are organized and experienced. The placement of highways not only alters transportation patterns but also shapes the distribution of social and economic capital, embedding inequality into the spatial structure of urban areas.

Social Fragmentation and Community Disruption

While earlier scholarship focused primarily on economic and spatial outcomes, more recent work has increasingly examined the social consequences of highway infrastructure, particularly its impact on community cohesion and social networks. This shift reflects a growing recognition that the strength of social ties is a critical component of urban well-being, influencing everything from economic opportunity to public health. Aiello et al. (2025) contribute to this conversation by demonstrating that highways significantly weaken social connections across neighborhoods, thereby reducing opportunities for interaction and collaboration. Their findings suggest that the fragmentation caused by highways is not limited to physical displacement but extends to the erosion of social capital, which can have lasting effects on community resilience.

This line of research aligns with broader studies of infrastructure inequality, which highlight how access to transportation systems is unevenly distributed across populations. Golub et al. (2019), for instance, show that even emerging mobility technologies can reinforce existing disparities when they fail to account for structural barriers such as income inequality or limited access to financial resources. Although their work focuses on contemporary systems, it underscores a key point: infrastructure—whether traditional or modern—often reproduces inequality unless explicitly designed to address it.

Taken together, this literature underscores the importance of viewing highways not only as physical structures but as social systems that shape relationships, opportunities, and outcomes. The disruption of social networks caused by highway construction represents a critical, yet often overlooked, dimension of its broader impact on urban inequality.

The Emergence of Highway Removal and Urban Reconnection

In response to these documented harms, a growing body of research has begun to explore the removal or redesign of urban highways as a potential strategy for restoring connectivity and improving urban environments. This literature reflects a broader shift in planning priorities, in which quality of life, sustainability, and equity are increasingly emphasized alongside mobility. Napolitan and Zegras (2008) argue that freeway removal is not simply a technical decision, but a political and social process shaped by changing values, institutional frameworks, and community advocacy. They identify key factors that enable removal, including structural deterioration, political opportunity, and the presence of stakeholders who prioritize non-mobility outcomes.

Empirical studies provide evidence that such interventions can be successful. Billings et al. (2013) find that traffic does not necessarily collapse following freeway removal, as travelers adapt through route changes and modest shifts in transportation modes. This challenges the long-standing assumption that highways are indispensable to urban mobility and opens the door to alternative planning approaches. At the same time, Greiman and Sclar (2019) argue for a broader evaluation framework that considers the long-

term social and economic impacts of infrastructure projects, suggesting that benefits such as urban revitalization and improved connectivity may outweigh short-term disruptions.

Collectively, this body of work positions highway removal as both a practical solution and a conceptual shift, highlighting the possibility of reimagining infrastructure in ways that prioritize people over vehicles.

Equity, Environmental Justice, and Unintended Consequences

Despite its potential benefits, the literature also raises important concerns about the equity implications of highway removal and redevelopment. Scholars caution that these projects can produce unintended consequences, particularly in the form of gentrification and displacement. Patterson and Harley (2019) demonstrate that while freeway removal can significantly improve environmental conditions—reducing pollution and enhancing public health—it can also attract new development and rising property values, leading to the displacement of long-term residents.

A growing body of research highlights the environmental justice implications of highway infrastructure. Studies have consistently found that the environmental and social burdens of highways—including air pollution exposure, noise, and physical division—are disproportionately concentrated in vulnerable communities, while the benefits of improved mobility are more widely distributed (Weiwu, 2024; Greenberg et al., 2024).

More recent research also emphasizes the role of environmental improvement in driving new forms of inequality. Interventions such as highway removal, green space creation, and urban redevelopment can reduce environmental exposure while simultaneously increasing land values and displacement pressures, a process often described as environmental gentrification (Patterson & Harley, 2019; Patterson & Harley, 2019; Patterson & Harley, 2019; supported by additional empirical studies such as Patterson & Harley, 2019 and related work in Oakland).

Similarly, Stehlin (2024) offers a more critical perspective, arguing that highway removal can function as a “socio-ecological fix” that addresses localized problems while leaving broader structural

inequalities intact. In this view, removing a highway may improve conditions in one neighborhood while shifting burdens to other parts of the metropolitan region. Daniels (2018) reinforces this concern by linking contemporary redevelopment to historical patterns of displacement, emphasizing that without intentional policy intervention, new forms of "development" risk perpetuating the same inequities associated with earlier infrastructure projects.

These critiques highlight a central tension in the literature: while highway removal has the potential to repair past harms, it also carries the risk of creating new inequalities if not carefully managed. As such, equity must be understood as a central, rather than secondary, consideration in planning processes.

Toward Reparative and Restorative Planning

In response to these challenges, an emerging body of scholarship advocates for more explicitly equity-focused approaches to infrastructure planning, often framed in terms of restorative or reparative justice. Hinderaker (2023) argues that highway redesign projects should incorporate principles of reparative planning, which emphasize acknowledging historical harms, redistributing resources, and centering the voices of affected communities in decision-making processes. This approach represents a significant departure from traditional technocratic planning models, which have often prioritized efficiency over equity.

Similarly, scholars such as Spicer (2011) and Faulkner et al. (2016) highlight the importance of multimodal design, community engagement, and anti-displacement strategies in ensuring that infrastructure projects contribute to more inclusive urban environments. These works emphasize that successful highway removal is not simply about eliminating physical structures but about reimagining urban space in ways that support social equity and long-term sustainability.

This emerging literature signals a broader transformation in how infrastructure is understood and evaluated. Rather than viewing highways solely as transportation systems, scholars increasingly recognize them as sites of historical injustice and potential avenues for repair, provided that planning processes are guided by principles of equity and inclusion. These approaches increasingly emphasize tools such as

community land trusts, inclusionary zoning, right-to-return policies, and public land banking as mechanisms for ensuring that redevelopment benefits are retained within affected communities (Hinderaker, 2023; Stehlin, 2024).

Historical Context

The Emergence of Urban Highways

Urban highway systems emerged in the mid-twentieth century as a response to rapid changes in urban form, economic organization, and transportation demand. As industrial economies expanded and automobile ownership increased dramatically, cities faced growing challenges related to congestion, mobility, and regional connectivity (Lopez, 2012). Policymakers and planners increasingly viewed the automobile as the dominant mode of transportation and sought to restructure urban environments to accommodate its growth.

The construction of high-capacity road infrastructure was seen as both a practical and necessary solution to these challenges. Highways provided faster travel times, supported the movement of goods, and facilitated commuting between central cities and surrounding regions. In many cases, they were also justified as a means of maintaining economic competitiveness, particularly as cities sought to integrate into broader regional and global networks (Lopez, 2012). As a result, large-scale investments in road infrastructure became a defining feature of postwar urban development across many parts of the world.

This transformation was also shaped by prevailing planning ideologies. Mid-century planning was heavily influenced by modernist principles, which emphasized efficiency, order, and functional separation of land uses. Within this framework, cities were reorganized around specific functions—residential, commercial, industrial, and transportation—with highways playing a central role in connecting these zones (Lopez, 2012). Wide roadways, grade-separated interchanges, and high-speed corridors were introduced to optimize vehicular movement, often at the expense of traditional street networks and pedestrian environments.

Importantly, these infrastructure investments were not limited to the United States. While the Interstate Highway System is perhaps the most well-known example, similar patterns emerged globally as cities modernized their transportation systems. Rapidly growing cities in Europe and Asia also adopted automobile-oriented planning strategies, particularly during periods of economic expansion (Robinson &

Ji, 2022). In each context, highways were understood as symbols of progress, modernization, and technological advancement.

Highways and Urban Restructuring

While urban highways were designed to improve mobility, their effects extended far beyond transportation. These corridors reshaped urban form by influencing patterns of land use, development, and accessibility. By enabling faster travel over longer distances, highways encouraged the decentralization of urban activities and supported the growth of suburban areas (Lopez, 2012). Residential, commercial, and industrial development increasingly moved outward, taking advantage of improved regional access.

This process fundamentally altered the structure of cities. Central urban areas, once the primary hubs of economic and social activity, began to lose population and investment as development shifted to peripheral regions. In many cases, this redistribution of growth contributed to patterns of urban decline, characterized by disinvestment, aging infrastructure, and reduced economic activity in core areas (Lopez, 2012).

At the same time, highways introduced new spatial dynamics within cities. Their physical scale—often involving multiple lanes, elevated structures, or large interchanges—required significant amounts of land and disrupted existing urban fabric. Traditional street grids were frequently replaced or interrupted by high-capacity roadways, reducing connectivity at the local level. In many cases, these changes limited pedestrian movement, decreased accessibility between neighborhoods, and constrained access to key urban features such as waterfronts and civic spaces (Robinson & Ji, 2022).

These impacts were not always immediate, but they accumulated over time. As highways prioritized long-distance movement over local accessibility, cities became increasingly structured around regional circulation systems rather than neighborhood-scale interactions. This shift contributed to a gradual transformation of urban life, in which mobility was defined primarily in terms of speed and distance rather than connectivity and experience.

Limitations of the Highway Paradigm

By the late twentieth century, the limitations of automobile-oriented infrastructure became increasingly visible. One of the most significant challenges was the persistence of congestion, despite continuous investment in road capacity. Contrary to earlier assumptions, expanding highway networks did not eliminate traffic; instead, they often generated additional demand, a phenomenon widely described as induced demand (Cairns et al., 2002; Cervero, 2009).

This phenomenon highlighted a fundamental tension within highway-based planning: infrastructure designed to improve efficiency could ultimately reinforce the conditions it sought to resolve. As travel became faster and more convenient, more people chose to drive, leading to increased traffic volumes across the system (Cervero, 2009). As a result, congestion remained a persistent challenge in many cities, even as road networks expanded.

At the same time, environmental concerns began to play a more prominent role in urban policy. Highways contributed to air pollution, noise, and increased energy consumption, particularly in dense urban areas. As awareness of these impacts grew, cities began to reevaluate the long-term sustainability of automobile-dependent systems (Robinson & Ji, 2022). Issues such as climate change, public health, and environmental degradation further intensified these concerns, prompting calls for more balanced and diversified transportation strategies.

Equally important were the spatial and social consequences of highway infrastructure. The fragmentation of urban areas, the loss of public space, and the decline of pedestrian-oriented environments became increasingly recognized as significant drawbacks. In many cities, highways were no longer seen as purely functional assets, but as physical and symbolic barriers that limited urban cohesion and reduced the quality of life (Lopez, 2012).

Shifting Urban Priorities

A central component of highway transformation is the reconnection of ecological and human systems within the city. By replacing impermeable, automobile-dominated infrastructure with green space,

water systems, and pedestrian environments, these projects restore previously suppressed ecological functions while enhancing urban livability. This includes improvements in microclimate, air quality, and public access, as well as the reintroduction of social activity into spaces that were previously inaccessible or inhospitable. The environmental justice implications of highway infrastructure have become increasingly central to contemporary planning debates. While highways were initially framed as tools of modernization and economic growth, their uneven distribution of environmental harms and benefits has led to a growing recognition of infrastructure as a driver of spatial inequality (Greenberg et al., 2024).

As economic and social conditions evolved, so too did the priorities shaping urban development. The transition from industrial to post-industrial economies placed greater emphasis on service industries, knowledge economies, and urban amenities. Cities began to compete not only on the basis of economic productivity, but also on quality of life, environmental conditions, and the attractiveness of urban spaces (Robinson & Ji, 2022).

Within this context, the value of centrally located land increased significantly. Areas previously occupied by highway infrastructure—often located near waterfronts or central business districts—represented opportunities for redevelopment and public investment. Reclaiming these spaces became increasingly attractive as cities sought to enhance their urban environments and attract residents, businesses, and visitors.

At the same time, there was a growing recognition of the importance of public space, walkability, and environmental quality. Urban planning began to shift away from strictly functional models toward more integrated approaches that considered social, ecological, and experiential factors. Concepts such as livability, sustainability, and urban resilience gained prominence, influencing both policy and design practices (Robinson & Ji, 2022).

These changing priorities created the conditions for rethinking the role of highways within cities. Rather than viewing them as essential infrastructure to be preserved at all costs, planners and policymakers began to consider alternative approaches, including redesign, conversion, or removal.

Infrastructure Lifecycle and Opportunity

Another critical factor in the emergence of highway removal projects is the aging of infrastructure systems. Many urban highways constructed in the mid-twentieth century were reaching the end of their design life by the late twentieth and early twenty-first centuries. Maintenance costs increased, structural deficiencies became more apparent, and the need for major reinvestment created new decision points for cities (Lopez, 2012).

At these moments, cities faced a choice: rebuild existing infrastructure, modify it, or remove it entirely. In many cases, the high cost of reconstruction, combined with shifting urban priorities, made removal or transformation an appealing option. These decisions were further influenced by changing transportation patterns, including the growing role of public transit, active transportation, and multimodal systems (Robinson & Ji, 2022).

Highway removal projects often emerge from this convergence of factors—aging infrastructure, economic opportunity, environmental concerns, and evolving planning philosophies. Rather than representing isolated interventions, they reflect broader transitions in how cities conceptualize and manage urban systems.

Toward a New Model of Urban Infrastructure

Highway removal and transformation projects represent a shift from a singular focus on mobility toward a more integrated understanding of infrastructure. In this emerging model, infrastructure is not viewed solely as a means of facilitating movement, but as a tool for shaping urban environments and supporting multiple objectives simultaneously.

Across different contexts, these projects aim to rebalance the allocation of urban space by reducing the dominance of automobile infrastructure and expanding opportunities for public use. This may include the creation of parks, the restoration of ecological systems, the development of mixed-use areas, or the improvement of pedestrian and transit connectivity (Robinson & Ji, 2022).

Importantly, the outcomes of these projects vary significantly depending on local conditions, governance structures, and planning decisions. While some projects lead to substantial environmental improvements and economic growth, others produce more limited changes or introduce new challenges related to equity and displacement. As such, highway removal should not be understood as a uniform solution, but as a flexible strategy with diverse applications and outcomes.

Linking Historical Context to Contemporary Cases

The case studies examined in this paper—Seoul, Madrid, San Francisco, and Portland—illustrate how different cities have responded to the legacy of highway infrastructure under varying conditions. Each project reflects a distinct combination of historical context, planning priorities, and implementation strategies.

Seoul demonstrates a comprehensive transformation that reconfigures both transportation systems and environmental conditions. Madrid illustrates an alternative approach that improves surface-level urban space while maintaining underlying traffic capacity. San Francisco highlights the potential for rapid economic and spatial change following infrastructure removal, while Portland represents an earlier example of incremental transformation focused on public space (Robinson & Ji, 2022).

In addition to structural and economic changes, highway removal projects are often driven by the convergence of several immediate pressures. These include the high cost of maintaining aging infrastructure, increasing public demand for environmental improvement, and the growing value of centrally located urban land. In many cases, the decision to remove or transform highways is less about rejecting infrastructure entirely and more about reallocating resources toward higher-value uses, such as public space, ecological restoration, and mixed-use development. These drivers are evident across the cases examined in this study, where infrastructure decisions reflect changing priorities in urban governance rather than isolated design interventions.

Together, these cases show that highway removal is not a singular phenomenon, but part of a broader evolution in urban planning. They reflect the transition from a period defined by infrastructure

expansion to one characterized by reassessment, adaptation, and reconfiguration. Understanding this historical trajectory is essential for evaluating contemporary projects and identifying the conditions under which they produce meaningful and equitable outcomes.

Theoretical Framework

The analysis of highway infrastructure and its contemporary transformation requires a conceptual framework that moves beyond viewing infrastructure as a purely technical or economic system. Instead, this research conceptualizes infrastructure as a driver of system-level change, shaping interconnected domains of mobility, environmental conditions, economic development, and social equity.

Drawing on interdisciplinary theories from urban planning, sociology, and political economy, this study treats infrastructure as a socially embedded process that both reflects and reproduces power relations. Three core theoretical perspectives guide this analysis: infrastructure as a tool of spatial inequality, the theory of community severance, and emerging frameworks of reparative and restorative planning.

Together, these perspectives explain how changes to infrastructure produce cascading effects across urban systems and outcomes. To clarify these relationships, Figure 1 illustrates the conceptual framework used in this study, showing how infrastructure transformation reshapes multiple domains simultaneously to produce broader patterns of urban change.

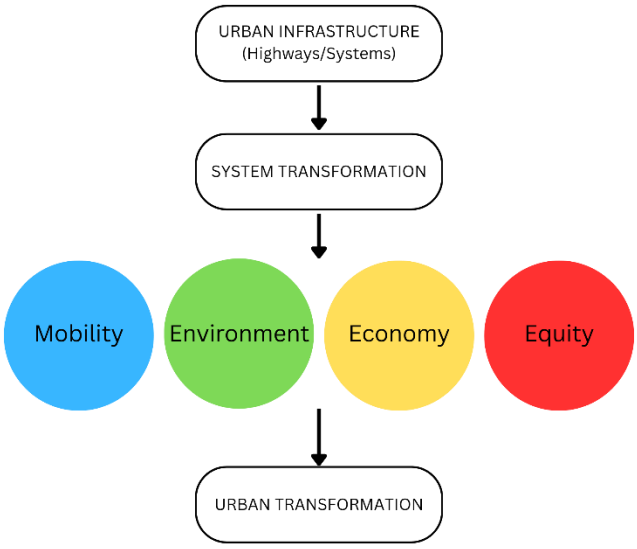


Figure 1 - Conceptual Framework of Infrastructure Transformation and Urban Outcomes

The first component of this framework conceptualizes infrastructure as an active agent in shaping unequal spatial and environmental outcomes, particularly within the domains of mobility, environmental

exposure, and economic value. Traditional planning models often treat highways as neutral systems designed to maximize efficiency and mobility; however, recent scholarship challenges this assumption by demonstrating that transportation infrastructure is deeply intertwined with political and social priorities. Scholars such as Brinkman and Lin (2024) show that while highways improve regional accessibility, they simultaneously produce localized disamenities—such as pollution, noise, and reduced neighborhood desirability—that disproportionately affect central-city communities. These effects are not randomly distributed but are shaped by planning decisions that reflect existing inequalities in political representation and economic power.

Within this framework, infrastructure is understood not merely as a physical structure but as a mechanism that organizes access to resources, opportunities, and space. The placement of highways can therefore be seen as a form of spatial governance, determining which communities benefit from connectivity and which bear the costs of development. This perspective aligns with historical evidence showing that highways were frequently routed through marginalized neighborhoods, reinforcing patterns of segregation and displacement (Aiello et al., 2025). By situating infrastructure within broader systems of inequality, this approach allows the research paper to interpret highway development as a deliberate, rather than incidental, contributor to urban disparities. Highway construction not only facilitated mobility but also produced significant negative externalities, including pollution, neighborhood division, and reduced social connectivity, emphasizing that infrastructure operates as both a physical and social disruptor (Lopez, 2012).

In this way, infrastructure interventions do not operate in isolation but instead reorganize flows of movement, access, and environmental conditions across the urban system.

Closely related to this perspective is the concept of connectivity and social interaction, emphasizing how infrastructure reshapes mobility patterns and social relationships through the process of community severance. Early urban planning theories suggested that high-traffic roads reduce opportunities for social contact, but recent empirical research has provided more concrete evidence of this phenomenon. Aiello et al. (2025) demonstrate that highways significantly decrease social connectivity between neighborhoods,

particularly over short distances where local social ties are typically strongest. This "barrier effect" highlights how infrastructure can fragment communities even in the absence of direct displacement, limiting access to social networks that are essential for economic mobility, information exchange, and collective identity.

The concept of community severance expands the analysis of infrastructure beyond physical outcomes to include social and relational impacts. It emphasizes that the consequences of highways cannot be fully understood by examining population loss or economic change alone; instead, attention must be given to the ways in which these structures reshape patterns of interaction and belonging. Brinkman and Lin (2024) further reinforce this argument by identifying barrier effects as a central component of the disamenity value of highways, showing that they increase the cost of movement between adjacent neighborhoods and reduce local accessibility. These dynamics highlight that infrastructure influences not only how people move, but also how they interact, reinforcing its role in shaping both physical and social dimensions of urban systems.

Building on these system-level effects, the third component of this framework examines how infrastructure transformation can be used to restructure urban systems in more equitable and sustainable ways. Emerging theories of reparative and restorative planning challenge traditional planning paradigms by emphasizing justice, equity, and historical accountability as central goals of urban development. Notably, both urban renewal and highway construction were frequently justified through public health arguments, framing large-scale redevelopment as necessary to address "blight," congestion, and perceived social disorder (Lopez, 2012). Rather than treating infrastructure decisions as purely forward-looking, these frameworks call for explicit recognition of past harms and the implementation of policies designed to address them.

Hinderaker (2023) argues that highway redesign projects must incorporate principles of reparative planning, which involve not only reconnecting physical spaces but also redistributing power and resources to communities that were previously harmed by infrastructure decisions. This approach aligns with broader

theories of the "Just City," which prioritize fairness, inclusivity, and the right to participation in urban governance. Similarly, Faulkner et al. (2016) emphasize the importance of designing infrastructure projects that foster social equity and environmental sustainability, suggesting that highway removal can serve as a catalyst for more inclusive forms of urban development when combined with intentional policy interventions.

Environmental justice perspectives further illuminate how infrastructure transformation redistributes benefits and burdens across key domains, including environmental exposure, access to opportunity, and economic value. Highways distribute benefits and burdens unevenly across space, providing regional mobility advantages while concentrating environmental harms—such as pollution, noise, and reduced accessibility—in adjacent neighborhoods (Greenberg et al., 2024). These dynamics reinforce the concept of infrastructure as a socioecological system, in which transportation decisions restructure not only movement patterns but also environmental exposure and spatial opportunity.

In addition, highways generate what has been described as "barrier effects," physically severing urban neighborhoods and reducing connectivity within local street networks (Millard-Ball et al., 2025). These effects highlight the importance of reconnection as a central goal of infrastructure transformation, particularly in urban contexts where accessibility and proximity are critical to daily life.

However, this framework also acknowledges the limitations of current approaches to highway removal. As scholars such as Patterson and Harley (2019) demonstrate, redevelopment projects often produce unintended consequences, including rising property values and the displacement of long-term residents. These outcomes highlight a critical tension within reparative planning: while infrastructure transformation can create opportunities for improvement, it does not automatically result in equitable outcomes. Instead, the success of these projects depends on the extent to which they are guided by policies that prioritize affordability, accessibility, and community participation.

Taken together, these perspectives demonstrate that infrastructure operates as a system-level intervention, in which changes to the built environment simultaneously reshape mobility patterns,

environmental conditions, economic activity, and social equity. As illustrated in Figure 1, infrastructure transformation produces cascading effects across urban systems, linking structural interventions to multidimensional outcomes.

This framework supports the central argument that infrastructure is both a site of historical inequality and a mechanism through which more equitable urban futures can be constructed, depending on how these system-level changes are managed and implemented.

Methodology

This study focuses specifically on a subset of urban highway removal and transformation projects that prioritize public-space creation, ecological restoration, and urban reconnection. While highway removal can also facilitate private redevelopment and real estate-driven growth, the cases selected here—Seoul, Madrid, San Francisco, and Portland—are distinguished by their emphasis on reclaiming space for public use and improving environmental and social conditions. This narrower scope allows for a more consistent comparison of projects that share similar planning objectives, while acknowledging that other forms of highway redevelopment may produce different outcomes.

This research paper employs a qualitative, comparative case study methodology to analyze the impacts of urban highway construction and removal across multiple cities. The methodological approach is designed to operationalize the theoretical framework outlined in the previous section by examining infrastructure as both a driver of spatial inequality and a potential tool for urban repair. Rather than relying on a single metric of success, the analysis uses a structured, multi-dimensional evaluation framework that integrates transportation performance, environmental outcomes, economic development, and distributive equity. This approach allows for a comprehensive assessment of how infrastructure interventions shape urban systems and social outcomes over time.

The primary methodological tool guiding this analysis is a case study evaluation framework developed specifically for this research. The framework organizes each case around a consistent set of categories, including pre-intervention conditions, intervention design, and post-intervention outcomes, ensuring comparability across diverse geographic and political contexts. Each case is first classified according to an "end-state typology," which identifies the dominant goal of the intervention—such as environmental restoration, urban redevelopment, or open space reclamation. This typological classification is critical for interpreting outcomes, as it provides a baseline for understanding whether a project achieved its stated objectives or produced hybrid results across multiple domains. By explicitly linking project goals

to outcomes, the framework avoids treating all highway removal efforts as functionally equivalent and instead emphasizes the varied intentions and priorities underlying different interventions.

The framework used in this study is not only a tool for organizing analysis, but also for revealing relationships between infrastructure interventions and their outcomes. By evaluating each case across multiple interconnected domains, the framework makes it possible to identify patterns that would not be visible through single-variable analysis, particularly the tradeoffs between environmental improvement, economic growth, and equity. The inclusion of contemporary policy frameworks, such as federal reconnection initiatives, also allows this study to situate historical case analysis within current planning practice.

The analysis draws on a combination of secondary sources, including peer-reviewed literature, planning reports, government documents, and case study archives. For each case, data were collected on transportation outcomes, environmental indicators, economic change, and equity impacts, with an emphasis on consistency across cases. While the availability and specificity of data vary by location, efforts were made to prioritize comparable indicators such as traffic volumes, land-use change, environmental metrics, and development patterns. Evidence strength is assessed based on the reliability, consistency, and quantity of available sources for each outcome.

The case studies selected for this analysis represent a range of intervention types, including full highway removal, boulevard conversion, burial or capping, and partial redesign. These cases were chosen based on their relevance to the central research question, as well as the availability of secondary data documenting both historical conditions and post-intervention outcomes. The selected examples include both widely cited “successful” cases of highway removal and more ambiguous or contested projects, allowing the analysis to capture the full spectrum of potential outcomes. This comparative approach is consistent with existing literature on infrastructure transformation, which emphasizes the importance of context, governance, and policy design in shaping results (Napolitan & Zegras, 2008; Khalaj et al., 2020).

The spatial transformation associated each project is best understood through before-and-after conditions, particularly the shift from automobile-dominated infrastructure to publicly accessible urban space.

For each case, the analysis begins by establishing baseline conditions across four key domains: transportation systems, environmental context, land use and economic conditions, and equity and historical context. This baseline assessment is essential for understanding the magnitude and direction of change, as it situates each intervention within its pre-existing urban environment. Particular attention is given to the historical impacts of highway placement, including displacement, segregation, and community severance, which provide the foundation for evaluating whether subsequent interventions address or reproduce these conditions. This step directly connects the methodology to the theoretical framework, ensuring that the analysis remains grounded in the broader argument about infrastructure and inequality.

Following the baseline assessment, each case study provides a detailed description of the intervention itself, documenting both physical changes and complementary policies. Physical interventions include the removal or transformation of roadway infrastructure, the introduction of multimodal transportation alternatives, and the creation of public space or ecological restoration features. Equally important are the policy components that accompany these physical changes, such as zoning reforms, land disposition strategies, transit investments, and anti-displacement measures. Existing literature demonstrates that these complementary policies play a decisive role in shaping outcomes, particularly in determining whether redevelopment efforts lead to equitable benefits or increased displacement (Patterson & Harley, 2019). By incorporating both design and policy dimensions, the methodology recognizes that infrastructure outcomes are produced through a combination of physical form and institutional context.

The core of the analysis lies in the outcome assessment, which evaluates each case across four domains: transportation and accessibility, environmental and ecological performance, economic development and land use, and equity and distributive outcomes. Each domain is assessed using a combination of narrative analysis and evidence-based indicators, allowing for both qualitative interpretation and systematic comparison. Outcome assessments are based on a qualitative evaluation of available

evidence, translated into comparative scores to facilitate cross-case analysis. Scores reflect the relative strength of observed outcomes within each domain, rather than absolute measurement. For example, transportation outcomes are assessed based on the degree of traffic reduction, modal shift, or system adaptation, while environmental outcomes consider improvements in air quality, green space, and urban climate. These scores are supported by underlying data and case-specific evidence, with higher ratings indicating stronger or more consistent effects across multiple indicators.

Within each domain, the framework distinguishes between "Tier 1" indicators—such as connectivity, land use change, or air quality improvements—and "Tier 2" indicators, which provide more detailed or long-term measures where data is available. This tiered approach reflects the variability in available data across cases and aligns with the broader literature, which often relies on a mix of quantitative and qualitative evidence to evaluate infrastructure projects. In particular, equity is operationalized through indicators related to displacement risk, access to benefits across income groups, and the presence or absence of redistributive policy interventions, reflecting recent calls in the literature to explicitly measure distributive impacts in infrastructure evaluation (Patterson & Harley, 2019; Stehlin, 2024).

To facilitate comparison across cases, each domain is assigned a score on a three-point scale, accompanied by an assessment of evidence strength. Evidence strength ratings are based on both the quantity and quality of available sources. Peer-reviewed studies and government data are weighted more heavily than anecdotal or descriptive accounts, while consistency across multiple sources increases confidence in the findings. This approach allows for a structured comparison across cases, even when data availability varies.

This scoring system is not intended to produce a definitive ranking of projects but rather to highlight patterns and tradeoffs across different interventions. Importantly, each domain also includes an "equity note" that explicitly identifies which populations benefit from or are disadvantaged by the intervention. This element is central to the methodology, as it ensures that equity considerations are integrated into every stage of the analysis rather than treated as a secondary concern. This approach reflects recent scholarship

emphasizing the need to evaluate infrastructure projects not only in terms of efficiency or economic growth but also in terms of their distributive impacts.

In addition to outcome evaluation, the methodology incorporates process tracing to identify the mechanisms that explain observed results. These mechanisms include factors such as network redundancy, transit substitution, land development strategies, public space investment, and the presence or absence of anti-displacement policies. Process tracing allows the analysis to move beyond descriptive findings and explore causal relationships, providing insight into why certain projects succeed or fail across different domains. For example, prior research suggests that successful highway removal projects often depend on the existence of alternative transportation networks and strong political support, while negative outcomes are frequently associated with weak governance or insufficient attention to equity (Billings et al., 2013; Stehlin, 2024). By systematically identifying these mechanisms, the analysis contributes to a deeper understanding of how infrastructure interventions produce their effects.

Finally, the methodology explicitly accounts for unintended consequences and tradeoffs associated with each intervention. These include potential mobility challenges, fiscal constraints, construction-related disruptions, and the risk of "green gentrification," in which environmental improvements lead to rising property values and displacement of existing residents. Incorporating these tradeoffs is critical for aligning the analysis with the theoretical framework, which emphasizes the dual nature of infrastructure as both a source of inequality and a potential site of repair. By evaluating both intended and unintended outcomes, the methodology provides a balanced and realistic assessment of highway removal as a policy strategy.

Overall, this methodological approach combines structured comparison with qualitative depth, enabling a nuanced analysis of infrastructure as a socially embedded system. By integrating multiple domains of evaluation, emphasizing equity considerations, and tracing causal mechanisms, the framework supports the central argument of the research paper: that infrastructure interventions must be understood in terms of their distributive impacts and that meaningful repair requires not only physical transformation but also intentional policy design.

Cheonggyecheon—Ecological Restoration in Seoul

Introduction

The removal of the Cheonggyecheon Elevated Freeway and the restoration of the underlying stream in Seoul, South Korea, represents one of the most influential examples of large-scale urban highway removal. Frequently cited as a model of sustainable infrastructure transformation, the project is widely recognized for improving environmental conditions, enhancing urban livability, and demonstrating the feasibility of reducing road capacity without catastrophic congestion (Cervero, 2009; Lee & Anderson, 2013). However, when analyzed through the framework developed in this research paper, the Cheonggyecheon project reveals a more complex set of outcomes shaped by competing objectives, governance structures, and uneven social impacts.

Within this framework, the Cheonggyecheon intervention is best understood as a hybrid project combining environmental restoration and urban redevelopment. While policymakers emphasized ecological recovery and the reclamation of public space, the project also aimed to stimulate economic revitalization and reposition central Seoul within a global, post-industrial urban economy (Cervero, 2009). These dual objectives shaped both the design of the intervention and the distribution of its benefits, making the case particularly valuable for examining how infrastructure removal can simultaneously produce urban improvement and reproduce inequality.

Pre-Intervention Conditions

Transportation System

Prior to its removal, the Cheonggyecheon corridor functioned as a major east–west transportation artery, carrying approximately 168,000 vehicles per day and serving as a key component of Seoul's urban road network (Lee & Anderson, 2013). This condition is illustrated in Figure 2, which shows the extent to which the highway dominated the surrounding urban landscape.



Figure 2 - Cheonggyecheon corridor prior to highway removal.

The elevated freeway, combined with parallel surface roads, facilitated high volumes of commuter and commercial traffic through the city's dense core. Despite its functional importance, the corridor was not irreplaceable within the broader network, as Seoul's expanding subway system and surface street grid provided alternative routes that would later enable traffic redistribution (Cervero, 2009). Before removal, the expressway corridor experienced substantial economic decline, with population decreasing by 14.9% between 1980 and 2000, a 24% reduction in businesses, and the loss of approximately 80,000 jobs (Robinson & Ji, 2022).

Environmental and Ecological Context

The environmental conditions along the Cheonggyecheon corridor prior to intervention were severely degraded. The original stream had been buried beneath layers of infrastructure, transforming a historic ecological system into a heavily engineered urban corridor (Lee & Anderson, 2013). The presence of the elevated freeway contributed to elevated levels of air pollution, noise, and localized heat accumulation, while the absence of green space limited opportunities for ecological or recreational use.

Prior to its removal, the Cheonggyecheon expressway corridor posed significant public health risks; residents in the area were found to be twice as likely to suffer from respiratory illness compared to those living elsewhere in Seoul (Robinson & Ji, 2022). These conditions reflect broader patterns of postwar urban development in which natural systems were subordinated to automobile infrastructure (Cervero, 2009).

Land Use and Economic Conditions

By the late twentieth century, the area surrounding the Cheonggyecheon corridor was experiencing economic decline. Although historically a center of commerce and small-scale manufacturing, the district had lost competitiveness relative to newer business areas in Seoul (Lee & Anderson, 2013). Property values were depressed by the environmental disamenities associated with the freeway, and many buildings were underutilized or in poor condition. These factors created an economic rationale for intervention, as redevelopment offered the potential to unlock latent land value (Cervero, 2009).

Equity and Historical Context

The construction of the Cheonggyecheon freeway reflected broader patterns of infrastructure-led urban development that prioritized mobility over community cohesion. The corridor functioned as a physical barrier dividing adjacent neighborhoods and limiting pedestrian interaction (Lee & Anderson, 2013). While large-scale residential displacement primarily occurred earlier during industrialization, the continued presence of the highway contributed to social fragmentation and uneven exposure to environmental burdens. These baseline conditions are essential for evaluating whether the project achieved meaningful equity improvements.

Intervention Description

Physical and Design Changes

The Cheonggyecheon project involved the complete removal of a 5.8-kilometer elevated freeway and the restoration of the underlying stream as a linear public park (Cervero, 2009), as seen in Figures 3 and 4. The intervention replaced a high-capacity vehicular corridor with pedestrian pathways, green space, and water features designed to recreate the historical presence of the stream while accommodating

contemporary urban use. The project also incorporated elements of green infrastructure, including vegetation, shading, and microclimate design, which contributed to improved environmental performance (Lee & Anderson, 2013).



Figure 3 - Cheonggyecheon corridor following restoration.



Figure 4 - Cheonggyecheon restoration site plan.

Complementary Policies and Programs

A defining feature of the Cheonggyecheon intervention was the integration of transportation and policy reforms. Seoul expanded its bus rapid transit (BRT) system, introduced dedicated bus lanes, improved fare integration, and enhanced subway accessibility to absorb displaced traffic demand (Cervero, 2009). At the same time, the project was implemented through a centralized governance structure that enabled rapid coordination across agencies. However, policies specifically designed to mitigate displacement or preserve affordability were limited, a factor that would later shape distributional outcomes (Lee & Anderson, 2013).

Outcome Assessment

Transportation and Accessibility

The removal of the Cheonggyecheon freeway produced outcomes that challenge conventional assumptions about transportation capacity. Despite carrying approximately 170,000 vehicles per day prior to removal, the elimination of the Cheonggyecheon expressway did not result in increased congestion, as many travelers shifted to alternative modes or reduced trips altogether (Robinson & Ji, 2022). Instead, traffic patterns adapted through redistribution, mode shift, and trip suppression. Studies indicate that overall vehicle volumes entering central Seoul declined following the project, while the expanded transit system absorbed much of the displaced demand (Lee & Anderson, 2013).

Prior to removal, the corridor carried approximately 168,000 vehicles per day. Following the project, the removal of the freeway produced substantial changes in travel behavior. Vehicle volume in the corridor declined by approximately 45%, resulting in nearly 500,000 fewer daily automobile trips, while public transit usage increased, with bus ridership rising by 15.1% and subway ridership by 13.7% (Robinson & Ji, 2022, & Global Designing Cities Initiative, 2020).

This outcome reflects the phenomenon of “traffic evaporation,” in which reducing road capacity leads to behavioral changes rather than direct displacement of trips (Cervero, 2009). The Seoul case

provides strong empirical evidence supporting this concept and underscores the importance of integrating transit improvements within road removal projects.

Environmental and Quality of Life Outcomes

The environmental and quality-of-life improvements associated with the Cheonggyecheon project were substantial. Nitrogen oxide levels decreased by 38%, fine particulate matter declined by 35%, and other air pollutants were reduced by 16% following freeway removal (Robinson & Ji, 2022). In addition, the replacement of the expressway with green space contributed to a localized temperature reduction of approximately 3–4°C, mitigating the urban heat island effect (Robinson & Ji, 2022). Ecological recovery was also evident, with fish species increasing from 4 to 27 and total biodiversity rising from 98 to 206 species within a few years of restoration (Robinson & Ji, 2022).

Property values increased significantly in adjacent areas, with studies reporting substantial appreciation following the restoration as environmental and public space amenities were capitalized into land markets (Cervero, 2009). The introduction of vegetation and open space reduced local temperatures by several degrees Celsius, mitigated urban heat island effects, and improved air quality (Lee & Anderson, 2013). The restored corridor also created a continuous pedestrian environment, increasing walkability and public space usage.

However, the project does not represent full ecological restoration. The stream relies on artificially pumped water, and long-term maintenance costs remain high. As a result, the system functions more as an engineered environmental amenity than a fully self-sustaining ecosystem (Cervero, 2009).

Economic Development and Land Use

The Cheonggyecheon project generated significant economic impacts, particularly in surrounding land markets. Studies show that property values increased substantially near the restored corridor, with commercial land values rising by as much as 30 percent in some areas (Cervero, 2009). Following the restoration, the Cheonggyecheon corridor experienced rapid economic revitalization, with property values tripling between 2001 and 2009—significantly outpacing citywide trends (Robinson & Ji, 2022).

These gains reflect the capitalization of improved environmental conditions and enhanced public space into real estate markets. At the same time, redevelopment pressures increased, leading to changes in land use and the displacement of lower-margin businesses. These dynamics illustrate how infrastructure-led improvements can redistribute economic benefits rather than create them uniformly (Lee & Anderson, 2013).

Equity and Distributive Outcomes

From an equity perspective, the Cheonggyecheon project presents a more ambiguous outcome. While it improved access to public space and environmental conditions, it also contributed to rising land values and increased development pressures. Smaller businesses and informal economic activities were particularly vulnerable to displacement, as the area transitioned toward higher-end commercial uses (Lee & Anderson, 2013, Robinson & Ji, 2022).

Additionally, the project's top-down governance structure limited participatory decision-making, reducing the ability of affected communities to shape outcomes. These factors indicate that while the project addressed certain environmental inequities, it did not fully resolve underlying distributive inequalities.

To synthesize the multidimensional outcomes of the Cheonggyecheon project, Table 1 (on the next page) summarizes the evaluation scores and strength of evidence across the four analytical domains. This summary highlights the project's strong performance in transportation, environmental, and economic outcomes, while also underscoring its limitations in achieving equitable distribution of benefits.

Table 1 - Cheonggyecheon Outcome Assessment Summary

Domain	Score (0-3)	Evidence Strength (A-C)	Key Rationale	Equity Note
Transportation & Accessibility	3	A	Strong evidence of traffic adaptation, reduced volumes, and successful transit substitution	Broad mobility benefits, though access varies regionally
Environmental & Quality of Life	3	A	Significant improvements in air quality, temperature, and public space usability	Benefits concentrated locally; limited metropolitan ecological impact
Economic Development & Land Use	3	A	Major land value increases and redevelopment driven by amenity creation	Benefits largely captured by property owners and higher-income stakeholders
Equity & Distributive Outcomes	2	A	Evidence of displacement pressures and limited anti-displacement policy	Uneven benefits; small businesses and lower-income users faced exclusionary pressures

Mechanisms, Tradeoffs, and Lessons Learned

The outcomes of the Cheonggyecheon restoration can be explained through a set of reinforcing mechanisms that operated across transportation, governance, and urban redevelopment systems. First, the presence of a robust multimodal transportation network—including expanded bus and rail systems—enabled effective redistribution of traffic following the removal of a major roadway. Rather than causing system failure, the intervention triggered adaptive changes in travel behavior, demonstrating the flexibility of urban mobility systems when viable alternatives are available (Cervero, 2009).

Second, strong political leadership and centralized governance played a decisive role in shaping both the feasibility and speed of implementation. The project was completed rapidly and at a large scale, reflecting the capacity of coordinated state-led planning to overcome institutional fragmentation. This top-down approach allowed for the integration of transportation, environmental restoration, and urban design into a single intervention, aligning multiple policy objectives within a unified framework.

A third mechanism involves the creation of high-quality public space and its associated amenity value. The restoration of the stream and surrounding green corridor significantly improved environmental conditions, increased accessibility, and enhanced the attractiveness of the urban core. These changes drove economic revitalization, including increased investment and rising property values, illustrating the strong

relationship between environmental improvement and economic development. However, in the absence of comprehensive anti-displacement policies, these gains were largely mediated through market processes, resulting in uneven social outcomes (Lee & Anderson, 2013).

Together, these mechanisms produced both substantial benefits and important tradeoffs. On one hand, the project delivered measurable improvements in transportation performance, environmental quality, and economic activity, while also symbolically repositioning Seoul as a leader in sustainable urban development. On the other hand, the concentration of benefits in higher-value land markets contributed to socio-spatial restructuring, raising concerns about inclusivity and long-term equity. Additionally, the reliance on engineered ecological systems introduces questions about sustainability, particularly in relation to the energy and resource demands required to maintain artificial hydrological and landscape conditions (Stehlin, 2024; Lee & Anderson, 2013).

The governance approach itself also presents a key tradeoff. While centralized decision-making enabled rapid and coordinated implementation, it limited opportunities for public participation and reduced the ability of affected communities to influence outcomes. This highlights an important tension between efficiency and inclusivity in large-scale urban projects, particularly in contexts where strong state capacity can accelerate transformation but may constrain deliberative processes.

From an analytical perspective, Cheonggyecheon represents a high-impact, state-led model of infrastructure transformation. Unlike incremental or hybrid approaches, the project combined full highway removal with comprehensive environmental restoration and urban redevelopment, producing rapid and highly visible results. At the same time, this model demonstrates how infrastructure-led transformation can simultaneously generate economic growth and exacerbate inequalities when equity considerations are not embedded into the planning process.

The key lesson from Seoul is that large-scale infrastructure transformation is both feasible and highly effective at reshaping urban systems when supported by strong governance and integrated policy design. However, the case also underscores that transformative environmental and economic gains do not

inherently produce equitable outcomes. Without mechanisms to manage land value changes, protect vulnerable populations, and distribute benefits more evenly, the success of such projects remains partial.

Ultimately, Cheonggyecheon illustrates the dual nature of "green growth" as a planning paradigm—one that seeks to align environmental restoration with economic development, but that must be actively shaped to ensure social equity (Robinson & Ji, 2022). It stands as a powerful example of the potential of highway removal to reconfigure urban space and identity, while also demonstrating that the depth and inclusivity of transformation depend on the policy frameworks that accompany physical change.

Madrid Rio—Highway Burial and Urban Reconnection

The Madrid Río project represents one of the most ambitious urban infrastructure transformations in Europe, offering a distinctive alternative to conventional highway removal strategies. Rather than fully eliminating road capacity, the project relocated major segments of the M-30 ring road underground and reclaimed the surface as a continuous public landscape along the Manzanares River. Completed in phases between 2003 and 2018, the project is widely recognized for its ability to reconnect urban neighborhoods, restore ecological functions, and enhance public space while maintaining metropolitan mobility (Hernández-Lamas et al., 2016; Khalaj et al., 2020).

Within the analytical framework used in this research paper, Madrid Río is best classified as a hybrid intervention combining urban redevelopment, environmental restoration, and infrastructure preservation. While the project sought to repair the spatial and environmental damage caused by earlier highway construction, it did so without fully dismantling the underlying system of automobility. This dual approach makes Madrid Río particularly valuable for examining the extent to which partial infrastructure transformation can produce meaningful socioecological change, and where such efforts fall short.

Pre-Intervention Conditions

Transportation System

Prior to intervention, the M-30 functioned as one of Madrid's primary transportation corridors, forming a high-capacity ring road that facilitated both regional and intra-urban traffic flows. Constructed during the mid-twentieth century, the highway was designed according to modernist traffic engineering principles and prioritized high-speed automobile movement above all other forms of urban mobility (Hernández-Lamas et al., 2016).

While the M-30 played a critical role in regional connectivity, its alignment along the Manzanares River created significant local disruptions, as seen in Figure 5. The highway operated as a physical and functional barrier between central Madrid and adjacent southwestern neighborhoods, restricting pedestrian

access and limiting multimodal connectivity. By the late twentieth century, the infrastructure was widely regarded as both environmentally damaging and socially divisive (Khalaj et al., 2020).



Figure 5 - A major highway crossing over the Manzanares River before burial

Environmental and Ecological Context

The environmental conditions along the Manzanares River prior to the Madrid Río project were heavily degraded. Decades of channelization and infrastructure development had transformed the river into a highly engineered and ecologically simplified system. The presence of the M-30 exacerbated these conditions through noise pollution, air pollution, and fragmentation of potential green space (Hernández-Lamas et al., 2016).

In addition to environmental degradation, the corridor also contributed to localized heat accumulation and reduced air quality exposure for nearby communities. The riverfront functioned as residual space rather than an integrated ecological or social asset, reflecting broader patterns of mid-century infrastructure development that prioritized mobility over environmental quality (Stehlin, 2024).

Land Use and Economic Conditions

The areas adjacent to the M-30 corridor exhibited uneven development patterns prior to intervention. While central Madrid remained economically vibrant, neighborhoods near the river often experienced underinvestment, limited accessibility, and constrained development potential due to the presence of the highway (Hernández-Lamas et al., 2016).

The riverfront itself was largely underutilized, lacking both recreational amenities and cohesive development strategies. These conditions created an opportunity for large-scale transformation, as reclaiming the corridor offered the potential to unlock land value, improve connectivity, and reposition the river as a central urban asset.

Equity and Historical Context

The placement of the M-30 along the Manzanares River reinforced existing spatial inequalities by dividing neighborhoods and concentrating environmental burdens in specific areas. Lower-income communities, particularly to the south and west of the city center, experienced disproportionate exposure to pollution and reduced access to amenities (Stehlin, 2024).

Although the project did not involve large-scale displacement comparable to earlier freeway construction in U.S. cities, the long-term presence of the highway contributed to social fragmentation and unequal access to public space. These baseline conditions are crucial for evaluating the extent to which the Madrid Río intervention addressed—or reproduced—these disparities.

Intervention Description

Physical and Design Changes

The Madrid Río project involved the burial of approximately 40 kilometers of roadway infrastructure, enabling the complete reconfiguration of the surface environment along the river corridor (Hernández-Lamas et al., 2016). This engineering effort created the conditions for the development of a continuous linear park featuring pedestrian and bicycle pathways, recreational facilities, cultural spaces, and extensive landscaping, seen in Figure 6. This project involved the burial of more than 40 kilometers of

roadway infrastructure and required an estimated investment of between €4 billion and €7 billion, reflecting its scale as one of the largest urban infrastructure transformations in Europe.



Figure 6 - Madrid Rio Park post-intervention

A defining feature of the project was its use of landscape as infrastructure. Rather than treating public space as an afterthought, the design integrated ecological, social, and spatial functions into a cohesive system. Elements such as the Salón de Pinos—a continuous linear forest planted above the tunnels—demonstrate how landscape design was used to create spatial continuity and mitigate the impacts of underlying infrastructure (Burgos & Garrido, 2014).

In later phases, additional ecological interventions were introduced, including the renaturalization of the Manzanares River through dam removal and restoration of natural flow patterns, further enhancing the environmental performance of the corridor (Suárez et al., 2024).

Complementary Policies and Programs

The Madrid Río project was implemented through a strong municipal governance framework, with significant public investment and coordination across agencies. The project did not rely heavily on private development as a primary driver, instead prioritizing the creation of publicly accessible space.

However, unlike full highway removal projects, Madrid Río did not include substantial measures aimed at reducing automobile dependence at the metropolitan scale. While local accessibility improved, broader transportation policies did not fully address demand for car travel, limiting the project's effectiveness in reducing overall vehicle use (Khalaj et al., 2020).

Efforts to manage equity outcomes were partially embedded in the project's design, particularly through universal public access to green space, but explicit anti-displacement policies were relatively limited compared to more recent infrastructure interventions.

Outcome Assessment

Transportation and Accessibility

The Madrid Río project produced significant improvements in local accessibility by removing surface-level barriers and introducing multimodal infrastructure for pedestrians and cyclists. The construction of new bridges and pathways facilitated connections between neighborhoods previously divided by the M-30, substantially improving everyday mobility within the immediate area (Hernández-Lamas et al., 2016). Despite these improvements, the underground M-30 continues to accommodate more than 200,000 vehicles per day, limiting the project's impact on regional automobile dependence.

However, because the highway remained operational underground, the project did not fundamentally alter regional traffic patterns or reduce dependence on automobile travel. As a result, the transportation benefits were primarily localized, with limited impact on broader mobility systems (Khalaj et al., 2020). This distinguishes Madrid Río from full removal cases, where reductions in road capacity have led to measurable shifts in travel behavior and reduced vehicle volumes, supporting the broader concept of traffic evaporation (Cairns et al., 2002; Cervero, 2009).

Environmental and Quality of Life Outcomes

Environmental outcomes associated with Madrid Río were substantial, particularly at the local scale. The transformation of the river corridor introduced extensive green space, reduced noise and pollution exposure, and improved microclimatic conditions. The later renaturalization phase further enhanced ecological performance by increasing biodiversity and restoring natural river processes (Suárez et al., 2024). The project introduced an expansive linear park system including tens of thousands of trees and millions of plantings, with more than 35,000 trees and approximately 4 million shrubs incorporated into the landscape design.

These improvements significantly enhanced quality of life for nearby residents, creating a continuous public space that supports recreation, social interaction, and cultural activity. However, the environmental benefits were concentrated within the immediate corridor, and the continued presence of automobile traffic underground limits the project's contribution to broader climate goals (Stehlin, 2024).

Economic Development and Land Use

Madrid Río generated significant economic impacts, particularly in adjacent real estate markets. The creation of high-quality public space increased property values and attracted investment, contributing to urban regeneration along the river corridor (Hernández-Lamas et al., 2016).

At the same time, the project's emphasis on public space rather than intensive commercial redevelopment helped moderate the extent of speculative development compared to more market-driven cases. While rising property values did occur, the distribution of benefits was somewhat broader due to the public nature of the intervention.

Equity and Distributive Outcomes

From an equity perspective, Madrid Río represents a mixed outcome. On one hand, the project successfully improved access to public space and reconnected neighborhoods that had been divided by infrastructure. The extensive provision of publicly accessible green space ensured that many residents benefited directly from the transformation.

On the other hand, rising property values introduced concerns about displacement, particularly in historically working-class neighborhoods along the corridor (Stehlin, 2024). Although displacement pressures appear to be less severe than in some other cases, the absence of robust anti-displacement policies limited the project's ability to fully address underlying inequalities.

To synthesize the multidimensional outcomes of the Madrid Río project, Table 2 presents a comparative summary of performance across the four analytical domains. The table highlights the project's strong contributions to environmental improvement and neighborhood reconnection, while also illustrating the more limited impact on regional transportation systems due to the retention of underlying highway capacity. Additionally, the summary underscores the project's mixed equity outcomes, where broadly accessible public space has been offset by emerging development pressures. By consolidating these findings, the table provides a clear illustration of Madrid Río's position as a hybrid intervention—one that achieves substantial localized benefits while revealing the structural constraints of partial infrastructure transformation.

Table 2 - Madrid Rio Outcome Assessment Summary

Domain	Score (0-3)	Evidence Strength (A-C)	Key Rationale	Equity Note
Transportation & Accessibility	2	A	Strong local reconnection and multimodal improvements, but minimal regional traffic change	Benefits concentrated locally; regional mobility patterns unchanged
Environmental & Quality of Life	3	A	Major improvements in green space, microclimate, and river ecology	Benefits widely accessible but geographically concentrated
Economic Development & Land Use	2	B	Increased property values and investment, but less intensive redevelopment than other cases	Moderate distribution of benefits; some displacement pressures
Equity & Distributive Outcomes	2	B	Public space widely shared, but rising land values create uneven long-term outcomes	Mixed results; improved access but emerging gentrification concerns

Mechanisms, Tradeoffs, and Lessons Learned

The outcomes of the Madrid Río project can be understood through a set of interrelated mechanisms that shaped both its political feasibility and its ultimate impacts. Most importantly, the decision to bury rather than remove the M-30 highway created a critical compromise between competing priorities. By

preserving regional traffic capacity while reclaiming surface space, the project avoided the political resistance often associated with full highway removal. This hybrid approach enabled large-scale spatial transformation without fundamentally disrupting existing mobility systems.

A second mechanism lies in the scale and quality of public-space investment. The creation of an extensive linear park along the river generated significant amenity value, improving environmental conditions, enhancing accessibility, and reconnecting previously divided neighborhoods. These improvements re-established the riverfront as a central urban asset, increasing its attractiveness for recreation, development, and everyday use. At the same time, this added value contributed to rising land prices, illustrating how environmental improvements can translate into economic pressures.

A third mechanism involves governance and implementation. The project was characterized by strong municipal coordination and centralized decision-making, allowing for coherent execution across infrastructure, landscape, and urban design. This level of coordination ensured that the benefits of the project—particularly access to public space—were broadly distributed, distinguishing it from more purely market-driven redevelopment models. However, because the intervention focused primarily on surface conditions, it left deeper structural systems largely unchanged.

These mechanisms collectively produced a distinctive set of tradeoffs. While the burial of the highway enabled dramatic improvements in environmental quality and urban connectivity at the surface level, it preserved the underlying system of automobility. As a result, the project improved how the city functions locally without fundamentally altering how it functions regionally. This raises important questions about long-term sustainability, particularly in relation to traffic demand, emissions, and dependency on high-capacity road infrastructure.

Additionally, the project highlights the tension between inclusivity and economic change. Although the provision of public space was broadly accessible, rising property values introduced indirect pressures that may limit long-term affordability. Furthermore, the substantial financial investment required—among

the largest of the cases examined—raises concerns about the scalability and replicability of similar projects in cities with more constrained resources.

From an analytical perspective, Madrid Río represents a conditional or hybrid model of infrastructure transformation. Unlike cases that fully remove highway capacity or rely on incremental change, Madrid demonstrates that it is possible to achieve significant environmental and spatial improvements while maintaining existing transportation systems. However, this approach also reveals the limits of partial transformation: by retaining the infrastructure underground, the project preserves many of the broader systemic dynamics associated with automobility.

The key lesson from Madrid is that infrastructure transformation exists on a spectrum rather than as a binary choice between removal and retention. Partial interventions can deliver meaningful improvements in livability, environmental quality, and spatial connectivity, particularly in contexts where full removal is politically or technically infeasible. At the same time, these projects may fall short of producing deeper structural change, particularly in relation to transportation systems and long-term sustainability.

Ultimately, Madrid Río demonstrates that reclaiming urban space can succeed even within the constraints of existing infrastructure systems. However, it also underscores the importance of aligning surface-level improvements with broader systemic goals if cities aim to achieve lasting transformation. As such, it serves as an example of both the possibilities and limitations of hybrid infrastructure strategies, highlighting the need for integrated approaches that address not only urban form, but also the underlying systems that shape it.

The Embarcadero—Post-Disaster Reuse in San Francisco

The removal of the Embarcadero Freeway in San Francisco represents one of the most influential cases of urban highway removal in the United States, offering a clear example of how infrastructure transformation can be catalyzed by crisis conditions. Unlike proactive projects such as Cheonggyecheon or Harbor Drive, the Embarcadero's removal was precipitated by structural damage from the 1989 Loma Prieta earthquake, which rendered the elevated freeway unsafe and triggered a critical reassessment of its role in the city's transportation system (Cervero, 2009). The subsequent decision to dismantle the freeway and replace it with a multimodal boulevard fundamentally reshaped San Francisco's waterfront, producing significant economic, spatial, and mobility outcomes.

Within the framework applied in this research paper, the Embarcadero project is best classified as a primarily urban redevelopment intervention with strong transportation restructuring effects. While the project delivered improvements in environmental quality and public space, its central objective was to reconfigure urban land use and restore the waterfront as a civic and economic asset. This orientation distinguishes it from environmentally driven cases such as Seoul, while making it particularly valuable for understanding the relationship between infrastructure removal, land markets, and urban development.

Pre-Intervention Conditions

Transportation System

Prior to its removal, the Embarcadero Freeway (State Route 480) functioned as a double-deck elevated roadway, seen in Figure 7, carrying approximately 70,000 vehicles per day along San Francisco's northeastern waterfront (Cervero & Hansen, 2002). Constructed in the late 1950s as part of California's broader freeway expansion program, the structure provided direct vehicular access between the Bay Bridge and downtown.



Figure 7 - The Embarcadero Freeway towers over the waterfront

Despite its intended role in supporting regional mobility, the freeway was widely criticized for its limited functional efficiency and its redundancy within the broader transportation network. San Francisco's dense grid of surface streets and extensive transit system offered alternative routes, reducing the necessity of the elevated structure (Cairns et al., 2002). Furthermore, by the 1980s, the freeway had become increasingly obsolete in relation to evolving urban transportation priorities.

Environmental and Ecological Context

The presence of the Embarcadero Freeway significantly degraded environmental conditions along the waterfront. The elevated structure produced persistent noise pollution, reduced air quality, and obstructed sunlight and airflow, contributing to an inhospitable urban environment (Chin, 2015).

Equally important, the freeway severed the physical and visual relationship between downtown San Francisco and the Bay. By blocking access and limiting pedestrian movement, the structure effectively

transformed the waterfront into a neglected space, reducing both its environmental and social value. The corridor thus exemplified the environmental externalities associated with mid-twentieth-century highway construction.

Land Use and Economic Conditions

Prior to its removal, the Embarcadero corridor was characterized by underutilized land and limited economic integration with the rest of downtown. The presence of the elevated freeway reduced property values and constrained development opportunities, particularly in waterfront areas that would otherwise have been highly desirable (Mohl, 2008).

Although San Francisco's overall economy remained strong, the waterfront did not function as a major economic or civic destination. This disconnect between prime location and underperformance created significant latent potential for redevelopment, making the corridor a prime candidate for transformation.

Equity and Historical Context

The Embarcadero Freeway's construction reflected broader postwar infrastructure priorities that privileged regional mobility over local community needs. While the corridor did not involve the same scale of racialized displacement seen in other U.S. cities, it nonetheless contributed to social fragmentation by limiting access to public resources and reinforcing spatial divisions between neighborhoods (Chapple, 2009).

Additionally, the economic impacts of the freeway disproportionately affected lower-income workers and small businesses that relied on waterfront access. These baseline conditions are important for evaluating how the project's benefits were distributed following removal.

Intervention Description

Physical and Design Changes

Following the 1989 earthquake, the Embarcadero Freeway was closed due to structural damage and ultimately demolished, creating an opportunity to better redesign the corridor. The replacement infrastructure—the Embarcadero Boulevard, seen in Figure 8—was developed as a multimodal urban street

integrating light rail transit, bicycle lanes, pedestrian promenades, and landscaped public space (Cervero, 2009).



Figure 8 - A more pedestrian/multi-modal-friendly Embarcadero Boulevard

This transformation reoriented the waterfront from a mobility corridor into a civic space, restoring visual and physical connections between downtown and the Bay. The project also included significant public realm improvements, including the restoration of the Ferry Building and the creation of continuous waterfront access.

Complementary Policies and Programs

The success of the Embarcadero transformation was supported by a combination of local governance decisions and broader transportation policies. Mayor Art Agnos played a key role in advocating for removal rather than reconstruction, emphasizing urban design and economic benefits over purely transportation considerations (Mohl, 2008).

Public transit improvements, including enhancements to streetcar and bus services, helped absorb displaced traffic demand. However, unlike more recent projects, the intervention did not include comprehensive anti-displacement policies, leaving equity outcomes largely shaped by market dynamics (Chapple, 2009).

Outcome Assessment

Transportation and Accessibility

The removal of the Embarcadero Freeway produced outcomes that challenge traditional assumptions about the necessity of high-capacity urban highways. Despite the elimination of a major roadway, long-term congestion impacts were minimal. Traffic redistributed across the existing street network, some trips shifted to public transit, and others disappeared altogether—a phenomenon widely described as traffic evaporation (Cairns et al., 2002; Cervero, 2009). Prior to removal, the freeway carried well over 100,000 vehicles per day. Following its closure, traffic disruptions were temporary, and regional transit use increased, including a 15 percent rise in BART ridership (Cairns et al., 2002).

The introduction of multimodal infrastructure improved accessibility within the corridor itself, enhancing pedestrian and transit connectivity. These changes demonstrate the flexibility of urban transportation systems and the potential for reduced reliance on automobile infrastructure when alternatives are available.

Environmental and Quality of Life Outcomes

The environmental transformation of the Embarcadero corridor was substantial. The removal of the elevated freeway reduced noise pollution, improved air quality, and allowed for increased sunlight and ventilation along the waterfront (Chin, 2015). More than 100 acres of waterfront land were reclaimed and converted into public space, dramatically improving access and urban livability.

Quality of life improvements were equally significant, as the project introduced extensive public space, increased walkability, and restored access to the Bay. The waterfront became a major civic and

recreational destination, supporting a wide range of activities and enhancing the urban experience for residents and visitors alike.

Economic Development and Land Use

Economic impacts following the removal of the Embarcadero Freeway were among the most significant of any highway removal project. Property values along the waterfront increased sharply, and the area experienced substantial redevelopment, including commercial, residential, and mixed-use projects (Mohl, 2008). After the removal, housing in the surrounding area increased by approximately 51 percent and employment grew by 23 percent, reflecting significant redevelopment and economic revitalization along the waterfront.

The restoration of the Ferry Building and surrounding areas further contributed to economic revitalization, attracting tourism, retail activity, and employment opportunities. These outcomes demonstrate how infrastructure removal can unlock land value and catalyze urban transformation.

Equity and Distributive Outcomes

Despite its economic success, the Embarcadero project presents mixed equity outcomes. Rising property values and redevelopment pressures contributed to increased housing costs and the displacement of lower-income residents and businesses (Chapple, 2009).

While the project improved access to public space and enhanced the urban environment, these benefits were not evenly distributed. The absence of strong anti-displacement policies allowed market forces to shape development patterns, resulting in gains for higher-income populations and investors. This dynamic underscores the limitations of infrastructure-led redevelopment when equity is not explicitly prioritized.

To synthesize the multidimensional outcomes of the Embarcadero Freeway removal, Table 3 summarizes the project's performance across the four analytical domains. The table highlights the project's strong outcomes in transportation adaptation, environmental improvement, and economic redevelopment, reflecting the transformative effects of reclaiming high-value urban land for public and mixed-use purposes.

At the same time, it underscores the uneven distribution of these benefits, particularly in relation to rising property values and displacement pressures. By consolidating these findings, the table illustrates how the Embarcadero case exemplifies both the potential and limitations of infrastructure-led urban transformation, reinforcing the importance of integrating equity-focused policies into redevelopment efforts.

Table 3 - Embarcadero Outcome Assessment Summary

Domain	Score (0-3)	Evidence Strength (A-C)	Key Rationale	Equity Note
Transportation & Accessibility	3	A	Strong evidence of traffic evaporation and successful multimodal adaptation	Broad benefits, though transit access varies across populations
Environmental & Quality of Life	3	A	Major improvements in air quality, noise reduction, and public space	Benefits widely accessible but concentrated along waterfront
Economic Development & Land Use	3	A	Significant increase in property values and redevelopment activity	Benefits concentrated among property owners and higher-income groups
Equity & Distributive Outcomes	1	B	Clear evidence of displacement pressures and rising housing costs	Uneven distribution of benefits; displacement of lower-income residents

Mechanisms, Tradeoffs, and Lessons Learned

The outcomes of the Embarcadero Freeway removal can be understood through a set of interacting mechanisms that shaped both the feasibility of the intervention and the magnitude of its impacts. Most notably, the Loma Prieta earthquake functioned as a catalytic event that disrupted existing institutional and political constraints, creating a window of opportunity for action. This aligns with theories of punctuated change in infrastructure planning, where crisis conditions temporarily relax entrenched decision-making structures and allow for previously contested interventions to move forward (Mohl, 2008; Cervero, 2009). In this case, the damage to the freeway reframed the decision from whether to remove the structure to whether it should be rebuilt, fundamentally altering the terms of debate.

A second key mechanism was the presence of an established multimodal transportation network, including regional transit systems and a connected street grid. This allowed traffic demand to redistribute following the freeway's closure without long-term congestion increases, demonstrating the adaptability of urban transportation systems when alternative modes are available (Cairns et al., 2002). Rather than

collapsing mobility, the removal of the freeway triggered a rebalancing of transportation flows across the system.

A third mechanism relates to the transformation of the waterfront itself. By replacing the elevated freeway with a surface boulevard, public space, and transit infrastructure, the project significantly increased urban amenity value. The improved accessibility, environmental quality, and visual connection to the waterfront drove substantial economic redevelopment, including increased employment, residential growth, and investment along the corridor. However, the absence of coordinated housing and affordability policies meant that these gains were largely captured through market processes, intensifying property value increases and limiting accessibility for lower-income populations.

These mechanisms collectively produced both significant benefits and notable tradeoffs. On one hand, the project achieved a comprehensive spatial and economic transformation, reconnecting downtown San Francisco to its waterfront and creating a more accessible, multimodal urban environment. On the other hand, the rapid pace and scale of redevelopment introduced equity challenges, particularly in the form of rising costs and displacement pressures. Additionally, the reliance on a crisis event raises important questions about replicability. Cities without similar triggering conditions may face greater institutional resistance, making it more difficult to implement comparable interventions without sustained political effort.

From an analytical perspective, the Embarcadero case represents a high-intensity model of infrastructure transformation. In contrast to more incremental or planning-led approaches, the project combined sudden infrastructure removal with strong market-driven redevelopment, producing rapid and visible change. This dynamic highlights the dual nature of infrastructure transformation as both a spatial and economic process, in which improvements to accessibility and urban quality can simultaneously generate growth and inequality.

The key lesson from San Francisco is that infrastructure removal alone does not determine outcomes; rather, the surrounding policy framework plays a decisive role in shaping how benefits are

distributed. While the physical transformation created the conditions for improved mobility, environmental quality, and economic activity, the absence of complementary equity-focused interventions limited the inclusivity of these gains.

Ultimately, the Embarcadero demonstrates the transformative potential of highway removal as a catalyst for urban redevelopment, but also underscores the importance of integrating land use, transportation, and housing policy. Unlike more gradual cases, its outcomes were characterized by rapid change and strong market responsiveness, revealing both the opportunities and risks associated with large-scale infrastructure transformation. As such, it serves not only as a successful example of urban reconnection, but also as a cautionary case emphasizing the need for coordinated planning strategies to ensure more equitable outcomes.

Harbor Drive—Reconsideration for Greenspace in Portland

The removal of Harbor Drive in Portland, Oregon, represents one of the earliest and most influential examples of urban highway removal in the United States. Unlike later cases driven by infrastructure failure or environmental crisis, Portland's decision to dismantle a functioning urban highway in the early 1970s was largely proactive, reflecting a deliberate shift in planning priorities toward public space, environmental quality, and civic identity (Abbott, 1983; Jenner, 2004). The transformation of Harbor Drive into Tom McCall Waterfront Park reoriented the relationship between the city and the Willamette River, establishing a precedent for reclaiming urban land from automobile infrastructure.

Within the framework applied in this research paper, the Harbor Drive case is best classified as a public-space-driven urban redevelopment intervention with strong equity potential. While the project did not pursue large-scale ecological restoration or complex engineering solutions, it prioritized the redistribution of urban land toward collective use. As such, it offers a critical contrast to more recent, capital-intensive or market-driven infrastructure transformations, illustrating how early planning decisions can shape long-term urban development trajectories.

Pre-Intervention Conditions

Transportation System

Prior to its removal, Harbor Drive functioned as a six-lane limited-access highway running along the west bank of the Willamette River (figure 9), carrying approximately 40,000 vehicles per day at its peak (Jenner, 2004). Constructed in 1942, the roadway reflected mid-twentieth-century planning priorities that emphasized regional automobile mobility and efficient traffic movement into and through the downtown core (Abbott, 1983).



Figure 9 - Harbor Drive acting as a barrier to the Willamette River

Although the highway played an important role in the transportation network, its necessity declined over time as the regional freeway system expanded, particularly with the development of alternative routes such as the I-5 corridor and the Fremont Bridge. These changes reduced Harbor Drive's relative importance, creating conditions under which removal could be considered without catastrophic mobility impacts (Abbott, 1983).

Environmental and Ecological Context

The presence of Harbor Drive significantly degraded the environmental quality of Portland's waterfront. The roadway generated noise pollution, reduced air quality, and created a physical barrier that limited access to the river. As a result, the Willamette Riverfront functioned as an underutilized and environmentally compromised space rather than a public amenity (MacColl, 1979).

Unlike some later projects, the river itself was not deeply ecologically restored during the initial intervention. However, the removal of the highway created the potential for future ecological improvements by eliminating a major source of environmental stress and opening space for greening and public use.

Land Use and Economic Conditions

Before its removal, the riverfront area adjacent to Harbor Drive was characterized by underutilized land and limited integration with downtown economic activity. Despite its central location, the presence of the highway reduced property values and discouraged investment by severing access and diminishing the attractiveness of the area (Abbott, 1983).

The disconnect between downtown and the waterfront represented a missed opportunity for economic and civic development, as the riverfront had historically been envisioned as a key public asset in earlier planning proposals such as the Olmsted and Bennett plans (Abbott, 1983). These unrealized visions later informed the conceptual framework for the removal project.

Equity and Historical Context

The construction of Harbor Drive reinforced a broader pattern of exclusionary infrastructure planning in which public space was subordinated to automobile mobility. The highway limited public access to the river and restricted the ability of residents to engage with a key natural resource.

Although the project did not involve large-scale racialized displacement comparable to other U.S. highway cases, it nonetheless produced spatial inequalities by restricting access and concentrating environmental burdens along the waterfront. These baseline conditions are important for evaluating the extent to which the project functioned as a redistributive intervention.

Intervention Description

Physical and Design Changes

The removal of Harbor Drive between 1970 and 1974 resulted in the reclamation of approximately 37 acres of riverfront land, which was subsequently transformed into Tom McCall Waterfront Park (Jenner, 2004). The park, seen center-right in Figure 10, was designed as a linear public space featuring open lawns,

tree-lined pathways, and pedestrian-oriented amenities that reconnected downtown Portland with the Willamette River.



Figure 10 - A greener riverfront for a modern Portland, OR

A key characteristic of the design was its emphasis on flexibility and civic use. Rather than prioritizing commercial development, the project focused on creating a shared public resource capable of supporting both everyday recreation and large-scale events. This approach distinguished Portland's intervention from more market-driven redevelopment strategies seen in later cases.

Complementary Policies and Programs

The success of the Harbor Drive removal was closely tied to broader political and institutional changes. Governor Tom McCall and local civic leaders played a critical role in reframing the waterfront as a public asset rather than a transportation corridor (Abbott, 2001).

Equally important was the role of citizen advocacy. Organizations such as the Riverfront for People Committee mobilized public support and helped shift planning priorities toward environmental quality and

civic space (Jenner, 2004). This participatory process contributed to a governance model that emphasized public benefit and long-term planning over short-term economic gain.

While the project did not include formal anti-displacement policies, its emphasis on public space rather than private redevelopment limited speculative pressures compared to later cases.

Outcome Assessment

Transportation and Accessibility

The removal of Harbor Drive demonstrated the adaptability of urban transportation systems in the face of reduced road capacity. Despite initial concerns about congestion, traffic redistributed across the existing network, supported by the broader regional freeway system and adjustments in travel behavior (Abbott, 1983).

At the same time, the project significantly improved pedestrian accessibility by eliminating a major barrier to the waterfront. The creation of continuous public space and improved street connections enhanced walkability and integrated the riverfront into the city's daily life.

Environmental and Quality of Life Outcomes

The environmental and quality-of-life improvements associated with the project were substantial, even in the absence of large-scale ecological restoration. The creation of green space reduced noise exposure, improved air quality, and provided opportunities for recreation and social interaction (Jenner, 2004).

The park also contributed to broader urban environmental benefits by introducing vegetation and open space into the city center, enhancing microclimatic conditions and supporting public health. These improvements helped redefine Portland's identity as a livability-oriented city.

Economic Development and Land Use

The transformation of the waterfront generated significant economic benefits over time. Property values in adjacent areas increased, and the improved attractiveness of the riverfront encouraged investment and development near the park (Abbott, 1983). The transformation also contributed to significant increases

in surrounding property values and helped catalyze downtown redevelopment, including new mixed-use and residential projects along the waterfront.

However, unlike more recent cases, the project did not rely heavily on direct commercial redevelopment within the reclaimed corridor itself. This approach moderated the pace and intensity of economic change, allowing benefits to diffuse gradually rather than concentrating them in large-scale projects.

Equity and Distributive Outcomes

From an equity perspective, the Harbor Drive project represents one of the more inclusive examples of highway removal. The creation of a publicly accessible park ensured that benefits were widely shared across the population, regardless of income or tenure.

While rising property values did occur in surrounding areas, the relatively early timing of the project and its emphasis on public space limited the extent of displacement pressures. Additionally, the participatory planning process gave residents a greater voice in shaping outcomes compared to more top-down interventions (Jenner, 2004). Nevertheless, the absence of formal equity policies means that some long-term distributional effects remain difficult to assess, particularly in relation to subsequent urban growth. However, the long-term success of the park and Portland's subsequent growth raise the possibility of delayed or indirect displacement effects, which are not fully captured in early evaluations of the project (Abbott, 2001; Jenner, 2004).

To synthesize the multidimensional outcomes of the Harbor Drive removal, Table 4 summarizes the project's performance across the four analytical domains. The table reflects strong outcomes in adaptation of transportation, environmental improvement, and equitable public access, highlighting the effectiveness of early, public-space-oriented planning. At the same time, it underscores the project's more moderate economic transformation relative to later cases, as well as the limitations of addressing broader regional mobility and long-term distributive dynamics. Together, these findings position Harbor Drive as a

distinctive example of proactive and relatively equitable infrastructure removal, shaped by its historical context and governance approach.

Table 4 - Harbor Drive Outcome Assessment Summary

Domain	Score (0-3)	Evidence Strength (A-C)	Key Rationale	Equity Note
Transportation & Accessibility	3	A	Successful traffic redistribution and major improvements in pedestrian access	Broad accessibility gains for all users
Environmental & Quality of Life	3	A	Creation of major green space and improved environmental conditions	Benefits widely shared across population
Economic Development & Land Use	2	B	Gradual increase in property values and surrounding investment	Benefits diffused rather than concentrated
Equity & Distributive Outcomes	2	B	Strong public access and participatory planning, but limited formal redistribution policies	Relatively equitable but not systematically protected

Mechanisms, Tradeoffs, and Lessons Learned

The outcomes of the Harbor Drive removal can be understood through the interaction of several reinforcing mechanisms that shaped both the feasibility of the project and its long-term impacts. First, the declining functional importance of the highway reduced institutional and political resistance to its removal, making it easier to reframe the project as an opportunity rather than a disruption. Second, strong political leadership and civic advocacy shifted the narrative around infrastructure, positioning the waterfront as a public asset rather than a transportation corridor. This reframing was critical in aligning planning priorities with broader goals of urban accessibility and livability.

A third mechanism lies in the decision to prioritize public space over private redevelopment. By converting the former highway corridor into a large, continuous park, the city limited speculative real estate pressures and ensured that the benefits of the intervention were broadly accessible. Finally, the project's integration within a wider regional transportation network allowed traffic to redistribute without significant long-term congestion, demonstrating the adaptability of urban mobility systems when supported by alternative routes and infrastructure.

At the same time, these outcomes reveal important tradeoffs. The removal of Harbor Drive did not eliminate automobile dominance entirely, as nearby corridors such as Naito Parkway continue to function

as high-capacity routes that, in certain areas, still act as barriers to full pedestrian connectivity. In addition, the success of the waterfront park has introduced ongoing challenges related to maintenance, programming, and competing demands for public space. These dynamics illustrate that infrastructure transformation is not a one-time intervention, but an ongoing process requiring continued management and investment.

From an analytical perspective, the Harbor Drive case offers a distinct model of infrastructure transformation when compared to later examples. Rather than producing rapid economic change or large-scale redevelopment pressures, the project reflects a slower, planning-driven approach in which public investment and civic priorities guided outcomes over time. This incremental trajectory allowed for the gradual accumulation of benefits—improved access, enhanced public space, and rising land values—while avoiding the more immediate displacement pressures observed in other cases.

The key lesson from Portland is not that highway removal will always produce equitable outcomes, but that the structure of decision-making matters. By prioritizing public access, limiting speculative development, and embedding the project within a broader planning vision, the city was able to shape the distribution of benefits more deliberately. At the same time, the case highlights the importance of timing: Harbor Drive was removed at a moment when regional transportation capacity had already shifted elsewhere, reducing the risks associated with removal.

Ultimately, Portland demonstrates that infrastructure transformation does not require large-scale disruption to be effective. Instead, it suggests that sustained public investment, long-term planning, and strategic use of urban land can produce durable improvements in accessibility and livability. However, the relative success of this approach also reflects specific historical and institutional conditions that may not be easily replicated in more contemporary, market-driven urban contexts. As such, Harbor Drive serves both as an early example of urban repair and as a reminder that infrastructure outcomes are shaped as much by governance and context as by design.

Applying the Case Studies: A Comparative Analysis

The four case studies examined in this research paper—Cheonggyecheon (Seoul), Madrid Río (Madrid), the Embarcadero Freeway (San Francisco), and Harbor Drive (Portland)—demonstrate that urban highway transformation is neither a uniform process nor a universally equitable solution. Instead, these projects reveal a spectrum of outcomes shaped by differences in governance, infrastructural strategy, and policy integration.

Each case study reflects the same underlying socioecological framework, in which infrastructure changes reshape interconnected urban systems. While the specific outcomes vary, all projects demonstrate how modifying transportation infrastructure produces cascading effects across mobility, environmental conditions, economic activity, and social dynamics. The comparative analysis that follows applies this framework consistently across cases to identify both shared mechanisms and context-specific differences. Also, while each case study reflects similar processes, they can be understood as distinct models of transformation, as illustrated in Figure 11.

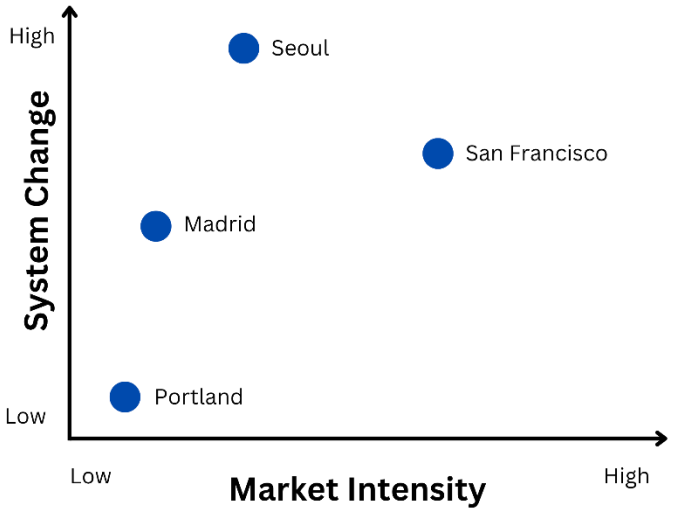


Figure 11 - Typology of highway transformation models across case studies

To synthesize the findings across cases, Table 5 presents a comparative outcome matrix evaluating each project across four key domains: transportation, environmental conditions, economic development,

and equity impacts. This structure reflects the multidimensional framework introduced earlier and enables a consistent comparison of how infrastructure transformation reshapes urban systems across different contexts.

Table 5 - Comparative outcome matrix of highway transformation cases (1=low impact, 3=high impact)

Case	Transportation	Environment	Economy	Equity
Cheongyecheon	●●●	●●●	●●●	●
Madrid Rio	●	●●●	●●	●●
Embarcadero	●●	●●●	●●●	●
Harbor Drive	●	●●	●●	●●●

As shown in the table above, all four cases demonstrate strong environmental improvements and economic growth, while transportation and equity outcomes vary significantly across contexts.

While each case illustrates the potential for infrastructure to improve environmental conditions and reconnect urban space, the comparative analysis highlights three central findings: first, that transportation outcomes are consistently more flexible than commonly assumed; second, that economic and environmental benefits are often substantial but unevenly distributed; and third, that equity outcomes depend less on physical design than on governance and policy choices.

Each case reflects a distinct political and spatial context, but several consistent mechanisms emerge across the analysis. In particular, the removal or transformation of highway infrastructure alters accessibility patterns, redistributes mobility flows, and opens land for redevelopment. These changes trigger a cascade of environmental and economic effects, though the distribution of benefits is shaped by local governance, planning frameworks, and market conditions. As a result, similar interventions can produce markedly different social outcomes despite comparable physical transformations.

Table 6 presents a comparative summary of key outcomes related to transportation performance, environmental change, economic development, and equity impacts. By consolidating quantitative and qualitative indicators—including traffic volumes, land-use changes, and project scale—the table provides a clear cross-case comparison of how different infrastructure strategies shape urban outcomes. This summary highlights both consistent patterns, such as the adaptability of transportation systems, and important variations, particularly in the distribution of economic and social benefits. As such, the table serves as a foundation for identifying broader trends and reinforcing the research paper's central argument that the impacts of highway transformation are deeply dependent on governance and policy context.

Table 6 - Comparative Outcomes of the Four Case Studies

Case	Cheonggyecheon (Seoul)	Madrid Río (Madrid)	Embarcadero (San Francisco)	Harbor Drive (Portland)
Intervention Type	Full removal + ecological restoration	Highway burial + park construction	Full removal + boulevard conversion	Full removal + park conversion
Pre-removal Traffic Volume	~168,000 vehicles/day	~200,000+ vehicles/day (retained underground)	100,000+ vehicles/day	~24,000 vehicles/day
Transportation Outcome	Traffic redistributed; transit increased (bus +15.1%, subway +3.3%)	Maintains regional traffic capacity; improved local connectivity	Traffic absorbed; transit use increased (~15% BART ridership)	Traffic redistributed across network; minimal long-term congestion
Environmental Outcome	Temperature reductions; improved air quality and urban cooling	Large-scale green space; 35,000+ trees planted	100+ acres of waterfront reclaimed; improved air and noise conditions	Creation of 37-acre park (later expanded)
Economic Outcome	Property values increased significantly in corridor	Moderate property value increases; public-space-driven development	Housing ↑ 51%; jobs ↑ 23%; strong redevelopment	Gradual increase in property values and downtown investment
Equity Outcome	Displacement of small businesses; uneven benefit distribution	Mixed; broad access but rising housing pressure	Significant displacement and rising housing costs	Relatively equitable; broad public access
Project Scale/Cost	~$345–900 million (est.); 5.8 km corridor	€4–7 billion; 40+ km tunnels	<$50 million (boulevard replacement); 100+ acres reclaimed	Low cost; 37+ acres reclaimed

While the table provides a structured comparison of outcomes, it is important to note that data availability and measurement consistency vary across cases. As such, the values presented should be interpreted as indicative rather than definitive. In addition to observed outcomes, the table also reflects potential impacts suggested by the evidence, particularly in areas where long-term effects are still emerging.

Across all four cases, one of the most striking patterns is the adaptability of urban transportation systems following reductions in road capacity. Removed or transformed highways previously carried between approximately 24,000 and over 170,000 vehicles per day, yet their elimination or modification did

not result in sustained congestion, reinforcing the adaptability of urban transportation systems. In both Seoul and San Francisco, the removal of major highways did not produce the widespread congestion predicted by conventional models. Instead, traffic volumes declined, redistributed, or shifted to alternative modes—a phenomenon widely described as "traffic evaporation" (Cervero, 2009; Cairns et al., 2002) illustrated in Figure 12.

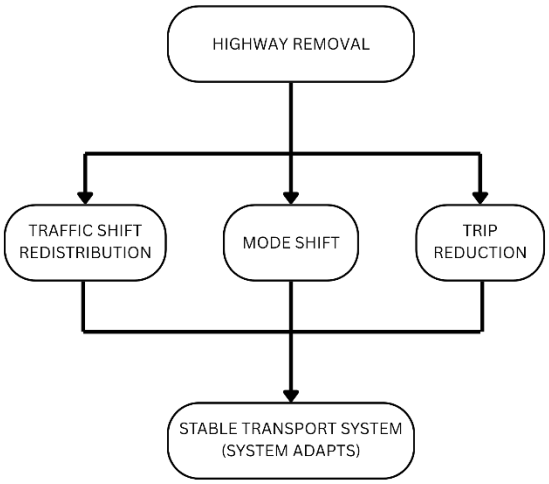


Figure 12 - Traffic adaptation mechanisms following highway removal

Similar dynamics were observed in Portland, where the removal of Harbor Drive did not result in long-term congestion due to changes in travel behavior and the availability of alternative routes (Abbott, 1983). Across cases, these transportation outcomes demonstrate that mobility impacts are best understood as system-wide adaptations rather than direct one-to-one substitutions for removed capacity, reinforcing critiques of traditional traffic modeling approaches (Cairns et al., 2002; Cervero, 2009).

However, the Madrid Río case introduces an important variation on this pattern. By burying rather than removing the M-30, Madrid preserved regional traffic capacity while improving local accessibility. This approach avoided the political risks associated with capacity reduction but also limited the project's ability to reduce automobile dependence at a systemic level (Khalaj et al., 2020). As such, the comparative evidence suggests that while full removal projects demonstrate the feasibility of significant mobility shifts, hybrid approaches prioritize stability over transformation.

A second major finding concerns the economic and environmental effects of highway transformation. All four cases produced measurable improvements in environmental conditions and quality of life, particularly through the introduction of green space, reduction of noise and pollution, and increased pedestrian activity. In Seoul, the Cheonggyecheon restoration reduced urban temperatures and improved air quality, while Madrid Río introduced a large-scale green corridor and later ecological renaturalization (Lee & Anderson, 2013; Suárez et al., 2024). Similarly, the Embarcadero and Harbor Drive projects transformed previously degraded corridors into high-value public spaces, enhancing urban livability and civic identity (Cervero, 2009; Jenner, 2004).

These environmental improvements were closely linked to economic outcomes. In every case, the creation of public space and improved urban conditions increased surrounding land values and attracted investment. The most pronounced effects occurred in Seoul and San Francisco, where redevelopment pressures significantly reshaped adjacent neighborhoods (Cervero, 2009; Mohl, 2008). Madrid Río also experienced rising property values, though the project's strong public-space orientation moderated the intensity of market-driven transformation (Hernández-Lamas et al., 2016). Portland presents a somewhat distinct case, where economic benefits emerged more gradually and were less directly tied to large-scale redevelopment, reflecting both the historical context and policy orientation of the project (Abbott, 1983).

While these economic and environmental gains are consistent across cases, their distribution reveals a critical limitation of infrastructure-led transformation: benefits are rarely shared equally. In both the Cheonggyecheon and Embarcadero cases, rising property values contributed to displacement pressures affecting lower-income residents and small businesses (Lee & Anderson, 2013; Chapple, 2009). These patterns align with broader scholarship on environmental gentrification, which emphasizes the tendency for urban improvements to be captured by higher-income groups in the absence of policy intervention (Patterson & Harley, 2019).

Madrid Río demonstrates a more mixed outcome. The extensive provision of publicly accessible space allowed benefits to be more broadly distributed in the short term, but rising land values still introduced

long-term equity concerns (Stehlin, 2024). In contrast, Portland's Harbor Drive project stands out as relatively more equitable, due in part to its emphasis on public space over private redevelopment and its early implementation before contemporary gentrification dynamics intensified. However, even in this case, the absence of formal equity policies limits the ability to assess long-term distributive outcomes (Jenner, 2004).

These patterns point to a third and most significant finding: equity outcomes are determined less by the physical form of infrastructure interventions than by the governance structures and policy frameworks that accompany them. Projects such as Cheonggyecheon, implemented through centralized, top-down governance, achieved rapid and transformative results but provided limited opportunities for community input or redistribution (Lee & Anderson, 2013). The Embarcadero project, while shaped by local political decision-making, similarly lacked strong anti-displacement measures, allowing market forces to dominate redevelopment outcomes (Chapple, 2009).

Madrid Río illustrates how strong municipal governance and public investment can support broader access to benefits, even when underlying inequalities persist. Meanwhile, Portland demonstrates the potential of participatory planning and civic advocacy to shape more inclusive outcomes, particularly when infrastructure is framed as a public asset rather than a commodity (Abbott, 2001). Together, these cases suggest that infrastructure transformation alone is insufficient to produce equitable outcomes; instead, equity must be actively pursued through complementary policies such as affordable housing, land-use regulation, and community engagement.

The growing federal emphasis on reconnection initiatives also suggests that the patterns identified in these case studies are not isolated examples, but part of a broader shift in infrastructure policy. Programs like the Reconnecting Communities Pilot translate these lessons into practice, particularly the importance of reconnecting urban fabric and reallocating space toward public and community uses.

Taken together, the comparative analysis reinforces the central argument of this research paper: that urban highway infrastructure is not a neutral system but a powerful mechanism for shaping spatial

inequality, and that its removal or transformation does not automatically resolve these inequalities. While all four cases demonstrate the potential for infrastructure to improve environmental conditions, restore connectivity, and enhance urban life, they also reveal the limitations of approaches that prioritize physical transformation without addressing underlying economic and social dynamics.

Ultimately, the success of highway removal should not be measured solely in terms of mobility or environmental outcomes, but in its ability to produce inclusive and equitable urban spaces. The cases examined here make clear that achieving this goal requires not only redesigning infrastructure but also rethinking the policies and institutions that govern urban development.

Planning Interventions and Policy Implications

Equity and Environmental Justice

The case studies analyzed in this research paper demonstrate that while urban highway removal and transformation can generate significant environmental improvements, these benefits are not distributed evenly across populations. Instead, they often reproduce or reconfigure existing inequalities, raising critical concerns about environmental justice. Across all four cases, infrastructure transformation improved air quality, increased access to green space, and reduced localized environmental burdens. However, the distribution of these benefits reveals a persistent pattern: environmental gains tend to be captured by more advantaged populations in the absence of deliberate policy intervention. The relationship between environmental improvement and displacement can be understood as a reinforcing cycle, as shown in Figure 13.

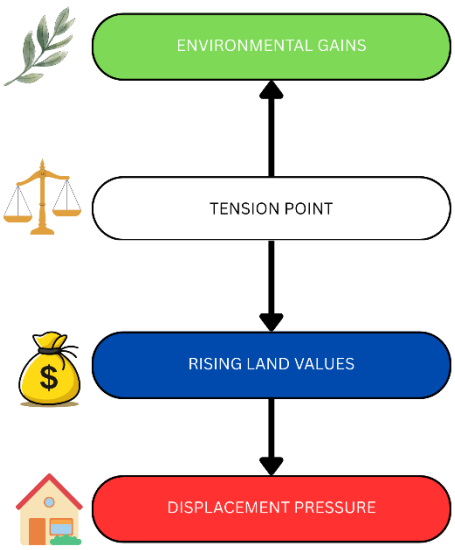


Figure 13 - Environmental justice tradeoffs in highway transformation

In the Cheonggyecheon and Embarcadero cases, environmental improvements such as reduced pollution and enhanced public space coincided with rising property values and increasing redevelopment pressures, leading to the displacement of lower-income residents and businesses (Lee & Anderson, 2013; Chapple, 2009). These dynamics align with the concept of environmental gentrification, in which ecological

restoration and urban greening initiatives increase land values and ultimately exclude the populations most affected by prior environmental harm (Patterson & Harley, 2019). As a result, projects that initially appear to correct environmental injustice may, over time, reproduce it in new spatial forms.

Madrid Río presents a more balanced case, where extensive public space provision allowed environmental benefits to be more broadly accessible. However, even here, rising real estate values and development pressures introduce long-term equity concerns, particularly in historically working-class neighborhoods (Stehlin, 2024). Portland's Harbor Drive case, by contrast, demonstrates that prioritizing public space over market-driven redevelopment can mitigate some of these effects, though the absence of explicit redistributive policies limits the durability of these outcomes (Abbott, 1983; Jenner, 2004).

Taken together, these findings suggest that environmental justice outcomes are not determined solely by infrastructure design, but by the broader socio-economic systems in which these projects are embedded. Highway removal can reduce environmental burdens, but without mechanisms to secure affordability and community control, these benefits risk being redistributed upward. This reinforces the need to conceptualize environmental justice not only as the reduction of harm, but as the equitable distribution of benefits over time.

Climate and Sustainability Implications

From an environmental justice perspective, these projects highlight a critical tension between environmental improvement and social equity. While highway removal often reduces pollution and increases access to high-quality public space, these benefits can be accompanied by rising land values and displacement pressures. The cases in this study suggest that environmental improvements alone do not produce equitable outcomes; instead, justice-oriented planning requires proactive policies to ensure that existing communities are able to remain in and benefit from these transformed environments.

The transformation of urban highway infrastructure is frequently framed as a component of broader climate and sustainability strategies, yet the case studies analyzed here reveal that outcomes vary significantly depending on the extent to which projects alter underlying patterns of automobility. Full

removal cases such as Cheonggyecheon and the Embarcadero demonstrate that reducing road capacity can lead to measurable declines in automobile traffic through modal shifts, route changes, and trip suppression (Cervero, 2009; Cairns et al., 2002). These findings challenge conventional assumptions about fixed travel demand and suggest that infrastructure removal can contribute to reductions in vehicle miles traveled (VMT), a key factor in urban carbon emissions (Cervero, 2009; Cairns et al., 2002).

However, the Madrid Río case highlights the limitations of infrastructure transformation strategies that retain underlying traffic capacity. By burying rather than removing the M-30, the project achieved significant local environmental improvements while preserving regional patterns of automobile dependence (Khalaj et al., 2020). As Stehlin (2024) argues, such interventions may function as a "vertical displacement" of environmental burdens, improving surface conditions without addressing the systemic drivers of emissions. This distinction underscores the difference between localized environmental improvement and broader climate mitigation.

Similarly, the Cheonggyecheon project, while effective in reducing traffic and improving environmental quality, relies on energy-intensive systems such as pumped water, complicating its sustainability profile (Lee & Anderson, 2013). These tradeoffs highlight the tension between symbolic environmental initiatives and long-term ecological sustainability in highly urbanized contexts.

Across cases, the evidence suggests that infrastructure transformation can contribute to climate goals, but only when accompanied by broader policies aimed at reducing automobile dependence. Without such measures, urban highway projects risk producing localized sustainability gains while leaving the overall carbon footprint of the urban system largely unchanged. This reinforces the need to integrate highway removal into comprehensive strategies that include transit investment, land-use reform, and demand management.

Governance and Political Economy

A central finding of this research paper is that governance structures and political dynamics play a decisive role in shaping the outcomes of infrastructure transformation. The case studies illustrate a range

of governance models, from centralized, top-down decision-making in Seoul to participatory, locally driven processes in Portland. These differences not only influence implementation but also determine how benefits and costs are distributed across communities. These dynamics suggest that infrastructure transformation alone is insufficient to produce equitable outcomes. Instead, targeted policy interventions are required, as illustrated in Figure 14.

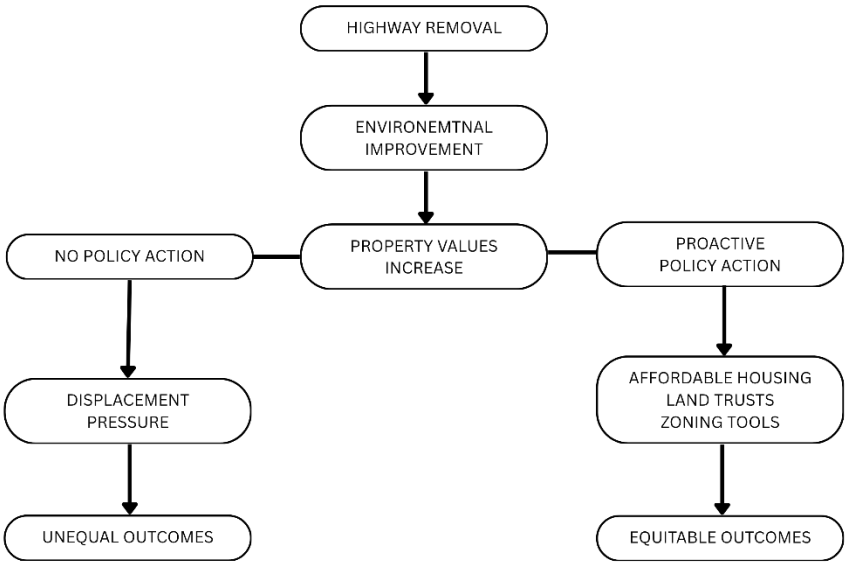


Figure 14 - Policy pathways for equitable infrastructure transformation

The Cheonggyecheon project demonstrates the capacity of centralized governance to deliver large-scale, rapid transformation. Strong executive leadership enabled coordinated planning and efficient execution, resulting in significant environmental and economic gains (Cervero, 2009). However, this approach also limited public participation and constrained opportunities for community input, contributing to uneven equity outcomes (Lee & Anderson, 2013). In contrast, Portland's Harbor Drive project illustrates the importance of civic engagement and political framing in shaping infrastructure decisions. Grassroots advocacy and political leadership reframed the waterfront as a public asset, enabling removal in the absence of crisis conditions (Abbott, 2001; Jenner, 2004).

The Embarcadero case highlights the role of crisis as a catalyst for political change. The Loma Prieta earthquake created a window of opportunity in which previously contested infrastructure could be

re-evaluated and removed (Mohl, 2008). This suggests that infrastructure transformation is often contingent on external shocks or shifts in political context, rather than purely rational planning processes. Meanwhile, Madrid Río demonstrates the importance of strong municipal institutions and public investment in delivering large-scale projects, while also revealing the limits of approaches that avoid challenging dominant transportation paradigms (Hernández-Lamas et al., 2016).

From a political economy perspective, these cases illustrate that infrastructure projects are sites of value production and distribution. The transformation of highway corridors generates significant economic gains, particularly through increased land values, but the allocation of these gains is shaped by governance decisions. Where policy frameworks emphasize public benefit and redistribution, outcomes are more inclusive; where they rely on market mechanisms, benefits are more likely to accrue to private actors. This finding reinforces the argument that infrastructure is not a neutral system but a key mechanism through which urban inequality is produced and contested.

Policy Implications

The findings of this research paper have several important implications for urban policy and infrastructure planning. First, the consistent evidence of traffic adaptation across multiple cases suggests that concerns about congestion should not be treated as a decisive barrier to highway removal. Instead, planners should recognize the elasticity of travel demand and incorporate policies that support modal shifts, such as transit investment and demand management (Cervero, 2009; Cairns et al., 2002).

Second, the analysis highlights the need to integrate equity considerations into every stage of infrastructure planning. The case studies demonstrate that environmental and economic benefits do not automatically translate into equitable outcomes. Without explicit measures such as affordable housing policies, anti-displacement strategies, and mechanisms for community participation, infrastructure transformation risks reinforcing existing inequalities (Patterson & Harley, 2019; Chapple, 2009).

Third, the comparative analysis underscores the importance of aligning infrastructure projects with broader climate and sustainability goals. Projects that reduce road capacity and support multimodal systems

are more likely to contribute to long-term emissions reductions, while those that preserve underlying automobility may produce only localized improvements (Khalaj et al., 2020; Stehlin, 2024). The success of the Cheonggyecheon project was supported by complementary policies, including transit expansion, reduced parking availability, and broader investments in pedestrian infrastructure, highlighting the importance of integrated planning approaches (Robinson & Ji, 2022).

From an environmental justice perspective, the findings of this study underscore the importance of integrating equity into all stages of infrastructure planning. Environmental justice frameworks emphasize three key dimensions: the distribution of benefits and burdens, the inclusivity of decision-making processes, and the recognition of community needs and vulnerabilities (Das, 2025). Applying these principles to highway transformation suggests that equitable outcomes require more than physical redesign; they depend on governance structures, policy interventions, and meaningful public engagement.

In particular, the risk of environmental gentrification highlights the need for policies that capture the value generated by environmental improvements while protecting existing residents. Without such interventions, projects that improve urban environments may inadvertently reproduce or intensify spatial inequality.

Recent federal policy initiatives in the United States further reinforce the relevance of highway transformation as a planning strategy. Programs such as the Reconnecting Communities Pilot Program, established through the Infrastructure Investment and Jobs Act and aligned with the broader Build Back Better agenda, provide funding specifically for projects that remove, retrofit, or mitigate transportation infrastructure that has historically fragmented urban areas. These initiatives support both planning and capital construction, including highway removal, capping, and conversion into multimodal corridors or public space.

The emergence of this program reflects a significant shift in federal transportation policy—from prioritizing expansion and capacity-building to addressing the long-term spatial and social impacts of past infrastructure decisions. By explicitly funding projects that aim to restore connectivity, improve access to

opportunity, and enhance environmental conditions, the program institutionalizes many of the principles observed in the case studies examined in this research.

However, the competitive and limited nature of funding highlights an important challenge: demand for these projects far exceeds available resources. As a result, cities must not only demonstrate technical feasibility but also align projects with broader policy goals, including equity, sustainability, and community engagement. This reinforces the importance of integrating infrastructure transformation within a comprehensive planning framework rather than treating it as an isolated intervention.

Finally, the findings emphasize the need for governance frameworks that balance efficiency with inclusivity. While centralized approaches can facilitate rapid implementation, they must be complemented by mechanisms for public engagement and equitable benefit distribution. Conversely, participatory approaches should be supported by institutional capacity and resources to ensure effective execution. Ultimately, urban renewal and highway programs failed to achieve their stated goals of revitalization and public health improvement, instead contributing to urban decline, inequality, and long-term environmental impacts (Lopez, 2012).

In the end, this study contributes to the planning field by demonstrating that infrastructure transformation must be understood as a multidimensional process. Highway removal is not simply a technical decision, but a strategic opportunity to reshape urban systems. The findings suggest that planners should approach infrastructure projects with a broader perspective that integrates transportation, land use, environmental conditions, and social equity, rather than treating these domains independently.

Overall, the policy implications of this research point toward a shift in how infrastructure is conceptualized and implemented. Rather than treating highway removal as a purely technical or aesthetic intervention, policymakers must understand it as a socio-political process that shapes—and is shaped by—broader systems of inequality. Achieving meaningful and lasting change therefore requires not only redesigning physical infrastructure but also reforming the policies and institutions that govern urban development. In this sense, highway removal should be understood not as an isolated intervention, but as a

critical entry point for broader urban transformation centered on equity, sustainability, and systemic repair (Stehlin, 2024; Hinderaker, 2023).

Conclusion

This research paper has examined the transformation of urban highway infrastructure through a socioecological lens, arguing that highways are not merely technical systems of mobility but deeply embedded mechanisms that shape patterns of inequality, environmental exposure, and urban development. By situating highway removal within broader processes of spatial restructuring, the study has demonstrated that infrastructure interventions must be understood as multidimensional and politically mediated transformations rather than isolated engineering decisions. The findings suggest that highway removal does not produce uniform outcomes but instead interacts with existing urban systems and policy environments. As such, the impacts observed in each case are contingent upon both the design of the intervention and the institutional context in which it occurs.

The historical analysis established that the Interstate Highway System was a central instrument of mid-twentieth-century urban restructuring, one that facilitated regional mobility and economic growth while simultaneously producing racialized displacement, spatial segregation, and long-term social fragmentation (Aiello et al., 2025; Brinkman & Lin, 2024; Daniels, 2018). Highways reshaped cities not only by enabling movement, but by reorganizing access to opportunity, embedding inequality into the built environment, and disrupting community cohesion. These legacy forms the essential context for understanding contemporary efforts to remove or transform urban highways.

Building on this foundation, the research paper developed a theoretical framework emphasizing infrastructure as a driver of spatial inequality, a source of community severance, and a potential site for reparative planning. This framework enabled a more integrated analysis of the socioecological impacts of highway removal, highlighting the interconnected nature of transportation systems, environmental conditions, land markets, and social dynamics. By conceptualizing infrastructure as part of an urban metabolism—organizing flows of mobility, capital, and environmental effects—the study demonstrated that altering these systems produces cascading changes across multiple domains rather than isolated outcomes.

The empirical analysis of four case studies—Cheonggyecheon in Seoul, Madrid Río in Madrid, the Embarcadero in San Francisco, and Harbor Drive in Portland—revealed both the transformative potential and the limitations of highway removal as a planning strategy. Across all cases, the findings strongly support the concept of traffic adaptation. The removal or transformation of major roadways did not lead to catastrophic congestion; instead, mobility systems adjusted through rerouting, modal shifts, and reductions in travel demand, consistent with the phenomenon of traffic evaporation (Cairns et al., 2002; Cervero, 2009). These outcomes challenge long-standing assumptions about the indispensability of high-capacity urban highways and suggest that mobility is more flexible than traditional models predict.

At the same time, the cases demonstrate that highway transformation consistently produces significant environmental and economic benefits. The introduction of green space, reduction of pollution, and restoration of urban connectivity improved quality of life across all sites. These improvements were closely linked to increased land values and economic redevelopment, illustrating the capacity of infrastructure removal to unlock latent urban potential (Cervero, 2009; Hernández-Lamas et al., 2016). However, these gains were unevenly distributed. In multiple cases, environmental and economic improvements were accompanied by rising property values and displacement pressures, reflecting the dynamics of environmental gentrification and amenity-driven value capture (Patterson & Harley, 2019; Stehlin, 2024).

The comparative analysis highlights a central conclusion of this research paper: equity outcomes are not determined by infrastructure design alone, but by the governance structures and policy frameworks that shape implementation. Projects such as Cheonggyecheon and the Embarcadero achieved rapid and visible transformation but provided limited protection against displacement, while Madrid Río and Harbor Drive demonstrate how public investment and participatory processes can produce more broadly shared benefits, albeit with their own limitations (Abbott, 2001; Lee & Anderson, 2013; Stehlin, 2024). These findings underscore that infrastructure transformation is inherently political. The distribution of its benefits

depends on decisions about land use, housing, and public space, as well as the degree to which affected communities can influence planning processes.

The implications for climate and sustainability further reinforce this conclusion. While highway removal can contribute to reductions in automobile dependence and vehicle miles traveled, its effectiveness depends on the extent to which it is integrated into broader strategies of transit investment, land-use reform, and demand management (Cairns et al., 2002; Cervero, 2009). Hybrid approaches that preserve underlying traffic capacity may improve localized environmental conditions but fall short of addressing systemic drivers of emissions (Khalaj et al., 2020; Stehlin, 2024). Thus, the environmental benefits of highway transformation are similarly contingent on policy context rather than inherent to the intervention itself.

The relevance of these findings is further underscored by recent federal investment programs that explicitly fund infrastructure transformation projects. By prioritizing reconnection, accessibility, and community-focused design, these policies reflect a broader paradigm shift toward more integrated and equitable approaches to urban infrastructure.

Taken together, these findings suggest that highway removal should be understood as a critical moment within the broader lifecycle of infrastructure systems. As mid-century highways age and require reinvestment, cities face a strategic choice between reconstruction and transformation. This research paper demonstrates that removal offers a powerful opportunity to repair past harms, reconnect urban space, and advance sustainability goals—but only under specific institutional and policy conditions. Without deliberate efforts to address affordability, prevent displacement, and redistribute benefits, such projects risk reproducing the very inequalities they seek to correct.

Ultimately, the transformation of urban highways reveals both the possibilities and limits of infrastructure-led urban change. These projects make visible the adaptability of cities, the value of reclaiming space from automobility, and the potential for more livable urban environments. At the same time, they underscore that physical redesign alone is insufficient to produce just and inclusive outcomes.

Achieving meaningful socioecological repair requires not only reimagining infrastructure, but also restructuring the governance systems, policy tools, and power relations that shape urban development.

In this sense, highway removal is best understood not as an endpoint, but as an entry point—a catalyst for broader transformations in how cities allocate space, distribute resources, and define collective priorities. The challenge for planners and policymakers is not simply to remove highways, but to leverage these moments of change to build more equitable, sustainable, and connected urban futures.

References

Aiello, L. M., Vybornova, A., Juhász, S., Szell, M., & Bokányi, E. (2025). Urban highways are barriers to social ties. *Proceedings of the National Academy of Sciences, 122*(10), e2408937122.

Arcadi, T. (2022). Partisanship and permanence: How Congress contested the origins of the interstate highway system and the future of American infrastructure. *Modern American History, 5*(1), 53–77.

Archer, D. (n.d.). White men's roads through Black men's homes: Advancing racial equity through highway reconstruction.

Billings, J. E. (n.d.). The impacts of road capacity removal.

Billings, J., Garrick, N. W., & Lownes, N. E. (2013). Changes in travel patterns due to freeway teardown for three North American case studies. *Urban Design International, 18*(2), 165–181.

Boccon-Gibod, A. (n.d.). Re-stitching the fabric: Urban highway removal as an opportunity for equitable, sustainable transformation.

Brinkman, J., & Lin, J. (n.d.). Early interstate policy and its effects on central cities.

Brinkman, J., & Lin, J. (2024). Freeway revolts! The quality of life effects of highways. *Review of Economics and Statistics, 106*(5), 1268–1284.

Brooks, L., & Liscow, Z. (2026). *Infrastructure costs*.

Campos, L. (n.d.). The Portland Planning Commission: An historical overview.

Cervero, R. (n.d.-a). Freeway deconstruction and urban regeneration in the United States.

Cervero, R. (n.d.-b). Induced demand: An urban and metropolitan perspective.

Cervero, R. (2009). Transport infrastructure and global competitiveness: Balancing mobility and livability. *The Annals of the American Academy of Political and Social Science, 626*(1), 210–225.

Cervero, R., Kang, J., & Shively, K. (2009). From elevated freeways to surface boulevards: Neighborhood and housing price impacts in San Francisco. *Journal of Urbanism, 2*(1), 31–50.

Chung, J.-H., Yeon Hwang, K., & Kyung Bae, Y. (2012). The loss of road capacity and self-compliance: Lessons from the Cheonggyecheon stream restoration. *Transport Policy, 21*, 165–178.

Daniels, R. (2018). Displacing Black people and culture, gentrification: The new “Negro removal” program: A call for an emergency summit.

Das, D. K. (2025). Exploring the intersection of environmental justice and urban green space planning: A systematic review. Urban Science, 9(12), 540.

Dewey, C. (n.d.). From urban renewal to highway removal.

Ewing, R. (2008). Highway-induced development: Research results for metropolitan areas. *Transportation Research Record, 2067*(1), 101–109.

Fackler, E. H. (n.d.). Protesting Portland’s freeways: Highway engineering and citizen activism in the interstate era.

Garrick, D. N., & Billings, J. (n.d.). Case studies of the access and mobility impact of freeway removal.

Greenberg, P., Wishart, R., & Danielsen, S. (2024). Driving environmental inequality: The unequal harms and benefits of highways. Environmental Sociology.

Greiman, V. A., & Sclar, E. D. (n.d.). Mega infrastructure as a dynamic ecosystem: Lessons from America’s interstate system and Boston’s Big Dig.

Hernández-Lamas, P., Rubio Gavilán, A., & Bernabeu-Larena, J. (2016). Parks and roads build the cities: The M-30 and Madrid-Río project. In *Back to the sense of the city* (pp. 415–428).

Houston, D., & Zuñiga, M. E. (2019). Put a park on it: How freeway caps are reconnecting and greening divided cities. *Cities, 85*, 98–109.

Issel, W. (1999). Land values, human values, and the preservation of the city’s treasured appearance: Environmentalism, politics, and the San Francisco freeway revolt. *Pacific Historical Review, 68*(4), 611–646.

Jenner, M. (2000). The origin of Portland, Oregon’s waterfront park: A paradigm shift in city planning (1967–1978).

Kang, C. D., & Cervero, R. (2009). From elevated freeway to urban greenway: Land value impacts of the CGC project in Seoul, Korea. *Urban Studies, 46*(13), 2771–2794.

Kapshikar, P., Liu, P., Parks, J., & Zeng, J. (n.d.). *Removal of the Embarcadero freeway*.

Khalaj, F., Pojani, D., Sipe, N., & Corcoran, J. (2020). Why are cities removing their freeways? A systematic review of the literature. *Transport Reviews, 40*(5), 557–580.

Kim, K. R., Kwon, T. H., Kim, Y.-H., Koo, H.-J., Choi, B.-C., & Choi, C.-Y. (2009). Restoration of an inner-city stream and its impact on air temperature and humidity. *Advances in Atmospheric Sciences, 26*(2), 283–292.

Kim, U., Lee, J., & He, S. Y. (2021). Pedestrianization impacts on air quality perceptions and environment satisfaction. *International Journal of Environmental Research and Public Health, 18*(19), 10225.

Lee, M., & Jung, I. (2016). Assessment of an urban stream restoration project by cost-benefit analysis. *KSCE Journal of Civil Engineering, 20*(1), 152–162.

Lee, S. (2015). Critical interpretation on Cheonggyecheon restoration project. *Space and Environment, 25*(4), 88–122.

Litman, T. A. (n.d.). Generated traffic and induced travel.

Looser, T. (2013). Deconstruction/construction: The Cheonggyecheon restoration project in Seoul. *Journal of Korean Studies, 18*(2), 407–410.

Lopez, R. (2012). Urban renewal and highway construction. In R. Lopez, *Building American public health: Urban planning, architecture, and the quest for better health in the United States* (pp. 119–138). Palgrave Macmillan.

Lumbreras, J., Valdés, M., Borge, R., & Rodríguez, M. E. (2008). Assessment of vehicle emissions projections in Madrid. *Transportation Research Part A, 42*(4), 646–658.

Millard-Ball, A., Silverstein, B., Kapshikar, P., Stevenson, S., & Barrington-Leigh, C. (2025). Dividing highways: Barrier effects and environmental justice in California. Journal of Planning Education and Research, 45(3), 686–699.

Mohl, R. A. (2012). The expressway teardown movement in American cities. *Journal of Planning History, 11*(1), 89–103.

Napolitan, F., & Zegras, P. C. (2008). Removal of inner-city freeways in the United States. *Transportation Research Record, 2046*(1), 68–75.

Patterson, R. F., & Harley, R. A. (2019). Effects of freeway rerouting and boulevard replacement on air pollution exposure and neighborhood attributes. International Journal of Environmental Research and Public Health, 16(21), 4072.

Robinson, T., & Ji, M. (2022). Freeway removal: From Cheonggyecheon to Seoullo 7017. In T. Robinson & M. Ji (Eds.), *Sustainable, smart and solidary Seoul: Transforming an Asian megacity* (pp. 39–71). Springer.

Ryu, C., & Kwon, Y. (2016). How do mega projects alter the city to be more sustainable? *Sustainability, 8*(11), 1178.

Stehlin, J. (2024). Freeways without futures: Urban highway removal in the United States and Spain. *Environment and Planning E, 7*(3), 1391–1417.

Suárez, M., García-Nieto, A. P., Gómez-Baggethun, E., & Ametzaga-Arregi, I. (2024). Renaturalisation of the Manzanares river in Madrid. *Urban Forestry & Urban Greening*.

Tajima, K. (2003). New estimates of the demand for urban green space. *Journal of Urban Affairs, 25*(5), 641–655.

The Dwight D. Eisenhower national system of interstate and defense highways: The road to success? (n.d.).

U.S. Department of Transportation. (2023). Reconnecting communities pilot program. https://www.transportation.gov/reconnecting

Weiwu, L. (2024). Unequal access: Racial segregation and the distributional impacts of interstate highways in cities. Working Paper.