

# RISING TIDES: RELOCATION AND SEA LEVEL RISE IN METROPOLITAN BOSTON

Brent D. Ryan, David Vega-Barachowitz, Lily Perkins-High

---

## Keywords

Boston  
sea level rise  
relocation  
climate change  
urban planning + policy

---

## Project Contributors

P. Christopher Zegras  
Victor Rocco  
Yafei Han  
Menghan Li

---

## Abstract

With sea levels projected to rise 6-10 inches by 2100, cities worldwide are bracing for impacts of global climate change. While much of the existing literature has focused on climate change adaptation, sustainability, and resiliency, far fewer studies have considered the implications of long-term population displacement caused by sea level rise or the necessary policy and planning implications of these anticipated environmental shifts. Using Metropolitan Boston as a case study, this paper considers potential scenarios for long-term climate change displacement and maps strategic principles and procedures that could be adopted as part of a regional relocation strategy for climate change refugees.

Three relocation scenarios, based on rigorous GIS analysis, were considered as part of the study. The three scenarios simulate potential considerations, available and necessary data, and the characteristics of planned relocation and development as a template applicable to the entire region. The Relocation Suitability Index (RSI), a parcel-level data analysis methodology and decision-making framework, is suggested here as a potential tool for site assessment and local scenario planning.

## INTRODUCTION

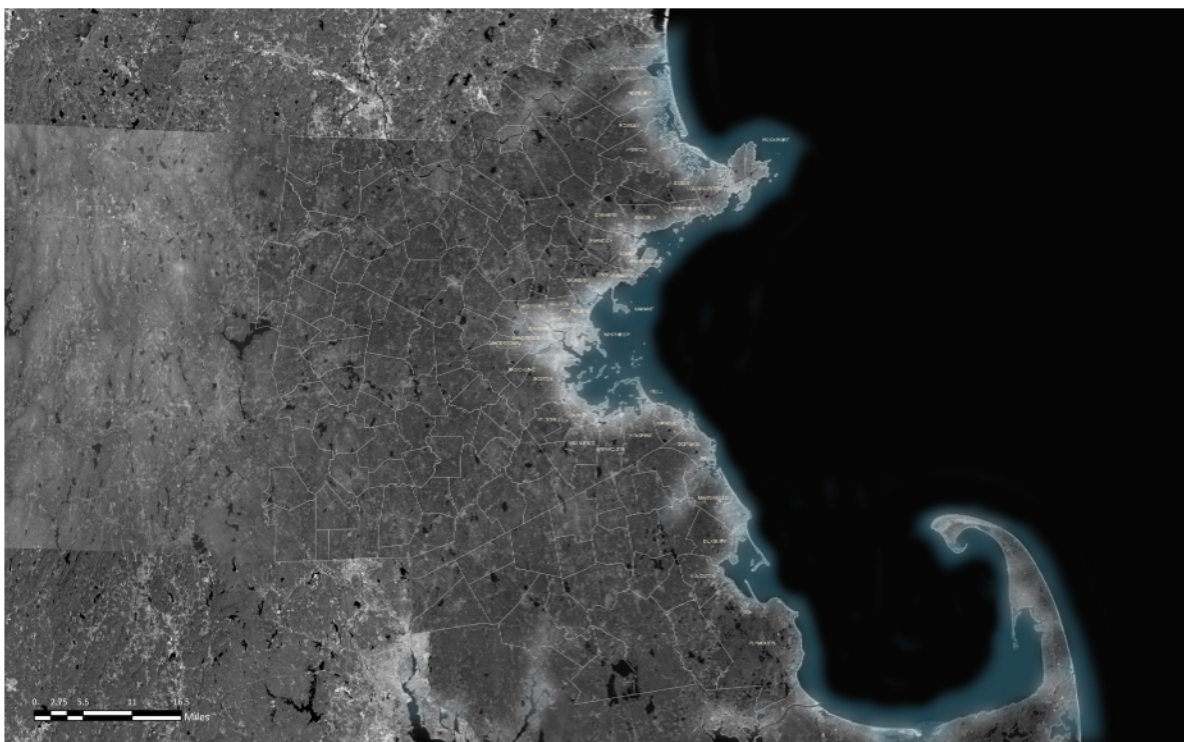
### Sea Level Rise on the Horizon

Over the past decade and a half, increasing recognition of the deleterious impacts of climate change has inspired critical changes in social and environmental policy. Many of these policy shifts, which have been passed at the local, state, and federal level, consider long-term adaptation to the impacts of climate change; sustainability policies aimed at decreasing carbon emissions; or the resiliency of communities, cities, and regions that will endure the uneven impacts of a changing environment. Less attention has been paid to those policy scenarios that would need to be considered in the face of long-term displacement resulting from climate change and the necessary regional relocation of jobs, housing, and infrastructure affected by rising sea levels (Bukvic, 2015; McAdam, 2015; Marino, 2012).

This paper maps hypothetical principles and procedures for regional climate change relocation policy in Metropolitan Boston. Boston, like many cities along the Northeastern coast of North America, is expected to be significantly impacted by rising sea levels, with 6-10 inches anticipated by 2100 (Hauer, 2016; Boston Harbor Association, 2013). With a total population of 4,628,910, sea level rise in the Metropolitan Boston area is expected to severely impact the region's economy and population, including many universities, hospitals, and businesses that drive the region's economy. With coastal concentrations of peoples and businesses constructed on former marshland, much of the city's critical infrastructure and economic core will be directly compromised by rising tides (Abel, 2016; Climate Ready Boston, 2016).

Existing research and proposals for Boston, reflecting those for New York City in the aftermath of Hurricane Sandy and other large coastal metropolitan areas, have considered the potential fortification of critical areas of the city through a combination of infrastructural interventions, such as deployable sea walls and artificial dikes, paired with long-term adaptation strategies, such as green infrastructure, increasing permeable surface area, changes to outdated building codes and carbon emissions reduction targets (Climate Ready Boston, 2016; OneNYC Plan: Resiliency, 2015; Kirshen et al, 2008). Smaller communities and cities that fall beyond the economic heart of the city often at times fall outside the scope of these studies, or receive less attention due to their geographic marginality.

Assuming that sea level rise predictions will come to fruition as predicted, this paper asks what principles should govern the large-scale relocation of jobs and housing? What processes may be undertaken to by local, state, and regional actors to ensure that climate change refugees are adequately housed (or compensated for their relocation)? What mechanisms are at the disposal of the state in the context of sea level rise and how can these mechanisms be used to not only encourage equitable and effective relocation, but to engender better patterns of housing and infrastructure that can ameliorate the environment while enhancing quality of life?



## Study Area

This study was broken into two parts. The first part considered the guiding principles and procedures for climate change relocation, with a focus on housing in vulnerable areas beyond Boston's core. The second part looked at an integrated land use and transportation model that would predict future populations shifts according to anticipated sea level rise. This paper focuses on the first part of the study.

The study area (Fig. 1) encompassed the Greater Boston Combined Statistical Area (CSA), including Bristol and Plymouth Counties, as well as the Merrimack Valley cities of Lowell, Lawrence, Haverhill, which are not part of the Metropolitan Area Planning Council of Greater Boston (MAPC). This area includes the majority of coastal communities in the region within state boundaries (with the exception of the Fall River-New Bedford area) and mirrors the basic geographic extents of Boston's commuter rail network and Route-495 corridor. In concert with the land use-transportation element of the study, the entire study area was divided into Transportation Analysis Zones (TAZs), geographic units used by transportation planners to collect data, analyze trends, and model future transportation impacts.

## Overview

The first section of this paper considers existing literature on climate change relocation in an urban design, planning, and public policy context. The second section briefly discusses the existing, prevalent paradigms of climate change policy, including market-driven relocation, long-term adaptation, and coastal fortification. The third section of the paper reviews

**FIGURE 1**

Six Feet of Sea Level Rise

By 2100, Massachusetts will experience roughly 6ft of sea level rise. At 6ft, the Commonwealth stands at risk of having 309,220 individuals displaced from their homes.

Data Layer and Calculations based on NOAA Coastal Services Center.

**FIGURE 2**

Isle de Jean Charles, LA

Isle de Jean Charles, LA is among the first communities in the United States grappling with the relocation of “climate change refugees”

Image Credit: Liz Jurey



five key principles of relocation planning and policy and then looks at these principles in the context of three relocation scenarios: in-town relocation, adjacent town relocation; and new town relocation. The fourth section of the paper proposes the ‘Relocation Suitability Index’ (RSI) as a tool for assessment of individual relocation sites (at the parcel level). The RSI translates the five core relocation principles into a tool for site selection using GIS data available through state and regional entities. The final section applies the RSI to three case studies, which have been selected based on the three relocation scenarios proposed in section three.

### Existing Literature on Climate Change Relocation

Due to the political sensitivity and speculative nature of relocation, the body of literature dealing with the prospects of climate change relocation in the United States remains relatively limited (Hauer, 2016). While climate change refugees have been a topic of increasing focus internationally (Bukvic, 2015; Bates, 2002), only recently has the United States ventured into the arena of climate change relocation planning. Two recent cases, one in rural Alaska (Shishmaref, AK) and another in rural Louisiana (Isle de Jean Charles, LA; Fig 2), foreshadow the impending debate over relocation of climate change refugees. In both cases, the affected populations were made up of Native American tribes living on small islands dislocated from larger metropolitan regions. The prospect of relocation was politically contested and many residents were unwilling or unable to move. The process of finding a relocation site suffered from a lack of adopted policy, and both cases renewed long-standing debates over local autonomy, eminent domain, and forced removal (Mele et al., 2016; Davenport et. al, 2016; Marino, 2012).

While climate change refugee relocation may be a relatively recent phenomenon, relocation and resettlement itself has a long and complex history in the field of urban planning. During the urban renewal era, significant numbers of families were uprooted and relocated. Relocation procedures proved to be a one of the most challenging and ineffective aspects of the program, resulting in the disintegration of many entrenched communities, often including ethnic enclaves, African American or Hispanic neighborhoods with the least resources and capital to reestablish themselves in a new location (Fullilove, 2011; Wilson, ed. 1966; Gans, 1962; Gans 1959).

Recent scholarship has articulated the potent and damaging legacy of forced relocation on mental (and physical) health. Fullilove and Wallace (2011) have used the term “root shock” to describe the long-term impacts of dislocation on both individuals and communities (Fullilove, 2001). Root shock represents a critical consideration in the context of climate change because it reaffirms the attachment of individuals and communities to physical spaces and the memories associated with those spaces. Keeping families and communities relatively close to their former homes following displacement preserves the valuable social capital of close-knit neighborhoods and must be a critical part of any relocation policy (Adams, 2015; Fullilove et al., 2011; Simms, 2008).

A second body of literature deals with relocation in the context of social programs and disaster planning. The Resettlement Administration, established in 1935 and led by Rexford Tugwell during the New Deal administration of Franklin Delano Roosevelt, was founded in part as a response to the widespread dislocation and suffering of families during the Dust Bowl crisis (Hall, 2014; Scott, 1969). The administration established basic procedures for rehousing families and individuals displaced by the economic disasters of the era, though far fewer units of housing were actually built than envisioned and the program was saddled by Congressional suspicion of socialism.

During the Cold War, from the 1950s through the 1980s, the prospect of nuclear warfare and the targeting of major urban areas resulted in a series of significant studies that considered large-scale relocation and decentralization of the urban population. These policies applied progressive era housing decentralization policy arguments (based on the premise that overcrowding caused disease and social alienation) to the mid-century fear of nuclear annihilation (Dudley, 2009; Farish, 2003). The impact of these policies was significant, if indirect. The construction of a national interstate highway network, for instance, though articulated in the 1950s as an agent of defense, decentralization, and national security, had been a longstanding dream of planners and policymakers since the early 1900s.

A more recent and relevant case to consider is that of Hurricane Katrina, which devastated the low-lying city of New Orleans in 2005 and displaced countless families, including those living in some of the city’s most impoverished wards. The aftermath of Katrina—viewed here as an example of market-driven or unplanned relocation policy—provides an instructive case study for how regions that are not prepared for climate change may be challenged by the prospect of large-scale relocation. Many families were left homeless. Others received inadequate compensation for their lost homes and livelihoods. The city’s population dropped precipitously, and many moved to surrounding urban areas like Houston, Texas and never returned (Sastry et al., 2014; Hori et al., 2010; Fussell et al., 2010).

The destruction wrought by Hurricane Katrina elicits several important debates relevant to both relocation planning and climate change. First, regions must prepare not only for long-term displacement, but also for the possibility of enduring a series of environmental shocks in sensitive coastal areas, similar to that endured by New York City in the wake of Hurricane Sandy (2012). Second, regions must consider relocation at two time scales—

both for short-term relocation sites capable of receiving a large segment of the population in temporary housing following a shock, as well as long-term relocation, which may assume a more multifaceted character, with the development of infill housing, transit-oriented development sites, and relocation zones for long-term habitation of the displaced. These policies will not only impact housing, but also business and commercial location as well. Especially in areas like Metro Boston, which stand at risk of losing all or part of their central business districts to sea level rise (Fig. 4), new housing will need to link to critical infrastructure planning and investments, as well as the development of satellite job centers at critical infrastructural nodes.

## CONFRONTING SEA LEVEL RISE

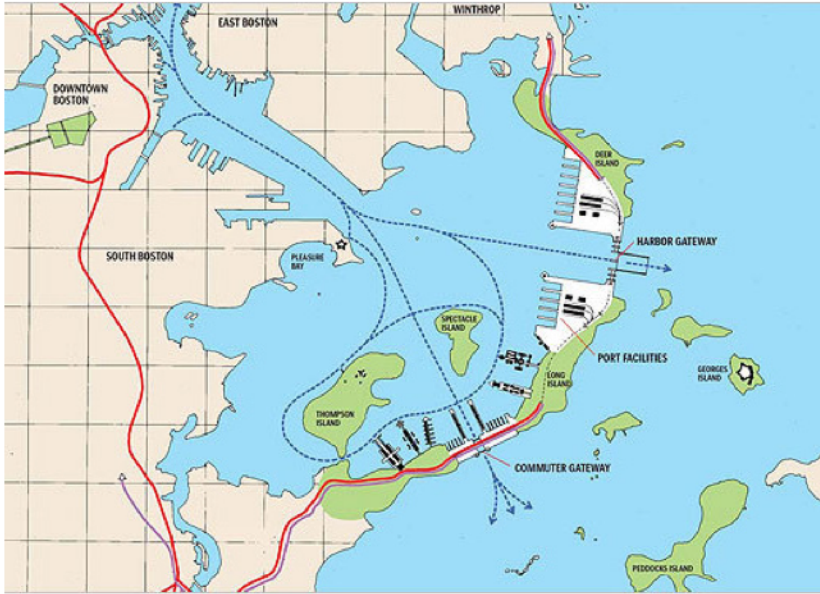
### Paradigms to Date

This study views existing relocation paradigms as inadequate to solving the long-term potential for widespread displacement in the context of sea level rise. Three dominant paradigms have been put forth for the Boston region and other similar metropolitan areas. These include 1) coastal fortification, such as the construction a sea wall or levee to prevent the encroachment of water into the core area; 2) Adaptation or “living with water,” characterized by proposals that strive to adapt the structural fabric the city to accommodate higher sea levels (Living with Water competition, 2015; Rebuild by Design, 2014); and 3) market driven relocation, which employs financial disincentives to living in affected areas, often through punitive insurance premiums that render impacted neighborhoods unaffordable and undesirable (Kousky et al., 2014).

### 1. Fortification

As a solution to sea level rise and flooding, fortification, in the form of levees, sea walls, and other hard infrastructures, has drawn significant press and critique. Though planners and policymakers have debated the merits of constructing immense sea walls across Boston or New York Harbor, few serious proposals have come to fruition. Sea wall and flood control barriers, however, remain a legitimate option to consider for Metropolitan Boston. London constructed its Thames barrier in 1982, while the Netherlands has famously been protected by a complex system of dikes, locks, and canals since the Renaissance. More recently, as part of the country’s ‘Room for the River’ program (begun in 2006), they have embraced softer engineering strategies that work with the natural flows of Dutch rivers.

Fortification has several drawbacks. Since flood barrier construction is necessarily selective, proposals tends to focus the economic heart of the region, where the most people would stand to be affected and the most economic loss to existing assets and infrastructures would take place (Fig. 3). Outlying areas impacted by rising sea levels, such as Revere, Hull, and Newbury, would likely fall beyond the scope of fortification and thus remain

**FIGURE 3**

Proposal for Boston Harbor Barrier, Antonio Di Mambro & Associates, 1988

Proposed in 1988 by Di Mambro Associates, a proposed sea wall protects Boston's core, while outlying areas remain vulnerable.

**FIGURE 4**

Sea Level Rise Projections

Recent sea level rise projections show large areas of central Boston inundated by water. Based on data from NOAA and the Boston Harbor Association.



at risk of large scale displacement. A parallel dialogue has taken place in New York, where heavily impacted communities, such as the Rockaways and Staten Island, would still remain imperiled beyond the prospective wall.

## II. Adaptation

Significant strides have been made in the field of climate change adaptation over the past several decades. These include changes to building codes that shift critical building equipment and infrastructure above sea level; coastal protection through the development of constructed

wetlands, oyster beds, and other habitats intended to dilute the impact of storm surges; and changes to infrastructure and building codes that aim to increase ground surface permeability, storage, and reduce discharge from combined sewer overflows. In urban design, a series of competitions, most notably Rebuild by Design (2014) in New York City, highlighted potential strategies for the adoption of new practices in coastal adaptation, including the development of various scenarios in which coastal populations “live with water,” as opposed to fighting against it. While the broad cadre of strategies falling under the rubric of adaptation merits consideration and adoption, many of these strategies remain incremental in their character and rely on decentralized local land use policies, which have historically proven an inadequate instrument for coherent regional or national change (Kayden, 2000). Adaptation and contingency relocation plans must work in parallel.

### **III. Market-Driven Relocation**

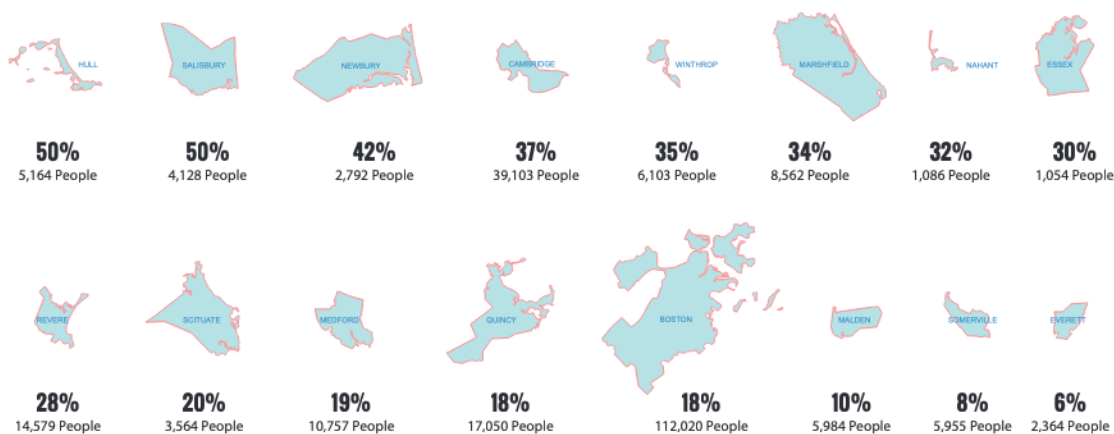
Market-driven relocation in the context of climate change, a scenario epitomized by the aftermath of Hurricane Katrina and other unanticipated disasters, is the least favored of these three scenarios. Those areas of Metro Boston that can expect the worst damage are also home to low-income populations with low mobility and scant resources to afford to move. Financial disincentives (such as high flood insurance premiums) could devastate families in Revere, Hull, Quincy, and other coastal cities that serve as gateways for immigrants and poorer families. Market-driven relocation, moreover, does not actually force families to leave, but instead leaves them in financial straits after already enduring the losses as a result of disaster.

### **Mapping Sea Level Rise Impacts**

Following a review of existing literature and policies on climate change fortification, adaptation, and relocation, a mapping analysis was undertaken to assess the overall impacts that sea level rise would have in Metropolitan Boston. Using parcel-level data obtained from the State of Massachusetts and the Metropolitan Area Planning Council (MAPC), the analysis investigated sea level rise predictions in order to determine the number of people, jurisdictions, and infrastructure that would be affected.

Sea-level rise data was obtained from the National Oceanographic Atmospheric Administration (NOAA, 2015) and served as a basis for impact analysis. Parcel-level data, which includes information on parcel ownership, land use, lot area, building coverage, open space, value, and other variables for individual properties, offered sufficient detail for a fine-grained analysis of the region’s land use and population demographics at present. Data from the Massachusetts Bay Transportation Authority (MBTA) and the State (MassGIS), including that for roads, bridges, rail lines, and other critical infrastructures, allowed for interpolation with parcel maps and sea level rise layers.





While Massachusetts, and Metropolitan Boston in particular, have made significant GIS data available for research, certain data points remained unavailable, resulting in certain key assumptions worth highlighting here. Specifically, future scenario transportation modeling, based upon a five-step model that predicts future travel demand and location trends, could not be embedded into the GIS analysis within the timeframe of the study. While breaks in critical infrastructural links, such as submerged subway stations, highways, and electric transmission lines, were studied, these “broken links” did not ultimately play a significant role in the regional perspective adopted by the study.

**FIGURE 5**

Cities and Towns by Percentage of Population Impacted by SLR

Data based on NOAA sea level rise projections and MassGIS population data and parcel data.

## Summary of Impact

Several conclusions were drawn based on the initial impact study. Given six inches of sea level rise by 2100, much of coastal metropolitan Boston will experience population displacement (Fig. 5). Fifty percent of the population of towns such as Hull and Salisbury stand to be inundated under current scenarios. Boston stands to see almost 120,000 people displaced, with Cambridge enduring displacement of nearly 40,000, or 37% of its population. While these displacement statistics are in some ways misleading, given the overall timeframe of impact and the land use and policy changes likely to respond to different scenarios, they provide a rough outline of the potential for risk and damage at a significant scale.

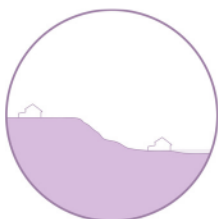
In addition to widespread population displacement, the initial study revealed significant losses in critical infrastructure and businesses. Interstate 93 and Route 1, both major regional arteries, stand to suffer significant damage due to their proximity to the imperiled coast. The city’s subway network, moreover, a hub-and-spoke system centered on downtown Boston, will be among the hardest hit elements of the transportation network, a significant challenge in a coastal region with the fourth-highest subway ridership in the nation.

## CHARTING RELOCATION

### Relocation Principles

- Out of Harm's Way

Relocation sites should be located on ground that will not be affected by future sea level rise. It is not only critical to move displace residents to safe, elevated land that removes them from risk of flooding and further displacement, but also to avoid other sites unfit for human habitation, such as contaminated brownfields, areas adjacent to heavy industry or polluted areas, and steep slopes.



- Minimize Stress

Literature relating to “root shock” in the aftermath of urban renewal demonstrates that displacement has long-term deleterious impacts on individual and community health (Fullilove & Wallace, 2011, 2001; Simms, 2008). Relocation should aim to preserve as much as possible continuity for those affected. This means ensuring that children can remain close to friends, adults in the same or similar jobs, and within reach of pre-existing social and community institutions should they so desire



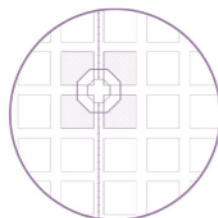
- Receiving Capacity

Relocation sites should be selected with attention to the receiving capacity and the preexisting infrastructure of those areas. While some communities may balk at assuming responsibility for climate change refugees, their infrastructure, in terms of roads, schools, and open spaces, may make them ideal sites for relocation. The ability to receive new residents, moreover, is never static and may be the result of careful planning and policy changes introduced incrementally over a number of decades. Equitable distribution of climate change refugees should be a priority.



- Build it Back Better

Relocation policies should be grounded in settlement design principles that redress some of the central drivers of climate change, such as high carbon emissions and inefficient land use planning. Sites with access to public transportation, in walking distance of necessary amenities, and with underutilized infrastructure are well suited to relocation. Ground permeability and other adaptation strategies should be considered as essential features of new housing and communities as well, in keeping with policies being developed at present.



- Feasibility of Implementation

The feasibility of implementation for a site is an important, if in some ways secondary, consideration in the overall relocation site selection process. Sites with historic or cultural significance may be considered less desirable here, whereas those with centralized ownership and low site utilization may be easier to acquire and develop. The process of acquisition and the potential obstacles involved in acquisition, such as state-owned versus private lands, should be considered in the context of relocation and will be discussed further in the paper.

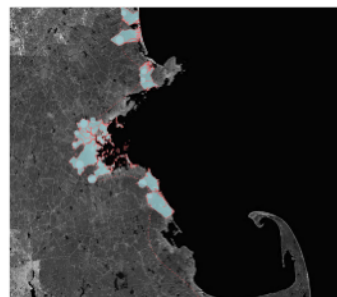


## Relocation Scenarios

This paper considered three potential relocation scenarios (Fig. 6). While other scenarios, such as in-state or extra-regional relocation may be considered elsewhere, this paper assumes that those displaced will desire to remain within the same region, and ideally as close to their former homes as possible.

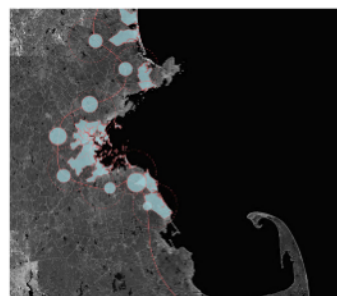
### In-town Relocation

In-town relocation refers to relocation of displaced persons within the same town as the displacement site. Large unbuilt parcels, low-density areas with sufficient receiving capacity, and former agricultural lands may all be candidates for in-town relocation. In-town relocation has significant benefits, since the process can be coordinated by the local jurisdiction, thus making it more feasible. Families can maintain some continuity with existing institutions, such as schools, while remaining proximate to neighbors and community institutions. (In this paper, the town of Newbury is considered as a case study of in-town relocation.)



### Adjacent Town Relocation

While less desirable and politically feasible than in-town relocation, adjacent town relocation represents an important strategy in cases where all or most of a community will be displaced by sea level rise. Keeping displaced residents in close proximity to their former places of residence marks an essential component of relocation planning and a priority in the context of sea level rise. Adjacent town relocation would need to be led by state and regional bodies, making it less feasible under current political circumstances. (In this paper, the case of Hull, Massachusetts and the adjacent town of Hingham are considered as paradigmatic of this condition.)



### New Town Relocation

In the history of resettlement and relocation programs, new towns and communities, often at a planned regional nexus, have a significant if checkered lineage. In this study, new towns are considered a secondary strategy for rehousing a large segment of the population and are considered more in the context of creating satellite economic centers that could reorient the regional economy in response to rising sea levels at the core. New town planning would necessarily be spearheaded at the state and federal level. (Hanscom Field in Bedford, Massachusetts was posited as a case study new town as part of this study.)



**FIGURE 6**  
Relocation Scenarios

**RELOCATION SUITABILITY ATTRIBUTES**

- 1 Out of Harm's Way  
Elevation data; Flood Risk (FEMA); Hurricane inundation; Site conditions
- 2 Minimize Stress  
Proximity to locus of dislocation; Qualitative attributes of relocation site
- 3 Receiving Capacity  
Existing infrastructural capacity (Ridership, Average Daily Traffic (ADT), etc.); school system capacity; Open Land
- 4 Build it Back Better  
Lot Coverage; Impervious Surface Area; Proximity to rail and major transportation networks; Proximity to amenities, open space, Connection to existing settlement
- 5 Feasibility of Implementation  
Ownership characteristics; Land cover; Site costs

COMPOSITE SCORE:  
65/100



FIGURE 7  
RSI Matrix

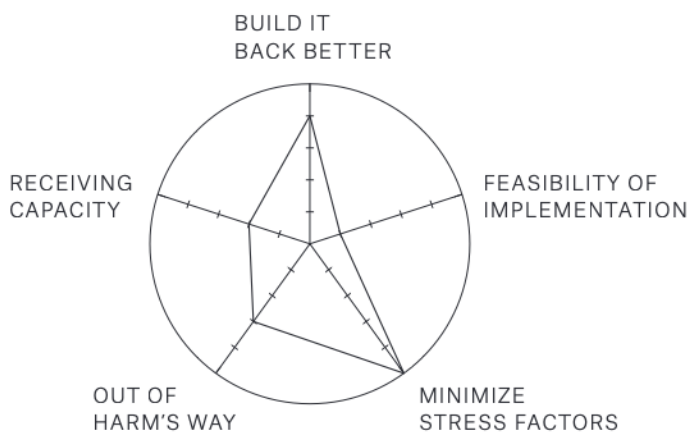
The Relocation Suitability Index (RSI) is calculated based on predetermined raw score thresholds and weight factors based on key land use data and characteristics. The final score serves as a tool for assessing potential relocation development parcels.

**The Relocation Suitability Index (RSI)**

Based on these relocation principles and the relocation scenarios considered at the outset, this study undertook a multi-faceted simulation of climate change relocation planning for the region using the three case studies as examples. These simulations, which were carried out for each of three case study scenarios, relied on parcel-level and infrastructure data, as well as established sea-level rise assumptions.

To determine the suitability of any individual parcel for relocation, this study suggests the adoption of a regional Relocation Suitability Index (RSI) (Fig. 7), which can serve as an objective and composite measure of land use attributes related to relocation. Using existing land inventories for the region, planners can assign each parcel with an RSI score based on the five principles. These principle scores, in turn, are weighted (at the discretion of the planning agency) to assess a final score for the suitability of a parcel for relocation. Parcel-level relocation suitability analysis could be used as a tool for impartial site selection, as a means of facilitating dialogue at the regional level, and as an instrument for federal, state, and local agencies to balance generally accepted measurement tools with nuanced community planning.

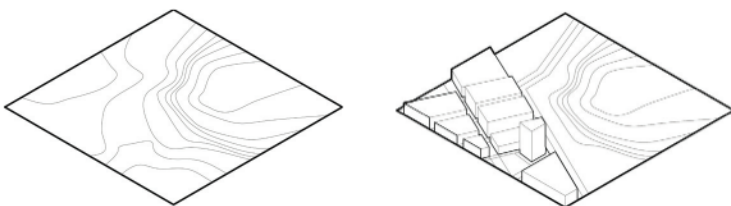
In the GIS analysis of this study, the land inventory was limited to sites with 15% lot coverage or less (at the regional level), which were subsequently classed according to individual measures, such as elevation, open land status, ownership, proximity to transit, and land use. For the purposes of this study, the total population of potential sites was artificially limited, though this would be neither necessary nor desirable in an implementation context.



As initially conceived, the Relocation Suitability Index (RSI) would have embedded a series of land characteristics applicable to individual parcels of land throughout the region. Within the limited scope of this simulation, the analysis permitted use of only parts of the fine-grained data needed for a comprehensive RSI. Data on school system capacity, infrastructure usage, and certain topographical gradients could not be readily assessed at a parcel level. Some of these elements, it should be noted, are ill suited to such a broad analysis and may need to be considered at a local level. In spite of these noted shortcomings, a basic simulation was undertaken using readily available data. These observations are recorded as part of the Case Studies section.

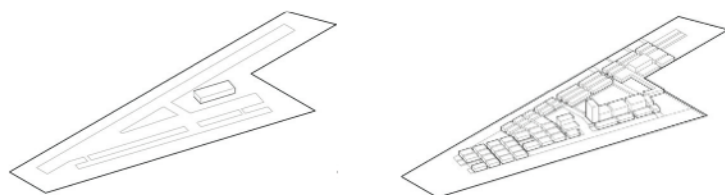
## Settlement Design Principles

While the Relocation Suitability Index (RSI) is envisioned as a regional mechanism for parcel-level scoring and assessment, the study also considered and proposed four basic principles of site design, which were, in turn, statistically embedded in the relocation principles.



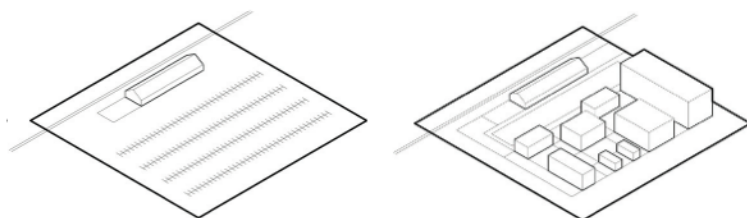
### - Develop

Develop unbuilt open lands in proximity to rail stations and key transportation corridors. Preserved farmland and underutilized lots with large impervious surface areas, ideally within a half-mile of a railroad station, were considered as ideal sites for future relocation development.



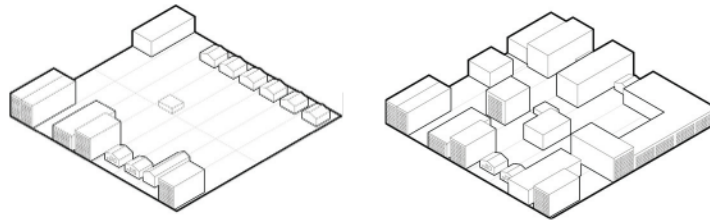
### - Re-use

Large brownfield sites, such as local airports and naval bases, should be considered as potential relocation new town sites, especially where they fall adjacent to preexisting infrastructures and impacted towns. These sites should ideally be developed over green field parcels, unless they have contamination or require extensive environmental remediation.



### - Access

Building off of existing transit-oriented development policies, relocation sites could strategically take advantage of sites either directly adjacent to, or within walking distance of existing or planned transit stations. The MBTA's commuter rail network, which currently operates largely on a park-and-ride model, could be substantially redesigned with settlement clusters geared towards displaced coastal communities at rail stations.



- **Densify**

Incremental densification, through strategic upzoning of low-density areas proximate to transportation infrastructure, could increase the supply of potential relocation sites (as well as the housing supply more broadly). Designated relocation priority zones, with housing designated for those displaced or for those in a potential displacement zone, could be considered as a policy mechanism to allow for transfers of population between areas or adjacent communities.

**SITE DESIGN**

Relocation site development should strive to make strong connections with existing infrastructures at high enough densities to justify development. Conventional site planning approaches need to be rethought to ensure effective land use patterns and access to on-site amenities.



Existing



Low-density

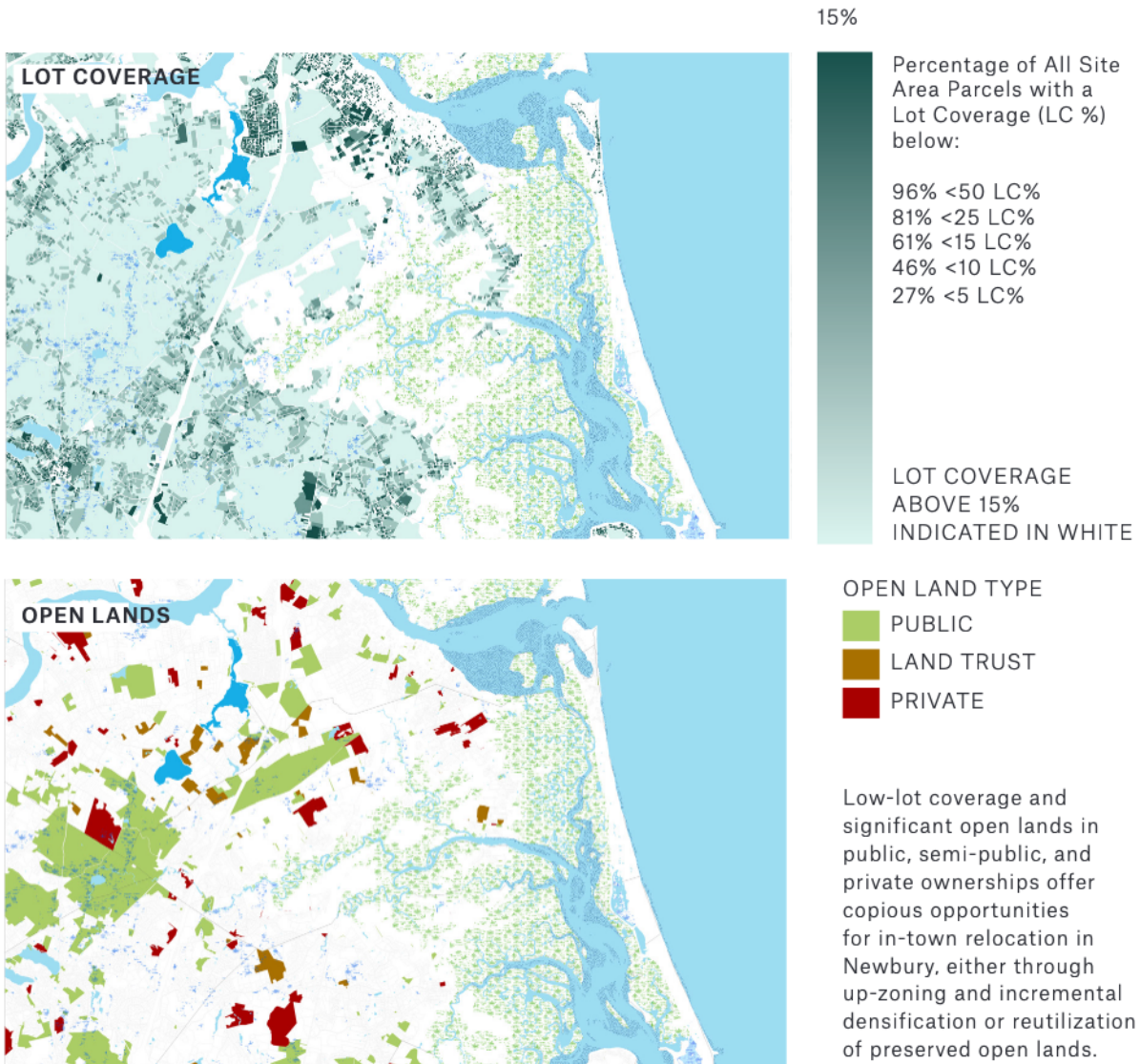


TOD | New Urbanism



Contemporary | High Density

## CASE STUDIES



### In-Town Relocation: Newbury, Massachusetts

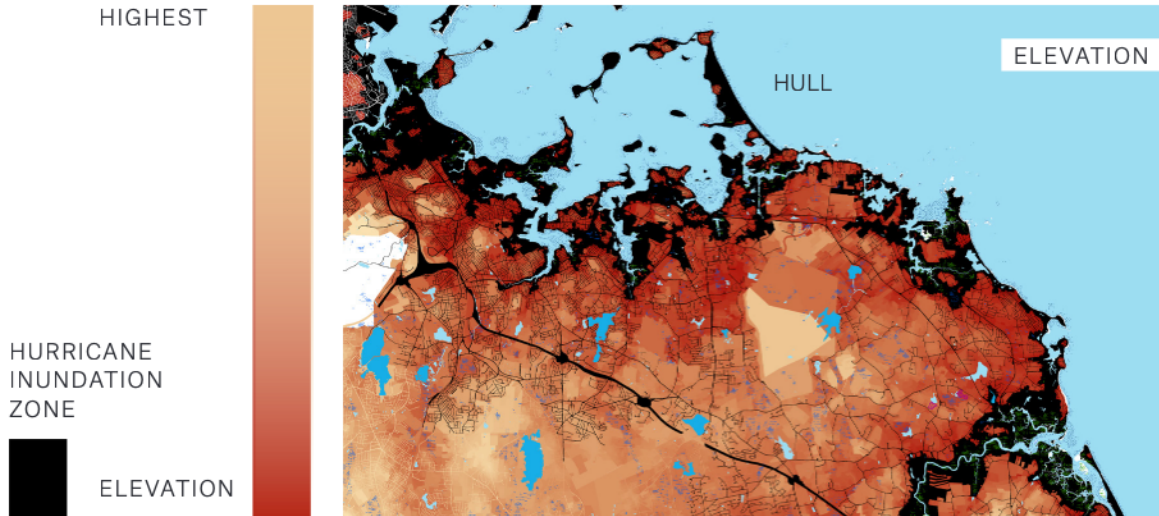
A small, outlying coastal settlement north of Boston, Newbury has the land area and characteristics to develop a plan for in-town relocation. Strategic upzoning, combined with localized relocation of affected sites, could relieve Newbury’s sea level rise impacts, while managing its population locally. Furthermore, internal planning could be largely coordinated through the jurisdiction, with state and regional cooperation involved only in limited redevelopment of open space and conservation land.

Population Affected:  
2,792 (42% total population)

Land Type: Coastal-Peripheral

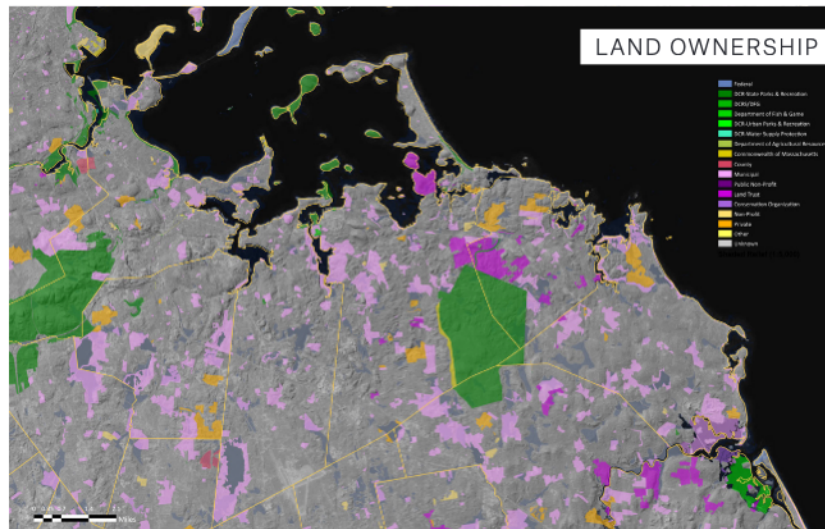
Density: 250/sq. mi.

Settlement Strategy:  
Incremental Densification;  
Open Land Development



OPEN LAND & ELEVATION

For communities like Hull, which suffer disproportionately from sea level rise, adjacent areas at higher elevations, like Hingham, offer the potential for relocation. Acres of open land, often preserved farmland and countryside, may present offer opportunities for development in proximity to existing infrastructures.



Hingham	4882 acres	.22 acres open space per capita
Hull	332 acres	.03 acres open space per capita

Adjacent Town Relocation: Hull, Massachusetts

Densely settled and highly vulnerable, Hull stands to see the greatest impact from sea level rise of all the towns in Metropolitan Boston. Due to the large impact on the city, an adjacent town relocation strategy, which allows for population distribution among Hull’s neighbors, including Hingham and Cohasset, is recommended. Multiple strategies may be employed to allow adjoining towns to adopt displaced residents. In addition to the gradual consolidation of service and transportation infrastructures, Hingham and other towns with low densities and well-connected rail service, could redevelop areas of the city adjacent to transit lines, while strategically developing or upzoning certain low-density areas suitable for development.

Population Affected:  
5,164 (50% total population)

Land: Coastal-Suburban

Density: 3,676/sq. mi.

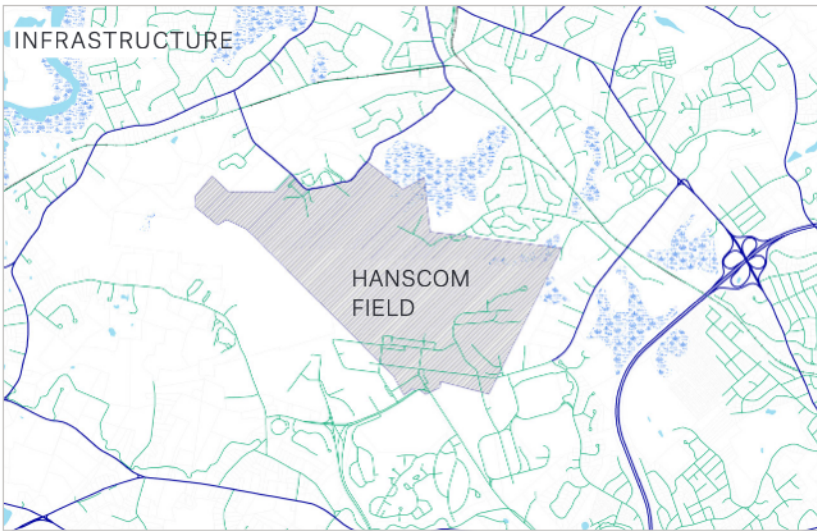
Settlement Strategy:  
Strategic Adjacent Town Relocation; Transit-Oriented Development; Open Land Development





REGIONAL NEW TOWNS

Large sites, such as Bedford's 800-acre Hanscom Field, a federally owned air field, have the potential for large-scale redevelopment, but are far from impacted areas. above: Mueller Airport Redevelopment, Austin, TX



INFRASTRUCTURE TYPE

- MAJOR ROAD
- MINOR ROAD
- RAIL

**New Town Relocation: Hanscom Field, Bedford**

Though not studied in great depth, Hanscom Field's (dormant) regional rail connection, existing service infrastructure, and connections to major highways, make it both a strong potential short-term and long-term relocation terminus. Redevelopment of the Hanscom Field, unlike the development of former Fort Devens site in Ayer and Shirley, Massachusetts and the Weymouth Naval Air Station, should develop sites to higher densities and with regional economic functions in mind.

Settlement Strategy:  
Brownfield Reutilization;  
Transit-Oriented  
Development

## CONCLUSION

Existing climate change research has largely focused on fortification, adaptation, sustainability, and resilience. This paper suggests the potential for rethinking climate change planning through the lens of regional relocation and resettlement. In the framework of a two-part land-use and transportation study, this paper calls for the development of strategic decision-making frameworks for assessing parcel-level suitability for relocation. Simulations of three relocation strategies have demonstrated the potential application of a variety of settlement design principles, including incremental densification and development of underutilized conservation land. These ideas provide a foundation for what will be politically volatile planning issue, and one that could form the basis of future studies in the field.

Several ideas could be further pursued or taken up in the context of a larger study. A more robust simulation, such as one that looks at the relocation of a specific coastal neighborhood in greater depth, would be a valuable means of further exploring issues where region-level data proved too general in its scope. More developed integration of these principles with land-use transport modeling software could provide valuable comparative data as well as critical indicators of how population and mobility may interact in the face of sustained climate pressures and sea level rise.

Regional planning and the cooperation of local governments present a challenge to sustained climate change planning. Moreover, top-down proposals for relocation are bound to provoke discord by both existing residents in low-lying areas as well as those in potential receiving zones. Despite the clear political challenge of this topic, planning for both short-term climate shocks and long-term displacement by sea-level rise is essential to maintaining the region's economic health and avoiding the disruptive economic and population losses suffered by coastal cities unprepared for short-term and long-term climate disruptions.

## Endnotes

- 1 Abel, David. "Climate change could be even worse for Boston than previously thought." *The Boston Globe*, June 22, 2016.
- 2 Adams, David, and Peter Larkham. "Walking with the ghosts of the past: Unearthing the value of residents' urban nostalgias." *Urban Studies* (2015): 1-19.
- 3 Bates, Diane C. "Environmental refugees? Classifying human migrations caused by environmental change." *Population and environment* 23.5 (2002): 465-477.
- 4 University of Massachusetts- Boston. *Climate Ready Boston: Climate Change and Sea Level Rise Projections for Boston*. The Boston Research Advisory Group Report. The City of Boston and the Boston Green Ribbon Commission (2016).
- 5 Boston Harbor Association. "Preparing for the rising tide." [www.tbha.org/preparing-rising-tide-report](http://www.tbha.org/preparing-rising-tide-report) (2013).
- 6 Bukvic, Anamaria. "Identifying gaps and inconsistencies in the use of relocation rhetoric: a prerequisite for sound relocation policy and planning." *Mitigation and Adaptation Strategies for Global Change* 20.7 (2015): 1203-1209.
- 7 Conroy, Julie. "Metropolitan Boston Climate Change Strategy/ Quincy Coastal Resiliency." Presentation to the City of Quincy (2016).
- 8 Davenport, Coral and Campbell Robertson. "Resettling the First American 'Climate Refugees.'" *The New York Times*. May 3, 2016.
- 9 Dudley, Michael. "Cold War, Hot Climate: City Planning In Times of Crisis." *Comparative Civilizations Review* 61 (2009): 147.
- 10 Farish, Matthew. "Disaster and decentralization: American cities and the Cold War." *Cultural Geographies* 10.2 (2003): 125-148.
- 11 Fullilove, Mindy Thompson, and Rodrick Wallace. "Serial forced displacement in American cities, 1916-2010." *Journal of Urban health* 88.3 (2011): 381-389.
- 12 Fullilove, Mindy Thompson. "Root shock: the consequences of African American dispossession." *Journal of Urban Health* 78.1 (2001): 72-80.
- 13 Fussell, Elizabeth, Narayan Sastry, and Mark Van Landingham. "Race, socio-economic status, and return migration to New Orleans after Hurricane Katrina." *Population and environment* 31.1-3 (2010): 20-42.

- 14 Gans, Herbert J. "The human implications of current redevelopment and relocation planning." *Journal of the American Institute of Planners* 25.1 (1959): 15-26.
- 15 Gans, Herbert J. *Urban Villagers*. New York: Free Press, 1962.
- 16 Geaghan, Kimberly A. "Forced to move: An analysis of Hurricane Katrina movers." Social, Economic, and Housing Statistics Division, US Census Bureau (2011).
- 17 Groen, Jeffrey A., and Anne E. Polivka. "Going home after Hurricane Katrina: Determinants of return migration and changes in affected areas." *Demography* 47.4 (2010): 821-844.
- 18 Gromilova, Mariya. "Revisiting Planned Relocation as a Climate Change Adaptation Strategy: The Added Value of a Human Rights-Based Approach." *Utrecht Law Review* 10.1 (2014): 76-95.
- 19 Hall, Peter. *Cities of tomorrow: An intellectual history of urban planning and design since 1880*. John Wiley & Sons, 2014.
- 20 Hauer, Mathew E., Jason M. Evans, and Deepak R. Mishra. "Millions projected to be at risk from sea-level rise in the continental United States." *Nature Climate Change* (2016).
- 21 Henry, Jacques. "Return or relocate? An inductive analysis of decision-making in a disaster." *Disasters* 37.2 (2013): 293-316.
- 22 Hori, Makiko, and Mark J. Schafer. "Social costs of displacement in Louisiana after Hurricanes Katrina and Rita." *Population and Environment* 31.1-3 (2010): 64-86.
- 23 Kayden, Jerold S. "National land-use planning in America: Something whose time has never come." *Wash. UJL & Pol'y* 3 (2000): 445.
- 24 Kirshen, Paul, Kelly Knee, and Matthias Ruth. "Climate change and coastal flooding in Metro Boston: impacts and adaptation strategies." *Climatic Change* 90.4 (2008): 453-473.
- 25 Kloos, Bret, et al. "Investigating the roles of neighborhood environments and housing-based social support in the relocation of persons made homeless by Hurricane Katrina." *Journal of prevention & intervention in the community* 37.2 (2009): 143-154.
- 26 Kousky, Carolyn, and Howard Kunreuther. "Addressing affordability in the national flood insurance program." *Journal of Extreme Events* 1.01 (2014).

- 27 Marino, Elizabeth. "The long history of environmental migration: Assessing vulnerability construction and obstacles to successful relocation in Shishmaref, Alaska." *Global environmental change* 22.2 (2012): 374-381.
- 28 McAdam, Jane, and Elizabeth Ferris. "Planned Relocations in the Context of Climate change: Unpacking the Legal and Conceptual Issues." *Cambridge J. Int'l & Comp. L.* 4 (2015): 137.
- 29 Mele, Christopher and Daniel Victor. "Reeling from Effects of Climate Change, Alaskan Village Looks to Relocate." *The New York Times*. August 19, 2016.
- 30 Metropolitan Area Planning Council. *South Shore Coastal Hazards Adaptation Study*. Prepared for the Towns of Duxbury, Marshfield, and Scituate (2011).
- 31 Morrice, Stephanie. "Heartache and Hurricane Katrina: recognising the influence of emotion in post-disaster return decisions." *Area* 45.1 (2013): 33-39.
- 32 Parris, Adam. "Global Sea Level Rise Scenarios for the United States National Climate Assessment. Silver Spring, MD: National Oceanic and Atmospheric Administration; 2012." NOAA Technical Report OAR CPO-1.
- 33 Piatt, Rutherford H. "The planner and nuclear crisis relocation." *Journal of the American Planning Association* 50.3 (1984): 259-260.
- 34 Sastry, Narayan, and Jesse Gregory. "The location of displaced New Orleans residents in the year after Hurricane Katrina." *Demography* 51.3 (2014): 753-775.
- 35 Scott, Mel. *American city planning since 1890: A history commemorating the fiftieth anniversary of the American Institute of Planners*. No. 3. Univ of California Press, 1969.
- 36 Simms 2, Eva-Maria. "Children's lived spaces in the Inner City: Historical and political aspects of the psychology of place." *The Humanistic Psychologist* 36.1 (2008): 72-89.
- 37 Wilson, James Q., ed. *Urban renewal: The record and the controversy*. MIT Press, 1966.