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Evaluation of Networks of Plans and Vulnerability to Hazards and Climate Change

A Resilience Scorecard

Philip Berke, Galen Newman, Jaekyung Lee, Tabitha Combs, Carl Kolosna, and David Salvesen

Problem, research strategy, and findings: Land use planning is key to mitigating natural hazards and the effects of climate change. Communities adopt multiple plans that directly and indirectly address hazard mitigation; the integration of local plans can significantly affect future community vulnerability to hazards. We develop a resilience scorecard to assess the degree to which the network of local plans targets areas most prone to hazards and then evaluate the coordination of local plans and test it in Washington (NC), a community vulnerable to coastal floods and projected sea-level rise. We find that local plans are not fully consistent and do not always address the areas in a community most vulnerable to floods or sea level risks; moreover, some plans actually increase physical and social vulnerability to hazards. While these results indicate the validity of a resiliency scorecard, we were forced to use a narrow range of vulnerability indicators; better data would improve the process.

Takeaway for practice: Planners can assume a crucial role in improving planning for hazards by using the scorecard to identify conflicts among local plans, assessing whether local plans target areas most vulnerable to specific hazards. Planners can inform the public and decision makers about missed opportunities to improve local hazard mitigation planning. To support such important efforts, the U.S. Federal Emergency Management Agency and other federal agencies should consider developing additional databases that are widely applicable and available.

Keywords: disaster resiliency, mitigation, land use planning, community vulnerability, network of plans, climate change

About the authors: Philip Berke (pberke@arch.tamu.edu) is a professor, **Galen Newman** (gnewman@arch.tamu.edu) is an assistant professor, and **Jaekyung Lee** (jklee1127@gmail.com) is a graduate research assistant at Texas A&M University. **Tabitha Combs** (tab.combs@gmail.com) is a lecturer at Lincoln University in Lincoln, New Zealand. **Carl Kolosna** (ckolosna@live.unc.edu) is a graduate student and **David Salvesen** (dsalv@email.unc.edu) is a deputy director for the Center for Sustainable Community Design at the University of North Carolina at Chapel Hill.

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Planning to mitigate hazards is often isolated from other planning efforts governing land use and development in hazard areas. As a consequence, there has been geometric growth in losses from disasters for much of the past century (Gall, Borden, Emrich, & Cutter, 2011), losses likely to increase due to climate change (Intergovernmental Panel on Climate Change [IPCC], 2014). To address this concern, the National Research Council (NRC) recommends development of a *resilience scorecard* (NRC, 2012, 2014). The NRC maintains that a resilience scorecard is “essential if communities want to track their progress toward resiliency” and “target efforts where they most need to improve” (NRC, 2012, p. 12).

We review the potential role of different types of local plans (e.g., the comprehensive plan as well as plans for hazard mitigation, infrastructure, and parks and recreation) in reducing the destructive effects of hazards. We then develop a resilience scorecard that evaluates both physical and social vulnerability to flooding and sea-level rise hazards and test that scorecard in the city of Washington, a North Carolina coastal community. The scorecard allows us to determine that the goals of some local plans conflict and actually increase vulnerability to floods and sea rise; moreover, local plans often do not recognize or respond to the physical or social vulnerability of different areas or populations.

Our research indicates that planners can use the scorecard to learn how well different local plans coordinate their objectives and the impacts of the network of local plans. The scorecard provides valuable insight on the policies and goals that unintentionally raise the vulnerability of certain areas or populations. This gives planners the ability to ask crucial policy questions about goals and priorities and how to improve the integration of multiple local plans.

We recommend that planners play a central role in applying the scorecard and in guiding communities to revise and improve plans by regularly evaluating the link between multiple local plans and vulnerability outcomes over time. We also recommend that the scorecard be used in planning research to examine what roles planners can play in addressing vulnerability to hazards in different kinds of communities and in relationship to other key stakeholders. We further suggest that the U.S. Federal Emergency Management Agency (FEMA) and other federal agencies develop readily available and widely applicable databases to foster broad use of the scorecard and this kind of analysis.

The Promise and Pitfalls of Local Planning Linked to Vulnerability

Planning can play an important role in guiding land use and development in areas vulnerable to hazards such as floods. Communities create and adopt a number of often-independent plans, each of which may touch on key issues related to different types of hazards and hazard mitigation. The combined impact of multiple and interdependent plans can decrease or increase vulnerability to community hazards. Communities can and should use a resilience scorecard to enable them to detect the degree of coordination among plans and to use that information to improve those plans and more explicitly reduce community vulnerability to hazards.

The NRC maintains that an approach that focuses on preventative land use is the most promising long-term solution to mitigating the destructive effects of hazards (NRC, 2006, 2014). Land use approaches can guide new growth to locations outside of current and forecasted hazard areas, assist property owners to relocate existing development to safer sites, and manage post-disaster redevelopment in ways that reduce future vulnerability to hazards (Burby et al. 1999; Burby, French, Cigler, Kaiser, & Moreau, 1985; Godschalk, Kaiser, & Berke, 1998). Prior research indicates local government plans with land use goals and policies that target reducing vulnerability have an important positive impact on local adoption of regulatory ordinances and infrastructure investments aimed at mitigating vulnerability (Berke et al., 2006; Burby & May, 1997), encouraging household mitigation actions (Horney, Simon, Grabich, & Berke, 2015), and reducing property damage from hazard events (Burby 2006; Nelson & French, 2002). The implication is that communities that invest in land use planning are more resilient—a critical concept in hazards research—because they are better able to anticipate and adaptively respond to extreme events, to rapidly recover, and to reduce future vulnerability (NRC, 2012). Rather than waiting for an event to occur and incurring the costs afterward, better planning means better anticipation and thus greater resilience (Godschalk, 2003).

A resilience scorecard should account for all the plans that govern land use and development in hazard areas. Of the multiple plans that local governments in the United States prepare, the comprehensive plan represents the predominant form of general governmental planning and is widely considered to have a prominent role in further reducing community vulnerability to hazards (FEMA, 2013; Godschalk, Beatley, Berke, Brower, & Kaiser, 1999; Masterson et al., 2015; Schwab, 2010). The comprehensive plan inherently deals with where and how public and private development takes place; it is the primary planning document that coordinates multiple community programs involving development and land use (Berke, Godschalk, & Kaiser, 2006). In addition, the comprehensive plan has legal standing that gives it prominence among all types of plans (Sullivan & Brager, 2014).

Hazards vulnerability reduction can also be integrated into other more specialized, standalone planning activities. The hazard mitigation plan is one of the most ubiquitous special-purpose plans adopted by local governments in the United States.[1] The Disaster Mitigation Act (DMA) enacted by Congress in 2000 requires all local governments to adopt a mitigation plan approved by FEMA to be eligible for federal pre- and post-disaster mitigation funds. Passage of the DMA marked a major shift in federal policy, moving the nation away from a reactive, disaster-driven approach to hazard mitigation to a more proactive approach (Nolan, 2009; Smith, 2009). Recognizing the importance of land use approaches, FEMA is placing more emphasis on integrating mitigation planning with land use planning in the second decade of the DMA's existence (FEMA, 2013, 2014).

Other types of standalone local plans can play an important role in decreasing a community's vulnerability to hazards. A parks and recreation plan or wildlife habitat management plan, for example, addresses the natural and open space needs of a community; these types of plans provide opportunities to complement hazard mitigation goals by using land acquisition funds to purchase at-risk properties that can be converted to parks or wildlife corridors. A capital improvement plan can have a significant impact on how and where a community grows. Constructing a highway intersection or sewer line can encourage growth if located in previously undeveloped hazard areas, or guide growth away from hazard areas if located outside such areas.

Hazard planning specialists have long been concerned that mitigation planning practice is fragmented and poorly integrated into the diverse sectors of planning (Boswell & Topping, 2008; Burby et al., 1999; Godschalk et al., 1998; Macintosh, 2013; Schwab, 2010). When planners do not integrate consistent hazard mitigation elements into multiple local plans they significantly raise the possibility of increasing the growing vulnerability of people and the built environment to hazards. For example, land use plans may designate areas prone to hazards for open space, while capital improvement plans locate roads, water and sewer utility pipes, and other infrastructure investments in the same areas, encouraging growth. Even when local governments are required to include hazard mitigation elements in their comprehensive plan, as in California, most (77%) of the elements fail to reference any actions in the complementary local hazard mitigation plan (Boswell & Topping, 2008).

Failure to integrate multiple local planning activities has become a national policy concern; Craig Fugate, FEMA director, calls for more integration of hazard mitigation planning with comprehensive planning and more cooperation between emergency managers and land use planners (Fugate, 2010). The need to infuse hazard vulnerability reduction into local planning processes reverberates at the international level; the United Nation's Strategy for Disaster Reduction 2015–2030, also known as the Sendai Framework, encourages governments and organizations to "Promote mainstreaming of disaster risk into planning…in all relevant sectors of human settlements" (e.g., ecosystem preservation, transportation, housing, and critical facilities; United Nations General Assembly, 2015, p. 7).

In sum, local plans that govern land use and development in hazard areas hold considerable promise to reduce future hazard vulnerability. However, local planning practice is constrained in achieving this promise because local plans are often fragmented and poorly integrated.

Conceptual Framework for Development of a Resilience Scorecard

Our primary goal is to develop a resilience scorecard that helps integrate and improve local plans in ways that reduce losses from hazard events. The resilience scorecard allows planners to assess the degree of coordination among local plans that address local vulnerability to hazards, accounting for both the positive and adverse effects of local plans. Using this scorecard will inform local planners, emergency managers, and other local officials about conflicting plan policies as well as identify opportunities to improve integration of planning efforts in different parts of the community in hazardous areas. Better information will enable communities to reduce counterproductive efforts and more efficiently use resources to reduce their vulnerability to hazards.

A scorecard is, of course, another way to evaluate plans, a topic on which there is an extensive research literature (Baer, 1997; Berke & Godschalk, 2009; Brody, 2003; Lyles & Stevens, 2014; Tang, 2008; Tang, Lindell, Prater, & Brody, 2008). A major limitation of that research, however, is that we know little about how well integrated any individual plan is with the network of other local plans. For example, scholars use a number of indicators of plan quality, including goals, fact base, policy, implementation, monitoring, participation, and interorganizational coordination. But these scholars have largely failed to consider if one local plan is consistent with other community plans.

We posit that a resilience scorecard should have two core capabilities. The first is to assess the degree of integration among plans that reduce vulnerability in different parts of a community, or in different planning districts. Most planning processes divide the community into geographic districts that encompass residential neighborhoods, downtowns, and commercial, industrial, and conservation areas. Focusing on districts with different needs, resources, and challenges is a core element of a comprehensive plan (Berke, Godschalk, et al., 2006). In doing so, planners can develop general land use and development goals responsive to the unique characteristics of each district while encouraging the coordination and integration of goals and policies with other standalone plans. Our aim is to derive a score specifying the degree to which that network of local plans affects the vulnerability of specific areas, or districts, within a community.

The second core capability of the scorecard is to enable comparisons between the degree of the integration of local plans on one hand, and levels of vulnerability to hazards by planning district on the other hand. We define vulnerability to mean the susceptibility of people and the built environment to loss from hazards. By comparing the degree of local plan integration with the level of vulnerability, we can identify the vulnerability issues unique to each planning district as well as the appropriate planning solutions. Having this information allows planners and other local officials to determine how the community might respond and adapt their plans.

The scorecard focuses on both physical and social vulnerability. Physical vulnerability is the susceptibility to losses based on exposure to hazards and characteristics of the built environment. Examples of physical characteristics that detect such vulnerability include the value and structural integrity of residential, commercial, and other structures (Brody, Kang, & Bernhardt, 2010; Brody, Peacock, & Gunn, 2012; National Oceanic and Atmospheric Administration [NOAA], 2015; Patterson & Doyle, 2009). Social vulnerability, by contrast, is associated with characteristics of certain populations that affect their capacity and resources to respond to hazards. As shown in Table 1, age (elderly and children), language capacity, income, and education are among the most important characteristics of vulnerable populations (Cutter, Boruff, & Shirley, 2003; Cutter, Burton, & Emrich, 2010; Cutter & Finch, 2008; Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011; Peacock, Van Zandt, Henry, Grover, & Highfield, 2012; Van Zandt et al., 2012). For example, people with lower incomes have fewer resources to mitigate the vulnerability of their homes; those with lower educational attainment are less likely to perceive threats and have less information to cope with hazards.

After developing a resilience scorecard with these two core capabilities, we test its applicability in Washington, a highly vulnerable community on the North Carolina coast. We use the scorecard to determine the degree of coordination among local plans that seek to reduce the physical and social vulnerability to coastal floods and projected sea-level rise by planning district.

Demonstration Community: City of Washington, NC

The precolonial city of Washington is located in Beaufort County on the North Carolina coast with a 2010 population of 9,074. Since the 1990s the economy has been shifting toward tourism, and the population increased 1.7% between 2000 and 2010.[2] The city's terrain averages about 10 feet above sea level, with slopes ranging from level to 4%; the city is exposed to several recurring natural hazards, including hurricanes, floods, and nor'easters (Beaufort County, 2010). Flooding due to storm surge and sea-level rise are major threats because of the area's low-lying land and proximity to surface water.

Washington has adopted four plans that influence land use patterns in areas affected by coastal floods and sea-level rise. The city's planning department indicates that two complementary documents serve as the city's comprehensive plan (City of Washington, 2013). A state-mandated plan adopted in 2006 under the Coastal Area Management Act (CAMA), the CAMA Land Use Plan, outlines broad planning districts that should be either protected (sensitive coastal and estuarine resources), designated for rural to urban conversion, or targeted for infill and redevelopment (City of Washington, 2006). The 2023 Comprehensive Plan, adopted in 2013, provides more detailed land policy guidance (e.g., density and types of land uses and location, timing, and capacity of infrastructure) within each of the broad districts of the CAMA Land Use Plan (City of Washington, 2013). The city also has a parks and recreation plan (City of Washington, 2014) and a mitigation plan that is included as an element in the Beaufort County Multi-jurisdictional Hazard Mitigation Plan of 2010 (Beaufort County, 2010).

Developing and Testing the Resilience Scorecard

We develop and test the resilience scorecard in the city of Washington in three phases: First, we delineate planning districts and hazard zones for current floodplains and future sea-level rise; second, we determine the physical and social vulnerability in hazard zones for each district; and third, we evaluate the degree of coordination among a local network of plans in support of decreasing hazards vulnerability by district.

Phase 1: Delineate Planning Districts and Hazard Zones

We delineate planning district using land use maps in Washington's 2023 Comprehensive Plan and the CAMA Land Use Plan. As noted, planning districts are relevant units of analysis to demonstrate how well the network of local plans reduce vulnerability (Berke, Godschalk, et al., 2006) because most local planning efforts focus on these delineated areas and attempt to coordinate plan policies to achieve the development goals for each district.

Next, we delineate hazard zones based on the National Flood Insurance Program (NFIP) flood maps and sea-level rise. We focus on NFIP flood zones and sea-level rise given their salience in national policy and the nationwide availability of data linked to these hazards, although there are other coastal hazards (including shoreline erosion,

Table 1. Variables that comprise social vulnerability based on U.S. Census 2010 definitions.

Domain	Variable	2010 Census table variable(s)	Census level	Description
Socioeconomic status	% individuals below poverty	T117	Block group	Individuals below poverty="under .50" +".50 to .74" + ".75 to .99." Percentage of persons below federally defined poverty line, a threshold that varies by the size and age composition of the household. Denominator is total population where poverty status is checked.
	Per capita income in 2010	T83	Block group	Mean income computed for every person in census block group (in <DollarYear> inflation-adjusted dollars).
	% persons with less than high school diploma	T25	Block group	Percentage of persons 25 years of age and older, with less than a 12th-grade education (including individuals with 12 grades but no diploma).
Household composition	% persons 65 years of age or older	T7	Block group	
	% persons 17 years of age or younger	T7	Block group	
	% male or female householder, no spouse present, with children under 18	B09002	Block group	"Other family: male householder, no wife present, with own children under 18 years" + "Other family: female householder, no husband present, with own children under 18 years."
Minority status	% minority	T13	Block group	Total of the following: "Black or African American alone" + "American Indian and Alaska Native alone" + "Asian alone" + "Native Hawaiian and other Pacific Islander alone" + "some other race alone" + "two or more races" + "Hispanic or Latino – White alone."
	% persons 5 years of age or older who speak English less than "well"	B16004	Block group	For all age groups and all languages – the total of persons who speak English "not well" or "not at all."
Housing/ transportation	% multiunit structure	T97	Block group	Percentage of housing units with 10 or more units in structure.
	% mobile homes	T97	Block group	Percentage of housing units that are mobile homes.
	Crowding	B25014	Block group	At household level, more people than rooms. Percentage of total occupied housing units (i.e., households) with more than one person per room.
	No vehicle available	B25044	Block group	Percentage of households with no vehicle available.

Note: The Flanagan et al. (2011) model uses 15 variables. We exclude three of these variables (percentage of persons more than 5 years old with a disability, percentage of persons in group quarters, percentage unemployed) because the 2010 U.S. Census did not include this data.
Source: ACS 2006–2010 (5 year estimates) from the U.S. Census Bureau (2015).

historical hurricane events, and precipitation-driven stormwater floods). We delineate NFIP flood hazard zones based on the probability of experiencing a flood as defined by the Digital Flood Insurance Rate Map (DFIRM) 100-year (1% occurrence probability per year) floodplain boundaries. The 100-year floodplains are widely used in formulating local hazard mitigation policy to administer and enforce NFIP policy goals.

We add sea-level rise forecasts to inundation surfaces indicated by the 100-year flood elevations on DFIRM maps, consistent with the method used to guide rebuilding of structures that received FEMA's public assistance funds after Hurricane Katrina (U.S. Army Corps of Engineers [USACE], 2014a). Our aim is to delineate the extent of flooding using the same 1% probability of occurrence as FEMA uses, to which we add the level of sea rise. Recent advances in downscaling the effects of global climate change on sea-level rise have made it possible to delineate areas exposed to sea-level rise (Climate Central, 2014). We use data derived from USACE's sea-level rise calculator, which provides alternative scenarios in 10-year increments up to 2100 for relative local sea-level rise along the U.S. coast (USACE, 2014b).[3] By adding sea-level rise to the base elevation of the 100-year floodplains, we determine the projected expansion of current flood zones. We recognize that adding sea-level rise over DFIRMs does not account for other changes in climate (e.g., storm intensity that could affect storm surge heights). However, our intent is to begin to fill a gap in knowledge about current plan policies that influence population growth and

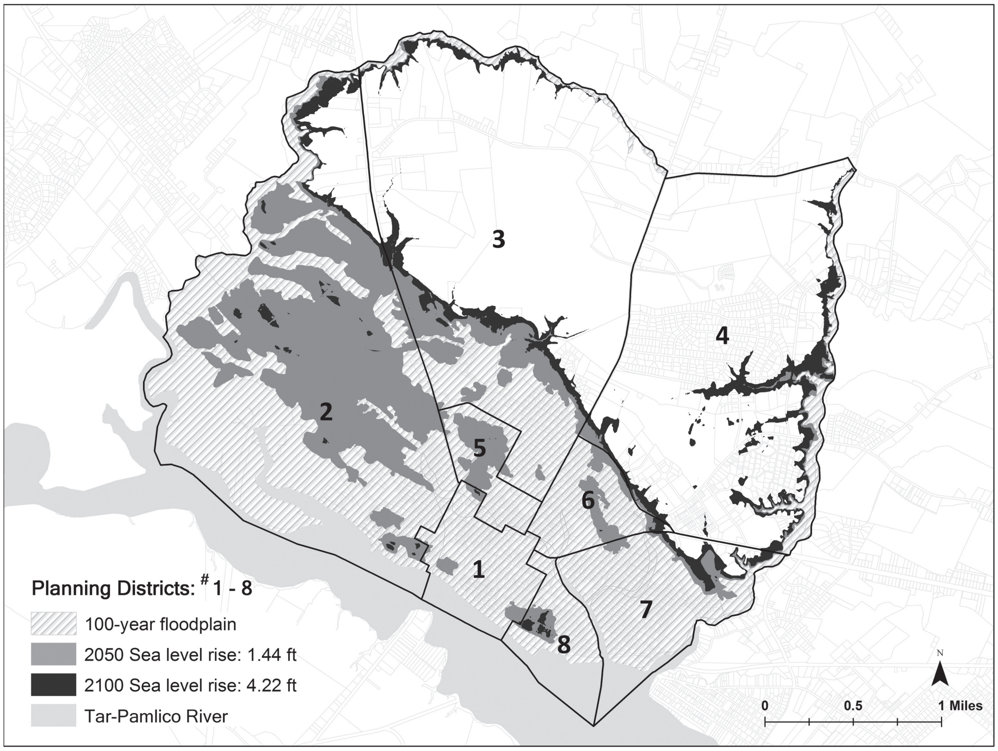

Figure 1. Hazard zones and planning districts in the city of Washington (NC).

development, and about ultimately hazard vulnerability in potential future hazard zones.

Our next step is to intersect the 100-year flood and sea-level rise hazard zones with the locally defined planning districts. Figure 1 shows the intersection of hazard zones and eight planning districts we developed for the city of Washington.[4] The map shows the potential impact of the current estimate of the 100-year floodplain, plus areas that could be subject to the 100-year flood in about 2050 and 2100 due to moderately high estimated projections for sea-level rise. We select the intermediate-high scenario for the years 2050 and 2100 from a range of possible sea-level rise scenarios (low, intermediate low, intermediate, intermediate high, and high) generated by the USACE sea-level rise calculator for the coastal region that includes Washington. We select a midterm horizon of 2050 (relative to 2014) as appropriate for making decisions regarding the life of a structural protection project such as a seawall, and a long-term horizon of 2100 (relative to 2014) because it aligns with the impacts of land use commitments for urban development (Deyle, Butler, & Stevens, 2013).

Phase 2: Determine Vulnerability

Our next task is to identify indicators of physical and social vulnerability. We use 2010 building tax values (U.S. dollars per square foot) as a proxy for physical vulnerability; this is consistent with methods of determining physical vulnerability in prior studies of the effect of land use policies on development in riverine floodplains in North Carolina (Patterson & Doyle, 2009) and coastal hazard zones in southeast region of Florida (NOAA, 2015; Southeast Florida Regional Compact, 2012).[5] We use land parcel data from the city of Washington, including building tax values.[6]

We measure social vulnerability by using variables from the Social Vulnerability Index for Disaster Management (SVI), an index developed by the U.S. Centers for Disease Control (CDC) using data from the 2010 U.S. Census at the census tract and block group levels (Flanagan et al., 2011). We choose the SVI because it offers a more straightforward and comprehensible measure relative to other complex statistical weighting schemes. The SVI organizes social vulnerability into four domains: socioeconomic status, household composition, minority status, and housing and transportation. These domains are represented by 15 demographic variables the CDC selected based on evidence derived from a comprehensive review of the hazards vulnerability literature. However, as shown in Table 1, we use only 12 indicators since the 2010 U.S. Census did not include data for three indicators.

To construct a SVI, we rank each social indicator, except for per capita income, from highest to lowest across all census block groups in the case study area ($N = 7$). We rank per capita income from lowest to highest because, unlike the other indicators, a higher value means lesser vulnerability. We then calculate a percentile rank for each block group for each of the indicators.[7]

To identify specific populations with high vulnerability, we apply a "flag" count procedure used by the CDC (Flanagan et al., 2011). Flag counts are an index that represents the number of individual indicators with percentile ranks of 90 or higher per block group. For this study, we use the 86th or higher percentile rank given the limited number of census blocks groups in the city of Washington ($N = 7$).[8] Flag counts are useful for identifying areas that have vulnerable populations, denoted by scoring high on one or more indicators, providing local planners the specific information needed to target plan policies. Once we compute the flag count indices, we assign them to each block group and enter them as a GIS layer.

We then map the distribution of the physical vulnerability scores (U.S. dollars per square foot) and SVI flag count indices in hazard zones of each planning district. Both sets of indicators were originally represented in a GIS layer as vector polygons. Such polygons contain great uncertainty in how the SVI flag count values and physical vulnerability (i.e., building tax values) are distributed inside each individual census block (population) or parcel (building tax). Polygon representation is problematic when only a portion of a polygon intersects a boundary of a hazard zone within each planning district because it is not possible to discern the physical vulnerability and SVI values located inside the hazard areas of planning districts.

We address this spatial distribution problem for both types of vulnerability. For social vulnerability, we use LandScan data to distribute SVI flag values at a finer resolution than the census block groups. LandScan is a national population distribution model developed at Oak Ridge National Laboratory (2013) that estimates the number of people within 90-meter cells for both residential and daytime populations to a higher degree of accuracy than other population distribution models (Patterson & Doyle, 2009; Sabesan et al., 2007).[9]

As illustrated in Figure 2, we divide each block group polygon into 90-meter cells using LandScan data. We then assign the SVI flag count value for a given block group to each cell. If a cell had zero population count, we assign a SVI flag count value of zero. Of course, it is possible that a cell has a very high proportion of socially vulnerable populations. For example, it is possible that more than 80% of the elderly who are living in any given cell are below the poverty level, but there are actually very few people living in the 90-meter cell itself. We correct for this by using a weighted SVI flag count measure calculated by weighting the SVI flag count score by the population density (number of people per cell) of the cell. In this way, a cell that has a high SVI flag count score and is relatively densely populated will score higher than one with a similar SVI flag count score but is sparsely populated. We then determine an average SVI flag count score for hazard zones in each planning district by summing the weighted score for each cell within the district and then dividing by the number of cells in the district.

Selecting the most appropriate approach to weighting the scores depends on local goals and the level of resources a community can and will allocate to reducing the vulnerability of its population to hazards. The unweighted approach identifies the locations of populations with the greatest vulnerability regardless of counts. In contrast, the weighted approach identifies where a higher proportion of the population is vulnerable, but not necessarily those with

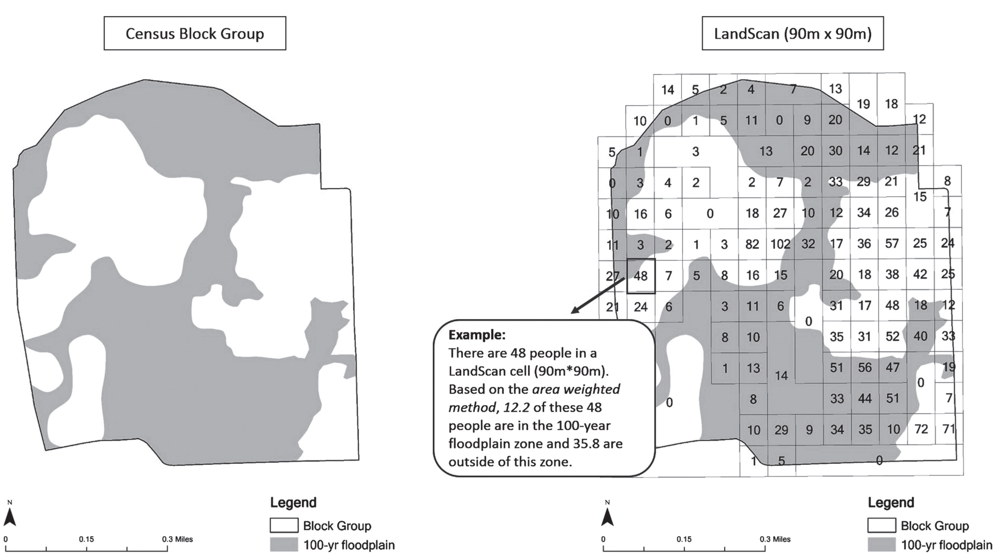

Figure 2. Application of LandScan.

Source: Data from Oak Ridge National Laboratory, 2013.

the greatest vulnerability. Consistent with Van Zandt et al. (2012), we choose to use the weighted measure that places emphasis on relative density of people.

For physical vulnerability, we use building footprint data to address the spatial distribution problem in determining the vulnerability of structures. We acquire a data set that includes building footprints and improved tax values from the City of Washington (2012). This data set specifies the spatial boundary of all structures greater than 800 square feet on each parcel within the city. We then overlay hazard areas for each planning district on each parcel. We include the total value of the building in the hazard zone if any part of the building footprint intersects the boundary of the hazard zone. We determine the building tax density (U.S. dollars per square foot) inside each planning district by summing the value of all vulnerable structures inside each hazard area (100-year floodplain, sea-level rise) and then dividing the summed value by the total square footage of the hazard area for each district.

Phase 3: Evaluate Plans

Next, we develop a method for evaluating the extent to which policies in each local plan integrate the elements that reduce hazard vulnerability. We identify each policy in each plan and spatially assign the policy to a hazard zone in a land policy district. We only include policies that influence land use and development in hazard zones. We then identify the type of land use policy instrument stipulated by each policy. Table 2 illustrates five categories of land use policy instruments (e.g., development regulations and public facilities improvement programs) that influence the type, location, and amount of development, and describe how these policy instruments can reduce hazard vulnerability. In some cases, a policy spatially targets land use activities within in a single land policy district; in other cases, a policy may be applicable to multiple districts. We then use the assigned policies to create indices for both physical vulnerability and social vulnerability for each plan by planning district. While the policies on which we focus can be—and often are—designed to reduce vulnerability, it is possible that the lack of coordination between and among local plans can actually increase vulnerability in certain hazard areas: We account for those impacts as well.

We compute each index based on well-established procedures of plan content analysis (Lyles & Stevens, 2014). The procedure consists of two steps. First, we classify each policy based on the intended physical or social vulnerability outcome linked to the policy. We determine whether a policy increased physical or social vulnerability (score = –1) or decreased either type of vulnerability (score = +1).[10] Figure 3 presents two examples of how we

Table 2. Categories of land use policies.

Policy category	Application to hazard vulnerability
Development regulations	
Permitted land use	Provision regulating the types of land use (e.g., residential, commercial, industrial, open space, etc.) permitted in areas of community; may be tied to zoning code
Density of land use	Provision regulating density (e.g., units per acre)
Subdivision regulations	Provision controlling the subdivision of parcels into developable units and governing the design of new development (e.g., site storm water management)
Zoning overlays	Provision to use zoning overlays that restrict permitted land use/density in hazardous areas; may be special hazard zones or sensitive open space protection zones
Setbacks/buffers	Provision requiring setbacks or buffers around hazardous areas (e.g., riparian buffers and ocean setbacks)
Cluster development	Provision requiring clustering of development away from hazardous areas, such as through conservation subdivisions
Land acquisition	
Acquire land and purchase land/property in hazard area Property	
Financial incentives and penalties	
Density bonuses	Density bonuses such as ability to develop with greater density in return for dedication or donation of land in areas subject to hazards
Tax abatement	Tax breaks offered to property owners and developers who use mitigation methods for new development
Special study	Provision requiring impact fees or special study fees on development in hazardous areas; fees could cover costs of structural protection
Land use analysis and permitting process	
Land suitability	Hazards are one of the criteria used in analyzing and determining the suitability of land for development
Site review	Provision requiring addressing hazard mitigation in process of reviewing site proposals for development
Public facilities	
Site public facilities	Provision to site public facilities out of hazard areas
Capacity public facilities	Provision limiting capacity of public facilities in hazard areas to cap amount of development
Public housing	Provision to site public housing out of hazard areas

apply the classification and scoring method. Second, for each hazard zone in each planning district we sum scores from all plans by vulnerability outcome. Higher total scores indicate the use of more policies aimed at decreasing vulnerability, while lower scores indicate that use of more policies that actually increased vulnerability.[11]

Our procedure follows guidelines established in content analysis and plan quality literatures (compare with Berke & Godschalk, 2009; Krippendorff, 2004; Stevens, Lyles, & Berke, 2014). Between October 2014 and March 2015, we independently doubled coded plans following established guidelines (Berke & Godschalk, 2009; Stevens et al., 2014). In line with the recommendations of Stevens et al. (2014), we calculate reliability scores for all items individually. Coder reliability scores by policy item for each plan are available from the authors (see http://faculty.arch.tamu.edu/pberke/). We include summary scores by land use policy category for each of the four plans in the Technical Appendix (Table A-1). We calculate reliability among plan coders using both percentage agreement (item range, 50% to 100% with mean 89.58%) and Krippendorff alpha (item range, –0.25 to 1.00 with mean 0.75). The mean percentage agreement is consistent with the reliability of plan quality items in previous studies (Berke & Godschalk, 2009).

Example 1. A policy in the infrastructure element of the City of Washington Comprehensive Plan states, "Assure the provision of public and private parking in support of increased development and activity" (City of Washington, 2013, p. 30). The rationale is to expand infrastructure capacity to foster physical development of the downtown (see District 1 in Figure 2), which is entirely in the 100-year floodplain and in the projected area to be inundated by sea-level rise by 2100. Thus, for District 1, this policy linked to *infrastructure capacity* received a score of –1 for physical vulnerability for the 100-year flood zone and a –1 for the zone covered by additional sea-level rise zone.

Example 2. A policy in the City of Washington hazard mitigation plan, which is part of a county multi-jurisdiction mitigation plan, states the need for "acquisition of properties located in the city's repetitive loss areas…including areas adjacent to Jack's Creek…passing through areas largely utilized for public housing" (Beaufort County 2010, p. 4–14). These areas covered four districts (5, 6 and 8; see Figure 1). The rationale is to reduce social vulnerability inside the 100-year floodplain. The policy of *acquisition* received a score of +1 for social vulnerability for each of the three districts.

Figure 3. Examples of the plan policy scoring method.

Are Local Plans Consistent With One Another?

In Figure 1, we present an overview of computed physical and social vulnerability by hazard zone in the city of Washington. We combine sea-level rise projections for 2050 and 2100 given the minor differences in both the area covered and in social and physical vulnerability.[12] Next, we report on two sets of resilience scorecard results.

Vulnerability by Hazard Zone and Remainder of City

The city of Washington faces high physical and social vulnerability from coastal flood hazards and projected sea-level rise. We find that 44.4% of investments in the built environment are in the 100-year floodplain; an additional 26.5% are exposed to projected sea-level rise (compared with 29.1% in the remaining areas of the city). Substantially more people live in hazard areas than in the remainder of the city: 55.5% (5,032) of the total population live in the 100-year floodplain; 21.3% (1,937) live in the sea-level rise zone, and 23.2% (2,105) live outside the hazard zones. Table 3 also shows other physical and social vulnerability characteristics.

Comparison of Plan Scores and Level of Vulnerability by Planning District

Figure 4 shows the summed scores for all plans by planning district; Figure 5 shows the vulnerability scores by planning district. We divide improved value (U.S. dollars per square foot), our proxy for physical vulnerability, and social vulnerability flag count scores, weighted by population density, into quintiles.

As findings in Figures 4 and 5 show, when we measure physical vulnerability, we calculate negative scores if plans actually raise physical vulnerability in the 100-year floodplain in three districts and have positive scores for the remaining five districts. We record negative scores for all eight districts in sea-level rise zones.

The relationship between the scores for local plans and the level of physical vulnerability is not consistent. Most notably, the network of local plans strongly raises physical vulnerability in the downtown (District 1), which has the lowest score for each hazard zone (–4 in 100-year floodplain; –11 in sea-level rise), but is in the highest quintile of physical vulnerability among all districts. This finding is due to the fact that a prominent theme of both the CAMA Land Use Plan and the 2023 Comprehensive Plan is downtown and waterfront revitalization. Plan polices for the downtown promote smart growth principles by increasing densities, shifting single-use to mixed-use development, incentivizing redevelopment and infill, and

Table 3. Physical and social vulnerability by flood hazard zone and remainder of city.

	100-year floodplain zone	**2100 sea-level rise zone**[a]	**Remainder of city**[b]
Physical vulnerability			
Total improved value	44.4% ($255,068,182)	26.5% ($152,491,151)	29.1% ($166,949,958)
Standardized improved value (by sq. ft)	$3.51	$3.04	$3.76
Social vulnerability			
Total population (no.)	55.5% (5,032)	21.3% (1,937)	23.2% (2.105)
Population density (per sq. mi.)	1,651.4	1,017.7	923.9
Mean social vulnerability flag counts[c,d]	1.9	1.7	0.6

Notes:

a. Excludes 100-year floodplain.

b. Excludes 100-year floodplain zone and 2100 sea-level rise (4.22-foot) zone.

c. Mean flag counts are the number of indicators with percentile ranks of 86 for each 90-meter cell in a geographic area (100-year, 2100 sea-level rise, and remainder of city) divided by the total number of non-zero cells in each geographic area. Twelve indicators (see Table 1) were used to measure social vulnerability for the seven census blocks that cover the city, with each block divided into 90-meter cells. A maximum score is 12 if all social vulnerability indicators were ranked in the 86th percentile. For example, the 90-meter cells within the100-year floodplain zone had an average flag count of 1.9 indicators that were ranked in the 86th percentile.

d. Table A-2 in the Technical Appendix includes values by social vulnerability indicator used to compute the flag count scores.

expanding public infrastructure investments to enhance pedestrian movement, amenities, and transit. But these plans do not consider the hazard implications of adding so much development in vulnerable areas.

District 6, however, is in the highest quintile of physical vulnerability for the 100-year floodplain, but local plans score highest (+4) in reducing physical vulnerability in the 100-year floodplain. Plan policies for District 6 include land acquisition, rezoning to lower land use densities, and overlay zones to protect wetland vegetation that mitigates flooding. These are the kinds of plan elements that tend to reduce additional development in areas vulnerable to hazards.

The local plans give some attention to lowering social vulnerability in three districts (6, 7, and 8), but pay no attention to social vulnerability in the remaining districts. The relationship between level of social vulnerability and

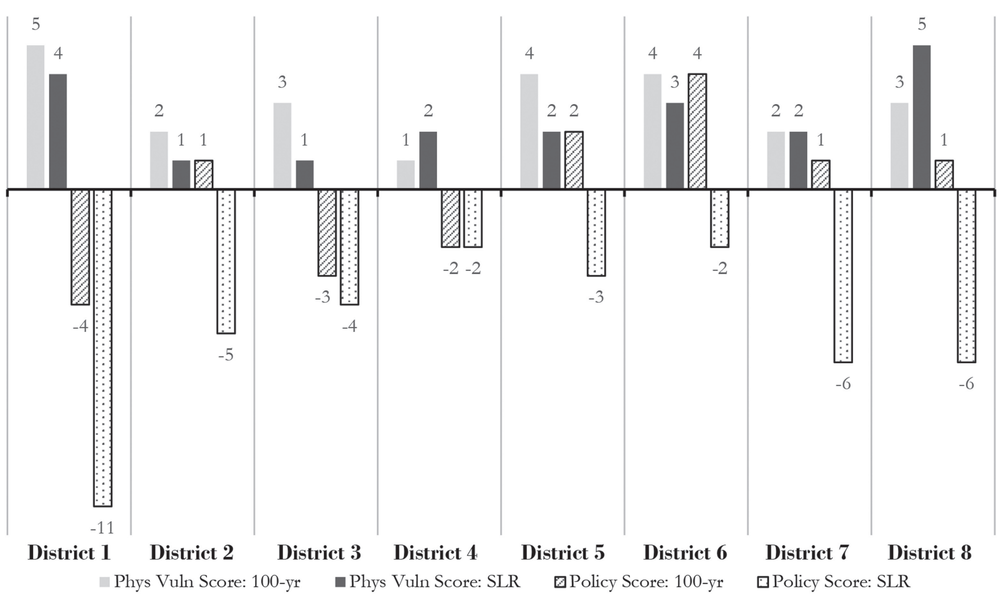

Figure 4. Improved value (U.S. dollar per square foot) and plan policy scores for 100-year floodplain and sea-level rise (SLR) zones.

Notes:

Improved values (U.S. dollars per square foot) by planning district were divided into five groups, with 5 = highest quintile and 1 = lowest quintile. Values across districts are $0.7 to $12.1 in the 100-year floodplain and $2.9 to $22.2 in the sea-level rise zone. Plan policy scores for each district were determined based on a three-step process: 1) Each policy in each plan was classified based on the intended physical vulnerability outcome, then a policy was determined whether it promoted increased physical vulnerability (score = –1) or decreased vulnerability (score = +1); 2) each policy was spatially assigned to a hazard zone (100-year floodplain zone or sea-level rise zone) in a land policy district (see Figure 2); and 3) scores were then summed by hazard zone for each district.

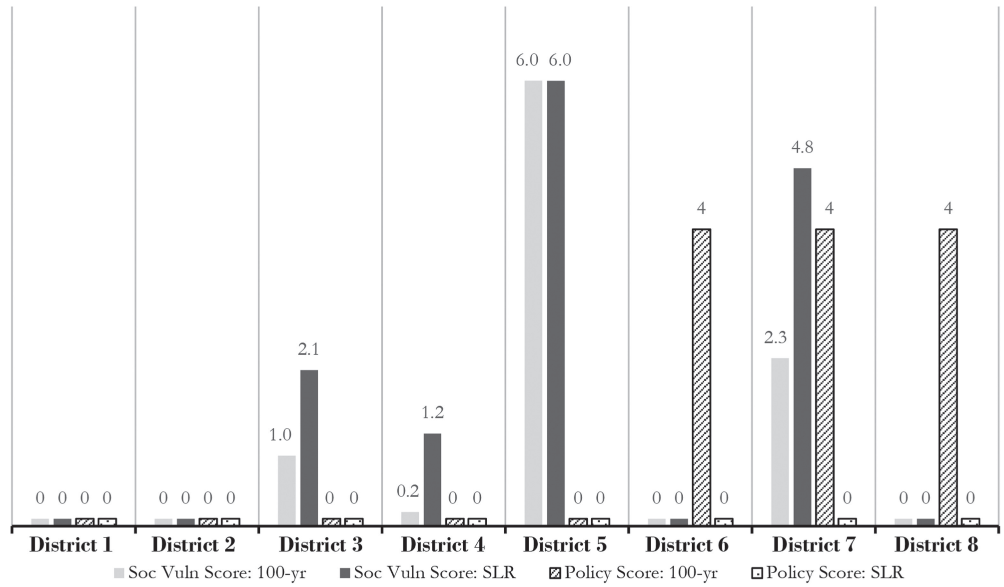

Figure 5. Social vulnerability scores and plan policy scores for 100-year floodplain and sea-level rise (SLR) zones.

Notes:
A weighted social vulnerability score was determined based on four steps: 1) determine a social vulnerability score by summing the total number of individual demographic indicators (Table 1) with percentile ranks of 86 or higher for each census block group within hazard zones in each planning district; 2) divide each census block group into high-resolution 90-meter cells and assign the score to each cell; 3) weight each score by population density (i.e., number of people per cell) of each cell; and 4) determine an average weighted score for hazard zones in each planning district by summing the weighted score for each cell within the zone and then dividing by the number of cells in the zone. Plan policy scores for each district were determined based on three steps: 1) Each policy in each plan was classified based on the intended social vulnerability outcome, then a policy was determined whether it promoted increased social vulnerability (score = –1) or decreased vulnerability (score = +1); 2) each policy was spatially assigned to a hazard zone (100-year floodplain zone or sea-level rise zone) in a land policy district (see Figure 2); and 3) scores were then summed by hazard zone for each district.

the strength of local plans is inconsistent. First, District 5 scored highest in social vulnerability for 100-year floodplains and sea-level rise zones, but none of the plans included policies to reduce social vulnerability in this district. Second, of the three districts that received plan policy scores (6, 7, and 8 = +4), only District 7 had significant levels of social vulnerability. These three districts are the focus of a repetitive flood loss program that targets low-income housing in the 100-year floodplain. The program includes policies for property acquisition and relocation to nearby safer areas, and a zoning policy that designates the floodplain as a publically owned greenway corridor.

We identify how each of the four individual plans adopted by the city of Washington contributes to increasing or decreasing vulnerability, given the large variation in scores for physical vulnerability and the fact that local plans only pay attention to reducing social vulnerability in a few districts. To assess the potential impact of each plan on physical and social vulnerability, we conduct a composite assessment that sums all district scores for each plan by land use policy category.

Comparison of Total Scores by Type of Plan

Table 4 shows the total scores for each plan and total scores by land use policy category aimed at physical vulnerability. Most notable, the resilience scorecard reveals that CAMA Land Use Plan policies and the 2023 Comprehensive Plan policies have strong negative scores that will lead to an increase in physical vulnerability in the 100-year floodplain (CAMA Land Use Plan = –29; 2023 Comprehensive Plan = –38) and projected sea-level rise zones (CAMA Land Use Plan = –17; 2023 Comprehensive Plan = –17; see Table 4). The CAMA Land Use Plan primarily relies on development regulations (e.g., raising zoning densities), while the 2023 Comprehensive Plan uses a wider mix of policy instruments (regulations, incentives, permitting, and expansion of public facilities).

In contrast, hazard mitigation plan policies have a strong positive score (+34) because they aim to decrease physical vulnerability in the 100-year floodplain using development regulations and a land acquisition and relocation program. However, none of the policies are directed toward areas exposed to projected sea-level rise. The parks and recreation plan policies do not consider hazards and have no effect on physical vulnerability in both hazard zones because these plans emphasize maintenance, recreational activities for tourism, and environmental education.

Policies aimed at social vulnerability receive no attention in the CAMA Land Use Plan, 2023 Comprehensive

Table 4. Composite scores for each plan by land use policy category that influence physical vulnerability across hazard zones (100-year floodplain and sea-level rise).

	Land Use Policy Category[a]					
	Development regulations	Land acquisition	Financial incentives and penalties	Land use analysis and permitting process	Public facilities	Total score by plan[b]
CAMA Land Use Plan						
100-year floodplain	–23	+6	0	0	0	–29
2100 sea-level rise	–38	0	0	0	0	–38
2023 Comprehensive Plan						
100-year floodplain	–5	0	–6	–4	–2	–17
2100 sea-level rise	–5	0	–6	–4	–2	–17
Hazard Mitigation Plan						
100-year floodplain	+24	+10	0	0	0	+34
2100 sea-level rise	0	0	0	0	0	0
Parks and Recreation Plan						
100-year floodplain	0	0	0	0	0	0
2100 sea-level rise	0	0	0	0	0	0

Notes:

a. Scores for each land use policy category were determined based on a three-step process: 1) Each policy in each plan was classified based on the intended physical vulnerability outcome; a policy was determined whether it promoted increased physical vulnerability (score = –1) or decreased vulnerability (score = +1); 2) each policy was spatially assigned to a hazard zone (100-year floodplain zone or sea-level rise zone) in a land policy district (see Figure 2); and 3) scores were then summed by hazard zone across districts by land use policy category.

b. The total score for each plan is the sum of scores across each land use policy categories by hazard zone

Plan, or the parks and recreation plan. The hazard mitigation plan has a moderate positive score because it contains policies aimed at reducing social vulnerability in the 100-year floodplain (+8). The policies in the mitigation plan focus on land acquisition and relocation as well as changes in zoning regulations from residential to permanent open space in flood-prone stream corridors in low-income neighborhoods.

How Well Did the Resilience Scorecard Do?

In this study, the resilience scorecard guides an analysis of the degree to which a network of local plans decreases physical and social vulnerability to hazards in the city of Washington. The scorecard includes indicators of plans and hazard vulnerability that leverage widely available national and local databases. Our approach responds to the NRC's call for a proposed resilience scorecard to provide a foundation for the development of metrics to gauge cumulative progress in local plans in reducing hazards vulnerability (NRC, 2012).

Our work in the city of Washington shows that communities can use a resilience scorecard to evaluate the degree of coordination among local planning programs and the level of vulnerability for current hazards and future climate change. By using the scorecard, planners can ask questions that indicate priorities, goals, and needs, and ultimately improve integration of measures and policies that reduce vulnerability across plans. Such questions might include: Should policies in the comprehensive plan promote extensive buildup in the current floodplain better integrate mitigation? Should policies in all plans be revised to give priority to mitigation in districts with the highest physical and social vulnerability? Can the parks and recreation plan be coordinated with the land acquisition program of the hazard mitigation plan? Are there opportunities to improve policies focused on socially vulnerable populations? Finally, how can new and freely available information about sea-level rise be introduced into the current network of plans?

We recommend that planners make efforts to play a central role in helping communities pose such questions, and in guiding the revisions and updates of local plans. Planners typically have the combination of skills that can facilitate the successful and coordinated integration of hazard vulnerability reduction efforts in local networks of plans. Within local governments, planners are best able to inject new thinking about the holistic approach to plan integration. Planners need to recognize the centrality of their role in local government and use their talents to enhance reduction of the growing threats.

We also recommend that planners use the resilience scorecard to regularly evaluate the linkage between multiple plans and vulnerability outcomes over time. Evaluating the outcomes of networks of plans warrants serious investigation. If planning is to play a significant role in decreasing hazards vulnerability, then the data on the effects of plans are needed. Better information would also improve the ability and legitimacy of planners in promoting a more holistic approach to integration of plans.

Next, we recommend that the resilience scorecard be used in research to examine alternative roles that planners can play and how their roles influence scorecard results: Do planners play different roles in communities with strong coordination among plans versus than in those with weak coordination? Research of this type will expand our knowledge on the planner's role in decreasing community vulnerability to current hazards and climate change. A potentially fruitful area of study is evaluating planning processes that have other stakeholders in the lead planning role, such as emergency managers in hazard mitigation planning (Lyles, 2015).

Finally, FEMA and other federal agencies charged with hazards vulnerability reduction should consider developing databases that facilitate the use of the resilience scorecard. Data used for the scorecard should be transparent, readily available, and widely applicable. Our initial application of the scorecard is limited since we only focus on improved property value as a proxy for physical vulnerability and characteristics of populations for social vulnerability. But the database could be supplemented with additional physical indicators (hospitals, schools, transportation infrastructure), social indicators (access to health care services, emergency shelters), economic indicators (capital stocks of businesses, jobs), and ecological indicators (wetlands, coastal dunes, and other natural resources that reduce disaster impacts) that determine the vulnerability of each community to hazards. We suggest that a resilience scorecard, especially with enhanced data, would allow a wide range of communities to examine their network of plans and tailor their efforts to reduce their vulnerability to local hazardous conditions based on local priorities.

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ORCID

Tabitha Combs http://orcid.org/0000-0002-0362-7015

Notes

1. As of 2011, more than 23,000 local jurisdictions had adopted FEMA-approved hazard mitigation plans (FEMA, 2015).

2. The city is stratified racially and economically. In 2010, the minority population was 46% Black or African American compared with the state average of 21.5%, with 5.5% of the population identifying as Hispanic or Latino. Per capita income is lower than the state average, and percentage of families living in poverty (25.3% in 2010) exceeds the state average (11.9%).

3. Sea-level rise experienced by an observer on land is referred to as "relative" sea-level rise. Relative sea-level rise is a function of changes in eustatic sea level as well as shifts in the elevation of the land. Eustatic sea-level rise is the increase in the volume of the oceans that results primarily from the thermal expansion of sea water as heat is transferred from the atmosphere and from the melting of glaciers, ice caps, and the Greenland and West Antarctic ice sheets. Relative sea-level rise is eustatic sea level adjusted for the local rate of vertical land movement.

4. The City of Washington Comprehensive Plan specifically delineates three land policy districts: the downtown and two adjacent neighborhoods east and west of the downtown. The remaining five districts are delineated based on census block group boundaries, which serve as proxies for neighborhood based land policy districts. Two of the census block groups are split by the downtown district. Further, since we use the city as a demonstration community to test the resilience scorecard, we do not include one area within the city's jurisdiction to simplify data collection. The area is located across the Tar River (see Figure 1) and will likely remain unchanged in the foreseeable future. It is primarily wetland, with the majority zoned as conservation and the remaining zoned as low residential developed.

5. Patterson and Doyle (2009), for example, examined change in physical vulnerability of structures inside the 100-year floodplain before and after enactment of changes in land use requirements under the National Flood Insurance Program based on a standardized measure of building tax value density (e.g., dollars per square foot) that could be used to compare across multiple places. NOAA's (2015) Digital Coast mapping system has recently been used to compare physical vulnerability based on taxable value of property threatened by sea-level rise at the subjurisdictional (neighborhood), jurisdictional (county and municipality), and regional scales in southeast Florida (Southeast Florida Regional Compact, 2012).

6. Since our interest was on use of indicators relevant to gauging the potential positive or negative influence of land use policies in multiple plans on physical vulnerability, we did not use indicators associated with structural integrity of the built environment (e.g., building elevation, flood proofing). We also recognize the presence of a wide range of biophysical indicators that detect vulnerability of built environments (compare with Brody et al., 2012; NRC, 2015). But we choose to use building value because it is a straightforward and widely available indicator that serves our purpose.

7. A percentile rank is defined as the proportion of scores in a distribution that a specific score is greater than or equal to. Percentile ranks were calculated using the formula:

$$\text{Percentile Rank} = (Rank - 1) / (N - 1),$$

where N is the total number of data points, and all sequences of ties are assigned the smallest of the corresponding ranks.

8. Given that the study, area included seven census block groups, each percentile rank equaled 14.29% ($7 \times 14.29\% = 100\%$). Thus, the highest possible percentile of social vulnerability for a given social vulnerability indicator is greater than 85.71% (rounded to 86% or more).

9. For this study, nighttime population estimates were used since these data represent the distribution of the residential population.

10. As discussed in comprehensive reviews of plan quality studies (Berke & Godschalk, 2009; Lyles & Stevens, 2014), indicators of plan quality (e.g., goals, facts, policies) are scored in a positive direction. For example, a +1 is assigned for presence of a policy such as zoning that advances mitigation, and zero is assigned for not present. We extend this traditional approach by examining each policy in a plan based on a potential negative effect on vulnerability. For example, the policy on zoning could decrease densities in a hazard area (score = +1) or increase densities (score = –1). This scoring approach is important given that we consider the spatial variation in application of a given policy. Prior studies on plan quality evaluation only consider the entire local jurisdiction as the unit of analysis, but the evaluation procedure presented here is at the sub-jurisdictional scale and accounts for spatial variation in application of plan policies. This permits a more fine-scale opportunity to code the strengths and weaknesses of a given policy across space.

11. We choose an equally weighted index based on a composite of individual policy indicator scores across plans for two reasons. First, this simple method of aggregation is transparent and easy to understand. Second, we find no theoretical or practical justification for the differential allocation of importance across policies. While methods exist for determining weights that are subjective or data reliant, such weighting schemes do not always reflect the priorities of decision makers (Esty, Levy, Srebotnjak, & de Sherbinin, 2005).

12. As shown in Figure 1, there is a slight change in area covered and in vulnerability in the area covered between the 2050 and 2100 sea-level rise projections. For example, the total area of the city under study is 10.1 square miles, and the 100-year floodplain is 3.1 square miles (30.3% of total area). While the 2050 projected sea level superimposed on the 100-year base flood elevation covers an additional 1.6 square miles (15.9% of total area), the 2100 projected sea-level rise superimposed over the 100-year and 2050 sea-level rise projections only adds 0.5 square miles (5.0% of total area). In addition, population counts are 9,074 (total city), 5,032 for 100-year floodplain (55.5% of total), 1,630 (18.0%) for 2050 sea-level rise, and only 307 (3.4%) for 2100. Thus, we choose to only report the 2100 estimates of vulnerability instead of separately reporting 2050 and 2100 estimates.

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Technical Appendix

Table A-1. Coder reliability scores by type of plan and land use policy category.

	Land use policy category				
	Development regulations	**Land acquisition**	**Financial incentives and penalties**	**Land use analysis and permitting process**	**Public facilities**
CAMA Core Land Use Plan					
Percentage of agreement	92.708%	100%	N/A[a]	91.250%	87.500%
Krippendorff's alpha	0.7559	1.00	N/A[a]	0.7957	0.5670
2023 Comprehensive Plan					
Percentage of agreement	91.667%	N/A[a]	81.250%	100%	96.250%
Krippendorff's alpha	0.7433	N/A[a]	0.5910	1.00	0.9258
Hazard mitigation plan					
Percentage of agreement	78.125%	68.750%	N/A[a]	96.875%	N/A[a]
Krippendorff's alpha	0.5871	0.2785	N/A[a]	0.9038	N/A[a]
Parks and recreation plan					
Percentage of agreement	N/A[a]	90.625%	N/A[a]	N/A[a]	N/A[a]
Krippendorff's alpha	N/A[a]	0.8215	N/A[a]	N/A[a]	N/A[a]

Note.

a. Percentage of agreement and Krippendorff's alpha scores were not calculated if plans did not include the policy in the corresponding land use policy category.

Table A-2. Social vulnerability indicators by flood hazard zone and remainder of city.

Social indicator[a]		**100-year floodplain % (Total)**	**2100 SLR: 4.22-foot % (total)[b]**	**Remainder of city % (total)[c]**
Socioeconomic status	Below poverty	10.8 (545)	8.5 (165)	
	Per capita income	21,326	21,012	20,745
	Less than high school education	43.1 (2,169)	36.4 (706)	28.3 (596)
Household composition	Older than 65	17.3 (873)	21.3 (413)	25.7 (540)
	Younger than 17	21.4 (1,079)	20.4 (395)	27.1 (570)
	Family with one spouse	10.9 (548)	11.8 (228)	8.7 (183)
Minority status	Minority	53.7 (2,704)	43.7 (847)	29.3 (617)
	English fluency less than well	3.7 (186)	0.8 (15)	0.8 (17)
Housing transportation	Multiunit housing	2.6 (130)	4.1 (80)	3.2 (68)
	Mobile homes	0.7 (34)	1.4 (27)	2.2 (46)
	Crowding (people/room)	1.3 (63)	1.8 (35)	0.8 (16)
	No. vehicles available	11.3 (571)	8.5 (164)	4.0 (84)

Notes: SLR = sea-level rise.

a. Overall, 8 of 12 indicators were highest in the 100-year or SLR zones (highest percentages for below poverty, less educated, family with one parent, minority, English fluency less than well, multifamily housing, crowded households, and no vehicle available). Three indicators were highest in the remainder of the city (highest percentages of older than 65 and under 17, and households in mobile homes). The difference in capita income was only $380 across the three zones.

b. Excludes 100-year floodplain.

c. Excludes 100-year floodplain and 2100 SLR (4.22-foot) zones.