Mapping Coastal Risks and Social Vulnerability:
Principles and Considerations

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About the Virginia Coastal Policy Clinic

The Virginia Coastal Policy Clinic (VCPC) at William & Mary Law School provides science-based legal and policy analysis of environmental and land use issues affecting the state's coastal resources and educates the Virginia policy making, non-profit, military, legal and business communities about these subjects.

Working in partnership with Virginia scientists, law students in the clinic integrate the latest science with legal and policy analysis to solve coastal resource management issues. Examining issues ranging from property rights to federalism, the clinic's activities are inherently interdisciplinary, drawing on scientific, economic, and policy expertise from across the university. VCPC has a strong partnership with the Virginia Institute of Marine Science (VIMS) and Virginia Sea Grant.

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Executive Summary

Over the past decade, geographic information has exploded, resulting in what National Geographic calls the Geospatial Revolution. Certainly, in the planning and coastal adaptation arenas, anything that can be mapped will be mapped as scientists, planners, government officials, and citizens strive to utilize data and increasingly sophisticated geographic information system (GIS) software to visualize more precisely coastal hazards and change. From local inundation risks to global sea level rise projections, the geospatial information available increases constantly. While overwhelming at times, the potential power of such information to inform decision-makers is profound, as they integrate layers of information to reveal new insights. Emergency planners, for example, can map the best evacuation routes in a hurricane for specific populations, and scientists can pinpoint specific wetlands at risk from storm surge and projected sea level rise. Including demographic data such as race, income, age, and/or disability as part of geospatial modeling creates a more comprehensive picture of the impact of disasters such as flooding, and may not only better predict risks but also provide a basis for better planning decisions. In the coastal adaptation context, the question is quickly becoming how best to ensure that the geospatial information developed guides planning in a useful and equitable manner that advances decision-making and solves problems instead of creating them.

The purpose of this project is to establish a set of principles designed to guide adaptation policy when geospatial modeling of the environment incorporates social vulnerability data.[1] Social vulnerability describes a population's ability to prepare for, respond to, and recover from hazards and disasters.[3] Notably, planners and decision-makers understand that nature does not exist or change in a vacuum – local land use and infrastructure siting decisions, for example, can greatly influence the size and scope of a disaster.[4] Meanwhile, demographic characteristics can influence a community's hazard-risk index as much as its location. Studies have demonstrated that vulnerable populations such as the poor, elderly, minorities, and the disabled are at much greater risk when disasters occur.[5]

As federal and state policymakers, regional and local planners, science advisors, community leaders, and public officials develop and rely upon geospatial modeling that includes social vulnerability data, they should inform the development and use of such information by values such as fairness, as well as take into account legal requirements and local government policy goals. This paper cannot identify every value or legal issue that could arise in the spatial modeling context. Rather, we have focused on an area that we perceive as lacking awareness in the geospatial modeling context as modelers begin incorporating social vulnerability data into coastal hazard mapping: potential local government vulnerability to "strict scrutiny" for making impermissible decisions based on racial or ethnicity information. Notably, while "strict scrutiny" is a concern, local governments may find that mapping socially vulnerable populations is profoundly useful in meeting Americans with Disabilities Act requirements. The paper suggests how on page 7.

Likewise, as a good as a map may be in modeling social vulnerabilities, it is unlikely to be able to illustrate direct institutional bias – which maybe even harder, if not impossible, to map. Geospatial modeling is a tremendous way to illustrate vulnerabilities and draw attention to important issues related to keeping diverse populations of people safe. As complicated and technically impressive as such modeling may be, however, the important

and hard work of building trust, engaging all stakeholders, and creating opportunities for shared decision-making and collaboration should not be diminished by the "wow" factor that geospatial modeling – or any technology – can create. Like all human problems, the means to solving them often rely upon leadership, access to resources, and a long-term commitment to engaging the political process. Geospatial modeling nevertheless promises to be an important tool in the community resilience toolbox. The purpose of this paper therefore is to highlight some of the issues and opportunities related to incorporating social vulnerability data into adaptation mapping in the form of principles that help guide decision-makers as they develop and use such information.

Drawing on key studies, academic literature, caselaw, and discussion with policymakers, these principles and considerations include:

1. **Promote Public Participation: Develop Maps that Non-Technical Experts Value and Understand**
2. **Value Multiple Perspectives: Utilize "Participatory Modeling"**
3. **Avoid Legal "Strict Scrutiny" Concerns By Utilizing Social Vulnerability Information Prudently in Local Government Decision-Making**
4. **Acknowledge Modeling and Data Constraints: Tools, not "Truths"**

This paper first provides an overview of why modeling social vulnerability matters for coastal adaptation efforts in Virginia and North Carolina. It then describes the principles and considerations above in further detail. It concludes with a series of questions the public should consider asking geospatial modelers and planners when presented with maps incorporating coastal hazard and social vulnerability data. An appendix in *Mapping Coastal Risks and Social Vulnerability: Current Tools and Legal Risks*, a companion paper to this paper, provides a list and brief description of mapping tools that are regularly used in the coastal hazard context.

Modeling Social Vulnerability: Why It Matters for Coastal Adaptation in Virginia and North Carolina

Increased data and advanced technological advancements are transforming environmental management. Geospatial modeling is changing how we conceptualize the interface between human and natural environments and predict coastal change and hazard impacts.[7] Such mapping that reveals where and how socially vulnerable populations are threatened is likely to build community resilience and improve planning and response.[8] As legal scholar Robert Verchick has put it, "Catastrophe is bad for everyone. But it is especially bad for the weak and disenfranchised."[9]

Modeling coastal hazards and social vulnerability is likely to be highly useful to decision-makers as they consider how to plan and direct resources to mitigate and respond to storm events and flooding. When developing comprehensive mitigation and adaptation plans, understanding how hazards impact populations differently based on their social vulnerability is critical: "[p]eople living in hazardous areas are not equally at risk."[10] For example, elderly populations are less likely to obey evacuation orders.[11] Minority households often experience more damage, possibly because the housing stock is less well built and maintained.[12] Recent research has found that "areas of higher social

vulnerability are much more likely to be abandoned than protected in response to [sea level rise]."[13] In both Virginia and North Carolina, waterfront locality demographics are highly variable and represent some of the most and least populated localities in their respective states. In addition, African-American populations in both states tend to be concentrated in the eastern localities, which are at the greatest risk from sea level rise.[14]

Virginia Snapshot	North Carolina Snapshot
Outside of New Orleans, the Tidewater region of Virginia is the nation's most populated area at the greatest risk from sea level rise.[15] It is also a demographically diverse region, having proportionately more African Americans (32.5%) than the national average (12.7%). Renters comprise approximately 33% of the population, in part because of the large military presence in the area.[16] A 2006 study of the Hampton Roads region found that the areas most likely to experience storm-surge flooding are "also home to the most socially vulnerable population segments – those people most likely to be sensitive to exposure to a significant hazard and least likely to cope with effectively with the impacts of a disaster."[17]	North Carolina has seen dramatic changes in demographics over the past ten years. For instance, the state has experienced an 84% increase in its Asian population and a 111% increase in its Hispanic or Latino population.[18] A majority of this growth was in the state's coastal counties, with 18% of its coastal population living in poverty.[19] Renters comprise approximately 26% of the coastal population, likewise due to the military presence. In addition, an average of 37% of the coastal population lives inside a FEMA floodplain; approximately 39% of households in poverty live inside a FEMA floodplain.[20]

Mapping Coastal Risks and Social Vulnerability: Principles and Considerations

The principles and considerations outlined below are modeled in part on legal and policy research related to ensuring equitable adaptation and promoting environmental justice.[21] These principles are designed to focus specifically on incorporating social vulnerability data into geospatial modeling in the coastal hazard context. They are not exhaustive. Rather, they should be a starting point for further conversation as local governments consider using social vulnerability data to inform planning and decision-making, especially in the coastal context. Given the very human component involved in modeling social vulnerability, our goal is to use these principles to suggest ways both modelers and decision-makers can better ensure successful use and adoption at the local level.

1. Promote Public Participation: Develop Maps that Non-Technical Experts Understand and Value

As experts develop geospatial models, they should strive to develop maps that best reveal their "communicative power" to make complicated information comprehensible.[22] Without question, geospatial modeling of risk has the great potential to improve decision-making and better protect human safety and the environment – the more we understand where impacts such as coastal flooding are likely to occur, the better we can design responses to mitigate and prevent such hazards.

Yet, any technological advance has the potential both to improve understanding as well as exacerbate existing barriers between the information-technology "haves" and the "have-nots."[23] To be sure, experts must develop and utilize sophisticated geospatial modeling to support their research findings and arrive at the most accurate conclusions possible. When communicating with the public, however, the goal of such communication should be carefully considered, as presenting too much data may obscure the most important and useful information for a public audience – most of whom will not have GIS expertise. Determining the purpose of the map, its intended audience, and whether users find the map useful and informative" are critical components of communicating mapped information to others.[24]

In addition, care should be taken to explain that integrating coastal hazard data, ecosystem impacts, and social vulnerability has "co-benefits" and the capacity to address a variety of problems and further diverse community goals."[25] Protecting wetlands and preserving open space, for example, not only have environmental benefits but also can protect public safety by controlling flooding and increasing quality of life by promoting "green space" in the neighborhood.[26] Including multiple layers not only has the capacity to increase our understanding of hazard risks, but also the potential to reveal information that can be used to develop solutions that serve multiple purposes. Previously unrecognized patterns may also emerge.[27]

Finally, in order to promote increased public participation and support of spatial mapping efforts, mapping advocates should emphasize that mapping tools have tremendous potential to improve decision-making at all levels of government, private enterprise, and individual action. Maps are powerful tools for visualizing and comprehending how risks, benefits, and burdens are distributed within a community.[28] Understanding the science or the hazard is not enough: "[w]e need to know where socially vulnerable populations are located, how close they are to fault lines and flood threats, and what resources (public and private) might be available to build more resilience."[29] In the coastal context, utilizing social vulnerability data can "provide an expanded view of community vulnerability, focusing on how social factors influence the ability of coastal communities and their populations (individuals and households) to anticipate, respond, resist, and recover from disasters."[30]

Modeling Social Vulnerability: Considerations from the Americans with Disabilities Act

In 2013, in *Brooklyn Ctr. for Independence of Disabled v. Bloomberg*, a federal district court found that the City of New York violated the American Disabilities Act when the city's emergency preparedness program failed to adequately ensure that people with disabilities were able to evacuate before or during an emergency; failed to provide sufficiently accessible shelters; and failed to sufficiently inform people with disabilities of the availability and location of accessible emergency services.[31] The class action lawsuit was filed on behalf of 900,000 New Yorkers with disabilities in response to the 9/11 attacks and Hurricanes Irene and Sandy. While the court found no evidence of intentional discrimination against people with disabilities by the City, it based its holdings under the ADA's prohibition against discrimination that arises out of "benign neglect."[32] Some of the court's findings and conclusions may be worth considering in the context of modeling social vulnerability. The following chart indicates some possible lessons for modeling social vulnerability in the coastal hazards context.

Court's Findings	Social Vulnerability Modeling Considerations
The 2005 version of the Area Evacuation Plan did not include any information regarding the evacuation of people with disabilities.[33]	Modeling social vulnerability could assist with providing such information in evacuation planning.
New York is a "vertical" city, and thus effective evacuation planning should consider evacuation needs from high-rise structures with multi-stories during a power outage.[34]	Considering the types of buildings and the number of stories could reveal new planning needs when modeling social vulnerability.
The City's plans did not mandate that "paratransit" – accessible public transportation -- be "available at all during an emergency."[35]	Considering para-transporation policies and accessibility when modeling evacuation routes and public transportation access could reveal new planning needs.
The City's Sheltering Plan was silent as to the architectural accessibility of the shelter system.[36] "Significantly, the City does not even know which of its shelters and evacuation centers are accessible."[37]	Modeling which shelters are accessible to people with disabilities could be critical.
People with disabilities often depend on access to electricity.[38]	Identifying as part of spatial modeling which shelters have back-up generators could better inform shelter planning for people with disabilities.

2. Value Multiple Perspectives: Utilize "Participatory Modeling"

Engaging non-technical stakeholders into model design, while clearly requiring resources and time investment,[39] has great potential to improve both data quality and increase community investment in modeled results.[40] "The challenge to the model developer is to assure that the modeling is responsive to interests of decision participants, and is not organized to answer questions solely of interest to scientists and technical experts."[41] "Public participation GIS" or "participatory GIS" describe ways for "capturing and using non-expert spatial information."[42] Benefits of "participatory modeling" include:

- Bringing new and various perspectives into model-development
- Creating usable information by identifying "what decision participants want to know"[43] and allowing the local community to prioritize need
- Balancing "policy preferences and unexamined assumptions held by the modelers"[44]
- Promoting active instead of passive learning [45]
- Promoting realism at the local level about limitations and uncertainties inherent in spatial modeling[46]
- Increasing trust and confidence at the local level in spatial modeling tools as understanding increases and relationships are made [47]

In the coastal context, the National Oceanic and Atmospheric Administration (NOAA) has identified that participatory mapping also has specific value for coastal resource management, as it can elicit "information on how communities perceive, value, and use coastal resources" and provide "a focal point for discussions on coastal issues."[48] In addition to these benefits, involving participants in model-development may be one way to protect against liability, at least under the Americans with Disabilities Act. In *Brooklyn Ctr. for Independence of Disabled v. Bloomberg*, which is discussed in more detail in the table above, the court emphasized that "[o]ne way in which emergency planners can help ensure that the needs of people with disabilities are incorporated sufficiently into emergency plans is to include people with special needs in the planning process."[49] Participatory mapping may be a productive way to do so.

Many of the benefits of participatory modeling reflect long-standing civic engagement and environmental justice values that should inform adaptation and risk management work as well. Incorporating social vulnerability data only highlights the need to involve vulnerable populations in the decision-making process, as the data itself is designed to inform decision-making that directly impacts these communities. Geospatial modeling, in fact, is one way to identify these populations so that they can be invited to participate in the policy-making process, along with non-profits and local stakeholders.[50] **Involving these communities as they are identified and including them as "co-producers of knowledge" is more likely to create authentic participation and increase trust.[51]**

Indeed, local engagement and participation are particularly critical because

effective adaptation planning requires "community-specific information"[52] and "authentic participation."[53] Local community leaders often know best how to identify site-specific information, trusted communication pathways, and understand resource needs and concerns.[54] These same leaders are likely to be able to use this knowledge to inform spatial model development, increasing its effectiveness as well as its credibility with the local community. Ways to include community input into mapping efforts include surveys, interviews, mapping in a group setting, and focus groups.[55] NOAA's *Stakeholder Engagement Strategies for Participatory Mapping* is an excellent resource for planners to use when considering whether a participatory mapping approach is appropriate and developing strategies for implementation.[56]

Fostering Trust and Engagement: Lessons for Participation

Community advocates promoting environmental equity and justice have extensive experience engaging policymakers in ways that include diverse members of the community. The following lessons drawn from the environmental justice movement and literature may be useful for spatial modelers, planners, and policymakers as they seek to incorporate socially vulnerability data most effectively in spatial modeling to inform policy-making. As legal scholar Alice Kaswan observes, adaptation planning consistent with environmental justice principles should "provide a vehicle for community empowerment and self-determination."[57]

Collaborative Problem-Solving: Build Trust, Establish Relationships, and Engage Stakeholders. Many environmental justice issues reflect complex public health, economic, social, and historical problems, and thus require "the concerted effort and active participation of all stakeholders" to foster conditions to create solutions.[58] EPA's *Environmental Justice Collaborative Problem-Solving Model* is an excellent guide for developing effective collaborative problem-solving at the local level.[59]

Adhere to Principles of Public Participation. Many environmental laws include public participation provisions designed to promote public input in the environmental policymaking process.[60] In 2003, EPA released a "Framework for Implementing EPA's Public Involvement Policy," which provides guidance for training, information sharing, and program evaluate for its employees to improve their capacity to seek genuine public engagement.[61] Some examples of specific mechanisms to promote citizen input include:

- **Citizen Advisory Boards/Advisory Committees.** Advisory committees can influence government decision-making *before* policies and regulations are proposed, thus avoiding "announce and defend" decision-making that allows for input only after a decision has been made. This approach has great potential to address community concerns by means of collaborative problem-solving earlier in the policy-making process.[62]
- **Notice and Comment.** Under most environmental laws, citizens "have the right to be notified of, attend, and comment upon a wide variety of hearings, including local permit hearings, rule-making proceedings, and advisory group meetings."[63] The structure of these forums, especially public hearings, have been widely criticized as serving as nothing more than "step up to the microphone and have your say in less than fifteen minutes."[64] Meaningful dialogue is possible, however, if the structure of such meetings is designed to provide for meaningful conversation, deliberation, and collaboration.[65]
- **Accessibility: Place and Time.** Meetings should be held in an adequate facility that is as accessible as possible, taking transportation, child care needs, and access for persons with disabilities into account.[66] Strong consideration should be given to holding meetings at a time and day that best accommodates working adults.[67]
- **Training and Technical Assistance.** For communities participating in Superfund cleanup programs, EPA provides for technical assistance to communities by providing grants to groups to hire technical advisers to assist with interpreting and commenting on site-related information.[68] Although, to the author's knowledge, similar funding is not available for vulnerability mapping in the coastal hazards context, requesting and/or advocating for similar technical assistance funding may be one avenue to increase capacity and technical expertise at the local level. Should the community have Superfund sites at risk from increased flooding and coastal hazards, its possible that technical assistance may be available.

Promote Access to Information. Most, if not all, states, including Virginia and North Carolina, have Open Meetings and Right to Know Laws (also called "Sunshine" and "Open Records" Laws), where state residents have the right to examine, inspect, and duplicate any public record of a public agency. Many agencies provide publicly available information as part of their overall missions as well. Because GIS databases are expensive to develop and maintain, and spatial mapping often requires GIS expertise, strong efforts should be made to provide access to this information to the public, especially given that maps and spatial modeling can be such critical tools for informing environmental, hazard, and planning policy.[69]

Design Culturally Appropriate Outreach. Socially vulnerable populations may face technological, linguistic, and cultural barriers to participating in decision-making. Strategies for engaging these populations effectively are therefore necessary, including a variety of media, door-to-door outreach, and working with non-governmental organizations that are already trusted sources of information.[70] When hosting community meetings, strong consideration should be given to providing a facilitator that knows the community and/or is trained in environmental justice issues.

Support Decisions that Promote Fairness and Preserve Cultural Diversity. In the end, the purpose of incorporating social vulnerability data into coastal hazard data is to better "identify, address, and protect against conditions that result in disproportionate or serious adverse effects on vulnerable populations, including minorities, women, children, the elderly, the disabled, non-English speakers, undocumented persons, and the poor."[71] Engaging these populations in discussion and decision-making should reflect, at a minimum, a commitment to developing tools and information that promotes increased fairness, protects human life and public safety, and preserves cultural diversity. [72]

3. Avoid Legal "Strict Scrutiny" Concerns By Utilizing Social Vulnerability Information Prudently in Local Government Decision-Making

As analyzed in detail in a companion paper entitled *Mapping Coastal Risks and Social Vulnerability: Current Tools and Legal Risks,*[73] using race as part of government decision-making could raise legal concerns under the Equal Protection Clause of the U.S. Constitution under what is known as "strict scrutiny" analysis. While some commentators have made a case that environmental justice initiatives that include racial characteristics should not violate strict scrutiny,[74] local governments may want to consider a more cautious approach. Ways to try to avoid strict scrutiny concerns include:

- **Avoid making funding or permitting decisions utilizing decision-support tools that use race or ethnicity as a factor;** or
- **Calculate social vulnerability without using race or ethnicity as factors.**[75] CalEnviroScreen, for example, is a mapping tool that includes social vulnerability data such as income and educational attainment -- but excludes race -- as part of its spatial modeling and mapping.

Mapping social vulnerability provides many positive benefits for local governments and the community at large – it has great potential to increase understanding of coastal risks and how best to protect the very populations facing these risks. The point of this discussion is not to discourage mapping of social vulnerability – or even race -- in the context of coastal hazards. Rather, it is simply to encourage the prudent use by government decision-makers of tools that incorporate race as a factor, as Equal Protection concerns could arise if a local government used such information to make funding or permitting decisions.

4. Acknowledge Modeling and Data Constraints: Tools, Not "Truths"

While it is beyond the scope of this white paper to analyze all of the methods and possible data sets utilized in geospatial modeling, an important point nevertheless remains when utilizing social vulnerability data to predict coastal and hazard risks: no model or map is perfect. Indeed, academics are still debating what metrics reveal social vulnerability and how best to incorporate these metrics into modeling and applied.[76] From "chi-squared tests" to "regression analyses,"[77] the debates are and will likely continue to be highly technical. Mapping techniques also vary, and scholars are actively studying and debating which techniques work best in certain contexts. For example, maps covering larger areas generally use "coarser" data and do not have the accuracy of a smaller, "neighborhood-scale" study.[79]

At a minimum, it is crucial to remember that the data incorporated into maps is frequently done so because it the best data available – not because it is the very best data set for the map's specific purpose.[80] Maps "often display data at the level of a convenient political unit (e.g., county, state, or nation) because the data is available for that level."[81] Convenient political units, meanwhile, do not necessarily fall squarely within watershed boundaries or floodplains. This is not to say that these political units are not useful; rather, it is simply to acknowledge that,

unless researchers conduct field research and collect the data themselves, they must rely on secondary sources of data. For example, to gain a very good understanding of a population, researchers often consult data collected by the U.S. Census Bureau. In most cases, this approach works well, as it provides good data that reveals important information when mapped instead of requiring the researchers to conduct what would be very expensive and time-consuming surveys of the populations themselves.[82] It is important to remember, however, that "[i]ncomplete, inaccurate, and nonexistent information does not necessarily reflect our state of knowledge about the issues, but may be merely an indication of our society's informational (and funding) priorities."[83] In sum, geospatial models are only as good as the data they rely upon.

Geospatial modelers and planners therefore should communicate to their audiences that the information presented has strengths and weaknesses -- that the maps they create are tools, not "truths."[84] Moreover, no matter how good that the underlying data used to develop the model may be, no map can ever serve as a completely "objective form of knowledge."[85] As a leading GIS textbook opines,

> Mapmakers must realize that maps can communicate unintended messages, and that the data they may have chosen to include on a map or the method of symbolizing the data might be a function of the culture of which they are a part. Conversely, map users must recognize that a single map might depict only one representation of a spatial phenomenon (e.g., a map of percent forest cover is only one representation of vegetation).

People live in complicated communities and the everyday world we live in is likely to be devilishly hard to model accurately. This is not to say that such work should not be done or does not have value. Rather, it is to acknowledge, with humility, the limits of data and technology by recognizing the complicated human and natural environments in which we live.

Conclusion

As community members and decision-makers strive to address some of the most pressing challenges related managing coastal hazards, geospatial modeling that incorporates social vulnerability data is – and will continue to be – a critically important tool. To better ensure that such tools are trusted and ultimately utilized by coastal communities, geospatial modelers should be aware that such modeling can raise not only difficult legal issues but also difficult social issues deserving discussion, respect, and patience – what seems like "just science" to a modeler may be a question of identity or community to a local citizen. Meanwhile, we, as a society, are still grappling with how government action should – or should not – involve factors such as race. Modelers should be aware that local governments are keen to avoid "strict scrutiny" problems. This does not mean that modeling socially vulnerable populations should be avoided; rather, understanding how a local government may be constrained from using the information to make funding or permitting decisions is critical. Finally, acknowledging the limitations of geospatial modeling is an important ethical consideration. Tackling the challenges of improving community resilience to increased coastal hazards will require many tools, various approaches, and diverse perspectives. Ultimately, geospatial modeling is a powerful tool only if it is developed, communicated, and utilized in a way that advances the goals and meets the needs of the very communities that it is designed to serve.

Key Questions When Presented with Maps of Coastal Hazards

In addition to following some of the basic principles of fairness and community involvement discussed throughout this paper, both local decision-makers and the public should not hesitate to ask the following key questions in order to gain bettering understand of how the maps presented to them were created and work, including:

- What is the purpose of the map?
- What is being mapped? What are the map attributes?
- What is the technology used to create the map?
- Who conducted the mapping?
- What is the geographic scale of the study?
- What GIS mapping method did you use and why?
- What metrics did you use to reveal socially vulnerability to hazards, and how and why did you select them?
- What are the strengths of your approach? What are the weaknesses?
- What is the most useful way to use this map?

Questions taken in part from *Thematic Cartography and Geovisualization. See* Terry A. Slocum, et al., Thematic Cartography and Geovisualization, 6, 3rd Ed. (2009).

Notes

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72 Tony Arnold, *Planning for Environmental Justice*, 59 PLAN. & ENVTL. L. 3 (2007).

[73] Lisa Schiavinato & Heather Payne, Mapping Coastal Risks and Social Vulnerability: Current Tools and Legal Risks (North Carolina Sea Grant and Virginia Sea Grant 2015).

[74] *See generally* Christine M. Foot, Scrutinizing Strict Scrutiny: Environmental Justice After Adarand Constructors, Inc. v. Pena, 11 BERKELEY J. AFR.-AM. L. & POL'Y 123 (2009).

[75] Schiavinato & Payne, *supra* note 73, at 21.

[76] *See*, e.g., Van Zandt, *supra* note 5; Martinich, *supra* note 13; Kleinosky, *supra* note 17.

[77] Wiki.GIS provides general introductory information related to some of the terms utilized in geospatial mapping. According to Wiki.GIS,

> Pearson's Chi-Square Test is a statistical test used to test the goodness of fit or to test if there is a difference between samples of data…. The Chi-Square statistical test can be used to asses geographic data. The one-sample test enables geographers to examine the differences between observed data and expected data. Two-or-more samples test enables geographers to examine the differences between samples.

The Wiki definition of Pearson's Chi-Square test goes on to provide examples and formulas demonstrating how it is used. *See* Wiki.GIS, Pearson's Chi-Square Test, http://wiki.gis.com/wiki/index.php/Pearson%27s_chi-square_test. Wiki.GIS also provides a similar overview of regression analysis, which, according to WikiGIS, "[i]n statistics . . . refers to techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables." *See* Regression analysis, WIKI.GIS.COM, http://wiki.gis.com/wiki/index.php/Regression_analysis#cite_ref-0 (last modified Oct. 28, 2013, 18:54).

[78] *See, e.g.*, Juliana Maantay & Andrew Maroko, *Mapping Urban Risk: Flood Hazards, Race, & Environmental Justice*, 29 APPLIED GEOGRAPHY 111 (2009)

[79] Maantay, *supra* note 27, at 166.

[80] Slocum, *supra* note 24, at 5.

[81] *Id.*

[82] The U.S. Census Bureau has a tremendous amount of information about its data collection methods as well as GIS. *See Geography*, U.S. CENSUS BUREAU, www.census.gov/geo/ (last revised Nov. 21, 2014).

[83] Maantay, *supra* note 27, at 166.

[84] Owen, *supra* note 7, at 246.

[85] Slocum, *supra* note 24, at 16.