Understanding the Vulnerability of Sullivan’s Island to Climate Change
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Introduction

Barrier island communities, like the Town of Sullivan’s Island, South Carolina, routinely face many environmental hazards such as flooding, erosion, hurricanes, tidal surges, and shoreline erosion. Interactions among these events coupled with potential impacts from climate change complicate existing management challenges and planning efforts. Expectations are that there will face increased exposure to extreme weather in years to come. Situated near Charleston Harbor, the Town sits at low elevations and faces many impacts from storms. Flooding has been a persistent problem. The Town faces challenges in preparing for hurricanes and in mitigating the impacts of storms.

To better understand and mitigate the impacts of extreme weather events and especially flooding from severe rainfall and coastal storms, a series of four two-hour meetings were held with participants from the Town of Sullivan’s Island and the University of South Carolina, South Carolina Sea Grant Extension, and the Social and Environmental Research Institute to identify current management challenges that may be intensified by climate changes and to identify what strategies and actions the Town can consider to improve long-term planning efforts. With funding from the NOAA Climate Program and with the cooperation of the Town government, the Social and Environmental Research Institute (SERI), University of South Carolina, and South Carolina Sea Grant Extension led the meetings that used a mediated modeling process called Vulnerability and Consequences Adaptation Planning Scenarios (VCAPS). The purpose of the meetings was to document the vulnerability of Sullivan’s Island to extreme weather events and to identify actions that the communities could undertake to increase their resilience.

Nine people from the Town of Sullivan’s Island participated in the meetings, including staff from the town’s Administration, Building, Finance, and Water and Sewer Departments, members of the Planning Commission, and Town Council Members. Dr. Jessica Whitehead of South Carolina Sea Grant Extension provided scientific input on current and projected future climate conditions. The process involved facilitating a dialogue in which people shared what they knew and were concerned about with regard to routine environmental hazards and how they might be affected by possible future challenges associated with climate change. This was not a comprehensive assessment. The group focused its attention on the potential impacts of more frequent heavy precipitation events, sea level rise, and resulting higher high tides on management of stormwater and wastewater.

Meetings centered on understanding major management considerations for Sullivan’s Island. The diagrams mapped the likely...
outcomes and consequences associated with increase in the number of extreme rainfall, sea level rise and higher high tides: options that the Town and individual residents have to respond, including “no regret” and “low regret” strategies\(^1\); and possible consequences of management approaches. This report summarizes briefly the major points identified in these meetings in both diagram and narrative-formats.

**The VCAPS Process**

The VCAPS (Vulnerability and Consequences Adaptation Planning Scenarios) process combines structured discussion with interactive concept mapping to create visual summaries of local knowledge about vulnerability and resilience. It helps government staff and stakeholders depict how a community is impacted by weather related hazards and the actions that could help reduce those impacts.

A VCAPS process begins by identifying a small set of concerns or hazards that the community would like to explore. This focuses and defines the boundaries of the discussion, ensuring that the exercise is relevant to decisions. The discussion centers on one concern at a time. During the discussion, a VCAPS diagram is constructed by the research team while listening to the facilitated dialogue in the room.

The participants at meetings choose which hazards to focus upon. Groups sometime define the hazards quite broadly (e.g. super storms) or quite narrowly (e.g. coastal erosion).

After selecting the hazard, VCAPS diagramming progresses to trace pathways that describe how that hazard affects the community and its environment. A pathway model is made that documents the sequence of steps that lead to harmful consequences. For example, precipitation causes run-off, which leads to storm sewer overflows, which leads to flooding of underground transformers, which leads to electrocution. Each box in this diagram is called an “intermediary outcome.” There are normally many intermediary outcomes in a pathway.

Examples of weather related hazards (a partial list):
- Intense precipitation
- Super storm events
- Increases in extreme heat
- Coastal erosion
- Flooding
- Drought

At some point, the pathway of outcomes ends in a consequence. A consequence is an outcome for which it is not necessary to ask the question, “Why do we care if this happens?” To take the example above about runoff, it is not obvious why we should care about run-off, the mobilization of debris, the clogging of a sewer drain, or flooding of basements. But if flooding leads to electrocution, then electrocution

\(^1\) While some changes may only be needed if specific climate change impact predictions become more likely, the group discussion also identified strategies that offer immediate benefits whether or not projected climate changes occur. These are called “no regret” strategies. For example, continuing to replace old pipes and improve the seals on manhole covers will reduce water treatment costs. “Low regret” strategies are those that present a tradeoff between greater future security against some limited current costs and benefits.
is a consequence, because it is obvious that we all care about loss of life. Management actions are also identified in the diagram. These are actions that can be taken to change the way the stressor affects the community. VCAPS differentiates between actions taken by private individuals and groups and actions taken by public organizations or government. The diagrams can include actions that are already in place or those that are proposed by the participants.

Contextual factors are the final component in the VCAPS diagram. These are specific qualities associated with an intermediary outcome or consequences that amplify the effect of the hazard. For instance, the mobilization of debris by run-off is made worse when there is more debris on the streets, therefore an amplifying contextual factor might be: “time since last street sweeping.” (For more details see Appendix A: How to Read a VCAPS Diagram.)

VCAPS in Sullivan’s Island

At the start of the first meeting, Seth Tuler from SERI led a discussion about which weather related hazards the meeting participants wanted to focus upon. The group decided to discuss the potential impacts of storms and flooding to waste water management and stormwater management, as well as consideration of the implications of weather related hazards and climate change for regulations governing building.

During the discussions, SERI diagrammed the causal pathways and added contextual factors and management actions to the diagrams as participants mentioned them. These diagrams were projected onto a wall in front of the participants. The remainder of this report will be a summary of those results. VCAPS diagrams that relate to these abbreviated narratives are attached to this report as Appendices.

Waste water management

Wastewater treatment capacities emerged as a critical infrastructure concern. Currently the infrastructure is able to capture and treat all wastewater, but there is a great deal of influent infiltration from leaking pipes and manhole covers. Both infiltration and inundation are a problem especially during periods of heavy rainfall and periodic elevated high tides when the ground becomes saturated with water. During these events the Town wastewater treatment plant receives more water than usual. If the wastewater treatment system capacity were to be exceeded and untreated or insufficiently treated water discharged, the Town could be cited or fined by the US Environmental Protection Agency.

Sullivan’s Island is already taking many actions to address wastewater management issues. For example, the town is replacing leaking sewer line pipes, which decreases inflow and infiltration from groundwater. It is also installing gauges to get a more accurate understanding of where infiltration problems are the worst. Expanding the capacity of the wastewater treatment plant is also an option, although this would be very expensive and result in a significant level of excess capacity that is rarely needed.

Sea level rise and flooding due to heavy rain events could add to wastewater management problems. For example, the infiltration of saltwater into the wastewater
collection system may disrupt biological processes required for wastewater treatment. Coastal erosion damaging the collection system at homes is one way that the treatment system could be at higher risk.

- Several “no regret” and “low regret” strategies were identified. For example, continuing to replace old pipes and improve the seals on manhole covers will reduce water treatment costs. Creating water recharge ponds with treated wastewater could serve to recharge the shallow aquifer that is used by homeowners for irrigation and push back saltwater intrusion from this aquifer.

**Stormwater management**

Stormwater management becomes a public and Town administration issue on Sullivan’s Island during periods of more intense rain events and higher tides, which can lead to flooding of many parts of the island. The combination of heavy rainfall and high tides sometimes results in flooding because the higher tides can temporarily prevent stormwater from draining. Flooding events have many consequences for the Town and residents of Sullivan’s Island including: damage to roads, cars, and buildings, restricted access to the beach, increased pest populations, and standing water on roads. Increased stormwater could result in flooding of residential structures, particularly those built on the ground level. Rising water tables from stormwater could also decrease drainage in the wastewater system leading to a backup of wastewater into homes, creating a health hazard, financial costs due to property damage, and nuisance. These issues are also likely to become more frequent under climate change scenarios of higher tides, more frequent, intense rainfall events, and sea level rise.

There are a number of management strategies that the Town can adopt to prevent or mitigate such consequences, including modifying infrastructure (e.g., raising manhole covers, installing drainage pipes and backflow preventers, phasing out on-grade structures that are more likely to flood) and encouraging alternative land development and landscaping practices (e.g., changing lot elevation requirements, using native salt water tolerant plants, increasing the amount of pervious surface). But there is no way to get around the fact that the Island’s low elevation makes it permanently susceptible to flooding when there are high tides, sea level rise, or severe storms. Many of the management actions identified can also be considered “no regret” or “low regret” actions that are helpful to do because they address both current and potential future hazards. For example, increasing pervious surface requirements would improve the performance of current stormwater and wastewater systems, as well as increase preparedness for predicted changes in precipitation frequency and intensity of coastal storms (a climate change impact). Similarly raising and sealing manhole covers is something that is important to do because of “normal” periodic flooding and
hurricanes, but it will also be important when mean high tides rise as a result of sea level rise.

The discussions of stormwater management also highlighted the fact that regulations can have unintended consequences. For example, regulations that require lot elevations can have unintended impacts to adjacent property owners. If primary homeowner elevates a lot (e.g., by 3 feet), then neighbors may get more water on their property. If regulations are created to keep all stormwater on a lot (e.g., with swales), then that increases groundwater levels, which can cause more infiltration into the wastewater system.

There are also significant barriers to Town-based adaptation planning in some cases because other government agencies and utilities have responsibilities and the Town cannot take action alone. Thus, the Town must persuade these agencies and organizations to act, which can be especially challenging in a time of budget constraints. For example, the County is responsible for controlling mosquito populations and most of the stormwater management infrastructure. The SC DOT is responsible for stormwater infrastructure under the roads. Higher tides associated with sea level rise could overtop the main access roads under some scenarios, but to better assess that risk more data is needed on roadway elevations. SCE&G is responsible for maintaining underground and above ground cables. While not strictly an issue with stormwater management, utilities such as electricity, phone, cable, and internet service on the island, can be affected by flooding and the ability to manage stormwater runoff. Additional research or consultation with utility companies is needed to resolve these questions. There would be potential tradeoffs between costs and aesthetics as it is more expensive to make changes to underground cables if they are damaged, but they are cheaper than above ground cables in the long term if no changes needed. Above ground cables can be damaged by salt spray, but underground cables have less impact on the visual environment.

**Discussion**

In summary, several observations can be made about the results of the meetings:

- Sullivan’s Island faces a variety of environmental hazards by virtue of its topography. It is a barrier island. This can limit the ability of the Town and residents to prevent some impacts, such as flooding.
- There are opportunities for no regret and low regret strategies to address current environmental hazards, but which will also be helpful if predictions about climate change impacts are accurate.
- There are current issues that are likely to become worse over time if some climate change scenarios and projections occur.
- Environmental hazards, coupled with climate change impacts, can result in a variety of impacts, including to public health, property damage, financial costs, and increased nuisance.
- Interactions among hazards and management strategies can be complex. Management strategies can have unintended consequences. Identifying interactions and
complexities requires conversations among people with detailed knowledge of the local areas and the potential changes

- There are limits to what the Town can do alone to address environmental hazards. Other state and county agencies, utilities, and other organizations are responsible for infrastructure and resources on the Island. There is a need for close coordination.
- Long-term planning requires additional data to assess potential risks.

Conclusion

Examination of local hazards with Town officials, interested citizens and members of the private sector can illuminate vulnerabilities and highlight potential mitigation projects for municipalities to adopt.

VCAPS is one approach to help elicit and organize this knowledge in a format that can empower local action. In Sullivan’s Island, SC meetings drew upon local experience to document vulnerabilities and mitigation actions.

Like other municipalities across the country, Sullivan’s Island will continue to experience increased exposure to extreme weather. The state, county, and city systems that are in place to manage, cope, and adapt to this weather can be improved upon and will need to innovate more efficient and effective systems to prepare for storms and to restore services. Such systems ought to be informed with the knowledge and experience of town employees and local stakeholders. VCAPS is one tool to bring this to fruition.