

HAZARD RESILIENCE IN COASTAL COMMUNITIES

IMPACTS

S.C. Sea Grant Consortium transfers successful vulnerability assessment methodology to a Maryland coastal community

Dr. Elizabeth Fly, S.C. Sea Grant Consortium

Relevance: After successful implementation of the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process in Beaufort County, SC, in spring 2015, a webinar was presented on the effort by Consortium staff to a Sea Grant Climate Network webinar. This fostered a relationship with the Eastern Shore Land Conservancy (ESLC) in Maryland, which was looking to complete a similar project with Kent County, a coastal county on the Eastern Shore of Maryland.

Response: The S.C. Sea Grant Consortium and North Carolina Sea Grant staff assisted ESLC in writing a grant proposal in 2016 to secure funding to bring VCAPS to Maryland. Upon securing this grant through the Maryland Department of Natural Resources, Consortium staff provided VCAPS training to an audience in Maryland, including staff of Maryland Sea Grant. Members who received this training then extended this information by conducting a VCAPS workshop with key stakeholders in Kent County to foster a discussion of resilience to sea level rise and help county planners incorporate this issue into their planning process.

Results: The VCAPS process and development of the *Climate Change and Sea Level Rise Adaptation Report for Kent County, Maryland*, resulted in Kent County incorporating climate change and sea level rise into the latest update of its comprehensive plan. In addition, Kent County has become part of a larger climate community of practice on the Eastern Shore of Maryland.

Recap: The S.C. Sea Grant Consortium trained outreach and extension professionals and local practitioners on the Eastern Shore of Maryland in the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) methodology. This training provided Kent County, Maryland, the opportunity to discuss sea level rise resilience and prioritize adaptation strategies in a report. As a result, the county incorporated these strategies in the latest update to its comprehensive plan.

City of Charleston Adopts a Sea Level Rise Strategy Developed with Assistance from the S.C. Sea Grant Consortium

Dr. Elizabeth Fly, S.C. Sea Grant Consortium

Relevance: Charleston, S.C., has seen a 409% increase in the number of nuisance flooding days since the 1960s. The city is now making a concerted effort to incorporate planning for future inundation into all its activities by developing a sea level rise (SLR) strategy. An important first step for the city was to determine the range of SLR scenarios to use.

Response: The city of Charleston sought the expertise of the S.C. Sea Grant Consortium (Consortium) when deciding what SLR scenarios the city would use in planning for the future. Consortium staff, along with representatives from NOAA Office for Coastal Management and NOAA National Weather Service, met with city officials to analyze current flooding trends and future SLR projections from the federally mandated National Climate Assessment.

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Results: In consultation with the Consortium and NOAA, the city of Charleston determined that planning for a SLR of 1.5 feet by 2040 and 2.5 feet by 2060 was most appropriate for the city's current needs; these targets will be reassessed every five years. The city developed a SLR strategy, a comprehensive inventory of initiatives that serve as a guiding framework to make the city more resilient to SLR and recurrent flooding. Charleston City Council adopted this strategy, and all department heads formed a Flood Action Work Group to address SLR in investments and projects moving forward.

Recap: To increase its resilience to future flooding due to sea level rise, the City of Charleston consulted with the S.C. Sea Grant Consortium to define the issue of sea level rise and to develop a sea level rise strategy. This strategy was adopted by Charleston City Council and is being considered as a priority by all department heads as part of their newly established Flood Action Work Group.

Beaufort County incorporates sea level rise adaptation into its Local Comprehensive Plan and Hazard Mitigation Plan

Dr. Elizabeth Fly, S.C. Sea Grant Consortium

Relevance: Beaufort County, S.C., is located at the heart of the Lowcountry, a coastal region named for the fact that most of its land sits just above sea level. In planning for the future, community leaders recognize the potential vulnerability of the county and its citizenry to long-term sea level rise (SLR).

Response: The County partnered with the S.C. Sea Grant Consortium (Consortium) to engage in a participatory process to discuss adaptation strategies, an effort supported by NOAA's National Sea Grant College Program Community Climate Adaptation Initiative. The Consortium, in partnership with Beaufort County, the Carolinas Integrated Sciences and Assessments, North Carolina Sea Grant, and the Social and Environmental Research Institute, published the *Sea Level Rise Adaptation Report: Beaufort County, South Carolina*. This report is the product of a multi-year engagement with the county to develop adaptation strategies to SLR that can be incorporated into the comprehensive planning process. The report contains 23 adaptation strategies vetted by a stakeholder group and public workshop participants.

Results: After publication, the report was presented to both the Rural and Critical Lands Preservation Program and the Natural Resources Committee of Beaufort County. The Natural Resources Committee recommended that all county departments reference the adaptation strategies as they develop policies, procedures, plans, and projects. Components of the report were written into the latest update to the County's Local Comprehensive Plan and Hazard Mitigation Plan.

Recap: Beaufort County, S.C., has increased its resiliency planning by incorporating sea level rise adaptation strategies into its Comprehensive Plan and Hazard Mitigation Plan, based on an engagement process conducted in collaboration with the S.C. Sea Grant Consortium.

ACCOMPLISHMENTS

City of Folly Beach Plans for Sea Level Rise Adaptation with the Assistance of the S.C. Sea Grant Consortium

Dr. Elizabeth Fly, S.C. Sea Grant Consortium

The City of Folly Beach, S.C., is a small barrier island community that faces a variety of coastal hazards, including the threat of rising seas from both the ocean and marsh sides of the island. The city requested

technical assistance from the S.C. Sea Grant Consortium (Consortium) to take a more proactive approach in planning for current and future sea level rise hazards. The Consortium, in collaboration with Elko Consulting, facilitated a Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) workshop with 13 key decision-makers from the city to discuss and prioritize strategies for dealing with sea level rise on the island. A draft report was produced that will be presented at public meetings in spring 2017 for further input and prioritization. It is anticipated that the final report will be adopted by city council and incorporated into city planning documents.

S.C. Sea Grant Consortium Fosters Professional Engagement through the Southeast and Caribbean Climate Community of Practice

Dr. Elizabeth Fly, S.C. Sea Grant Consortium

The Southeast and Caribbean Climate Community of Practice (CCoP) brings together individuals from local, state, and federal governments, academia, non-profit organizations, and the private sector in the Southeast US (NC, SC, GA, FL, Puerto Rico) to apply climate science and assess how coastal communities and ecosystems can adapt to the impacts of climate variability and change. The S.C. Sea Grant Consortium (Consortium), in partnership with the Carolinas Integrated Sciences and Assessments (CISA) program, has fostered momentum for the CCoP since 2014. The Consortium led the grant-writing effort to secure \$20,000 in funding from the National Sea Grant Office to host an in-person meeting in 2016. This meeting was held on Tybee Island, Georgia, with 64 attendees. Based on the evaluation, 85% agreed or strongly agreed their awareness of the steps communities are taking to address extreme events increased. In addition, 100% of attendees agreed or strongly agreed that the workshop was a good opportunity to foster long-term engagement with other community leaders, extension professionals, agency representatives, and scientists who work on climate issues. The CCoP indicated strong preference that another in-person meeting be held in 2017.

S.C. Sea Grant Consortium Interviews 25 Stake-holders on Climate Impact on Working Waterfronts

Susan Lovelace, S.C. Sea Grant Consortium

The S.C. Sea Grant Consortium, working with graduate students at the College of Charleston, conducted 25 interviews to identify threats and opportunities related to commercial working waterfronts in five communities: Murrells Inlet, Georgetown, McClellanville, Mount Pleasant and Port Royal. Respondents were asked to: define working waterfronts, discuss the ways their communities are changing, identify their current needs, and envision the future. Respondents indicated a successful working waterfront should include sustainable income opportunities, a balance of industrial and non-industrial uses, flexible fishery uses, community support, maintenance of water quality, and safe, easy access to the water. The majority of respondents stated a changing climate will have little impact on the success of their future working waterfronts. The results were presented, along with other research and communications products, at Working Waterfront Community Forums held in each community. The full project results were published on an interactive webpage, <http://www.scseagrant.org/Content/?cid=946>.

S.C. Sea Grant Consortium Researchers Document Wind Resistance Performance for Cross-laminated Timber Buildings

Weichi Pang, Clemson University

High winds and water intrusion can cause substantial damage to coastal South Carolina buildings. Cross-laminated timber (CLT) is an emergent building system that has a history in Europe and Canada. However, little is known about its performance characteristics in a humid, subtropical climate such as

South Carolina's. Currently, the U.S. model building code, *Minimum Design Loads for Buildings and Other Structures*, suggests a wind tunnel test for buildings with large balconies or other projections. This is not practical or economically feasible for many mid-rise buildings. Engineers need to know how to design for the unique wind loads, and architects need to be familiar with cladding design issues specific to CLT. S.C. Sea Grant Consortium researchers at Clemson University tested a method engineers can use to determine the design wind loads for a particular CLT structure. The investigation involved a series of wind-tunnel studies on scale models of CLT buildings in various configurations to gather data on surface wind pressures and overall wind forces, as well as rainwater intrusion tests. Results indicate that wind pressures can be safely assumed to be the same on balconies as on the façade of a building, falling below the recommendations of the ASCE 7-10 building code guidance for wind load. This is an assumption that has been widely supported already in the engineering community, and the research confirms that the ASCE 7-10 wind-load guidance is sufficient for designing balconies. Rainwater-intrusion testing examined differences between bare and silicone-coated CLT panels. While the silicone-coated panels did demonstrate significantly increased water-resistive capacity, the bare CLT panels were already so effective at preventing water intrusion due to wind-driven forces that no changes were recommended for building-code guidance.

S.C. Sea Grant Consortium Researchers Examine Resiliency of Charleston's Water Infrastructure to Predicted Sea Level Rise

Kalyan Piratla, Ashok Mishra, and Brandon Ross, Clemson University; Daniel Harrison, Lander University

Sea level rise and climate change will have societal impacts in the southeastern United States, especially in low-lying regions like the coastal plain of South Carolina. Addressing inadequate and outdated water infrastructure is necessary for instilling hazard resilience in coastal communities. In many coastal areas, stormwater infrastructure managers are faced with the challenges of inundation risks, inadequate pumping capacity, and insufficient storage capacity. However, limited research has been conducted on the impacts of climate change to stormwater infrastructure in the region. S.C. Sea Grant Consortium researchers from Clemson and Lander universities are collaborating with water infrastructure agencies and consumer groups to predict the future impacts of climate change on water infrastructure, develop appropriate adaptation strategies, and evaluate the strategies relative to South Carolina's coastal regions. They also are analyzing implications on cost, environment, and social well-being. Focusing on peninsular Charleston, researchers analyzed relevant drainage infrastructure data. The data do not completely capture the current drainage infrastructure in the Charleston peninsula region and lack the critical flow data that can be used to calibrate and eventually validate the stormwater management model locally. The project team is addressing data quality issues by coordinating with participating stakeholder group and preparing to finalize the model for sea level rise-related impact prediction capabilities. Additionally, an online survey was prepared to disseminate to numerous coastal water agencies to determine the prevalence and suitability of various adaptation measures to specific sea level rise issues.

S.C. Sea Grant Consortium Scientists Develop Low Impact Development Technologies to Respond to Increased Rainfall, Stormwater

Nigel Kaye and Will Martin, Clemson University

Climate change will lead to increased rainfall frequency and intensity across South Carolina. At the same time, the South Carolina coastal plain faces increased flooding impacts from sea level rise. This additional flooding will stress existing stormwater infrastructure, which was designed to control

historical flooding levels and is insufficient for projected future rainfall amounts. One way to mitigate the impacts of increased rainfall and sea level is the use of low impact development (LID) stormwater management technologies. These technologies retain rainfall onsite by allowing infiltration or evapotranspiration to occur, reducing runoff peak and total flow. Examples of LID technologies include porous pavements and green roofs. For LID technologies to be widely accepted, the hydraulic and hydrologic behavior of a technology needs to be well quantified, models need to be developed for use in performance-based designs of stormwater infrastructure, and economic and engineering benefits need to be identified and clearly communicated to all stakeholders. S.C. Sea Grant Consortium researchers at Clemson University hope to provide stakeholders with increased decision-making capability on the use of LID stormwater management techniques, particularly green roofs and porous pavement, in coastal South Carolina. Researchers developed a test rig to quantify performance of green roofs. Initial results demonstrate that current modular green roof systems do not retain rainfall long enough to significantly reduce runoff, and improved design engineering is needed to increase water retention.

S.C. Sea Grant Consortium Successfully Competes in the NOAA Regional Coastal Resilience Competition on behalf of the Charleston Resilience Network to Link Parcel-level Flood Mapping with Neighborhood Engagement

M. Richard (Rick) DeVoe, S.C. Sea Grant Consortium

The Charleston, S.C., region is home to more than 500,000 people and is one of the fastest growing areas of the country. The economy of Charleston is strong and diverse, with concentrations on tourism, shipping, manufacturing, health care, education, and an emerging technology sector. Each of these sectors, along with the individuals employed therein, depends on transportation, water, energy, and other critical infrastructure facilities for continuity, successful daily operations, and quality of life. Effective long-term regional preparedness and resilience planning and implementation requires a concerted and coordinated effort among governmental entities, businesses and industries, non-governmental organizations, and owners/operators of critical infrastructure. This \$500,000 project seeks to advance the collaborative approach being fostered by the Charleston Resiliency Network by addressing specific stakeholder informational needs that will result in more effective implementation of infrastructure planning and operation, land-use planning, and water management, with overall goals to:

- 1) Examine and determine on a parcel-level scale the capacity of critical infrastructure in the Charleston region to effectively absorb impacts of flooding events, both in the short term and long term, and enhance the region's response to immediate water-hazard impacts and support its adaptive capacity ("resilience") to future hazards events;
- 2) Produce detailed information and analyses that will assist multiple stakeholders and organizations as they move from resiliency planning to implementation;
- 3) Foster a unified strategy and provide a forum to share science-based information, educate stakeholders and enhance long-term planning decisions that result in resilience.

S.C. Sea Grant Consortium proposal on behalf of the Charleston Resilience Network "Selected to Advance" by the U.S. Department of Homeland Security

M. Richard (Rick) DeVoe, S.C. Sea Grant Consortium

Residents and visitors of the Charleston, S.C., region are currently being affected by daily, weekly, and monthly episodes of flooding in low-lying areas, exacerbated by "King tide" events, coastal storms, regular thunderstorms, occasional rain "bombs," and gradual coastal erosion and land subsidence. These events have attracted the attention of residents, tourists, and government officials. As a means by which to address these challenges, the Consortium prepared and submitted a proposal on behalf of

the Charleston Resilience Network to the U.S. Department of Homeland Security's 2016 National Infrastructure Protection Plan Security and Resilience Challenge. The proposal seeks to research, design, develop, and implement multi-hazard indices and tools for coastal resilient infrastructure assessment and adaptation for small business, municipalities, and individuals in the Charleston region. The proposal has been "selected to advance" to the negotiation stage. Implementation of this proposed project will build awareness and promote safety in the Charleston region regarding the vulnerability of the region's critical infrastructure to these increasing conditions affecting our businesses, our municipalities, and our citizens. The effort will also enhance our collective ability to support advance planning, safety, and science-based infrastructure-investment decisions, which are crucial for the region.

S.C. Sea Grant Consortium joins Charleston Resilience Network and National Academy of Sciences Partners in Convening "Understanding the October 2015 Charleston Floods" Symposium

M. Richard (Rick) DeVoe, S.C. Sea Grant Consortium

Residents and visitors of the Charleston region are currently being affected by daily, weekly, and monthly episodes of flooding in low-lying areas, exacerbated by "King tide" events, coastal storms, regular thunderstorms, occasional rain "bombs," and gradual coastal erosion and land subsidence. These issues were brought to bear on the Charleston community when, during the first week of October 2015, the region experienced a major rainfall event, with total rainfall amounts of 15 to 25 inches common across Charleston, Dorchester, and Berkeley counties, resulting in severe flooding of many low-lying areas and major economic impacts of some \$1.2 billion across the state of South Carolina. On February 23, 2016, the Charleston Resilience Network hosted a symposium in partnership with the National Academy of Sciences (NAS) Resilient America Roundtable to examine the Charleston region's resilience through the lens of the major rainfall and flooding event that occurred in October 2015. At the Symposium, a diverse range of stakeholders assembled to share information and lessons learned across key sectors, as well as discuss practices, partnerships, and opportunities to enhance resilience to similar future events. Topics covered during the symposium included Public Safety and Health; Business and Economic Impacts; Critical Infrastructure/Lifelines; and Strategies for Moving Forward. Symposium proceedings can be found at <http://www.charlestonresilience.net/flood-symposium>.

Advancing understanding of risk: Increasing accuracy of hazard damage assessment tools by improving base data and analyzing opportunities and barriers for use in adaptation

M. Richard (Rick) DeVoe, S.C. Sea Grant Consortium

Coastal communities are at risk from the flooding from storm surges, intense rainfall and in the future, sea level rise. Rural communities lack the resources of large metropolitan areas to conduct the analysis of risk to their infrastructure from those threats and to do the necessary planning. The Sea Grant programs of the southeastern Atlantic region formed a partnership with the NOAA Office of Coastal Management to co-fund a 2-year project in which a regional research team is doing hands-on work with a coastal rural community in each state (Monroe County, FL; Liberty County, GA; Nags Head, NC; and Beaufort, SC). The aim is to use visualization tools and other approaches to help residents and decision-makers understand flooding risks and adaptation options. The focus is on critical infrastructure such as hospitals, water treatment facilities, police and fire stations, and historic buildings. The team has developed visualization scenarios of damages from storm surge and sea level rise for the four communities and has begun holding participatory community engagement events. Those events have included presentations on legal issues related to adaptation to flooding and sea level rise. This is an ongoing project, and we anticipate reporting the impacts in 2017 or 2018.