

Compound Flooding in Eastern North Carolina: Understanding Stakeholder Perceptions and Needs

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ABSTRACT

While our scientific understanding of compound flood risk has made great strides in recent years, there is a lack of studies related to stakeholder awareness of the non-linear combination of pluvial, fluvial, and tidal flooding, which often occur in coastal storm environments. Here we present the concept of our NOAA-funded project “Preparing for, Responding to, and Mitigating Coastal Compound Water Hazards for Resilient Rural Communities” and describe some preliminary survey and focus group data collected from planners, emergency managers, and elected officials from across eastern North Carolina.

1. Background

The fact that Hurricanes Floyd, Matthew and Florence devastated eastern North Carolina within a period of twenty years calls for a paradigm shift in hazard preparation, response and mitigation. A common question following a storm is: “Why did my house/business flood?” Some people rely on the fact that their properties are outside the 100-year flood zone, but understanding flood risk goes beyond reliance on one tool or map. Even multiple flood risk tools that are not properly integrated can be inadequate for effective disaster management.

The hurricane hazard is composed of several storm related hazards, with water hazards: surge, pluvial flooding (flooding caused by storm water runoff), fluvial flooding, and water-borne health risks often receiving highest priority in the coastal plain of North Carolina. However, the consideration of one hazard at a time ignores how these water hazards intersect spatially and temporally. Water hazards in the storm environment are not independent of each other. For example, copious precipitation, which leads to flash flooding locally, accumulates over watersheds and is correlated to fluvial flooding. Strong storm surge, which has been related to the co-occurrence of heavy precipitation (Wahl *et al.* 2015), can also back-up riverine flow, exacerbating coastal flooding.

The combination of multiple hazards that contribute to societal, environmental or health risk is known as a compound event (Zscheischler *et al.* 2018). While compound events have been described in the climate literature, they have not been integrated into the disaster management cycle. However, these impactful events can “provide a bridge between climate scientists, engineers, social scientists, impact modelers and decision-makers, who need to work closely together to understand these complex events” (Zscheischler *et al.* 2018).

Risks, vulnerabilities and pathways to resilience in rural regions are less well studied and understood as compared to their urban counterparts (Cheng, Ganapati and Ganapati, 2015), and rural communities tend to be disproportionately affected by compound coastal water events (CCWE) and this cumulative effect of CCWE is rarely analyzed. Economic drivers in rural communities, especially in North Carolina tend to be land- and place-based (MDC 2016); thus, the main source of economic benefit is highly sensitive to CCWE. This project focuses

on rural counties in eastern North Carolina located along the coast and those adjacent to it that share estuarine environments or linked riverine systems.

2. Methods

The objectives of our NOAA-funded project “Preparing for, Responding to, and Mitigating Coastal Compound Water Hazards for Resilient Rural Communities” are to 1) assess the perceived risks and needs of the hazards management and planning community in eastern North Carolina through two-way communication, 2) examine the physical nature and economic and health impacts of CCWE from 2010 to present, and 3) use the information obtained to co-produce knowledge and tools with our study group for better preparation, response and mitigation plans. This paper focuses on objective 1 by analyzing select anonymous survey and transcript data collected before, during, and after our February 26, 2020 workshop. At this event 41 planners, emergency managers, and elected officials from across eastern North Carolina met at East Carolina University to discuss CCWE issues in small focus groups. Tabletop conversations focused on past experiences with the frequency and intensity of rain, river, and ocean induced flooding, and whether they have seen changes in the forecasting and communication of these disruptive events. Each table had a facilitator, who was a project team member or Ph.D. student, to guide discussions and a recorder, who was a student, to write key themes and quotes on a flip chart. All conversations were captured with a digital recorder. Thus, this paper is structured around three sources of data: a Qualtrics survey administered prior to the workshop (n=24), paper/audio recordings and transcriptions during the workshop, and a Qualtrics survey administered following the workshop (n=13). FEMA flood zones and land cover data were provided by First Street Flood Lab and USGS, respectively.

3. Results

3.1 Pre-workshop survey: Perceptions of flooding frequency

Figure 1 shows the pre-survey results for the question: “How frequent are the following types of floods?” in regards to rain-caused, ocean-caused and river-caused. To minimize confusion in terminology, rain flooding was described as “storm water, flash flooding, ponding or pluvial”; ocean flooding was described as “high tide flooding, king tide, storm surge, or coastal”; and river flooding was described as “flood plain flooding, overtopping banks, or fluvial”. No one thought pluvial flooding was “not applicable” to their community/jurisdiction, and 37% felt it was “very frequent” or “constant”. Thirteen percent of respondents believed that fluvial flooding did not apply to them. Of those that did, 20% felt this type of flooding was “very frequent” or “constant”. Thirty-eight percent of respondents believed that tidal flooding did not apply to them. Of those that did, about the same percentage (19%) also placed this flooding into the same two highest categories. Interestingly, 79% of respondents believed that pluvial flooding had become more frequent over the past 10 years and no one thought it had become less frequent. This is compared to 56% (58%) of respondents who believed that fluvial (tidal) flooding had become more frequent over the past 10 years. Further, nine of the respondents believed that all three types of flooding were at least “somewhat frequent” in their community/jurisdiction and four of the nine believed all three flood types had become more frequent over the past 10-years. This speaks to the nontrivial threat of compound flooding in the study area.

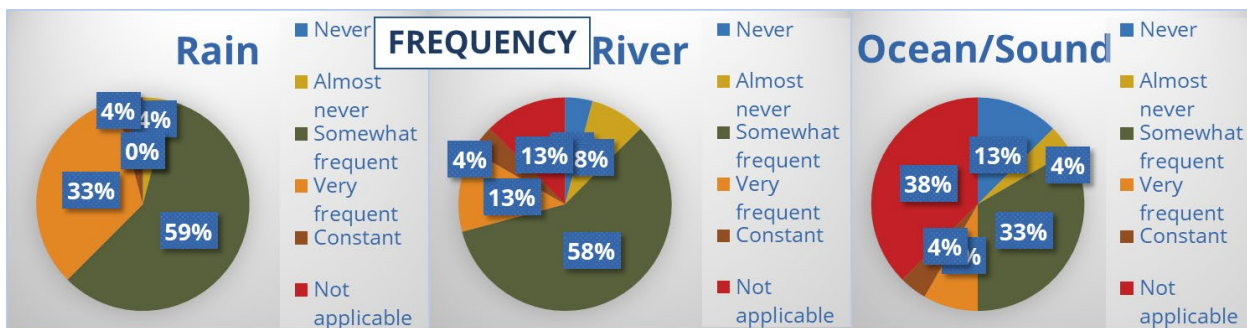


Fig 1. Responses to the question of the frequency of different types of flood.

3.2 Workshop data: Tyrrell County

As a case study, we isolated concerns from participants in Tyrrell County, NC. This low-lying rural county is constantly threatened by flooding. Nearly the entire county falls within the 100-year floodplain (Fig. 2a). About 7% of its citizens are employed in agriculture (ranking 7th out of 100 counties) and over 25% are living in poverty (ranking 5th). Over 28% of the land is classified as cultivated crops, but 55.5% are woody wetlands (Fig. 2b), which are mostly federally or state owned. As seen in Fig. 2b, there are distinct boundaries between these two land types. As expected, the wetlands are more flood prone than the agricultural land and this can lead to public-private tensions in flood management. As one participant put it: “53% of Tyrell County is owned by the state or federal government, who won’t let us touch it, who won’t go move a tree in it, and then wonder why we’re screaming about the fact our farmland is flooding...”

Another participant from Tyrrell described how the Soil and Water Conservation Districts have evolved in response to CCWE: “the Soil and Water Conservation Districts in every county have for years been more directed towards agriculture. It’s all about agriculture. They are slowly evolving what they see as their mission to a larger discussion, whether it be climate change or flooding or whatever. They need to be more in this discussion now, because used to they were all about agriculture. That was it. It’s a different world now, and they have accepted that. I’m just not so sure they have been viewed regionally for the expertise they bring to this discussion, because they have kind of transcended beyond agriculture. And particularly for Tyrrell, it’s rain-caused and it’s river-caused”.

3.3 Post-workshop survey: Assessment and COVID-19

Of the 13 participants who completed our post-workshop survey, 11 (85%) were moderately to extremely satisfied overall with the outcomes and all 13 would consider participating in the follow-up workshop (originally scheduled for 2021, but now slated for 2022). A couple of the participants wanted suggestions of flood prevention and mitigation measures, which will be a topic of discussion in the second workshop. There was also room for improvement in the facilitation and recording. As one participant observed: “some seemed knowledgeable and did a good job of capturing the concepts presented. Others seemed more unsure and the responses recorded on paper either missed a key point or didn’t capture the full breadth of the information shared”. Another participant thought moderators should have been more assertive in guiding the discussion or reeling in the focus to the topic at hand.

Given that the second survey was administered at the onset of the COVID-19 shut down, questions were included that asked how the pandemic might change the handling of flood hazard management either temporarily or permanently. Besides delays in implementing ordinances, working virtually and interacting with

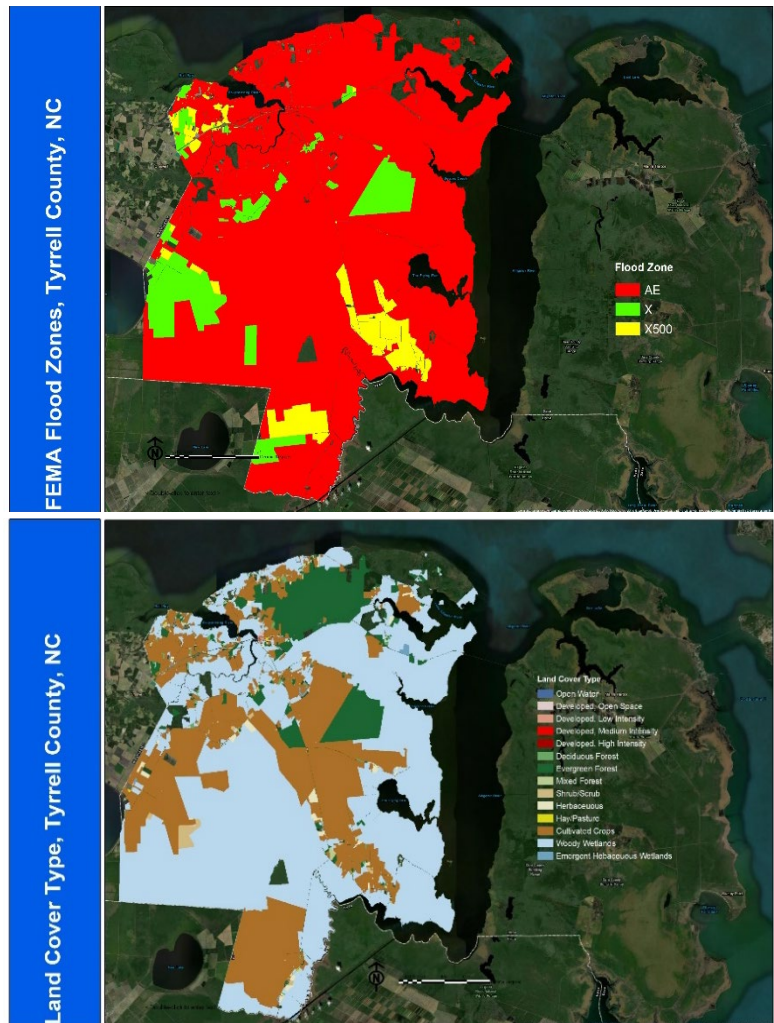


Fig. 2 (a) FEMA designated flood zones by property and (b) majority land use type by property in Tyrrell County, NC.

partners remotely, it was too early for most respondents to provide insights. However, one participant worried about the future: “What if this [shut down] had coincided with a flood event? What if people in isolation also had to be evacuated? What if the only staff in a county or municipality that understood the hazard mitigation grant process was also sick? Hurricane season is 8 weeks away. A significant flood could cause response and recovery issues in the flood plain that have never been thought of until now.” His/her advice was for people to plan for the worst-case scenario and to emphasize a message of self-responsibility. “The combination of a pandemic and a flood event will overwhelm even the best system in a very short amount of time.”

4. Conclusions

This paper presented some preliminary results from a NOAA-funded project: “Preparing for, Responding to, and Mitigating Coastal Compound Water Hazards for Resilient Rural Communities”. Our sample of the hazard management and planning communities in eastern North Carolina thought that pluvial flooding was more pervasive and persistent than fluvial and tidal flooding. In the minds of many of the participants, this water hazard had also become more frequent over the past 10 years. Regarding the compound nature of floods (*i.e.* CCWE), the pre-workshop survey and tabletop discussions confirm that it is of growing concern.

During the workshop we asked whether there was cooperation across professional and jurisdictional boundaries to address CCWE risk. While most participants gave examples of functional partnerships, two themes on the importance of local knowledge and non-local governmental inflexibility did emerge. One case in point is Tyrrell County, NC where there is a disconnect in flood management between state and federally owned wetlands and adjacent privately-owned farm lands. Furthermore, the Soil and Water Conservation District is one source of local expertise that is not currently being exploited. Many more questions were explored in the workshop and we’ve identified ten key themes: flood causes, flood preparation, flood response, flood recovery, impacts, infrastructure, jurisdictional responsibility, networking and communication, planning and policies, and solutions. To view a mental map of the ten themes and keep up to date on project outcomes, we invite the reader to visit the project webpage: <https://tinyurl.com/yyzzzz2t>.

Finally, workshop participants were generally pleased with the event and wanted to continue the conversation. Plans are underway to hold a second workshop to satisfy objective 3 and “co-produce knowledge and tools with our study group for better preparation, response and mitigation plans”. Given the concurrence of the pandemic with our project, we will also investigate this additional compounded hazard in the second workshop.

References

- Cheng, S., E. Ganapati, and S. Ganapati, 2015: Measuring disaster recovery: Bouncing back or reaching the counterfactual state? *Disasters*, **39**, 427-446.
- MDC, 2016: Building an infrastructure of opportunity. A REPORT FOR THE JOHN M. BELK ENDOWMENT. North Carolina’s Economic Imperative. <https://www.mdcinc.org/wp-content/uploads/2018/01/North-Carolinas-Economic-Imperative-Building-an-Infrastructure-of-Opportunity.pdf>
- Wahl, T., S. Jain, J. Bender, S. D. Meyers, and M. E. Luther, 2015: Increasing risk of compound flooding from storm surge and rainfall for major US cities. *Nat. Clim. Change*, **5**, 1093-1097.
- Zscheischler, J., S. Westra, B. J. J. M. van den Hurk, S. I. Seneviratne, P. J. Ward, A. Pitman, A. AghaKouchak, D. N. Bresch, M. Leonard, T. Whal, and X. Zhang, 2018: Future climate risk from compound events. *Nat. Clim. Change*, **8**, 469-477.