

Flood Hazard Awareness at Old Dominion University: Assessment and Opportunity

*Nicole S. Hutton and Michael J. Allen

Department of Political Science and Geography, Old Dominion University, Norfolk, VA
 *Corresponding Author

Abstract: Building resilience to flooding is a commitment of several universities; however, student interest in flood education programs is unclear. The goals of this research are three-fold: 1) to determine the origin of flood messaging on the Old Dominion University (ODU) campus, 2) to assess on-campus flood awareness, and 3) to evaluate the interest in additional flood education. This study evaluates student awareness of flooding via a survey of ODU students and contextual analysis of University warning messages. Many students experienced reduced access to campus as a result of flooding and expressed an interest in additional flood information. Some students reported receiving flood-related information through in-class instruction or orientation-based programming. However, the content varies in detail, and ODU could formally integrate additional resources into outreach and flood education programming. These findings could support the development of a campus wide flood awareness program at ODU and other universities.

Keywords: *flood, risk perception, survey, hazards, education, resilience*

Students often have limited situational awareness about flood risk around the universities they attend (Williams et al. 2017; Ponstingel et al. 2019). Additionally, students may experience elevated risk due to a limited financial capacity and lack of familiarity with local emergency management systems (Burningham et al. 2008; Hung et al. 2016). These conditions affect an individual's ability to understand flood impacts or associated risks (Burningham et al. 2008). Individuals who perceive a low risk are less likely to invest time or financial resources in precautionary measures, such as planning alternate routes or purchasing flood insurance (Lopez-Marrero 2010; Hung et al. 2016). The flood-related information received from universities does not fully prepare them for or eliminate their anxiety about flooding (Williams et al. 2017; Ponstingel et al. 2019). Improving risk communication by integrating flood-related messaging throughout the university as a coordinated program could improve student preparedness and outcomes by adjusting risk perception (Birkholz et al. 2014; Ponstingel et al. 2019).

Research Implications

- Old Dominion University students who experienced reduced access to campus because of flooding are interested in additional flood hazard awareness.
- Opportunities to strengthen flood-related material from classes and orientations supports the development of a coordinated campus-wide program.
- Since courses and orientations do not convey consistent or comprehensive flood risk information, flood-related warnings should assume no pre-existing flood knowledge.

Knocke and Kolivras (2007) found that young people perceive less flood risk than other age groups and benefit from increased understandings of floods and related emergency guidance. A four-year study by Ponstingel et al. (2019) found that overall student flood risk perceptions were low but increased with time spent at university and age, which may reflect knowledge gained. Students with a more comprehensive understanding of

flood risk were more likely to take precautions but also reported anxiety associated with limited preparedness. To increase Texas State University's flood knowledge, promote preparedness, and moderate social amplification of risk, campus-wide educational outreach was recommended (Oliver-Smith and Hoffman 2019; Ponstingel et al. 2019). The suggested program included heuristic principles, which state that multimodal flood information such as university email, public news outlets, social media, and combinations thereof improve student risk perception and reduce negative impacts, such as missed classes or car stranding (Mussweiler et al. 2004; Yamamura 2010; Harvatt et al. 2011).

The values and mutual interests of information sources influence how risks are managed and characterized (Moser and Ekstrom 2011; Johnson and Covello 2012). For example, universities typically monitor the National Weather Service (NWS) and comply with resultant weather-related closures and evacuation orders issued by the local government to ensure local student safety. Universities may go beyond simply issuing warnings to also provide for basic needs, transportation, and counseling services to ensure student well-being. However, if the goals and outcomes of institutional flood management efforts are not clearly communicated, students may not perceive the threat accurately (Fatti and Patel 2013; Ponstingel et al. 2019). For example, university warnings are important in preparing students for floods; however, students express that neither those nor city efforts are sufficient, and some experience frustration with university warnings when bad outcomes occur (Ponstingel et al. 2019). Campus and community education strategies may incorporate existing community networks such as civic organizations and business associations to improve flood risk perceptions and trust (Storr et al. 2017; Tierney 2019). The NWS also offers community educational opportunities focusing on severe weather (e.g., SKYWARN Spotter Training) and flood outreach (e.g., Turn Around Don't Drown).

The ability to deal with disturbances, such as flooding, remains low without adequate risk communication (Lopez-Marrero 2010). Proactive hazard education increases resilience at the

individual and community level. Dufty (2008) states that flood risk education should extend beyond awareness and preparedness to develop adaptive capacity. Engaging communities in a participatory education process from design to evaluation increases willingness to implement protective measures and contributes to more holistic flood resilience (Dufty 2008; Muro and Jeffrey 2008; Charalambous et al. 2018). Activities, such as flood simulations, reduce anxiety and improve understandings of risk (Bosschaart et al. 2016; Bathke et al. 2019). Utilizing interactive maps to assimilate risk data also helps overcome powerless feelings (Houston et al. 2019; Sanders et al. 2020). In developing comprehensive flood-related literacy, both short-term guidance and long-term knowledge building are important. Specific skills include identification of flood zones and protective actions that individuals and communities may take (Birmingham et al. 2008). This is particularly relevant with respect to regional flooding in "hotspots" like southeast Virginia (Sallenger et al. 2012) which intersect both short-term weather phenomenon (e.g., hurricanes, heavy rain events) and long-term climate impacts (e.g., sea level rise). This study builds upon Ponstingel et al. (2019) and utilizes the Old Dominion University (ODU) campus to ask 1) What sources of flood information exist on campus?, 2) How personal experience and available information shape student flood awareness?, and 3) What additional flood education is of interest?

Study Area

A metropolitan campus of nearly 25,000 students, ODU is in Norfolk, Virginia, one of the seven cities commonly referred to as Hampton Roads (i.e., Norfolk, Virginia Beach, Chesapeake, Newport News, Hampton, Portsmouth, and Suffolk). The University is a minority serving institution with a large commuter population. Situated near the world's largest Navy base, many students are also affiliated with the military and represent a more transient student population when compared to other institutions of similar size.

Located at the mouth of the Chesapeake Bay with the Atlantic Ocean to the east and a multitude of interlaced rivers and creeks, the University and

greater Hampton Roads region regularly experience flooding. In the 19th and 20th centuries, many creeks and wetlands were filled and used for development purposes (Spanger-Siegfried et al. 2014). Adding to the complexity, over the last 80 years, Norfolk has observed twice the average global rate of sea level rise (SLR) due to land subsidence caused by geologic factors and groundwater depletion (Eggleston and Pope 2013). Consequently, land-use and geographic features affect the local hydrologic dynamics, and routes to campus go through multiple flood zones (Figure 1). In addition to tidal cycles that contribute to flooding, the area is often impacted by tropical cyclones, nor'easters, and heavy rain events that put commuters at risk (Allen and Allen 2019; Ponstingel et al. 2019). Sweet et al.'s (2018) analysis also showed sunny day flooding events accelerating throughout the region. While much of this flooding is considered

nuisance flooding, everyday life certainly can be disrupted by a heavy rain event, a minor tropical cyclone, or a nor'easter. Together, short-term weather phenomena along with more long-term climate impacts, such as SLR, compound risk and help explain why ODU and the Hampton Roads region have a unique opportunity and heightened necessity to engage with students to increase flood-related resilience (Kleinosky et al. 2007; Li et al. 2013).

Yusuf et al. (2018b) facilitated community discussions focused on the resources needed to address flooding in Hampton Roads. The study showed that individual perceptions of flood risk improved through learning across public, private, and non-profit sectors. However, behavioral changes to facilitate adaptation, such as individual investments into flood-proofing, remained controversial (Yusuf et al. 2018b). This

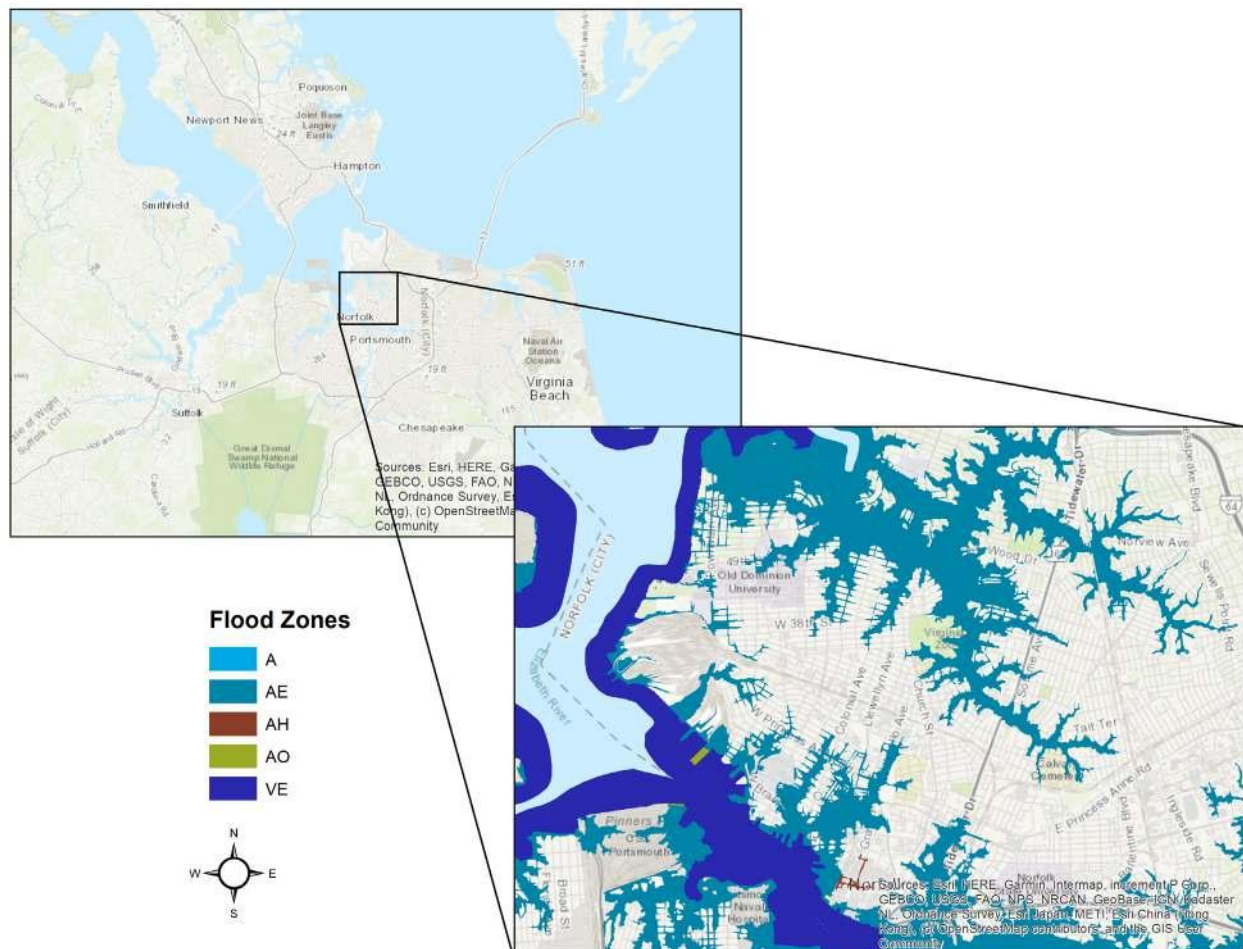


Figure 1. Federal Emergency Management Agency Flood Zones in Norfolk inset from Hampton Roads (adapted by authors from HRPDCGIS 2019). Flood zone descriptions can be found at <https://www.fema.gov/glossary/flood-zones>.

is consistent with Harvatt et al.'s (2011) study in England where participants externalized the responsibility for flooding associated with SLR but ascribed the responsibility to address other types of flooding to an individual level. The Commonwealth Center for Recurrent Flooding Resilience (CCRFR), ODU's Institute for Coastal Adaptation and Resilience (ICAR), and The Hampton Roads Forum engage stakeholders in dialogues, research, and policy-making efforts to mitigate current and future flooding. These regional partners present opportunities for ODU to better inform perceptions and behaviors associated with flood hazards, risk, and impacts on campus and throughout the community.

Methods

Student receptivity is critical to establishing a comprehensive flood awareness program at a university. This study included a student survey and a separate content analysis of University warning messages from 2015 – 2019. The ODU Arts and Letters Human Subjects Committee declared the study exempt research (Package 1502472-1) on October 7, 2019. The survey questions drew upon student experiences with flooding and consider the origin, availability, and receipt of flood-related information. The warning messages provided context regarding the frequency and severity of and guidance for flood events affecting campus operations. The influence of information and experiences upon risk perception and interest in additional flood-related education was assessed using mixed methods.

Survey Design

The online survey of 28 multiple choice and open-ended questions was distributed using Qualtrics software (Appendix 1). It required approximately 10 minutes to complete. The survey built upon student flood perception questions posed by Ponstingel et al. (2019) and addressed community specific flood hazards and management expectations identified by Allen and Allen (2019) and Yusuf et al. (2018b). The survey included demographic and geographic questions outlining student areas of study, student standing, commuter status, and prior residence. A series of flood

experience and perception questions followed focusing on how many classes were missed due to flooding, damage and injuries incurred, as well as, perceived flood risk, contributors to flooding frequency and severity, and responsibility for management. Terms used in the survey did not include any definitions or examples. The survey concluded with questions about flood information received or of interest including orientation materials and course content.

Participant Recruitment

The ODU Office of Institutional Effectiveness and Assessment provided a representative sample of 1007 randomly selected graduate and undergraduate students (~4.25% of total student population) who completed at least one course on campus. Demographic characteristics of the recruitment pool appear in Appendix 2. A total of 110 individuals, 10.9% of the sample, consented to and participated in the online survey. Students received email invitations along with multiple follow-up reminders from the research team to complete the online survey. The survey link was available between November 12 and December 12, 2019, which coincided with the end of hurricane season.

Survey Analysis

Survey results were analyzed using both qualitative and quantitative approaches. Simple statistical tests conducted in Qualtrics included frequency counts and percentages. Crosstabulation determined significant relationships ($p < 0.05$) with a 95% confidence interval between commuter status, student status, experiences, or perceptions and the source of additional information of interest. Chi-squared and pairwise z-test statistical tests evaluated the difference in expected and observed frequencies. For example, the relationship between each type of student status (freshman, sophomore, etc.) and commuter status was tested using z-tests. Chi-square tests were used to assess the relationship such as that between classes missed due to flooding and interest in additional flood education through classes or orientations.

Qualitative data from open ended questions were manually analyzed to further explore what key messages were received in orientation and

classroom instruction. Themes emerged from the data. For example, the information received in classes or orientations was either behavioral guidance, scientific explanation, or a combination of both. Selected quotes were included to illustrate how students characterized the information received in courses and orientations. Areas where reliable flood information already exists may be expanded to improve flood awareness across campus.

Geographic analysis was also conducted to provide detail for tailoring an ODU flood awareness program to the array of experiences students bring with them to campus. Zip code data were mapped using ESRI ArcMap to show where students resided prior to attending ODU. Zip codes within Hampton Roads, Virginia, the Commonwealth of Virginia, and the United States were selected in ArcGIS to determine frequencies and percentages of flood perceptions based on student origin.

University Warning Message Collection and Analysis

The University and Student Announcements communicate advisories that warrant significant action. Strategic Communication and Marketing sends out ODU Alerts advising on the status of the University for weather-related hazards. From 2015 – 2019, 24 flood-related alert messages notified ODU students. The data contextualize the flood experiences and information reported in student surveys and provide insight as to the type of messaging sent by the University during flood events. It is beyond the scope of this study to determine if students received all of these messages. Descriptive text indicating the origin and severity, as well as the recommended action for each event was manually coded based on hazard type, advisory source, and operating changes to generate and organize themes and identify connections between them from the data. Quotes were included to elaborate upon behavioral recommendations in the advisories.

Results

Participant Characteristics

Demographic information included prior residence, on- or off-campus residence, commuter

status, and class standing. Figure 2 shows the zip codes provided within the United States for residence location prior to attending ODU. Of the surveyed students, 65.1% commuted. Z-tests showed a statistically significant relationship between student status and commuting, with commuting occurring at the highest rates amongst juniors, graduate students, and seniors. Table 1 outlines the break-down of student standing and College. Like other universities with majority commuter populations, ODU may benefit from flood awareness programming that promotes identification of alternate routes in advance of a flood (Ponstingel et al. 2019). A transient, military community, Hampton Roads prioritizes the transportation network, and the identification of alternative routes is not only valuable to students but also the greater community

Collective Experience with Floods at the University

This survey conducted two months after Hurricane Dorian, likely featured some enhanced awareness because the storm impacted ODU and the greater Hampton Roads; though, as stated in the ODU Alerts, the campus *did not experience serious impacts*. Tidal flood events, such as highest annual tidal cycle which occurred in October 2019, may influence participants, but these nuisance events were typically not the subject of ODU advisory messages.

Between 2015 and 2019, ODU sent 24 notifications of changes in operating posture in anticipation of or response to tropical systems; few specifically focused on flooding (Table 2). The collective results indicated what flood hazard experiences students may have shared during their time at ODU. There were no records to indicate which students experienced these events or received the messages.

All advisories had common components: 1) the name of the weather system or general hazard category, such as flood, 2) the actions taken on campus from monitoring, to delays, to closures, 3) recommended behavior, and 4) contact information for campus emergency management. Beyond these commonalities, the descriptions of risk and behavioral recommendations varied. One advisory described the flood level as *shallow*.

Another notice stated that there would be *some flooding*. Alerts in 2019 incorporated language to suggest appropriate behavior, such as *avoid driving through or walking in flooded areas*, and *turn around, don't drown*. Similar guidance issued in 2015 stated: *do not drive through flood water or into running water and remember not to drive around barricades or through floodwater*. Notices associated with the mandatory evacuation in 2018 offered planning support for students in residence halls and guidance on which zones ordered to evacuate, where to go, and what to bring. Hazards overlapping with the fall holiday breaks in 2015 and 2016 involved recommendations to stay or go home with friends and family, which assume an understanding of driving in flood conditions as well as evaluating safe structures. Nine ODU notifications advised the campus community to *use their best judgement*, typically discussed in the context of traveling to or from campus. Six alerts recommended to *use or exercise caution*.

Additional outlets suggested for monitoring the approaching hazard appeared in 13 notifications including ODU's webpage, ODU's social media, local news channels, 511 (travel information phone number), Google's map application, and National Oceanographic and Atmospheric Agency's All Hazards Radio. Links to preparedness resources from ODU or Virginia's Department of Emergency

Management, including evacuation zones, were provided in five instances. In four communications, the text included NWS forecasts (e.g., warnings, outlooks). Opening these links, however, required additional action, which students may or may not be willing to take.

Alert language occasionally invoked external scientific organizations or relayed University pride. Despite the inclusion of NWS warnings and guidance, terminology did not reflect collaborations with state and local agencies until 2019. This addition may improve credibility. The term "MonarchReady" once encouraged readers to prepare in 2015 and 2016. Drawing on the University identity of Monarchs, this tactic may inspire a sense of community and connection that motivates students to rely on campus resources and promote additional flood awareness.

Individual Flood Experiences

The majority of students (60.8%) either had a class canceled or were unable to attend a class as a result of flooding. Eighty percent of those who experienced a cancellation or absence due to flooding perceived Norfolk to have high flood risk; of those that did not, 88.1% perceived Norfolk to have high flood risk. Chi-squared tests showed no statistically significant relationship between missed class and flood risk perception. Of total



Figure 2. Prior zip codes of Old Dominion University students.

survey participants, 63.8% experienced flooding resulting in a canceled or missed class more often than once a year but few experienced property damage (14.3%) or injury (9.57%). Even with a small percentage of students reporting damage or injury, it is important to increase perceived risk to reduce future occurrences because most students encounter flooding.

Flood Risk Perceptions

The perception that Norfolk is prone to floods generally increased with student status during the undergraduate degree but then declined among graduate students (Table 3). The perception of Norfolk being flood prone increased by 31.8% from freshman to senior standing, whereas 5.7% fewer graduate students perceived Norfolk as flood prone than seniors. A chi-square test showed no statistically significant relationship. While the vast majority (96.7%) of students perceived

that Norfolk has high flood risk, no students that provided prior residence information from outside Virginia thought Norfolk was a high flood risk area.

Only 19.4% of participants noted the relationship between flooding and SLR. When asked which climate change influenced weather-related hazards affect Hampton Roads only 28.1% noted flooding, 27.3% hurricanes, and 15.4% nor'easters. Students identified precipitation (37.9%) as major causal factors to flooding (Table 4) but did not significantly differentiate between other factors such as tidal processes, SLR, or storm surge. The low range of variation may indicate that students perceive that these factors are related, which is critical to understanding coastal hazards whether that awareness is from experience or information absorption. Few students acknowledged the relationship between flooding and climate change from either orientation or class information as well. Only one participant described the main

Table 1. Participant characteristics.

Residence Prior to Attending ODU (%)					
Norfolk	Hampton Roads (excluding Norfolk)	Virginia (excluding Hampton Roads)	United States (excluding Virginia)	International	
7.22	62.89	15.46	12.37	Not Applicable	
Student Standing (%)					
Freshman	Sophomore	Junior	Senior	Graduate Student	
17.27	20.91	18.18	18.18	25.45	
College (%)					
Arts and Letters	Business	Education	Engineering	Health	Sciences
31.40	11.63	8.14	8.14	18.60	22.09

Table 2. ODU Alerts, 2015-2019 (developed by authors from ODU Alert messages).

Year	Event(s)	Action
2019	Hurricane Dorian	Closure
2018	Hurricane Florence	Evacuation
	Tropical Storm Michael	Partial electrical failure
2017	Unnamed Tropical System	Coastal flood advisory
2016	Hurricane Matthew	Flash and coastal flood warnings
	Tropical Storm Hermine	Class cancelation
2015	Hurricane Joaquin	Route/schedule modification
	Wind driven high tide	Route/schedule modification

message of information received in class as, “Sea level rise caused by climate change [is] having a huge effect on Hampton Roads.” Since perceptions of risks associated with climate change are highly politicized, particularly in the United States (Lorenzoni and Pidgeon 2006; Whitmarsh 2011; Brulle et al. 2012; Lee et al. 2015), a balance of messages, materials, and delivery methods could improve student perceptions regarding risk, the intersection of climate change and flooding, and student capacity to mitigate adverse outcomes.

Interest, Responsibility, and Sources of Information

There is a continued need for the University to expand flood-awareness initiatives. Only 8.3% of participants identified students as responsible for developing their own flood awareness. Students suggested emergency and flood managers were largely responsible for increasing awareness followed by administration and faculty (Table 5).

Of the students surveyed, 36.8% of participants reported receiving flood information in class. Students gained flood-related resources from three

of the six University Colleges (i.e., College of Sciences, College of Arts and Letters, and College of Education & Professional Studies), and received this information in a wide-variety of courses including but not limited to Biology, Oceanography, Psychology, Political Science, Geography, and Human Development. Although some general education courses reach a broad set of students, this study suggests that there is a need to increase and formalize the cross-curriculum integration of flood information across the University.

Participants reported receiving information about emergency management and weather in Norfolk at incoming freshman orientation as well as transfer and graduate student programming. Twenty-five point four percent of respondents received flood information in orientations. This low percentage may be associated with inconsistent messaging or recall but indicates room for improvement. One student also reported a flood studies orientation associated with the community work of Yusuf et al. (2018b).

Participants’ summaries of the main messages from classes explained more than those of

Table 3. Perception of flood risk by student standing.

Student Standing	--Norfolk Has High Flood Risk (%)--		
	Yes	No	No Response
Total Student Body	80.9	4.5	14.6
Freshman	63.2	10.5	26.3
Sophomore	78.3	8.7	13.0
Junior	75.0	0.0	25.0
Senior	95.0	0.0	5.0
Graduate Student	89.3	3.6	7.1

Table 4. Factors causing flooding.

Factor	Percent
Rain	29.13
Snow	8.74
Tides	18.12
Storm Surge	24.60
Sea Level Rise	19.42

Table 5. Perceptions of responsibility for student flood awareness raising.

Responsible Party	Percent
Emergency Managers	28.68
Flood Managers	29.06
Administrators	19.62
Faculty	12.45
Students	8.30
Other	1.89

orientations, which were more warning and action oriented. Students reported receiving flood risk messages including “It floods here”; and “Norfolk is sinking” in orientations. Emergency contact, warning alert information, and action recommendations were also reported from orientations, such as “don’t drive through flood waters” and “get to higher ground.” These terms connect with suggested NWS best practices. Although the orientation messages do not provide a foundation for the complex science behind SLR, they may improve the receipt of more general flood warnings and resultant behaviors for vehicle protection. Participants’ summary statements of course messaging associate a range of attitudes with the human-environmental interactions contributing to flooding from, “That it is a problem that we have to come together to try and solve for our future” to “We’ve killed our wetlands so water floods now.”

There is both room for and interest in improved outreach to the ODU campus with flood awareness information. Approximately half of the students wanted to learn more from some education outlet. Chi-squared tests showed statistically significant relationships between reduced access to classes from flood events and interest in additional flood information in orientation and courses. By addressing knowledge gaps and providing additional context and information, a coordinated flood awareness program may improve general understanding by also improving resilience to flood impacts.

Discussion

Pairing behavioral advice with best judgement recommendations minimizes the flood knowledge needed to reduce risk (Montz et al. 2017). Since ODU already invests in building community resilience and producing warnings in conjunction with city, state, and federal partners, implementing a flood awareness campaign could leverage these resources to benefit University emergency management by improving warning message content as well as students’ understandings of and reactions to messages. Students perceive that the responsibility for management falls upon emergency and flood managers yet interest in flood

education remains high, thereby, positioning ODU to complement its flood awareness offerings with existing government resources, a capacity also indicated by Yusuf et al. (2018a).

The types of material presented in orientations and classes influence attitudes toward the problem. Covi and Kain’s (2016) study of Hampton Roads shows that framing and visualization increase understanding of the complex and politicized connections between climate change and SLR. For example, interactive maps increase urgency to protect homes and interest in capacity building amongst community members and government agencies (Hutton and Allen 2020; 2021). To create flood resilience, students need to see the socio-ecological connection and be able to identify ways to adapt (Adger et al. 2005).

With only 19.4% of ODU respondents noting a relationship between flooding and SLR, there is an opportunity to improve climate literacy. Whereas warmer world temperatures do not directly cause flooding, warmer temperatures enhance the probability of extreme events as the capacity for air to hold water increases with temperature. Recent studies indicate changes in historical precipitation (e.g., Allen and Allen 2019) and the role anthropogenic climate change has on flood events (e.g., Kirchmeier-Young and Zhang 2020). Norfolk, due to both natural and anthropogenic factors, is sinking, but the seas are also rising as a result of heat-trapping gases warming the planet. Consequently, SLR in Norfolk is a greater hazard than for many other coastal areas. These factors indicate that the interconnected dimensions of climate impacts and flood risk should be more effectively communicated across multiple modes.

Aytur et al. (2015) show that it takes several months and multiple means of education from interactive activities to conversations with scientists to raise awareness of how flood risk and climate change are intertwined. On the one hand, geography courses involving water resources, for example, address the human-environmental interactions associated with flooding through climatology (Pease et al. 2019). Enrollment in a course with flood-related content is not required at ODU or many universities as a general education requirement, which shows in that only 36.8% of students reported receiving flood information

from a class. On the other hand, the short duration and large amount of content presented at required orientations may reduce retention. Only 25.4% of ODU students reported receiving flood information in orientations. Comparisons between information provided and retention are beyond the scope of this study but merit additional research. A framework with both interdisciplinary and disciplinary learning is needed to establish a broad foundation, offer practical flood management solutions (Grigg 2019), and adjust the range of views on flood risk.

Conclusions

The results of this study identify an area of opportunity to increase climate literacy and interconnected flood-impacts at ODU. This case study of ODU assesses: 1) sources of flood-related information on campus, 2) the role of information and experience in student flood awareness, and 3) what additional education is of interest. Over the past five years, the campus received several flood-related warnings about hurricanes, tropical storms, and tides that rely upon pre-existing flood knowledge that is not thoroughly conveyed to students through orientations or course curriculum. Reported receipt of flood information in orientations and classes was low. Classes that did address flood risk had more information about natural and human systems than orientations, which provided contacts and behavioral advice.

The large majority perceived Norfolk to have flood risk regardless of personal experiences on campus. However, few students noted the connection between flooding and climate change impacts. Most students experienced flooding while attending ODU. Although local experience matters, risk perception at ODU, unlike some other universities (i.e., Texas State), was not related to missing classes due to flooding. Interest in receiving additional flood awareness information was associated with missing a class due to flooding.

Students expect emergency and flood managers to raise flood awareness more so than administrators, faculty, or themselves. Balancing the messengers, means, and amount of information received over time is important for making human-environmental connections and fostering

resilience. These findings will prepare flood prone universities to develop more comprehensive risk perception evaluation and integrate awareness programs to increase knowledge of, readiness for, and resilience to hazards.

Limitations and Future Research

The full relationship between the information received and increased resilience among ODU students requires additional exploration. This study features limitations regarding sample size and terminology. A relatively small participant count ($n = 110$) may influence the results. Student interpretations and understanding of terms such as hurricane and nor'easter may not be sufficient to differentiate between terms. These exploratory results, however, illuminate areas for future research.

This survey could be expanded in size and scope and conducted annually to determine changes in flood awareness availability and perception longitudinally amongst a larger percent of the student population. More detailed iterations could collect the information available in classes and orientations and determine how much information is sufficient, specific types of information of interest, the role of social networks, a timeline for distribution in relation to the student standing, variation in flood risk perception at the graduate level, and motivations for coordination between campaigns. Such longitudinal studies could also examine: 1) existing emotional, social, and demographic relationships with risk perception, and 2) the current range of preparedness behaviors implemented by students. If a program was to be developed and started during that time, it would also be a way to determine behavioral change and efficiency, and assess reactions to specific warning texts or modes of presentation to refine offerings. Finally, comparative studies could allow for robust regional flood awareness programs connecting universities with their surrounding community.

Acknowledgements

The authors would like to thank Jared Hoernig, Director of Emergency Management, for providing ODU Alert messages. No funding was received for this study.

Author Bio and Contact Information

NICOLE S. HUTTON (corresponding author) is an Assistant Professor of Geography at Old Dominion University. As a hazards researcher she identifies the contributions of agency connections to organizational resilience. Her research on the 2010 earthquake sequence in Christchurch, New Zealand and levee breaks in Yuba County, California appears in *The Professional Geographer*, *Third Sector Review*, *Papers in Applied Geography*, *Journal of Flood Risk Management*, and *Emerging Voices in Hazards Research*. Nicole's current research tracks nursing compliance with emergency power legislation in Florida and identifies the role of traditional ecological knowledge in sea level rise adaptation with the Pamunkey Indian Tribe. She may be contacted at nhuttons@odu.edu or 7012 Batten Arts and Letters, Norfolk, VA 23529.

MICHAEL J. ALLEN is an Associate Professor and currently serves as Geography Program Director at Old Dominion University. A climate scientist, Dr. Allen explores the intersection of weather impacts on a variety of societal outcomes with particular attention on heat-related health issues. Michael's research on seasonal climate change was cited by National Geographic, and he has published in journals including *Physical Geography*, *International Journal of Biometeorology*, and *Climate Research*. Most recently, Dr. Allen has worked to build capacity with K-12 educators to improve climate literacy and develop hands-on applications for geographic education. He may be contacted at mallen@odu.edu or 7035 Batten Arts and Letters, Norfolk, VA 23529.

References

- Adger, W.N., T.P. Hughes, C. Folke, S.R. Carpenter, and J. Rockström. 2005. Social-ecological resilience to coastal disasters. *Science* 309(5737): 1036-1039.
- Allen, M.J. and T.R. Allen. 2019. Precipitation trends across the Commonwealth of Virginia (1947–2016). *Virginia Journal of Science* 70(1). DOI: 10.25778/3cay-z849.
- Aytur, S.A., J.S. Hecht, and P. Kirshen. 2015. Aligning climate change adaptation planning with adaptive governance: Lessons from Exeter, NH. *Journal of Contemporary Water Research & Education* 155(1): 83-98.
- Bathke, D.J., T. Haigh, T. Bernadt, N. Wall, H. Hill, and A. Carson. 2019. Using serious games to facilitate collaborative water management planning under climate extremes. *Journal of Contemporary Water Research & Education* 167(1): 50-67.
- Birkholz, S., M. Muro, P. Jeffrey, and H.M. Smith. 2014. Rethinking the relationship between flood risk perception and flood management. *Science of the Total Environment* 478: 12-20.
- Bosschaart, A., J. van der Schee, and W. Kuiper. 2016. Designing a flood-risk education program in the Netherlands. *The Journal of Environmental Education* 47(4): 271-286.
- Brulle, R.J., J. Carmichael, and J.C. Jenkins. 2012. Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. *Climatic Change* 114: 169-188.
- Burningham, K., J. Fielding, and D. Thrush. 2008. 'It'll never happen to me': Understanding public awareness of local flood risk. *Disasters* 32(2): 216-238.
- Charalambous, K., A. Bruggeman, E. Giannakis, and C. Zoumides. 2018. Improving public participation processes for the floods directive and flood awareness: Evidence from Cyprus. *Water* 10(7): 958.
- Covi, M. and D. Kain. 2016. Sea-level rise risk communication: Public understanding, risk perception, and attitudes about information. *Environmental Communication* 10(5): 612-633.
- Dufty, N. 2008. A new approach to community flood education. *Australian Journal of Emergency Management* 23(2): 3-7.
- Eggleston, J. and J. Pope. 2013. Land subsidence and relative sea-level rise in the southern Chesapeake Bay region. U.S. Geological Survey Circular 1392. Available at: <http://dx.doi.org/10.3133/cir1392>. Accessed January 21, 2021.
- Fatti, C.E. and Z. Patel. 2013. Perceptions and responses to urban flood risk: Implications for climate governance in the South. *Applied Geography* 36: 13-22.
- Grigg, N.S. 2019. IWRM and the nexus approach: Versatile concepts for water resources education. *Journal of Contemporary Water Research & Education* 166(1): 24-34.
- Hampton Roads Planning District Commission (HRPDC). 2019. FEMA Flood Zones in Hampton Roads, VA. Available at: <https://geo.hrsd.com/hrgeo/rest/services/regionalgis/Floodzones/MapServer/0>. Accessed on January 11, 2021.
- Harvatt, J., J. Petts, and J. Chilvers. 2011. Understanding householder responses to natural hazards: Flooding and sea-level rise comparisons. *Journal of Risk Research* 14(1): 63-83.

- Houston, D., W. Cheung, V. Basolo, D. Feldman, R. Matthew, B.F. Sanders, B. Karlin, J.E. Schubert, K.A. Goodrich, S. Contreras, and A. Luke. 2019. The influence of hazard maps and trust of flood controls on coastal flood spatial awareness and risk perception. *Environment and Behavior* 51(4): 347-375.
- Hung, L.-S., C. Wang, and B. Yarnal. 2016. Vulnerability of families and households to natural hazards: A case study of storm surge flooding in Sarasota County, Florida. *Applied Geography* 76: 184-197.
- Hutton, N.S. and T.R. Allen. 2021. Perceptions of visual and in situ representations of sea level rise and tidal flooding: The blue line project, Norfolk, VA. *Geojournal*. DOI: 10.1007/s10708-020-10356-4.
- Hutton, N.S. and T.R. Allen. 2020. The role of traditional knowledge in coastal adaptation priorities: The Pamunkey Indian Reservation. *Water* 12(12): 3548.
- Johnson, B.B. and V.T. Covello (Eds.). 2012. *The Social and Cultural Construction of Risk: Essays on Risk Selection and Perception*. Springer Netherlands, Heidelberg, Germany.
- Kirchmeier-Young, M.C. and X. Zhang. 2020. Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences* 117(24): 13308-13313.
- Kleinosky, L.R., B. Yarnal, and A. Fisher. 2007. Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards* 40(1): 43-70.
- Knocke, E.T. and K.N. Kollivras. 2007. Flash flood awareness in southwest Virginia. *Risk Analysis: An International Journal* 27(1):155-169.
- Lee, T.M., E.M. Markowitz, P.D. Howe, C.-Y. Ko, and A.A. Leiserowitz. 2015. Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change* 5(11):1014-1020.
- Li, H., L. Lin, and K.A. Burks-Copes. 2013. Modeling of coastal inundation, storm surge, and relative sea-level rise at Naval Station Norfolk, Norfolk, Virginia, U.S.A. *Journal of Coastal Research* 29(1): 18-30.
- Lopez-Marrero, T. 2010. An integrative approach to study and promote natural hazards adaptive capacity: A case study of two flood-prone communities in Puerto Rico. *Geographical Journal* 176(2): 150-163.
- Lorenzoni, I. and N.F. Pidgeon. 2006. Public views on climate change: European and USA perspectives. *Climatic Change* 77: 73-95.
- Montz, B.E., G.A. Tobin, and R.R. Hagelman III. 2017. *Natural Hazards: Explanation and Integration*. The Guilford Press, New York, New York.
- Moser, S.C. and J.A. Ekstrom. 2011. Taking ownership of climate change: Participatory adaptation planning in two local case studies from California. *Journal of Environmental Studies and Sciences* 1(1): 63-74.
- Muro, M. and P. Jeffrey. 2008. A critical review of the theory and application of social learning in participatory natural resource management processes. *Journal of Environmental Planning and Management* 51(3): 325-344.
- Mussweiler, T., B. Englich, and F. Strack. 2004. Anchoring effect. In: *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory*, R. Pohl (Ed.). Psychology Press, London, United Kingdom, pp. 183-200.
- Oliver-Smith, A. and S.M. Hoffman (Eds.). 2019. *The Angry Earth: Disaster in Anthropological Perspective*. Routledge, New York, New York.
- Pease, M., P.L. Chaney, and J. Hoover. 2019. A review of water resources education in geography departments in the United States. *Journal of Contemporary Water Research & Education* 168(1): 93-105.
- Ponstingel, D., C. Lopez, and R. Earl. 2019. Flood awareness among college students in Flash Flood Alley: A case study of Texas State University in San Marcos, Texas, USA. *Papers in Applied Geography* 5: 236-255.
- Sallenger, Jr., A., K. Doran, and P. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic Coast of North America. *Nature Climate Change* 2(12): 884-888.
- Sanders, B.F., J.E. Schubert, K.A. Goodrich, D. Houston, D.L. Feldman, V. Basolo, A. Luke, D. Boudreau, B. Karlin, W. Cheung, S. Contreras, et al. 2020. Collaborative modeling with fine-resolution data enhances flood awareness, minimizes differences in flood perception, and produces actionable flood maps. *Earth's Future* 8(1): e2019EF001391.
- Spanger-Siegfried, E., M. Fitzpatrick, and K. Dahl. 2014. Encroaching tides: How sea level rise and tidal flooding threaten U.S. East and Gulf Coast communities over the next 30 years. University of Minnesota Digital Conservancy. Available at: <http://hdl.handle.net/11299/189228>. Accessed January 21, 2021.
- Storr, V.H., S. Haeffele-Balch, and L.E. Grube. 2017. Social capital and social learning after Hurricane Sandy. *The Review of Austrian Economics* 30(4): 447-467.

- Sweet, W.W.V., G. Dusek, J.T.B. Obeysekera, and J.J. Marra. 2018. *Patterns and Projections of High Tide Flooding along the U.S. Coastline Using a Common Impact Threshold*. NOAA Technical Report NOS CO-OPS 086, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, USA.
- Tierney, K. 2019. *Disasters: A Sociological Approach*. Polity Press, Medford, Massachusetts.
- Whitmarsh, L. 2011. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change* 21(2): 690-700.
- Williams, S., L.J. McEwen, and N. Quinn. 2017. As the climate changes: Intergenerational action-based learning in relation to flood education. *The Journal of Environmental Education* 48(3):154-171.
- Yamamura, E. 2010. Effects of interactions among social capital, income and learning from experiences of natural disasters: A case study from Japan. *Regional Studies* 44(8): 1019-1032.
- Yusuf, J.-E., M. Covi, C. Considine, B. St. John III, M.M. Jordan, and J.G. Nicula. 2018a. Toward a whole-of-government and whole-of-community approach for regional adaptation to sea level rise: Lessons learned from the Hampton Roads Intergovernmental Pilot Project. In: *Environmental Policy and the Pursuit of Sustainability*, C. Schelly and A. Banerjee (Eds.). Routledge Taylor and Francis Group, London and New York, pp. 47-62.
- Yusuf, J.-E., B. St. John III, M. Covi, and J.G. Nicula. 2018b. Engaging stakeholders in planning for sea level rise and resilience. *Journal of Contemporary Water Research & Education* 164(1): 112-123.

Appendix 1. Survey Materials

Recruitment Email

Subject: Flood Hazard Awareness Questionnaire

Dear ODU Student,

Please consider answering this “Flood Awareness among Old Dominion University Students” questionnaire linked here https://odu.co1.qualtrics.com/jfe/form/SV_6gRkAmwox9KiTqZ.

The questionnaire should require no more than 10 minutes to complete.

No identifying information is requested, nor will it be included in the analysis of the responses.

Responses will be used to assess Old Dominion University (ODU) students’ awareness, experiences, and perceptions of floods. Results will contribute to

awareness raising activities on-campus, presentations at professional conferences, and publications in academic journals.

Your participation is voluntary. You may choose not to fill-out the questionnaire, skip questions in the questionnaire, or stop the questionnaire at any time with no consequence. If you chose to take the questionnaire, please only do so once.

Additional participant information is provided on the introductory page of the questionnaire.

Sincerely,

Drs. Michael Allen and Nicole Hutton

Survey Questionnaire

Thank you for your interest in the “Flood Hazard Awareness among Old Dominion University Students” study.

The questionnaire should require no more than ten minutes to complete. Most questions will be yes or no. Some will be multiple choice or fill in the blank. Questions will collect consent, as well as flood experience and perceptions.

Your participation is voluntary. You may choose not to fill-out the questionnaire, skip questions in the questionnaire, or stop the questionnaire at any time with no consequence. If you chose to complete the questionnaire, please do so by November 30, 2019.

Your name, student number and/or any other identifying information is not requested, nor should it be provided in any responses to protect your anonymity. No grade may be assessed by any instructor based on the answers to the questionnaire.

No risk of harm is expected from the questionnaire; however, should the questions cause any unsettling feelings or emotions, please contact the ODU Office of Counseling Services at 757-683-4401.

If you have any questions or concerns, please contact Dr. Michael Allen (Principal Investigator) at mallen@odu.edu, Dr. Nicole Hutton (Co-Investigator) at nhuttons@odu.edu, or Dr. Randy Gainey (Chair of the Arts and Letters Human Subjects Review Committee) at rgainey@odu.edu.

Do you understand the information provided to you about this study?

Yes

No

Do you consent to participate in this study?

Yes

No

What is your student standing?

Freshman

- Sophomore
- Junior
- Senior
- Graduate Student

Are you a campus resident?

- Yes
- No

Where did you live prior to attending ODU? (Zip code)

Are you a commuter?

- Yes
- No

Do you have a declared major?

- Yes
- No

Display This Question:

If Do you have a declared major? Yes Is Selected

What is your major?

Has street flooding ever caused a class cancellation or affect your class attendance in the time you have been a student at ODU?

- Yes
- No

Display This Question:

If Has street flooding ever caused a class cancellation or affect your class attendance in the time...Yes Is Selected

How often has street flooding caused you to miss class or cause one of your classes to be canceled?

- Less than once a year
- Once a year
- Once a semester
- Multiple times each semester
- Monthly
- Weekly
- Daily
- Multiple times each day

Have you experienced damage to your residence or other property as a result of flooding in the time you have been a student at ODU?

- Yes
- No

Display This Question:

If Have you experienced damage to your residence or other property as a result of flooding in the ti...Yes Is Selected

What part(s) of your property was damaged as a result of flooding in the time you have been a student at ODU? (select as many as apply)

- Yard
- Building
- Vehicle

- Parking area
- Clothes
- Other

Do you consider Norfolk as having a high flood risk?

- Yes
- No

How do you receive warnings, if at all, about flooding in Norfolk? (select as many as apply)

- Text
- Email
- Call
- News
- Social Media
- Other
- I do not receive warnings

What factor(s), if any, do you perceive to cause flooding in Norfolk? (select as many as apply)

- Rain
- Snow
- Tides
- Storm surge
- Sea level rise

How often have you experienced flooding in the past year?

- Never
- Once a year
- Twice a semester
- Multiple times each year
- Monthly
- Weekly
- Daily
- Multiple times each day

Have you or someone you know been injured in a flood?

- Yes
- No

Who should be responsible for flood risk awareness at ODU? (select as many as apply)

- Flood management experts
- Emergency management experts
- Faculty
- Administrators
- Students
- Other

Has climate change affected the frequency and/or intensity of any of these events in Norfolk: (select as many as apply)

- Floods
- Hurricanes
- Droughts
- Earthquakes
- Tsunamis
- Tornados
- Heatwaves
- Nor'easters

None of the above

Have any of your ODU course materials alerted you to flood risks in Norfolk?

Yes

No

I don't know

Display This Question:

If Have any of your ODU course materials alerted you to flood risks in Norfolk? Yes Is Selected

What is the name of the course(s) from which you received materials related to local flood risk? (list all that apply)

Display This Question:

If Have any of your ODU course materials alerted you to flood risks in Norfolk? Yes Is Selected

What was the key message of the course material related to flood risk that you received?

Do you wish you learned more about local flood risk in courses?

Yes

No

Have any of ODU orientations alerted you to flood risks in Norfolk?

Yes

No

I don't know

Display This Question:

If Have any of ODU orientations alerted you to flood risks in Norfolk? Yes Is Selected

What was the topic of the orientation in which you received materials related to local flood risk? (list all that apply)

Display This Question:

If Have any of ODU orientations alerted you to flood risks in Norfolk? Yes Is Selected

What was the key message of the orientation material related to flood risk that you received?

Do you wish you learned more about local flood risk in orientations?

Yes

No

Appendix 2. Sample Characteristics

Ethnicity	%
African American	33.57
Asian	4.27
Hispanic	9.04
Native American	0.10
Native Hawaiian / Pacific Islander	0.30
Non-Resident Alien	4.07
2 or more	7.45
Unknown	1.49
White	39.72
Gender	%
Female	52.63
Male	47.37