

Flooding Mitigation Techniques in Other Flood-Prone Regions and an Analysis of Their Possible
Use to Charlottesville

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Kiri Nicholson
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On my honor as a University Student, I have neither given nor received
unauthorized aid on this assignment as defined by the Honor Guidelines
for Thesis-Related Assignments

Signature *Kiri A. Nicholson* Date 04/26/2020
Kiri A. Nicholson

Approved _____ Date _____
Michael E. Gorman, Department of Engineering and Society

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Comments from Professor Gorman regarding Thesis in Spring 2020:

I quickly re-read your draft and it looks like you have most of the info necessary to follow the path I suggested. Trading zones and interactional expertise give you a way to frame the solution, to talk about the kind of collaboration that will be necessary to achieve the goal of getting multiple stakeholders and expertises involved in coming up with solutions to the way incidental and recurrent flooding can damage housing, cut off roads, etc.

The grade above is a placeholder until you get your next draft in.

In addition, Professor Gorman made some suggestions in our meeting, and the ideas I took away from this meeting include but are not limited to:

- *Lean on the 4 behaviors*
- *Boundary Organizations → NGOs*
- *Are there more NGOs in Hampton Roads?*
- *One framework would be ANT -> who has to be pulled together?, another is interactional expertise -> UVA & the City of Charlottesville, trading zones; these result in “symbiotic” relationships*
- *The homeowner has expertise over time -> collaborate*
- *Identify main stakeholders*
- *Do I need a diagram?*
- *ANT -> one group recruiting others*
- *At the end → Ideas for more research*
- *Engaging locals → How is the system changing?*

I chose to talk more about the 4 behaviors, and do some more research on NGOs in Hampton Roads, as well as used Prof. Gorman's guidance in my execution and content. I also heavily relied on ideas given by Prof. Gorman to do my analysis and to guide content, including his ideas about getting individuals to "buy-in" and many of the ideas mentioned above. I chose not to include a diagram, as I felt it did not add much value, but I did add a "future research" section because I felt it was valuable.

Flooding Mitigation Techniques in Other Flood-Prone Regions and an Analysis of Their Possible

With the pressing threat of climate change becoming ever more apparent, one starts to consider the personal implications of such a massive problem on our daily lives. An increase in catastrophic weather events is a widely accepted consequence of climate change. More specifically, such events have "become more frequent and intense in the past decades" (Cheng et al., 2017, p. 25). With these changes comes an increase in storms and rain levels. These events, in turn lead to flooding.

Even in more inland areas such as Charlottesville, Virginia, flooding is an issue when heavy rainfall is frequent. Efforts to mitigate the impacts of this flooding are already underway. This work includes but is not limited to a capstone project performed for the City of Charlottesville by University of Virginia students and faculty in collaboration with a grassroots, non-profit organization, Smart Cville (*Smart Cville*, n.d., "About"). This capstone project was funded by the National Science Foundation.

Flooding mitigation strategies are not one-size-fits-all; numerous technical, economic, and social factors need to be considered when deciding the optimal set of solutions for any ecosystem. However, it is not necessary to "reinvent the wheel," either. A community can look to other areas of the world for inspiration, and seek out data on tried-and-true flooding mitigation

strategies. In my thesis I will look at flooding mitigation strategies employed in other flood-prone areas, and will analyze them and their potential use to the community of Charlottesville, VA. I will use trading zones and interactional expertise as the STS frameworks with which these technical, economic, social, and political factors are evaluated. The concepts for these two STS frameworks were introduced to the author in STS 4500 in Fall 2019. The meanings of these concepts were outlined in class discussions, the Sept. 22, 2019 class forum and a few class readings (Gorman & Werhane, n.d., Collins et al., 2007).

In this thesis, only mitigation efforts will be considered, as opposed to disaster relief efforts. These efforts include “actions taken to reduce loss of life and property by lessening the impact of disasters” (United States. Congress. House. Committee on Transportation and Infrastructure. Subcommittee on Economic Development, 2014, p. iv). When compared to disaster relief, mitigation has been shown to both save lives and save money in the long run (United States. Congress. House. Committee on Transportation and Infrastructure. Subcommittee on Economic Development, 2014, p. iv). In fact, in a study, “Potential Cost Savings from the Pre-Disaster Mitigation Program,” Congressional Budget Office, September 2007, mitigation has been found to be cheaper than disaster relief by “an overall ratio of 3 to 1” (United States. Congress. House. Committee on Transportation and Infrastructure. Subcommittee on Economic Development, 2014, pp. iv-v). For many communities, flooding mitigation may end up being more feasible than responding to every flooding event as it occurs, since this practice would certainly prove to be more costly in the long run, as cited above. Therefore, it is important that proper consideration be given to these flooding mitigation practices now, and not just disaster relief efforts later. Some of these mitigation efforts may involve changes to a community’s infrastructure, so it’s important to understand what kinds of infrastructure are available and used.

When infrastructure is being looked at with regards to flooding, there is one major distinction that should be made, the one between: (1) gray infrastructure and (2) green infrastructure. According to USEPA (2016), green infrastructure includes things “such as Green Roof, Bio-Retention Cell, Rain Barrel/Cistern, Vegetative Swale and Permeable Pavements” that “reduce runoff, minimize pollutant discharges, decrease erosion, and maintain base flows of receiving streams” (Xie et al., 2017, p. 144). Also according to USEPA (2016), gray infrastructures, however, include “gutters, storm sewers, tunnels, culverts, detention basins, pipes and mechanical devices” and are “used collectively in a system to capture and convey runoff” (Xie et al., 2017, p. 143). As Qin et al. (2013) and Chen et al. (2015) note, while gray infrastructures are a “typical approach”, these infrastructures are also seen as stop-gap measures; it’s hard for communities to keep up with the demand for these infrastructures (or for an increase in their capacity) since they’re relatively expensive and not terribly efficient (Xie et al., 2017, p. 143). However, “grey infrastructure such as new pipes, pump stations and deep tunnels (Kang et al., 2016; Wu et al., 2016) are frequently applied at flooding hotspots” but may actually make matters worse; when new gray infrastructure is implemented, there’s a good chance all it’s doing is moving the problem to another area in the ecosystem, since extra water is being carried elsewhere (Huang et al., 2018, p. 395). Huang, et al. also notes “[i]n response to urban flooding, green infrastructure is the best measure because it has less impact on natural hydrological characteristics (Ishimatsu et al., 2017; Pappalardo et al., 2017)” (Huang et al., 2018, p. 395) As Cheng (2016) points out, green infrastructure also provides a possible avenue of achieving climate justice in communities (as cited in Cheng et al., 2017, p. 25). This is an important social and political factor to be considered in Charlottesville, VA, given its unique history fraught with systemic racial and social issues. There are many examples of this history in Charlottesville,

including, an article published in 1991 “suggests that discrimination related to race is a reality in Charlottesville’s public housing” and of course the white supremacist rallies on August 11th and 12th of 2017 (Harr Sr. & Olmsted, 1991, p. 172).

There are many possibilities to consider as to what mitigation strategies should be employed, but the question remains: Who should be leading this effort? This question is without a simple answer. Research indicates that leadership of these efforts needs to be positioned carefully. Harvatt et al. express a distrust of the individual, noting that there is “evidence that householders living in natural hazard areas often fail to act, or do little to lessen their risk of death, injury or property damage (e.g. Kunreuther 1978; Peek and Mileti 2002; Siegrist and Gutscher 2008)” (Harvatt et al., 2011, p. 64). While the dangers of not acting quickly to address flooding may seem obvious to some, that is not the case with all people or all communities. In one work, it is suggested that the “reason for farmers’ lack of behavioural engagement is the invisible and intangible nature of climate change, often leading individuals to deem it ‘psychologically distant’ (Kollmuss and Agyeman 2002; Pidgeon and Fischhoff 2011)” (Hamilton-Webb et al., 2017, p. 1381). Another example of such a disconnect can be seen in the the following behavioural patterns identified by Burton et al. (1993) which Harvatt et al. (2011) reference on page 65:

- (1) Absorb – denial of a risk or that the hazard poses a threat to them personally.
- (2) Accept – understanding of hazard effects may be significant but no perception of a personal action role.
- (3) Reduce – understanding of potential damage and willingness to take emergency action upon receipt of a warning.
- (4) Change – willingness to take preventative action to reduce a future hazard, for example moving house or changing land use. (Burton et al., 1993 as cited in Harvatt et

al., 2011, p. 65)

Perhaps a community will never get to steps “(3) Reduce” or “(4) Change” by themselves, and need some larger body to recognize risk and organize a response; when a community is ready to deploy disaster relief efforts, this would fall under (3), a “willingness to take emergency action”(Burton et al., 1993 as cited in Harvatt et al., 2011, p. 65). However, what really needs to be happen, is for a community to be at (4), or a “willingness to take a preventative action to reduce future hazard,” which we know to be a mitigation effort (Burton et al., 1993 as cited in Harvatt et al., 2011, p. 65).

To summarize the study as presented in Harvatt et al., it “show[ed] that individual householders’ understanding and response to both flooding and sea-level is driven by a diversity of evidence and experience drawn from and reflecting people’s immediate physical and social environments” (Harvatt et al., 2011, p. 69) Therefore, it is perhaps preferred that decisions regarding safety and the possible employment of these mitigation strategies not be entirely left up to the individuals or even smaller, more independent communities. It is apparent that government or some other broader organizational body must get involved. However, as was also stated in Harvatt et al., trust is very important when conveying risk, and there is “evidence that those unsure about the source of warnings tend to rely more on their social networks than on official communication (Drabek 1986; Parker and Handmer 1998)”; so it is obvious that if efforts come too heavily from only the government or another large, disconnected body, their warnings may not be taken seriously (Harvatt et al., 2011, p. 65). The question then changes to one of a fine balance: How do we ensure that (1) a suitably broad and safe mitigation plan is organized, while (2) also getting buy-in on an individual level? Using the STS framework of trading zones, a trading zone

must be established between all parties: citizens, communities, and the government. By interacting in a positive way and trading resources as well as knowledge, these trading zones can help foster the special relationship that these parties must have in order to properly support flooding mitigation plans. The government would be able to provide resources like federal funding and higher-level organization. Communities know what is best for their respective ecosystems, and can work on the ground level with the help of individual citizens to take care of the environment and address flooding mitigation through infrastructure changes. Without either party, this relationship would fall short and either lose community backing or larger resources needed by those communities.

Given this predicament, some of the most valuable work may come from NGOs, or Non-Governmental Organizations which can provide room for these trading zones. We've started to see some success with this in Charlottesville already, with the development of Smart Cville (*Smart Cville*, n.d.) In Hampton Roads, Virginia, though, there are a few major NGOs that lead various waterway conservation efforts that would affect community flooding levels: Wetlands Watch, Elizabeth River Project, and the Friends of Norfolk's Environment (*Wetlands Watch*, n.d., *Elizabeth River Project*, n.d., *FRIENDS OF NORFOLK'S ENVIRONMENT*, n.d.).

Hampton Roads, Virginia is another part of the state that experiences flooding when increased precipitation happens. In fact, it was the site of a previous iteration of the capstone work funded by the NSF mentioned in the introduction of this thesis.

As is stated on their website, "Wetlands Watch works with both a top-down approach, through state and federal policy advocacy, and a bottom-up approach, using grass roots education and activism to influence local government land use and regulatory decisions" (Wetlands Watch, n.d., "Who We Are"). Among many other efforts, Wetlands Watch puts on educational

programs, organizes donors, and helps involve the private sectors in their work (Wetlands Watch, n.d., “Who We Are”). Under their belief statement, they write: “Environmental regulators and local government need the support of these informed and engaged citizens to effectively enforce laws and regulations. Wetlands protection and conservation cannot be achieved without consensus, commitment, and partnership” (Wetlands Watch, n.d., “Who We Are”). This belief statement echoes the conclusion reached in a prior section of this thesis. A larger body needs to be available to organize mitigation efforts, but these efforts will come to nothing if they’re not backed up by the time and energy of individuals in the affected community. Wetlands Watch has specific efforts aimed towards Floodplain Management, specifically in their work with the Community Rating System, or CRS, which “is a FEMA program that incentivizes a strong floodplain management program by offering discounts on flood insurance rates for all policyholders within that community” (Wetlands Watch, n.d., “Floodplain Management”; *Community Rating System*, n.d.). Wetlands Watch is advocating the use of the CRS in an effort to get Virginian coastal communities ready to be more resilient against flooding and sea-level rise (*Community Rating System*, n.d.). Also noted on their website, “allowing floodplains to revert back to their natural state is the ideal strategy for sea level rise adaptation” (Wetlands Watch, n.d., “Floodplain Management”). This advocacy on behalf of the CRS is an excellent example of the reward that comes out of a trading zone relationship between local and state communities and the federal government.

Another NGO that is present in the Hampton Roads area is the Elizabeth River Project. Their mission is “[t]o restore the Elizabeth River to the highest practical level of environmental quality through government, business and community partnerships” (Elizabeth River Project, n.d., “About the Elizabeth River Project”). The Elizabeth Project provides several educational

resources, many aimed at youth, including their Learning Barge, which is a boat frequently used for field educational trips (Elizabeth River Project, n.d., “Education”; Elizabeth River Project, n.d., “The Learning Barge”) They also have published a “Watershed Action Plan” (2016) that can be downloaded from their website, and while flooding is not directly addressed, their work to conserve the watershed is a helpful tangential effort (Elizabeth River Project, n.d., “Watershed Action Plan”). The Elizabeth River Project is somewhat unique in its emphasis on youth-oriented outreach, including programs they put on in partnership with schools and school children, such as the recent Youth Resilience Expo that brought together students from Chesapeake, Portsmouth, and Norfolk, Virginia (Elizabeth River Project, n.d., “Education”; David Macaulay, *Virginian-Pilot Correspondent*, 2020). This focus on advocacy in the youth community sets up a notable trading zone between children, who can offer time and interest, and the larger community, who will benefit from this interest down the road when the children age and join the community as adult stakeholders and citizens. As stated by Thew, youth are “most impacted by climate change” and “will also inherit responsibility for tackling it” so “the participation and agency of youth is a particularly pertinent concern” (Thew, 2018, p. 370).

Friends of Norfolk’s Environment is another NGO also located in Hampton Roads, Virginia, though they take a broader focus when it comes to their efforts (*FRIENDS OF NORFOLK’S ENVIRONMENT*, n.d., “WHO WE ARE”). As written on their website, “FONE supports projects throughout the City of Norfolk. These projects include but are not limited to increasing the tree canopy, promoting sustainable wetland practices, supporting green infrastructure, volunteering for waterway and park clean ups, and planting urban gardens” (*FRIENDS OF NORFOLK’S ENVIRONMENT*, n.d., “WHAT WE DO”). While their efforts do span to waterway projects, such as the Lafayette Wetlands Partnership, this is not their only focus

(*FRIENDS OF NORFOLK'S ENVIRONMENT*, n.d., "WHAT WE DO"). FONE also "believe[s] that citizen-based initiatives build stronger, more resilient neighborhoods" and "that partnerships among government, businesses, non-profits, and citizens afford the best opportunity for success" which again backs up the idea that successful trading zones are crucial. (*FRIENDS OF NORFOLK'S ENVIRONMENT*, n.d., "WHO WE ARE")

In Charlottesville, Virginia, work is being done by students and faculty of the University of Virginia for the City of Charlottesville in order to address infrastructure issues that worsen flooding. The City brought in a capstone team of Civil Engineering, Systems Engineering, and Computer Engineering students and faculty to help find solutions for these flooding issues. This particular trading zone established a working relationship between the City and the University in a way that allowed for the sharing of each of their interactional expertise. For example, the City employees have a lot of knowledge surrounding Charlottesville and the constraints of their budget and abilities, but not necessarily knowledge of the desired technological solution-space. They were able to present the University team with information regarding the social and economic factors that pose as barriers to solving some of these infrastructure issues, which the team was able to take into account during their technical development of a possible solution. So, in this way the University faculty and students were able to bring engineering knowledge and ideas to the table that the City may not have had available. The University team also had to learn to consider the City's perspective more often; functionalities that were not immediately obvious to the University team proved to be very important to the City. For example, developing a system that was able to be deployed without drilling into or damaging a pipe upon installation was very important to the City, whereas the University team might not have considered installation much in their design process. Overall, this trading zone proves to be beneficial to

both the City and the University, and serves as an excellent example of the possible roles of academic groups and governments working together on these mitigation solutions. Academic organizations can generally bring a lot of expertise and time to a problem that the government would like to be solved or worked on.

In the future, further research on a few topics could be suggested. More work covering Charlottesville's residents' feelings on the topics of flooding mitigation and climate change mitigation efforts in general would be useful, as well as a survey of the knowledge of these topics had by these residents at the current time. This would allow for a more informed set-up of trading zones in the community. In addition, further research in an area with a perhaps "failed" trading zone that tried to address flooding or other climate change related effects would be particularly useful. Through these failures, lessons could be learned about specific missteps that could be avoided in future work.

Climate change is known today to be a pressing issue that will affect our way of life for generations to come. It is therefore very important that both we as citizens of local communities and our respective governments fully consider how best to respond to the many consequences of climate change, including but not limited to flooding. In Charlottesville, Virginia, specific mitigation work is starting to be done in an effort to reduce flooding, though it is far from over. The Charlottesville community needs support from citizens and NGOs as well as local, state, and federal government. Through setting up trading zones, we can ensure that these flooding mitigation efforts are properly supported. Citizens and local communities will provide the trust and buy-in needed to make sure that these efforts survive over time. Their knowledge of the communities they live and work in everyday will be invaluable moving forward. State, local, and federal governments, in turn, are sorely needed as an organizational layer in this situation.

They can provide various levels of legislative, judicial and executive support, as well as more man-power and funding when needed. In addition, academic groups such as universities can bring lots of time and specialized knowledge to the table. Each of these parties has a certain interactional expertise that will be invaluable in the success of these trading zones. Perhaps Harvatt et al. said it best when they asserted: “[n]atural hazard management requires a careful ‘combining of individual, community and national action’ (Burton et al. 1993, 163)” (Harvatt et al., 2011, p. 63). Charlottesville can look to other areas of the state and of the world as a guide to how best maintain the safety of its community through proper flooding mitigation strategies.

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