A Land Suitability Analysis for Post-Disaster Housing Relocation: An Application in Fair Bluff, North Carolina after Hurricane Matthew

BY

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“For me, a key point is that some of the catastrophic events, such as the series of three extremely damaging hurricanes, or the very severe flooding in South Asia after extraordinarily heavy monsoon rains, are giving us a foretaste of what is to come.”

– Torsten Jworrek, Board Member of Munich Re, Global Reinsurance Business Group

“There’s a lot we can and must do to limit the economic costs and human toll from disasters. First and foremost, we must do more to prepare and protect communities ahead of time by investing in risk reduction and disaster preparedness and by ensuring that our federal, state and local policies are guided by the best available science”.

– Rachel Cleetus, Lead Economist and Climate Policy Manager, Union of Concerned Scientists

“Hope isn't something you have. It's something you do, an attitude, an approach to life, something we share with one another. If we create a collective capacity to hope, then we can use our courage and wisdom to make real change”.

– Dr. Hawthorne Smith, Psychologist and Clinical Director at Bellevue/NYU Program for Survivors of Torture

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Chapter 1: Introduction

After major floods in the U.S., when dozens or even hundreds of homes and business are damaged or destroyed, entire neighborhoods can be displaced for months or even years. In many cases, the individual or family will never return to live in the home and instead will take money through federal government programs (and others) to have their home demolished, the property kept as open space in perpetuity, and the opportunity to relocate to a more desirable area, thus reducing future flood damages (a form of 'hazard mitigation'). When more than just a few households leave a neighborhood or dozens to hundreds leave a municipality, a number of challenges and issues can arise. From the financial impact of a reduced property tax base to the physical and social severing of connections within a tight-knit community, the damage as a result of flooded residents moving away can be devastating and long-lasting.

Abandoned homes are often left unoccupied and can fall into disrepair or, as required by federal home acquisition programs, the property becomes open space or a vacant lot which if left unmanaged, can contribute to blight and reduced property values in the neighborhood. Additionally, since FEMA's Hazard Mitigation Grant Program (HMGP) is voluntary, some residents leave and others stay, resulting in a 'checkerboarding' effect of interspersed vacant and occupied properties, producing a feeling of incompleteness and disconnection. 'Checkerboarding' also leaves the local government's responsible for maintaining infrastructure (i.e., water, sewer, roads, sidewalks) for remaining homes, an inefficient process because the repairs and maintenance needed serves fewer people than it did before the flood. All of these factors lead to a number of negative effects that can be minimized or eliminated through thoughtful planning and decision-making about where those who choose to leave end up relocating.

While many communities undertake some sort of comprehensive planning process, attempting to understand how and where a community wants grow or evolve in the future, major floods or disasters introduce an urgent and critical need to find safe, permanent locations for families to move to after the temporary shelters or housing assistance (i.e., motel, hotel, mobile home) expire. Projected areas of future growth or development guided through comprehensive

planning efforts often fails to take into account the risk associated with known hazardous areas. Instead communities often wait to act after a major disaster as was the case in many North Carolina communities following Hurricanes Floyd (1999) and Matthew (2016). After a disaster, a land suitability analysis (LSA), like the one used for this project, can be used to identify and prioritize the most appropriate areas for development or redevelopment outside of hazardous areas that are also within the community and close to existing infrastructure. This type of analysis can inform communities as they try to develop relocation strategies for those who are displaced or are considering permanent moves while alleviating some of the negative effects described above. An LSA could also be used before a disaster, knowing that there are areas or neighborhoods at risk from flooding, especially when considering that future changes in climate could increase both the severity and frequency of floods. The LSA's flexibility makes it a powerful tool for climate adaptation planning and in mitigating any natural hazard that can be geospatially defined (i.e., floods, wildfires, sea-level-rise, volcanic eruptions, etc.) during the disaster recovery process. A similar method could also be used when there is major displacement of housing due to large infrastructure projects (i.e., highway construction) or other human-caused disturbance.

I will demonstrate the usefulness of a tailored land suitability analysis for post-disaster recovery using the Town of Fair Bluff following Hurricane Matthew. In Chapter 2, I discuss the consequences of increasingly damaging floods, the experience in Eastern North Carolina with Hurricane Matthew, how the FEMA Hazard Mitigation Grant Program (HMGP) works, what makes it challenging to implement, and the role of planning in hazard mitigation and disaster recovery. In Chapter 3, I describe the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI) and the goals of its relocation strategy (RS). Chapter 4 summarizes the history and various types of land suitability analysis (LSA), including the methods used here, and how variables and thresholds were chosen, the geographic information systems (GIS) and community engagement steps taken, as well as the limitations of the analysis. The results of the LSA conducted for the Town of Fair Bluff, North Carolina are discussed in Chapter 5 in the context of the Town's major recovery priorities. Lastly, Chapters 6 and 7 discuss conclusions and offer recommendations and suggestions for future research.

Chapter 2: Flooding and Disaster Recovery Planning

I. Impacts of Floods

A. A Growing National Concern

Since the passage of the Disaster Management Act of 2000 (DMA2K), a landmark hazard mitigation policy that requires all local, state and Indian Tribal governments to develop hazard mitigation plans to be eligible for federal mitigation funds, there have been 38 disasters costing *at least* one billion dollars as a result of either major floods or tropical cyclones, which includes tropical storms and hurricanes (NOAA NCEI, 2018). Altogether those events have resulted in over $768 billion in damage (adjusted for inflation), with hurricanes Harvey, Irma, and Maria in 2017 accounting for about $265 billion or about one third of the total damages seen in the past 17 years from floods and tropical cyclones (Figure 1). To date, 2017 has been the costliest year in U.S. history, with over $306 billion of damage, exceeding the previous record set in 2005 of $215 billion (Cleetus, 2018). Disaster damages from all types of natural hazards have significantly escalated in the U.S. from $145.7 billion in the 1980s and $211.3 billion in the 1990s to $418.4 billion in the last decade –a two-fold increase compared to the 1990s and an almost three-fold increase, compared to the 1980s (Universal Ecological Fund, 2017). The staggering numbers seen in 2017 represent a remarkable year in terms of major tropical cyclones impacting heavily populated areas of the U.S., but many other flooding or hurricane events have had devastating consequences for communities that may have less absolute infrastructure or population as risk. Additionally, the billion-dollar disaster statistics do not consider the dozens of extreme flooding events that occur annually on a more localized scale, therefore not receiving

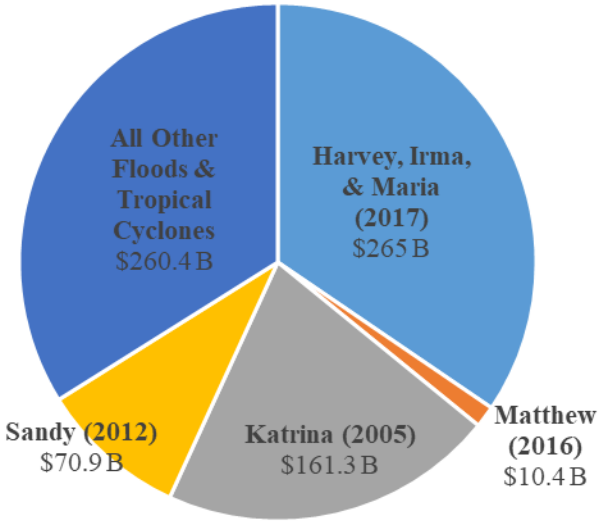


Figure 1. 2000-2017 U.S. Costs ($ Billions) of Tropical Cyclones and Floods

Presidentially Declared Disasters (PDDs), but still cause significant physical, economic, environmental, and social damage to communities across the country.

The overall risk of impacts from flooding is expected to increase as human-induced climate change produces more frequent and intense extreme precipitation events as well as more intense tropical cyclones which will be exacerbated by accelerating sea-level-rise in low-lying coastal areas (National Climate Assessment, 2014). It's also been made clear throughout human history, that those who are the worst off tend to experience the greatest impacts of floods and other disasters and take longer to recover due to socio-economic status, ability to access political power, etc. A recent working paper from the National Bureau of Economic Research concluded that "During a time of increased concern about income inequality and climate change risk, natural disaster exposure risk could become another cause of rising quality of life inequality between the rich and the poor" (Boustan, L. et al., 2017). These increasingly difficult, frequent, large-scale issues demand a more effective blending of disaster recovery and hazard mitigation planning and implementation, including an assessment of resettlement strategies.

B. Hurricane Matthew Impacts in North Carolina

In October of 2016, Hurricane Matthew took a track parallel to the Southeast coast from Florida to North Carolina producing widespread heavy rainfall amounts totaling 10-18 inches and resulting in numerous record river flood stage levels (Appendix Figure A1). North Carolina was especially hard hit, partly because soils had been saturated by Tropical Storms Julia and Hermine earlier in the season, and subsequently saw the Tar, Cape Fear, Cashie, Lumber and Neuse Rivers reach record water levels, remaining at flood stage for close to two weeks (NC Office of the Governor, 2017).

While half of North Carolina's 100 counties were impacted and were eligible for FEMA's Public Assistance program (forty-five were eligible for FEMA's Individual Assistance Program), the four counties of Cumberland, Edgecombe, Robeson, and Wayne counties saw 64% of the states' impacts in terms of homes that sustained 'major' or 'severe' damage (NC Dept. of Commerce, 2017). With more than 300,000 businesses experiencing physical and/or economic impacts and about 35,000 households sustaining varying levels of damage during the storm (5,000 considered unlivable), many North Carolinian communities are struggling to bounce back

and will be recovering for the years and perhaps decades to come (NC Department of Commerce, 2017). Many of these same communities also saw devastation during major floods associated with Hurricanes Fran (1996) and Floyd (1999), with some experiencing floods prior to and since then, creating an interesting, but challenging timeline of overlapping recovery.

The Town of Fair Bluff, a small community in Columbus County, North Carolina (population about 1,200) impacted by Hurricane Matthew in 2016, has a historic downtown that lies adjacent to the Lumber River. Since the flooding almost two years later, there's still a great worry about what will happen to the severely damaged commercial buildings as well as the many households who are not expected to return to their flooded homes (Figure 2). Introduced as a case study for this project, Fair Bluff is dealing with several issues, including some that existed before the storm (i.e., aging and declining population, high poverty rates, and poor health), that they're trying to address in an ongoing disaster recovery planning effort.

However, given their small size and severe lack of dedicated or trained staff to engage in post-disaster planning, they rely heavily on outside organizations (i.e., religious disaster relief, regional council of governments, state government) and have received assistance through the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI) described in greater detail below.

Figure 2. Flooded Downtown in Fair Bluff, NC. Source: The News & Observer, 2016

II. Flood Hazard Mitigation

Defined in the literature, natural hazard mitigation refers to "advance action taken to reduce or eliminate the long-term risk to human life and property from natural hazards" (Godschalk et. al. 1999, pp 5). Types of mitigation actions can include: local plans and

regulations, structural projects, natural systems protection, education programs, and preparedness and response actions (Beyond the Basics, 2008). Under the umbrella of non-structural flood mitigation actions are measures such as the acquisition of structures in flood prone areas, elevation of buildings or critical elements within (i.e., electrical wiring, HVAC units, etc.), whereas structural measures include the construction of floodwalls, levees/dikes, or other retaining wall. The opportunity to inject risk reduction or hazard mitigation measures exists throughout the traditional disaster management cycle of preparedness, response, and recovery, though most communities may not recognize the importance of hazard mitigation until after their vulnerabilities have been made clear or even worsened post-disaster. Typically, the investment in hazard mitigation is greatest immediately after the event through FEMA's HMGP, which is explained later in this chapter.

Investments in hazard mitigation actions and disaster risk reduction strategies have proven to be cost effective over time, especially in the long-term. Using benefit-cost analysis, organizations can determine how effective an action is in terms of its cost versus future benefits (often expressed in dollars), which is usually referred to as a return on investment (ROI) or benefit-cost ratio (BCR)[1]. The most commonly cited rule of thumb for the potential ROI for federal mitigation measures has been 4 to 1 (National Institute for Building Sciences, 2005), but the most recent report, which includes projects from other federal agencies outside of FEMA, found that for riverine flooding, the benefit-cost ratio is as high as 7 to 1 as shown in Figure 3 (Multihazard Mitigation Council,

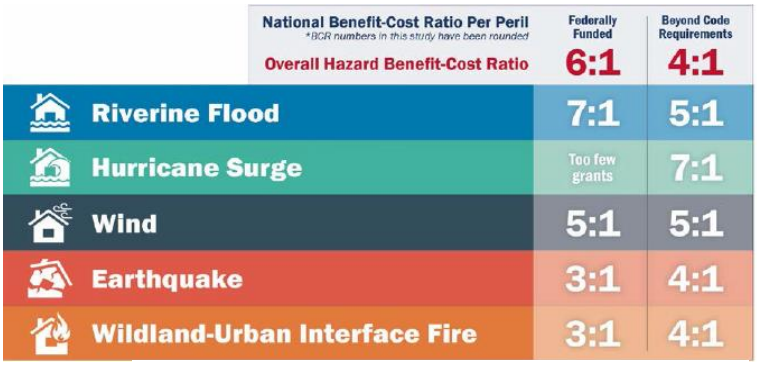


Figure 3. Federal Mitigation Benefit-Cost Ratios from 2017 MMC Interim Report

[1] "The Stafford Act requires every project funded by HMGP to be cost effective, as demonstrated by a Benefit-Cost Analysis (BCA). BCA involves estimating and comparing the expected costs and future benefits of a project; dividing a project's total net benefits by its total cost results in the benefit-cost ratio (BCR). A project is considered cost-effective when its BCR is greater or equal to 1.0".

2017)[2]. Other reports have calculated disaster risk reduction measures can produce benefit-cost ratios as high as 10 to 1 (Swiss Re, 2016).

Knowing how powerful these mitigation actions can be in reducing flood risk, it's crucial for communities to implement them when possible. However, there are many challenges and unforeseen costs associated with implementing hazard mitigation measures which are further described later in this chapter. Successful projects benefit from the application of planning practices, particularly before a disaster occurs when there is less political, financial, and emotional pressure to make decisions. How and where a community builds (or rebuilds) is mostly determined by local land use codes and regulations which can advance community development and economic goals along with hazard mitigation goals if the efforts are coordinated and informed by each other. To achieve this, greater collaboration is needed between disciplines of planning, emergency management, floodplain management, public works, public health, housing, and others. With concerted effort, this collaboration can greatly enhance the success of federal hazard mitigation programs.

A. FEMA's Hazard Mitigation Grant Program

When major storms or flood events lead to presidentially declared disasters (PDD), a number of FEMA-funded programs are triggered, including the Hazard Mitigation Grant Program (HMGP)[3] which is authorized under Sector 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Among other mitigation project types (i.e., retrofitting of buildings, educational outreach, etc.), the HMGP allows communities to implement hazard mitigation measures for homes that were significantly flooded. Each state is responsible for developing a HMGP Administration Plan that establishes and prioritizes, subject to federal rules,

[2] Following the Natural Hazard Mitigation Saves: 2017 Interim Report, FEMA released the draft National Mitigation Investment Strategy for comment in January of 2018. The report, which was developed by the Mitigation Framework Leadership Group (MitFLG), claims to "provide a national approach to investments in mitigation activities and risk management across federal, state, local, tribal and territorial governments and the private and non-profit sectors" (FEMA, 2018).

[3] In most states, HMGP funding is based on 15% of total federal disaster costs and requires a 25% non-federal match. Because the State of North Carolina developed an Enhanced State Hazard Mitigation Plan, it is eligible to receive HMGP funds equivalent to20% of the total federal recovery assistance funds following a presidentially declared disaster.

which mitigation activities can be implemented. Some states may decide to focus their HMGP funds on non-structural measures such as creating hazard mitigation plans, conducting research or funding education and training programs, while others may focus on flood proofing or relocating at risk housing and critical public facilities and implementing stormwater management projects.

The two primary flood risk reduction measures for individual homeowners implemented through the HMGP in North Carolina are:

1) **Elevation:** structure or home is elevated off of the ground to a safer height usually dictated by a municipality's local Flood Damage Prevention Ordinance; if elevation of structure isn't structurally feasible, the home may be demolished and completely rebuilt to the higher standard and elevation to reduce flood risk.
2) **Acquisition or 'Buyout':** the structure or home is purchased by the government and demolished or physically relocated outside of the floodplain. In both cases, the purchased land on which the structure was located is converted to open space as such in perpetuity (Smith 2014, pp 202). See detailed overview in Appendix Figure A2.

Both measures were used throughout North Carolina after Hurricanes Fran in 1996 and Floyd in 1999 with 1,146 home acquisitions and 401 elevations implemented post-Fran and over 4,000 acquisitions post-Floyd (Glavovic & Smith 2014, pp 202-203). Aside from communities like Kinston and Rocky Mount, which successfully and strategically relocated many of those displaced within its own boundaries, most implemented the HMGP program in a more ad-hoc fashion that was driven by grant administration as opposed to thoughtful planning. Additionally, most communities did not use any kind of land suitability analysis to inform a relocation strategy for residents which lead in part, to the 'checker boarding effect' and a loss of tax base.

For those who choose to follow through with the 'buyout' program, they receive the pre-disaster fair market value of their home, sometimes supplemented with additional state or local funds. FEMA also administers the Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) programs which fund eligible hazard mitigation planning and projects that are not triggered by a federal disaster declaration. While the goals of the HMGP program are to reduce risk and save money, actually implementing the program presents a series of challenges for local governments.

B. Buyout Implementation Challenges for Local Governments

Since some federal programs like HMGP and CDBG-DR can take years to implement, residents in flood-stricken communities often get frustrated and impatient with the pace of recovery assistance. When entire towns or cities are flooded as was the case for many in Hurricane Matthew, their long-term recovery can be grueling and complex. Buyout participants who want to relocate will often stay in temporary housing (i.e., motel, hotel, trailer) or stay with friends or family, all the while waiting for the funding to be approved and released to the state and local government who then can complete the buyout projects. For local staff and officials, managing the buyout and its participants, including efforts to relocate them to a desirable home, can take years to complete. Not having a clear picture of when grant funding will or won't come is a challenge throughout the disaster recovery planning process and is particularly burdensome for participants and local officials.

From a fiscal standpoint, there are two sides to the story for implementing buyouts. On one hand, local governments see the benefits by avoiding certain future costs that would come with the next flood (i.e., emergency response activities such as swift water rescues, debris removal, opening and maintaining shelters, police and fire staff time, sand bagging, not to mention extreme stress and anxiety for both staff and residents involved). Some federal and state recovery programs and grants may reimburse these costs, but not always. At the same time, the local government incurs significant costs upfront (i.e., staff time managing buyout cases) while experiencing potential long-term losses such as reduced property tax revenue (if participant leaves municipality), water/sewer/electric utility revenue, cost to maintain past buyout property, and maintenance of infrastructure for remaining residents who opted not to participate in the

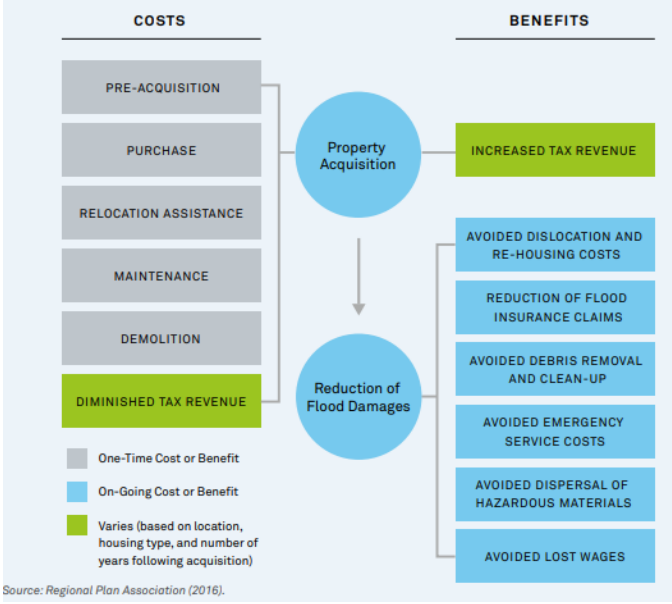


Figure 4. Fiscal Impacts of Buyouts: Costs and Benefits. Source: Regional Plan Association (2016).

buyout (Bukvic & Owen, 2017). How each of these costs and benefits balance out for local governments in the long-term is poorly understood. Figure 4 summarizes some of these costs and benefits of buyouts from a financial stand point. There are other challenges tied to the uncertainty of when the funds will arrive, coordination across stakeholder groups, and capacity to use the best available tools and information, all of which, can be enhanced by sound planning.

III. The Role of Planning in Hazard Mitigation

While reports about the value of mitigation are important, the idea that the federal government should invest more in facilitating the implementation of mitigation actions before an event occurs, as opposed to solely focusing on emergency response, is not a new concept. Injecting hazard mitigation during the immediate response and short-term recovery is difficult because actions based on a long-term view are typically seen as less urgent or less of a priority. Repeated calls for increased mitigation investment as a way to break the "natural disaster syndrome" have been especially loud in the wake of major events, including the Midwest Flood of 1993 as well as Hurricanes Andrew, Floyd, Katrina, and Sandy (Galloway, 1995; Kunreuther, 2006). Others have argued that there is "…limited emphasis placed on pre-event capacity building versus an overreliance on the delivery of post-disaster monetary aid, of which, the latter approach tends to disproportionately drive recovery trajectories in a way that is often less sustainable and resilient" (Glavovic & Smith 2014, pp 422).

One of the major shifts in U.S. federal hazard mitigation policy was the Disaster Mitigation Act of 2000 (DMA2K), passed by congress in part "to address long-standing issues (i.e., the need to initiate more proactive hazard mitigation measures through planning and pre-event grants)…" and required that all local jurisdictions have to adopt a local hazard mitigation plan in order to be eligible for pre- and post-disaster hazard mitigation funding (Glavovic & Smith 2014, pp 204-205). With local plans in place, the idea is that HMGP funds could be implemented more rapidly and with greater effectiveness to in some sense, mimic the successes seen in North Carolina through their state Hazard Mitigation Planning Initiative (HMPI), in which pre-event hazard mitigation plans helped to streamline projects and reduce long-term

flooding risk. However, mandating the creation of local hazard mitigation plans has created a wide variety of results in terms of their quality and effectiveness.

A 5-year study conducted by the Coastal Resilience Center and the Center for Sustainable Community Design at the University of North Carolina Chapel Hill assessed the quality of 30 coastal state hazard mitigation plans and 175 local hazard mitigation plans to identify strengths, weaknesses, and provide recommendations for improvement. The study assessed the plans based on seven plan quality principles and found that for the local plans, five out of seven principles scored less than half the maximum total points, leaving substantial room for improvement in areas such as the plan's policies, inter-organizational coordination and plan monitoring (Lyles et. al, 2014). Similar weaknesses were found as part of similar assessment of 84 rural county hazard mitigation plans in the Southeast U.S. where the mean scores for most of the plan principles were even lower, especially for 'implementation (Horney et. al., 2017). These assessments point to a widespread phenomena in local hazard mitigation plans that can become a 'check the box' exercise to ensure the community is eligible for federal hazard mitigation assistance, rather than a systemic means to reduce risk.

The plans' lack of emphasis on "modifying or adopting land use planning measures that proactively limit development in known hazard areas" and "inability to link findings of the risk assessments to selection of hazard mitigation policies or projects" is troubling, especially in North Carolina where there's been significant state investment and multiple disasters (Glavovic & Smith 2014, pp 205). It is the detailed hazard vulnerability assessments, required as part of the DMA2K, that can help inform additional planning activities, such as a land suitability analysis for post-disaster housing, and guide the development of pre- and post-disaster hazard mitigation policies. This additional effort to consider planning when designing and implementing hazard mitigation programs can alleviate many issues and challenges experienced by those who do not engage in such planning. For example, when communities are going through the buyout process, enhanced planning and land use tools can lead to: 1) the acquisition of contiguous parcels, leading to less checker boarding and a greater potential for recreational use, and 2) identification of the most appropriate areas for resending of buyout participants. Chapter 3, Section II further describes how a thoughtful relocation strategy, informed by a land suitability analysis method outlined in Chapter 4, can advance short and long-term recovery and resilience building goals.

A. Pre-Event Disaster Recovery Planning

Berke et al., describe three types of disaster recovery tools to guide a general redevelopment strategy for communities, including "(1) regulatory controls (e.g., building codes, zoning, development moratorium); (2) incentive measures (e.g. development density bonus, capital improvement program, property acquisition); and (3) informational measures (e.g., rebuilding workshops, reconstruction plans, dissemination programs on availability of disaster assistance) which enable people to make informed redevelopment decisions" (Berke et al., 1993). The HMDRRI Relocation Strategy and LSA are unique 'informational measures' that take into consideration related regulatory and incentive-based measures associated with housing redevelopment.

The buyout program and RS are pieces in the larger recovery planning process which involves six steps as described by APA's Planning for Post-Disaster Recovery PAS 576 Report. Steps 1 and 2, initiating the process and organizing public participation involves the determination by officials and the public that floodplain acquisition and relocation are possible options in the community (APA, 2014). Development of the LSA and overall RS occur during steps 3 through 6 and include conducting research and analysis, facilitating input, developing and adopting the plan, and implementing the plan (APA, 2014).

Ideally, the creation of a RS and LSA would be done prior to a disaster, through a post-disaster redevelopment, climate adaptation, comprehensive or hazard mitigation planning effort. Making decisions about how and where a community will live is much more difficult in the midst of disaster because of the "convergence" of resources as well as the political pressure to act quickly (Smith 2011, pp 49). The burden of a disaster and its impact on a community's ability to conduct effect post-disaster recovery planning varies across communities who may have different capacities to coordinate among other recovery organizations. Berke, Kartez, and Wenger describe this variation of capacities using a horizontal and vertical integration typology for communities, ranging from Type 1 (strong in both directions), to Type 4 (weak in both directions). Horizontal integration refers to the strength of local relationships (i.e., local government, business owners, local financial institutions, the media, community groups and residents) and vertical integration refers to the strength of a community's relationship with

external agencies (i.e., state and national government and non-governmental groups). Combined the four major types can describe the nature of inter-organizational coordination. Smaller, rural communities like Fair Bluff might be characterized as a Type 2 community (strong horizontal and weak vertical integration) because they have less interaction or familiarity with state and federal agencies and depend more heavily on regional planning organizations, state emergency management, private sector consultants and others during recovery.

Along with the 'convergence' of resources and challenges with coordination, communities must also deal with the inevitable tension of "speed versus deliberation" (Olshansky, 2006). After major events like Hurricane Matthew, there is immense pressure to quickly make decisions to bring urgently needed relief. Taking the time required to deliberate or engage in an in-depth discussion of an issue, such as post-disaster housing relocation requires confronting this dilemma. The ability to undertake these discussions before an event can lead to more timely and effective decisions immediately after the event. Yet in practice, this proactive approach remains uncommon.

Berke and Campenella summarize the great potential of pre-event planning can have, noting that:

> "…a pre-disaster recovery plan can identify potential sites free of hazards that could serve as relocation zones for developments in hazardous areas that are likely to be significantly damaged during a disaster. Where hazard areas have significant cultural or economic advantages for redevelopment that cannot be foregone, a well-conceived recovery plan can reduce potential losses by including provisions that guide redevelopment to the least hazardous parts of building sites and modify construction and site design practices so that vulnerability is minimized" (Berke & Campanella, 2006).

Pre-disaster redevelopment planning in Hillsborough County, Florida has done this successfully, designating priority redevelopment areas which were consistent with county and city comprehensive plans (by considering future land use), transportation investment plans, and existing economic incentive zones as well as "establishing construction standards, and instituting policies for redeveloping areas that have suffered repeated damages from past events (Smith

2011, pp 54).[4] Looking to other communities like Hillsborough County for ideas is important, but any effort to do so should recognize the local context in which ideas are applied in other locales, including those with varied capacity to implement them.

The conceptual model (Figure 5) that illustrates the interaction between various community plans, stakeholder input, and the disaster recovery process helps to frame the importance and usefulness of the LSA. If a community is required to or has the resources to create a Pre-Disaster Recovery plan, they can use goals, data, and components of the local hazard mitigation, comprehensive, economic development, and other community development plans to inform proposed recovery policies, including a LSA.

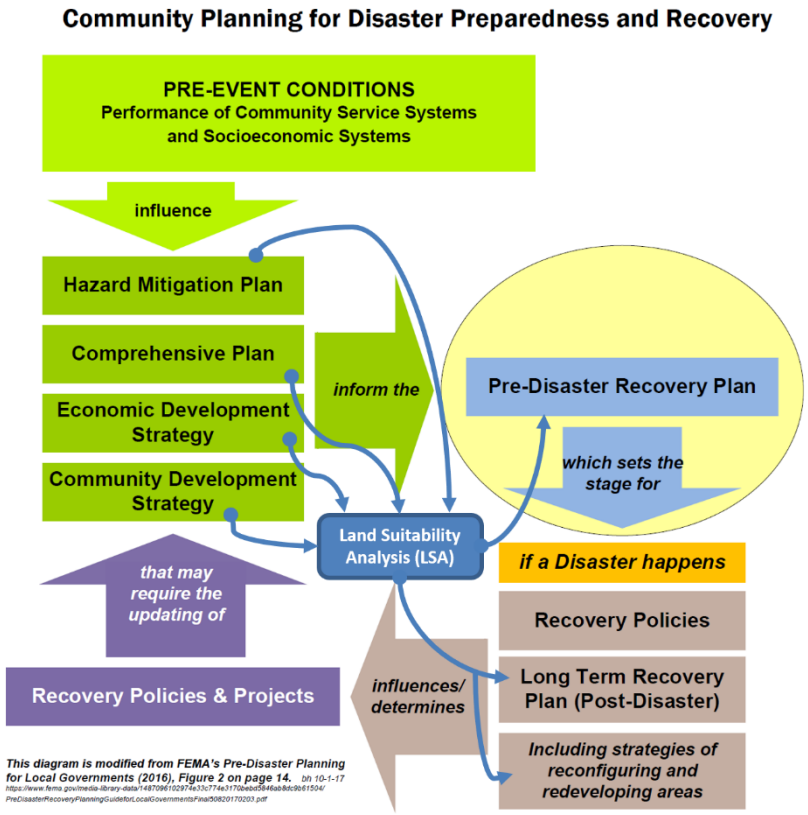


Figure 5. Links between LSA and Community Disaster Preparedness and Recovery Planning. Adapted from Barry Hokanson and FEMA.

After a major event, especially if it considered the worst on record (as Hurricane Matthew was in Fair Bluff), new issues and challenges can emerge that were not conceived of or

[4] After a record-breaking 2004-2005 hurricane season, the State of Florida embarked on the state-wide Post-Disaster Redevelopment Planning Initiative, which involved three phases to create guidelines, pilot them in five communities, and update and create a comprehensive guide which was completed in 2010 (State of Florida Department of Economic Opportunity, 2018).

addressed in prior plans or planning process. Regardless, it's important to use the knowledge gleaned from previous plans, in conjunction with new information gathered post-disaster as well as ongoing public engagement, to develop a long-term disaster recovery plan (LTDRP). The LTRP should inform the recovery policies and projects that are pursued which may include making amendments or updates to policies found in previous plans. The quality of pre-existing community plans depends on the pre-event conditions characterized by the performance of community service systems (i.e., capacity and coordination amongst local groups) and socioeconomic systems (i.e., median household income, age, race and ethnicity, etc.). A GIS-based Land Suitability Analysis (LSA) is representative of one tool that can be developed as part of or informed by existing community plans and tailored for use in both pre- and post-disaster planning contexts.

Berke et. al. describe the idea of a "network of plans" (hazard mitigation, comprehensive, etc.) as having the potential to complement each other or conflict with one another in a way that can increase or decrease community resilience (Berke et. al., 2015). The research team developed a method for evaluating a community's network of plans using a Resilience Scorecard that assesses how well various plans are integrated to reduce physical and social vulnerability in a community. This scoring process can identify conflicting policy objectives like those seen in a New Jersey city prior to Hurricane Sandy in 2012, where "the hazard mitigation plan called for acquisitions and buy-outs in high-hazard areas, while the comprehensive plan set goals to increase investments in the same location" (Berke, 2016). Similarly, a tailored LSA provides a tool that can span the network of plans and be adapted to meet a set of coordinated goals defined by the community.

The devastation seen in eastern North Carolina after Hurricane Matthew required that affected communities reevaluate their goals for the future and presented an opportunity to inject cost-beneficial hazard mitigation and land use planning strategies like a LSA to facilitate a key element of a successful long-term disaster recovery.

Chapter 3: The Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI)

I. Purpose of HMDRRI

Following Hurricane Matthew in 2016, the North Carolina Policy Collaboratory, North Carolina Division of Emergency Management (NCEM), the North Carolina State Legislature, and the North Carolina Community Foundation funded the creation of the Hurricane Matthew Disaster and Resilience Initiative (HMDRRI), an ongoing partnership between NCEM and the University of North Carolina (UNC) System.[5] Led by Dr. Gavin Smith, Director of the Coastal Resilience Center[6], HMDRRI's focus is "to provide six hard-hit communities with the technical assistance needed to address issues typically uncovered by post-disaster programs… [including] the development of disaster recovery plans; the development and implementation of a housing relocation strategy; the creation of open space guidance; and the flood retrofit of historic downtowns. Other issues continue to be identified during the planning process and through ongoing dialogue with residents, community officials, and others" (HomePlace, 2017). The six communities include Fair Bluff, Kinston, Lumberton, Princeville, Seven Springs, and Windsor (Figure 6).

Figure 6. HMDRRI Six Communities

[5] HMDRRI relies on a number of partnerships to advance its mission, including the University of North Carolina, North Carolina State University, the North Carolina Division of Emergency Management, the Governor's Office, Federal Emergency Management Agency (FEMA), other federal agencies, experienced disaster recovery experts (hired using other funding sources), and local communities recovering from Hurricane Matthew (Coastal Resilience Center, 2017).

[6] The Coastal Resilience Center is a U.S. Department of Homeland Security Center of Excellence led by the University of North Carolina at Chapel Hill. It is a consortium of universities, private companies, and government agencies focused on applied research, education, and outreach addressing threats to coastal communities due to natural hazards and climate change.

The HMDRRI has emphasized deep engagement and intensive collaboration with communities, resulting in a number of reports and analyses, but more importantly helped to facilitate the creation of a shared vision and understanding of major challenges and opportunities for successful recovery and increased resilience in these communities. With thousands of families displaced and left in state of uncertainty after the storm, HMDRRI has attempted to assist local leaders in finding a clearer and more resilient path forward, including a focused effort on assisting each community develop a relocation strategy.

II. HMDRRI Relocation Strategy

A. Post-Disaster Housing as a Priority

While some federal funding sources like FEMA's HMGP are automatically made available after a PPD, others such as the Community Development Block Grant – Disaster Recovery (CDBG-DR) must be appropriated by Congress.[7] These supplemental appropriation funds help address the unmet needs identified and outlined by the grantee in an Action Plan which can include the acquisition or repair of flooded homes. In many cases, CDBG-DR funds are used to implement additional flood acquisitions that are not covered or eligible through the HMGP. As the CDBG-DR grantee after Hurricane Matthew, the North Carolina State Action Plan states clearly that the number one priority "is to allow families to return to their homes…" and ensure that "…resulting recovery programs also account for long-term sustainability…" helping "…homeowner[s] and renter[s] finding safe and suitable housing rather than simply rebuilding a damaged unit" (NC Dept. of Commerce, 2017). The importance of reliable, affordable housing after a disaster was reiterated time and time again during initial public meetings and visioning sessions that HMDRRI facilitated and has been noted as the corner store of successful long-term recovery because it "can be a platform for families' education, health, and economic wellbeing," factors key to increased resilience (Brennan 2011; Brennan and Lubell 2012; Cohen 2011). An assessment of affordable housing for the entire Eastern North Carolina

[7] CDBG-DR funds must be used for "… necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure, housing, and economic revitalization" (HUD, 2017).

Region conducted by HMDRRI concluded that even prior to the storm "One in two renters is cost-burdened; one in three homeowners with a mortgage is cost-burdened, and one in six homeowners without a mortgage is cost-burdened[8] by housing costs, indicating very low incomes and high utility costs or property taxes." (Nyguen, 2017). While the region is struggling to find affordable housing, they also have found many homes at considerable risk to flooding.

As a result of the flooding from Hurricane Matthew, the State of North Carolina received over 3,000 HMGP applications, with individuals choosing between a) demolition and reconstruction, b) elevation or c) acquisition or "buyout". One major component of HMDRRI's work is to help communities assist residents who participate in the buyout program relocate to areas within their community that are at a reduced risk for future flooding. This Relocation Strategy (RS) is designed to be an element of a larger disaster recovery plan for the communities and is being informed by multiple components:

a) **Disaster Survivor Intake Survey[9]**: information gathering technique designed to better understand survivors' current financial situation, preferred housing and neighborhood characteristics (size, cost, location, etc.)
b) **HomePlace – A Conversation Guide for the Fair Bluff[10], Rebuilding After Hurricane Matthew**: menu that provides high-quality, community-specific designs and strategies at household, community, and regional scales and addresses home rebuilding factors of accessibility, curb appeal, affordability, comfort, efficiency, and flexibility. It also includes a Greenspace Concept plan which illustrates how existing and expected future open space (i.e., parks, trails, "buyout properties", etc.) can be integrated towards public health and economic development goals.
c) **Land Suitability Analysis (LSA)**: land use-planning tool that uses geographic information systems (GIS) to identify potential areas for redevelopment, using set of variables with specified criteria and weights, that have reduced risk to flooding,

[8] "By common definition, housing is considered *affordable* if the total cost for housing, including rent or mortgage payments, utilities, and property taxes, a household spends is less than 30% of its income. Households are considered *cost-burdened* if they spend more than that" (Nyguen, 2017).
[9] At the time the LSAs were conducted, the Intake Survey had not been completed. It's expected that the survey will be completed in the Spring of 2018.
[10] HomePlace was created for each of the six HMDRRI Communities.

are within the municipal limits, and help meet other community development goals

Using results from the intake survey and recommendations from HomePlace, combined with the land suitability analysis (LSA), communities will be able to limit the loss of their property tax base and reduce future flood risk by limiting future development in the floodplain. Table 1 shows how each of the components is designed to meet various goals of the RS outlined by HMDRRI and influenced by input from each community.

Table 1. Goals of the HMDRRI Relocation Strategy (RS)

Goal	Disaster Survivor Intake Survey	HomePlace Conversation Guide	Land Suitability Analysis (LSA)
Discover desired characteristics (household type, income, location, etc.) of potential buyout participants	**X**		
Understand local needs and preferences for post-disaster housing	**X**	**X**	
Incorporate best design principles for resilience and local vernacular to guide housing redevelopment[11]		**X**	**X**
Tie together potential greenspace/greenways and recreation needs with future economic and housing development strategies	**X**	**X**	**X**
Identify areas within community that have reduced flood risk suitable for infill development or multi-family development			**X**

A comprehensive post-disaster survivor intake survey about how and where flooded buyout participants prefer to relocate has not been done before as a way to inform redevelopment housing. This unique pairing of the survivor's needs and preferences with best design practices for sustainable and healthy housing development will make successful relocation more viable. Finally, integration with the multi-variate LSA provides the spatial perspective required to

[11] Example of the housing types designed for HomePlace can be seen in Appendix Figure A3.

ensure the RS complements existing plans that have goals to reduce flood risk or revitalize an area of the community.

The HomePlace Guides are "a means of communicating the potentially significant roles that buildings, landscapes, and communities could play in disaster recovery, to include addressing the challenges and opportunities associated with the relocation of flood-prone housing" (HMDRRI HomePlace, 2017). A major output of HomePlace for Fair Bluff is a Greenspace Concept (Figure 7) that illustrates a set of potential recovery strategies and includes two major components:

1) An expanded trails network that takes advantage of the community's location on the Lumber River, and
2) Additional greenspace east of the downtown resulting from voluntary relocation and residential buyouts (HMDRRI Homeplace, 2017).

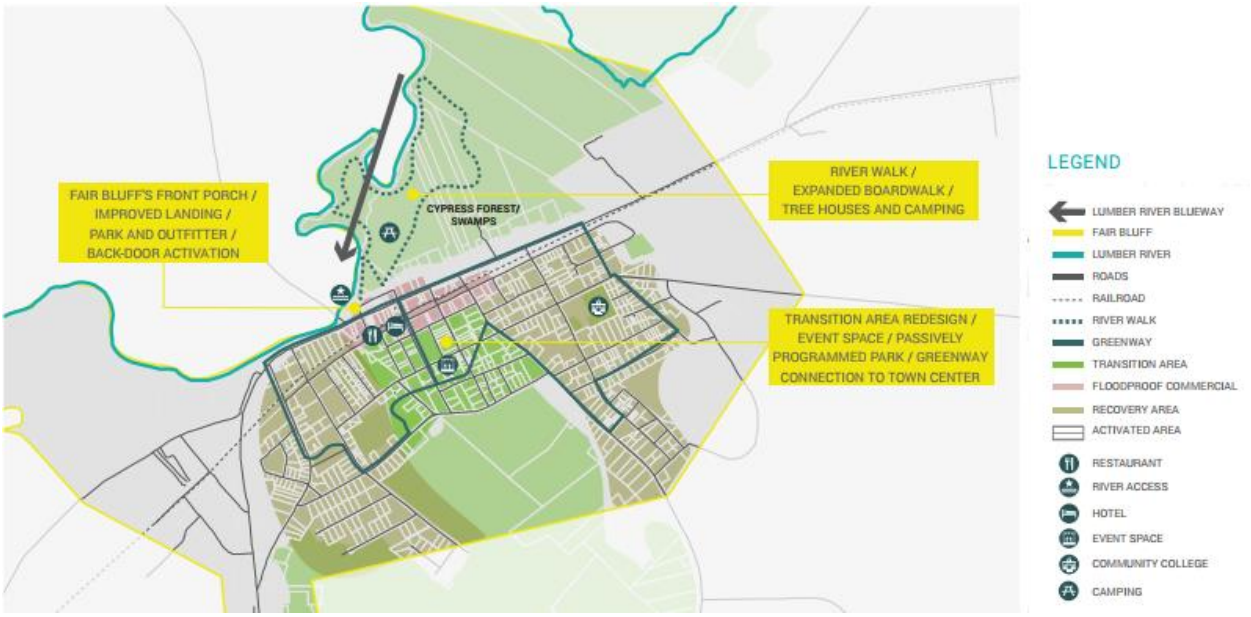


Figure 7. Fair Bluff Green Space Concept from HomePlace Guide.

Along with addressing housing needs, Fair Bluff is focused on repairing and revitalizing its commercial downtown which is in the floodplain and was severely damaged by several feet of water after Hurricane Matthew. The Green Space Concept involves a combination of strategies including: floodproofing and beautification of commercial downtown that would connect with existing river walk; transforming buyout properties into a programmed park/event space that

connects to future greenways and trails; and the relocation of homes outside of the 100-year floodplain. Discussed further in Chapter 5, the RS and LSA are key to addressing Fair Bluff's long-term recovery needs.

It's helpful to note that the HMDRRI RS approach follows best practices outlined by the American Planning Association's PAS Report 576, which recommends that "decisions on where and how to rebuild affordable housing should be guided by the goal of greater resilience in the future, along with recognition of the particular needs of the community's low-income residents" (APA, 2014). Ideally, the components of the RS will help the local governments and their recovery partners take actions toward helping residents find a safe and affordable home in their community that is not located in the floodplain. Malczweski's description of what a GIS-based LSA achieves and the relative importance of 'hard' and 'soft' information links directly to best practices for long-term recovery planning and HMDRRI goals:

> "… the GIS-based land suitability analysis should be viewed as a process of converting data to information that adds extra values to the original data. At subsequent stages of the process, the original data are interpreted and analyzed to produce information useful to those involved the planning process. The data are progressively converted into information about the planning problem. The problem at hand determines the need and the nature of the information required. To this end, it is useful to make a distinction between 'hard' and 'soft' information used in the land-use suitability analysis as a part of a planning process. The hard and soft information are sometimes referred to as objective and subjective information, respectively. The former are derived from reported facts, quantitative estimates, and systematic opinion surveys; for example, census data, remote sensing data, meteorological surveys, etc. The soft information represents the opinions (preferences, priorities, judgments, etc.) of the interest groups and decision makers, based on intuition, ad hoc surveys, questionnaires, comments, and similar sources" (Malczweski, 2004).

In the case of Fair Bluff and other community's recovery from Hurricane Matthew, one of the major problems at hand is the challenge of permanently relocating flood survivors who are displaced from their homes to areas within the community that are at reduced risk to flooding and are desirable to live in.

Chapter 4: Land Suitability Analysis Methods

I. Types of Land Suitability Analyses

A. History and Forms of Land Suitability Analysis

The idea of land suitability analysis (LSA) can be traced back to the late nineteenth and early twentieth century through the work of Charles Eliot who used sun prints produced on their office windows and more formally through Jaqueline Tyrwhitt's 1950 article in the *Town and Country Planning Textbook* which described how four separate maps of relief, hydrology, rock types and soil drainage were blended into one land characteristic map (Collins et. al., 2001). Major advancement in the methodology and popularity of LSAs is tied to work done by Ian McHarg in the 1960s described in his book *Design with Nature*, which introduced the ecological inventory process that overlaid multiple variables such as elevation, water bodies, and others to illustrate suitability for various types of land uses as well as an overall composite suitability map (McHarg, 1964; McHarg 1993). In *Design with Nature,* McHarg even highlights the connection between damages caused by a 1962 Nor'easter in New Jersey and design principles that complement the region's coastal ecology. His methods for manual cartographic overlaying are "widely recognized as a precursor to the classical overlay procedures in Geographic Information Systems (GIS)" (Malczewski, 2004). Most LSAs have a specific goal for a specific use of land (i.e., agriculture, wetland/habitat restoration, etc.) and can inform decisions about where communities should do what based on the LSA approach and data that are selected. Malczewski's review of GIS-based LSAs outlines the three general approaches, which include: 1) computer-assisted overlay mapping, 2) multi-criteria decision-making methods (MCDM), and 3) artificial intelligence (AI) methods.

The computer-assisted overlay mapping is the most basic advancement beyond McHarg's original manual method and where GIS's capabilities are introduced. Mcharg's work can be described as the first discretized raster suitability analysis, a method also used by Burrough et. al., who used simple overlays of data layers to eliminate undesirable areas step by step (1993). MCDM, which can be separated into two approaches of multiobjective methods (i.e.,

mathematical programming models) and multiattribute methods (i.e., weighted linear combination [WLC], analytical hierarchy process [AHP], etc.) involves "the utilization of geographical data, the decision-maker's preferences and the manipulation of the data and preference according to specified decision rules" (Malczewski, 2004). Multiattribute methods such as the WLC or linear combination model developed by Hopkins are the simplest and most common within LSAs (Hopkins, 1977). AI methods such as 'neural networks' are more complex, less transparent, and less easily integrated into the GIS environment making the approaches "inaccessible to most planners, mangers and decision-makers" and it is "unlikely that that [their] solutions or set of solutions…will be acceptable to those who make decisions regarding land use and the public" (Malczewski, 2004). Computer-assisted overlay and MCDM are often combined to form a hybrid approach, which was used in this project, and can still be powerful without having to use more complex AI methods.

Suitability analyses can also be separated by the type of underlying GIS data used which include raster-based (a matrix of uniform grid cells or pixels) or vector-based (points, lines and polygons with defined spatial boundaries). Most LSAs use the raster data model for area-oriented structure which allows for easier operation of proximity, buffer and overlay analysis (Malczewski, 2004). One example of several raster-based LSAs were conducted by Bertie County, North Carolina (which includes the Town of Windsor[12]), for the County's 2015 Land Use Plan[13] with the goal to "provide information to local decision-makers on land that may have fewer environmental and regulatory restrictions, land where services can be provided at lower cost, or land that is most attractive given its proximity to existing development or to the waterfront areas" (Bertie County, 2015). Their approach was simple and not geared toward disaster recovery, but is still useful in terms of knowing the spatial relationships between various sets of landscape features. Other land suitability analyses that focus on affordable housing such as those used by the Central Florida Regional Planning Council or a group at Portland State University offer other approaches, but don't incorporate natural hazards or flooding risk as a

[12] The Town of Windsor, NC is one of the six communities that HMDRRI has worked with to create a LSA and Downtown Retrofit Study.
[13] Coastal counties like Bertie are required to perform a land suitability analysis as defined in the Coastal Area Management Act. Section .0702 (c)(5).

component, severely limiting the tool's ability to guide development patterns that reduce risk and increase a community's resilience to flooding (CFRPC, 2014; Mallon et al., 2017).

Because the goal of HMDRRI RS and LSA is identifying specific parcels of land (vector-based data) within a community that would be most appropriate for resilient housing infill development or redevelopment, a vector-based hybrid computer-assisted overlay and WLC were used to incorporate flood risk variables, among others described in section III of this Chapter. For local governments and recovery partners who aim to relocate flood survivors seeking safe, permanent housing, the vector-based approach to an LSA facilitates the identification of suitable property for development or redevelopment.

B. Suitability Analyses Used in Post-Disaster Contexts

A literature review found only a few examples describing how an LSA was used in a pre- or post-disaster context. A 2016 report on Reducing Disaster Risk by Managing Urban Land Use from the Asian Development Bank recommends the inclusion of hazard information into existing land suitability analysis used for master planning, but doesn't provide many details about its usefulness in recovery planning or provide examples.

Ibrahim et. al., 2015 used a raster-based weighted overlay technique to perform an LSA for the resettlement of flood disaster victims in Lokoja, the administrative capital of the Kogi State in Nigeria which sits near the rivers Niger and Benue. The LSA included variables such as elevation, proximity to the river channel, slope, land cover, and proximity to infrastructure. This resulted in the identification of five potential resettlement sites of at least 100 hectares each, which covered only 4.14% of the total land (Ibrahim et. al., 2015). After 272 housing units targeted for flood survivors were built on these sites, Abdulquadri et al., 2016 then conducted an evaluation of the development that was partly guided by Ibrahim et al. LSA to see if various goals for the redevelopment were met. The evaluation's findings conclude that disaster risk reduction, through non-structural measures such as multi-hazard vulnerability analysis, the LSA, and relocation of housing outside high risk zones, was "achieved" (Abdulquadri et. al, 2016). But, results for other categories such as structural measures, social recovery and others were "not

achieved" due to a lack of community consultation regarding the relocation site, building design types, and construction process (Abdulquadri et al., 2016). Each of the factors not achieved during the Lokoja flood-survivor relocation were addressed in the HMDRRI RS approach.

Often referenced and hailed as a success of hazard mitigation, resident relocation, and post-disaster planning, the city of Kinston, NC[14] endured major floods during Hurricane Fran in 1996 and again during Hurricane Floyd in 1999. After hundreds of voluntary buyouts were completed, the City implemented several programs including:

> "…Call Kinston Home, a redevelopment effort focused on relocating families to existing neighborhoods located outside the floodplain (emphasizing the use of infill lots), thereby avoiding sprawl into the countryside while maintaining the city's tax base and revitalizing established neighborhoods; establishing a community-college led program called Housing and Employment Leading People to Success (HELPS) which sought to assist low income families (primarily renters) involved in the housing relocation program with job training (focused on the reconstructions and repair of flood-damaged housing) and financial counseling in order to assist them become the first-time home buyers; developing a green infrastructure plan that guided the use of large amount of now vacant land adjacent to the Neuse river; and relocating a flood-prone waste water (that released raw sewage into the river following Hurricanes Fran and Floyd) as well as several local junkyards thereby improving local water" (Smith 2011, pp 65).

While the green infrastructure plan for acquired property has not been fully implemented, the city's efforts to reduce future flood risk while supporting relocation of flood survivors within town are both admirable and cost-effective. For Kinston, their adept use of GIS, strong vertical integration, experience with past floods like Hurricane Fran in 1996 greatly aided the success of project post-Floyd.

Other communities have likely used some form of a GIS-based LSA in the post-disaster context, but their reported use and levels of success have either never been documented or are

[14] Kinston, NC is also a HMDRRI community for which an LSA was completed.

not readily accessible. Further research should be done to assess the use of the tool and its historical application in pre- or post-disaster recovery planning.

II. HMDRRI LSA Process Overview

A multi-phase approach was conducted to identify variables, the associated criteria, and thresholds for use in the LSA that incorporates stakeholder feedback and achieves HMDRRI's RS goals, while considering the different issues, constraints, and opportunities found within each community. The approach follows Malczewski's suggestion for GIS-based LSAs to incorporate both 'hard' and 'soft' information by following the steps illustrated in Figure 8.

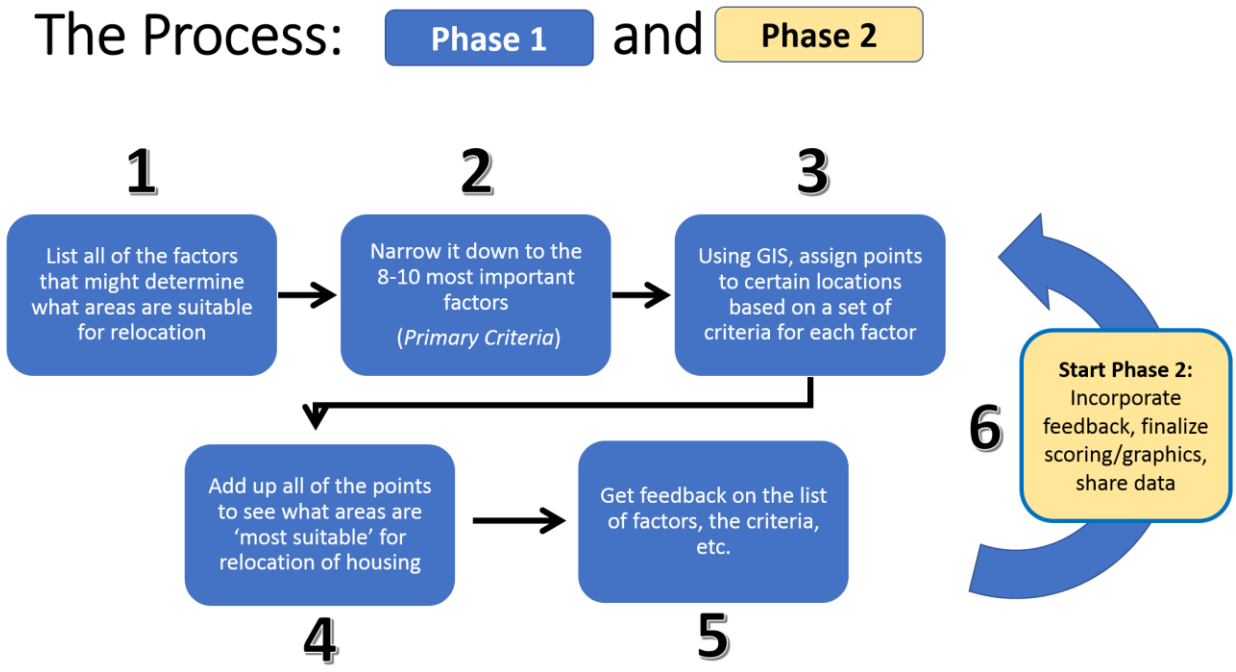


Figure 8. Multi-phase LSA process used by HMDRRI.

Phase one consisted of several steps including: 1) listing of all potentially relevant factors for housing development suitability; 2) prioritizing and selecting a subset of variables within the comprehensive list that contributes to the LSA goal; 3) identifying thresholds and relative weights for short list variables; 4) conducting a preliminary LSA using GIS; and 5) obtaining community feedback on factor, criteria, and thresholds. Phase two builds off the phase one

preliminary LSA and incorporates feedback from stakeholders who either have interest in the results or expertise in an area that is related to the analysis or to the variables or data being used. Since the LSA is part of a larger RS, community input involved identifying a set of preferences and needs through a comprehensive survey of flood survivors, including those who have applied for the HMGP buyout program. This process can and should be further informed by existing plans, knowledge of existing (or lack of) affordable housing stock, and other factors.

As a vector-based, hybrid computer-assisted overlay and WLC method, the analysis depends on the creation of an overlay rule or threshold that determines how and whether a parcel is attributed points for a given variable (Phase 1 – Step 3). The simplest rule to apply in this situation is the 50/50 rule. For example, if a property has less than 50% of its area covered or overlapping with any given variable such as the 100-year flood zone, it would be considered to have a lower risk of flooding and therefore attributed points toward a higher suitability score (Figure 9).

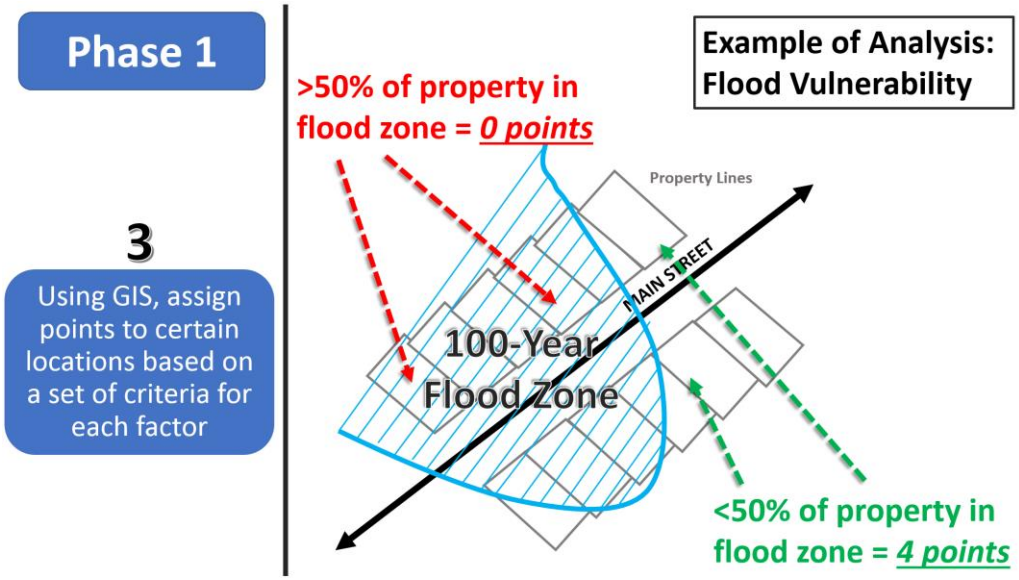


Figure 9. Conceptual example of the 50/50 rule used in Phase 1 - Step 3 for parcel point attribution.

Using this 50/50 threshold, each vector-based variable (i.e., jurisdictional boundaries, water infrastructure buffer, etc.) can be overlaid on top of existing parcel boundaries and have their overlapping percentage calculated which then determines the attribution of points toward overall suitability. Though the method's simplicity allows for easy execution, replication, and explanation, it also has its limitations as far as accounting for and displaying the variability in

percentage overlap. However, providing alternate perspectives as described below, can help to address this issue. The 50/50 rule does was not necessary for every variable because some are included or associated with the parcel data already (i.e., size, zoning) and can have points directly attributed based on set thresholds.

III. LSA Variable Identification, Weighting, and Procedures

A. Identifying Variables and Thresholds for the LSA

The selection of variables to include in the LSA began with a broad review and consideration of 36 variables of various types (i.e., proximity to community services, transportation, environment and topography, planning, and flood risk) (Appendix Table A1). Since many variables were not applicable in Fair Bluff (i.e., proximity to hazardous waste sites, sea level rise vulnerability) or may not be major determinants of a sites' development potential (i.e., bus stop proximity, park proximity, etc.), members of the HMDRRI team prioritized the top 8-10 variables based on past LSA experience and available knowledge about flood risk issues. Comparison of each member's interpretation led to strong consensus on the most important factors to focus on to conduct a preliminary LSA. Described in further detail below and in Table 2, some of the key variables included the designated 100- and 500-year flood zones, proximity to existing water and sewer infrastructure, land/building vacancy, parcel size, and zoning.

Many variables such as the municipal boundary or 100- and 500-year flood zones have thresholds of Boolean nature (binary in/out or yes/no) and therefore, had simple criteria for point attribution. Other factors such as parcel size and zoning contained a range of values, both quantitative and qualitative, and needed criteria and thresholds established. These were determined after further exploration of the variability of each factor and discussion with HMDRRI team members about what planning and development concepts were most applicable. Descriptions and justifications of each variable, its associated thresholds, and data sources are explained below and summarized in Table 2.

Table 2. Fair Bluff LSA Variables and Criteria Thresholds

Category	Variable	Criteria Thresholds	Points	Max
Jurisdictional Boundaries	Municipal Limits	Out	0	1
		In	1	
	Extraterritorial Jurisdiction (ETJ)	Out	0	1
		In	1	
Proximity to Infrastructure	Water Line (0.25 mi. buffer)	Out	0	1
		In	1	
	Sewer Line (0.25 mi. buffer)	Out	0	1
		In	1	
Parcel Size*	Infill Potential	< 3,000 ft^2	0	2
		3,000 ft^2 - 20,000 ft^2	1	
		20,000 ft^2 - 100,000 ft^2	2	
	Multi-Structure Potential	100,000 ft^2 - 500,000 ft^2	1	3
		500,000 ft^2 - 1,000,000 ft^2	2	
		> 1,000,000 ft^2	3	
Building/Land Vacancy	Vacant/Abandoned Building	Occupied - FP	0	3
		Occupied - NO FP	1	
		Vacant - FP	2	
		Vacant - NO FP	3	
Vulnerability to Flooding	100-yr Floodplain (Zone AE)	In	0	4
		Out	4	
	500-yr Floodplain	In	0	1
		Out	1	
	Hurricane Matthew Flood Extent	In	0	2
		Out	2	
Areas of Future Development	Zoning	CB-O, LM-W	0	2
		HS-B and LD-A	1	
		MED, MOD, NC	2	
*Each parcel, based on its size will fall into infill potential or multi-structure potential with possible totals of 18 and 19 respectively			Total:	18

Vulnerability to Flooding/Flood Risk

Source: NCEM, 2017

(100-Year Flood Zone; 500-Year Flood Zone; and Hurricane Matthew Flood Extent)

Perhaps the most crucial set of factors for the RS and LSA are related to flood risk and vulnerability. The 100-year floodplain (Zone AE) or base flood elevation delineates the area that is expected to be inundated by a 0.1% annual chance flood. The 500-year floodplain represents the area of inundation experienced by a flood with 0.2% annual chance of occurring. Hurricane Matthew's Flood extent is also relevant as the flood of record for the Town and generally followed boundaries in between the 100- and 500-year floodplains. The event's flood extent represents areas that officials and residents have actually seen flood versus designated floodplains which are calculated using hydrology and statistics and included a certain amount of uncertainty/inaccuracy.

Together, these flood risk variables account for both estimated flood risk that is tied to various regulations and programs as well as the lived experience which is easier to understand from the public's perspective. These factors provide a range of possible flood elevations and while it is somewhat duplicative to include all three, it provides a more comprehensive view of a property's vulnerability to future flooding and meets a main goal of the RS to develop in safer areas.

Jurisdictional Boundaries

Source: Columbus County, 2017

(Municipal Limits; Extraterritorial Jurisdiction (ETJ)

The Town of Fair Bluff can only control or influence development within its municipal limits. Additionally, identifying areas within municipal limits is critical to reduce any future property tax revenue that is lost when flood survivors relocate outside of town. The ETJ is also important since the town can enforce a majority of their ordinances within the ETJ, even if residents in that area cannot vote in municipal elections. Additionally, avoiding the need to annex land, which can be an administrative burden makes locations within these boundaries

more attractive. Incorporating these jurisdictional boundaries as factors in the LSA help meet the second major goal of the RS to retain residents who get displaced by flooding and thereby reduce the loss of residential tax base.

Proximity to Existing Infrastructure

Source: NC OneMap, 1997

(Water Distribution System; Sewer System)

New housing development is much more cost-effective when it's located near existing water and sewer infrastructure. These factors are key to identifying suitable areas for infill development. One limitation of these data is that it is outdated (1997). Another limitation is that this data does not take into account the sewer replacement work that has been occurring in late 2017 and early 2018 within Fair Bluff. The use of a 0.25-mile buffer helps to address some of this uncertainty.

Parcel Size

Source: Columbus County, 2017

(Infill Potential; < 3,000 sq. ft.; between 3,000 and 20,000 sq. ft.; and between 20,000 and 100,000 sq. ft.)

Some lot sizes are only suitable for development of single family homes or lower densities. The thresholds were selected based on size of existing single-family home building footprints and lots sizes within the Town of Fair Bluff. The smallest existing lots in the town that have single family homes on them are at least 3,000 sq. ft. and the median parcel size found within the ETJ is about 21,000 sq. ft. Therefore, any parcel less than 3,000 would not be considered suitable while the other two categories already do or could support a small- to medium-size single family home and larger homes for which existing lots didn't exceed 100,000 sq. ft. Square feet was used instead of acres because some lot sizes were so small that multiple decimal places would've been required to display variability.

(***Multi-Structure Potential: between 100,000 and 500,000 sq. ft.; between 500,000 and 1,000,000 sq. ft.; and >1,000,000 sq. ft.)***

Larger lots may be suitable for development of multiple structures or that of moderate density for replacement housing such as apartment buildings. This form of development could be more attractive to developers or investment partners that can house a greater number of relocated families. Thresholds were selected based on size of larger parcels within town that had multiple housing structures on them.

Building/Land Vacancy

Source: NC OneMap and NCEM, 2017

(Parcel Use: 'OCCUPIED' or 'VACANT'; Building Footprint Present: FP or NO FP)

Two sources of data were used to create a proxy to distinguish vacant lots versus lots with vacant buildings because vacant lots would be the easiest to develop relocation housing on, whereas if there is a building footprint (FP), it may or may not have to be demolished. NC OneMap standardized parcel data includes a field describing the parcel use as either 'OCCUPIED' or 'VACANT' along with intended use (i.e., VACANT RESIDENTIAL). A proxy was created because it was observed that numerous properties listed at 'VACANT' appeared to have building footprints on them when overlaid in GIS. The latest building footprint data was obtained through North Carolina Emergency Management so that four categories could be created with the goal of identifying properties listed as vacant that do not have a building footprint on them. The following categories listed from lowest to highest relative suitability include: Occupied - FP; Occupied - NO FP; Vacant - FP; and Vacant - NO FP.

Areas of Future Development

Source: Columbus County, 2017

(*Zoning: CB-0, MED, HS-B, MOD, LM-W, LD-A, and NC*)

Existing zoning reflects the community's intent for use of that property usually based on a number of factors. It may be more difficult to develop replacement housing on properties that have been zoned for something different from residential, such as Light Manufacturing – Wholesale whereas a property already zoned for residential, will not require a rezoning, variance, or other procedural action. Fair Bluff's zoning is fairly simple and consists of seven categories (Table 3). Zones of greatest interest for the RS and LSA include Neighborhood Residential, Medium Density Residential and Moderate Density Residential, all of which would require little to no extra administrative burden. Developing housing in zones like light manufacturing – wholesale (LM-W) or highway service – business (HS-B) would go against prior planning goals and require rezoning.

Table 3. Fair Bluff Zoning Codes

Zoning Code	Description
CB-O:	Central Business - Office
MED:	Medium Density Residential
HS-B:	Highway Service – Business
MOD:	Moderate Density Residential
LM-W:	Light Manufacturing – Wholesale
LD-A:	Low Density – Agriculture
NC:	Neighborhood Residential

The eleven variables represent the factors that determine a parcel's composite suitability for housing development or redevelopment. The factors and thresholds dictate the results of the LSA which can inform decisions that meet goals of the HMDRRI RS of reducing flood risk, retaining flood survivors within their communities, and minimizing construction costs.

B. Weighting

Perhaps as important as the selection of variables for the LSA is the determination of the relative weights attributed to different factors and for various thresholds. For almost every variable, there are zero points given for the most undesirable or unsuitable case and more suitable cases incrementally receive one additional point. This falls in line with typical WLC or simple 'additive weighting techniques' used in other LSAs. The exceptions to this incremental case are with two of the variables related to the vulnerability of flooding. One of the primary goals of the RS is to reduce flood risk for the buyout participants as they relocate. For estimating flood risk, the most direct measure is the 100-year flood zone (1.0% annual chance of occurring), hence the highest weight (Outside = 4; Inside = 0). Hurricane Matthew's Flood Extent is also a prominent variable since it ties to the direct experience and lasting memory of the community as the flood of record, warranting a higher weight beyond a single point (Outside = 2; Inside = 0). Since the 500-year flood zone in Fair bluff includes and goes beyond both the 100-year flood zone and Hurricane Matthew Flood Extent, it represents the area least likely to flood. For development to occur outside this area would be operating at the highest standard for reducing flood risk and receives just one additional point.

For variables such as municipal limits, extraterritorial jurisdiction, and water/sewer line buffers, large continuous swaths of parcels are affected meaning changes in weight wouldn't necessarily distinguish parcels within those areas as more or less suitable. These 'base' variables can be thought of as the bottom layer in the WLC or simple additive weighting process so they were assigned 0 or 1 point. Another variable with a higher weight and potential maximum score included building/land vacancy. Vacant land with no structure on it is much easier for developing new housing than a property that meets all the other criteria, but has already been developed and is occupied.

While the weights associated with each of the criteria are somewhat subjective, the key is to be consistent across the variables so that no one variable is inappropriately weighted or scored. The relative weights and thresholds are something that should change slightly depending on the community, their values or preferences, as well as any special circumstances.

C. GIS and MS Excel Suitability Scoring Procedures

The LSA was done using ArcGIS 10.5 (ArcMap and ArcCatalog) and Microsoft Excel 2013 and involved a series of steps using several geoprocessing tools. Some of the data used for the LSA required some minor processing (i.e., creation of 0.25-mile buffer around existing water and sewer lines) in GIS, but after all relevant data layers were vectorized, the next step was to apply the 50/50 rule described earlier. This was done primarily using the Tabulate Intersection tool found under the Statistics section of the Analysis Tools in the ArcToolbox. Tabulate Intersection calculates the overlapping area and its percentage of total area between two vector-based data layers (i.e., parcel and 100-year flood zone) (Appendix Section A). For all variables that were not already part of the parcel data set (i.e. zoning, parcel size, etc.), Tabulate Intersect was used to calculate the overlapping area percentage, which fell either below or above 50%.

With each calculation, there was a new comma separated values (csv) table created containing: 1) a common identifier (i.e., FID); 2) the calculated area in specified units; and 3) the percentage of overlap for the parcel and data layer of interest. After conducting each Tabulate Intersection, the results of the output table can be compiled into one excel spreadsheet which can then be joined with the original parcel data file using the common identifier. After joining, each parcel record contained the necessary data to begin calculating scores using the thresholds and weights. After exporting the joined table from ArcMap back into MS Excel, this is a simple procedure done using a combination of IF and nested IF-AND functions. The result is the joined table with eleven new data fields appended to the end containing the relative scores for each variable. Creating one final field for summing the scores creates the total or composite suitability score for each parcel record. Rejoining this fully scored spreadsheet to the parcel GIS file using the common identifier, the user can then symbolize the total suitability score into six equal interval classes with a range of colors (i.e. oranges and reds communicating inappropriate or unsuitable areas and greens and blues denoting higher suitability for development). How the map is symbolized could be altered or changed based on preferences of stakeholders involved. Step by step procedures can be found in the Appendix Section A.

IV. Community Feedback on LSA Process

The LSA's goals, initial methods, variables and thresholds selected, relative weights, and results were shared and discussed with the Town of Fair Bluff at a Town Council meeting. The Town was generally receptive and acknowledged the value of LSA, eager to know more about its relationship to the rest of the long-term recovery plan that was being developed by HMDRRI. One town council member proposed incorporating flood depth and this is accounted for using the various flood risk variables since each of their areal extents represents a different magnitude of flooding event. The comment was valuable, though, because it brings up the idea for future LSAs to include another flood risk threshold such as 'experienced less than 2 feet of flooding' which could relate to the suitability or feasibility for encouraging elevation of the structure as opposed to acquisition and demolition.

V. Limitations of the LSA Method

Any GIS-based LSA is going to make some assumptions or otherwise introduce uncertainty. These factors can limit the effectiveness of the LSA, whether due to potentially inaccurate data, shortcomings of a chosen method, or lack of stakeholder engagement. First, the water and sewer line data from NC OneMap represents a state-wide dataset from 1997 which was easily accessible and applied to all HMDRRI communities. Given that most water and sewer distribution data is privacy protected and more difficult to obtain since the 9/11 terrorist attacks in 2001.

Additionally, the use of a proxy for a land/building vacancy variable was not ideal. The most suitable location would be land with no building, but metadata for occupancy code field of county parcel file was not available. The county file also did not have a field for whether a structure was on the property, so we used GIS and a supplemental data source to determine if the building footprint (FP) existed on a given property. For parcel use description, I took data from the standardized parcel data set for Columbus County from NC OneMap, but those listed as vacant parcels often had a footprint on it, so the proxy reduces uncertainty as to whether a given property is vacant. The LSA for Fair Bluff used the best data available, but ideally, a local

government parcel shapefile would contain both use with appropriate metadata as well as whether or not there's a structure on the property.

Another limitation is that this LSA could not include more advanced measures of flood risk such as future floodplain conditions, which would take into account future development upstream of community as well as the projected increase in frequency and intensity of heavy rainfall events caused by climate change. Fair Bluff does not have the capacity for this level of flood risk planning and no other organization has conducted this analysis for the area.

Another consideration is that the higher weight (3 points) assigned to the largest parcels (>1,000,000 ft^2) may be misleading for towns with prime or productive farmland within the ETJ which some would argue is much less likely to be developed. Upon further investigation using aerial imagery, the largest parcels do indeed appear to be working farms. The weight for the largest parcels could be lowered or a simple crosshatched overlay could be used to show alternate perspective by highlighting known working farms on top of total suitability score.

This LSA included eleven variables, but it could be argued that other variables would impact suitability and would be worth including (soils, distance to community resources, property owner, land value, etc.). However, some variables that were omitted such as property ownership were considered to not be as relevant for Fair Bluff from the perspective that the most easily developed properties would be those that the Town already owns. During exploration of Columbus County's GIS mapping portal, it was discovered that there was essentially no town owned property that wasn't already heavily developed or a designated park. The variables that were chosen were developed through consensus of both HMDRRI staff and confirmed by the community.

Finally, the use of the linear combination method doesn't account for interdependent variables (Hopkins, 1977), but these facts are acknowledged with HMDRRI's LSA and no significant interdependencies were determined to significantly alter results.

Chapter 5: LSA Results

I. Fair Bluff, North Carolina

A. Background on Recovery Issues

The Town of Fair Bluff was founded in 1873 along the Lumber River (a National Wild and Scenic River) in Columbus County near the North Carolina – South Carolina Border and is home to just under 1,000 residents. Hurricane Matthew's heavy rainfall in October of 2016 lead to record flood levels on the Lumber River, impacting more than 100 households and 84 percent of the commercial square footage within its downtown where the water was 4 feet deep in some buildings (Figure 9). The flooding also significantly damaged a number of key public facilities located downtown including the Town Hall, Visitors Center, U.S. Post Office, Senior Center, and Fire Station. Even before Hurricane Matthew, the Town was dealing with challenges associated with a declining and aging population, lack of affordable housing, extremely low indicators of health, residents in poverty, and difficulty in affording the management of water and sewer systems. The town's draft Recovery plan has identified eight major issue areas, including: infrastructure, public facilities, housing, health, environment, land use, administration and finance, and economic development (HMDRRI, 2018).

Figure 9. View of flooded downtown Fair Bluff looking east down Main Street. Source: wbtw.com

Through a long-term recovery planning process led by HMDRRI, Fair Bluff has established a community vision for recovery (Figure 10), been awarded a number of grants (via CDBG-DR[15], Golden Leaf Foundation, etc.) for reconstruction, repair and relocation of facilities, and is exploring opportunities for integrating downtown revitalization and eco-tourism while working to address the immediate needs of the residents most heavily impacted by the storm.

> **Recover from Hurricane Matthew and create a more resilient community that once again has a vibrant downtown, a diverse and affordable housing market, and a local economy that continues to serve the needs of the surrounding agricultural community and promotes an eco-tourism economy tied to services and facilities that draw upon the beauty and recreational assets of the Lumber River.**

Figure 10. Proposed Community Vision for Fair Bluff Recovery

With a significant number of buyout participants expected through the HMGP, the Town is concerned about losing part of its tax base should individuals relocate outside of municipal boundaries. To minimize this loss, the Housing section of the Fair Bluff Recovery Plan recommends that about 60 new single-family and/or 40 rental housing units should be built by the end of 2019 using information derived from the Land Suitability Analysis and HMDRRI HomePlace document. However, getting from the LSA to the reality of flood survivors living inside dozens of new affordable homes will take a significant amount of time, energy, investment, planning and determination on the part of the Town officials/staff, their recovery partners, and of course, the survivors themselves.

The challenges and opportunities seen in Fair Bluff are numerous and varied, but they are taking steps to reinvent their town in a way that makes it more resilient to future flooding. HMDRRI has facilitated taking many of the first steps in a long recovery process, including the following LSA which can inform future resilient housing development strategies for the town.

[15] CDBG-DR funds may supplement, but cannot duplicate, funding available from FEMA or other federal agencies. CDBG funds must be approved by Congress. These flexible grants, administered by the U.S. Department of Housing and Urban Development (HUD), can be used to assist disaster recovery and resilience efforts by local governments, states, or tribes. CDBG may be used to fund a broad range of activities so long as they meet at least one of three national objectives: 1) benefit low- and moderate- income persons, 2) help prevent or eliminate slums or blight, or 3) address urgent risks that pose a serious and immediate threat to the health and wealth of the community where other financial resources are unavailable. (U.S. HUD, 2016).

B. Interpretation and Findings of the LSA

The results of the LSA reveal significant spatial variation in the total suitability score within the Town's ETJ. For instance, there are areas in close proximity to one another, but with major differences in suitability, most likely a result of the irregular shape of the floodplain and its relative weight and influence on the scoring. Of the 1,012 parcels analyzed that intersected the ETJ, 102 were found to be within the 'highest' suitability category (Figure 11). Over 350 parcels received a 'high' suitability score, though this may be skewed upwards due to inclusion of three scores (14-16) as opposed to just two (17-18). Figure 12 illustrates areas in blue that are of highest suitability just southwest near the Minton St. – Gapway Rd - Holmes St. – Orange St. area and east of downtown near Waddell St. – Conway Rd. – Graham St. – Patterson St. area, which is centered around Fair Bluff Elementary School. These areas are on generally higher ground, about 66-72 ft above sea level (ASL) compared to the lower scoring, low-lying area south of downtown, known as Barden Bay, whose elevations range from 62-65 ft. ASL.

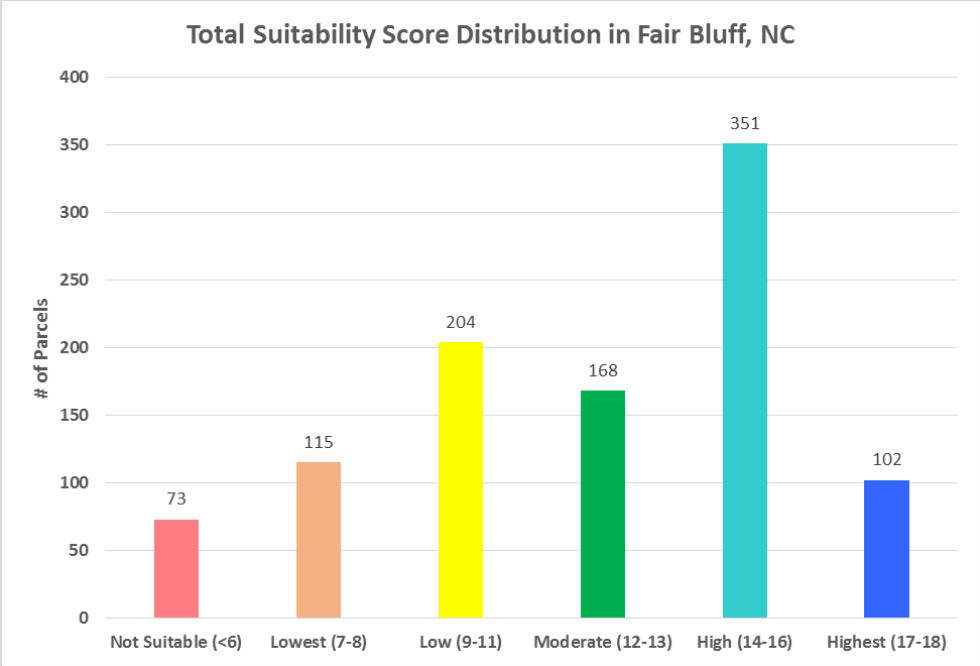


Figure 11. The color-coded distribution of total suitability scores for 1,012 parcels.

Figure 12 shows how much of the more densely developed parcels that make up downtown and lie in the 100-year floodplain are considered 'not suitable' for development.

However, less than 0.1 miles east down Main Street are a few parcels with moderate to high suitability scores, which typically lie just outside the 100-year flood plain shown with a grey-filled hash pattern. The highest

possible scores for a parcel are 18 for infill potential (smaller sized lots) and 19 for multi-structure (larger sized lots) (Table 2).

Within the next year, the NC Housing Finance Agency is helping to build a 36-unit affordable housing development east of downtown. The property is about 0.5 miles from the town's municipal limits, but within the Extraterritorial Jurisdiction (ETJ) off of Rough and Read Road. The parcel is zoned for Low Density – Agriculture (Labeled on Figure 12). The parcel received a moderate suitability score because of its location outside of town limits, it's current zoning, and status as occupied with a building footprint. Because this is a significant housing development and is about 1.75 miles from downtown, it could be considered a potential second, somewhat smaller 'node' of activity for the town, given how many people may end up living there.

It's not clear what led to the selection of this specific site, but it was done prior to the LSA being developed and had to be approved for annexation during the Town Council meeting during which there were contrasting arguments for and against the annexation. On one hand, the town was worried about being able to fill the 36-units, which would be crucial to paying the water and sewer bills that the Town can barely keep up with. On the other hand, town council members and some individuals of the public, noted that the development would attract people back into the Town, spurring business downtown and an overall sense of hope at a time when it feels like there's not many positive actions happening. The council was split 3-3 on the decision, which led to the Mayor breaking the tie in favor of annexation, citing other proponents' arguments that the town can't afford to give up the opportunity to utilize the grant money and demonstrate meaningful recovery progress post-Matthew. The approval of the development illustrates the fact that what leads to housing getting built is driven more strongly by economic and political forces and may or may not incorporate best-practice planning tools such as an LSA. Future LSAs should consider and operate in acknowledgement of these realities.

This addition of housing stock could satisfy some of the needs of flood survivors as far as affordable housing, but there still could be reasons to pursue infill development in areas of highest suitability, listed in Table 3, to capture the population who either are not interested in living in the new 36-unit building or can't secure a unit if it were to become fully occupied in the short-term.

*Table 3. Top 16 Highest Scoring Properties from LSA in Fair Bluff, NC**

ID	Property #	Total Score	Total Value	Acres	Sq. Ft.	Zoning	Building/Land Vacancy	Matthew Extent % Overlap	500-Yr % Overlap
1	87753	18	$ 19,100	0.76	33,304.43	MED	VACANT - NO FP	1.91	19.33
2	18139	18	$ 10,300	0.72	31,379.41	MOD	VACANT - NO FP	0	38.93
3	17918	18	$ 6,700	0.55	23,974.00	MED	VACANT - NO FP	0.24	0
4	18138	18	$ 19,900	1.55	67,621.25	MOD	VACANT - NO FP	0	0
5	17357	18	$ 9,200	0.54	23,400.33	MOD	VACANT - NO FP	0	0
6	17886	18	$ 11,400	0.76	32,898.26	MED	VACANT - NO FP	0	0
7	18271	18	$ 8,200	0.50	21,973.06	MED	VACANT - NO FP	0	0
8	63107	18	$ 17,300	0.58	25,261.77	MED	VACANT - NO FP	0	0
9	82556	18	$ 6,400	1.59	69,298.00	MOD	VACANT - NO FP	0	0
10	82895	18	$ 3,900	0.50	21,799.79	MOD	VACANT - NO FP	0	0
11	85628	18	$ 5,400	0.91	39,640.43	MOD	VACANT - NO FP	0	0
12	92300	18	$ 3,000	0.50	21,799.86	MOD	VACANT - NO FP	0	0
13	93877	18	$ 3,000	0.50	21,799.79	MOD	VACANT - NO FP	0	0
14	95258	18	$ 2,500	0.50	21,799.99	MOD	VACANT - NO FP	0	0
15	96017	18	$ 3,000	0.50	21,799.79	MOD	VACANT - NO FP	0	0
16	96072	18	$ 3,000	0.50	21,801.06	MOD	VACANT - NO FP	0	0

**An additional 86 properties had a total score of 17 (highest suitability).*

The 16 highest scoring parcels found in Table 3 all lie outside the 100-year flood zone, overlap less than 50% with the 500-year flood zone and Hurricane Matthew Flood Extent, zoned for either moderate or medium density residential, of adequate size for infill development (20,000 -100,000 ft^2), listed as vacant, and do not have a structure located on them. Three of the properties slightly overlap either the 500-year flood zone (property # 18139), the Hurricane Matthew flood extent (property #17918), or both (property #87753) meaning there's greater than 50% of those parcel that are not subject to flooding levels associated with those variables. While parcel ownership was not included as a factor with the LSA (due to fact that there isn't any vacant town-owned land which would be more suitable), knowing who owns the land deemed suitable for development and their willingness to sell would be a key factor to pursuing new housing development and relocation in these locations. The top 30 highest scoring properties and additional data fields can be seen in Appendix Table A2.

Figure 12. Town-Wide Land Suitability Analysis for Fair Bluff

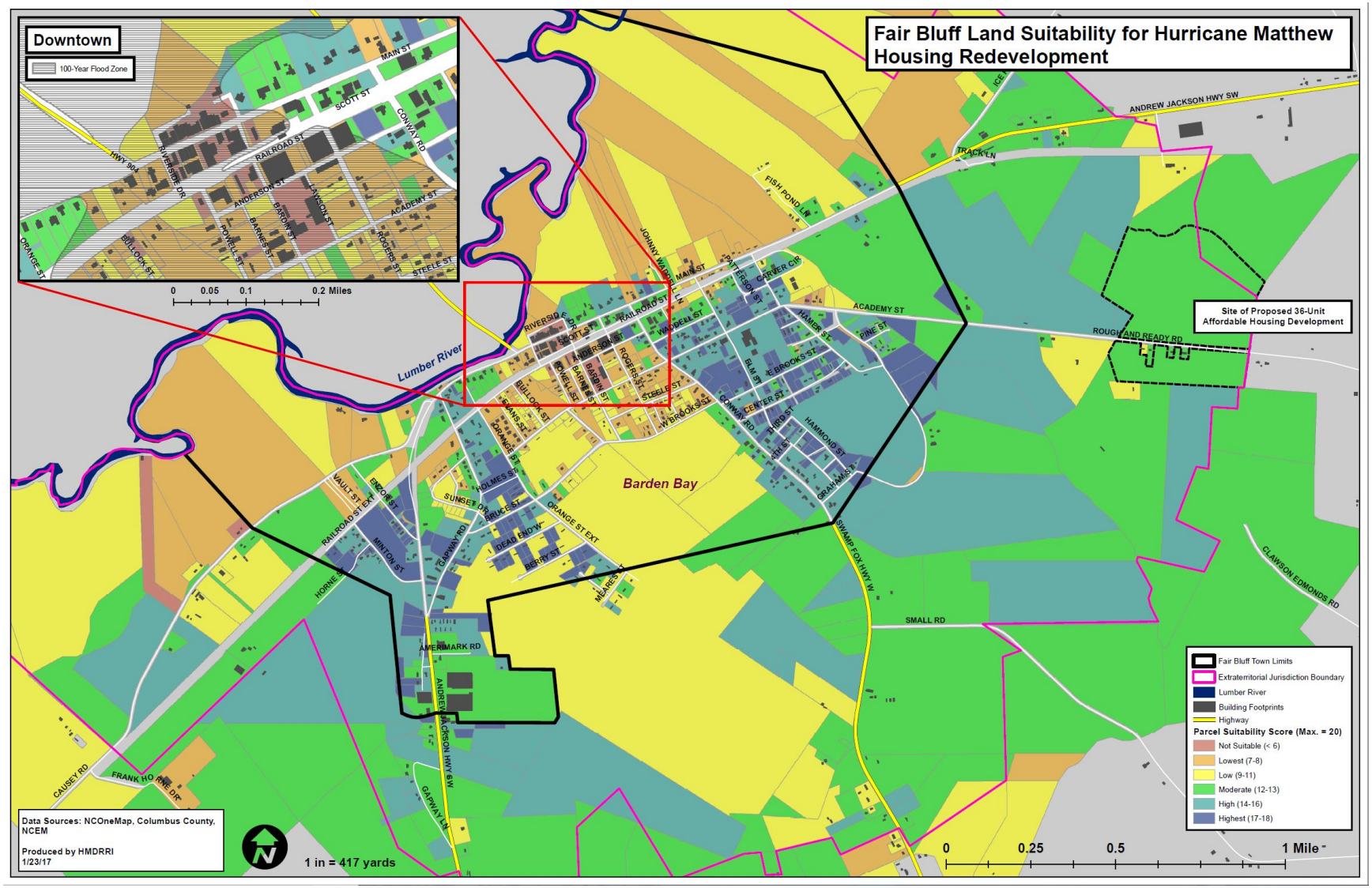
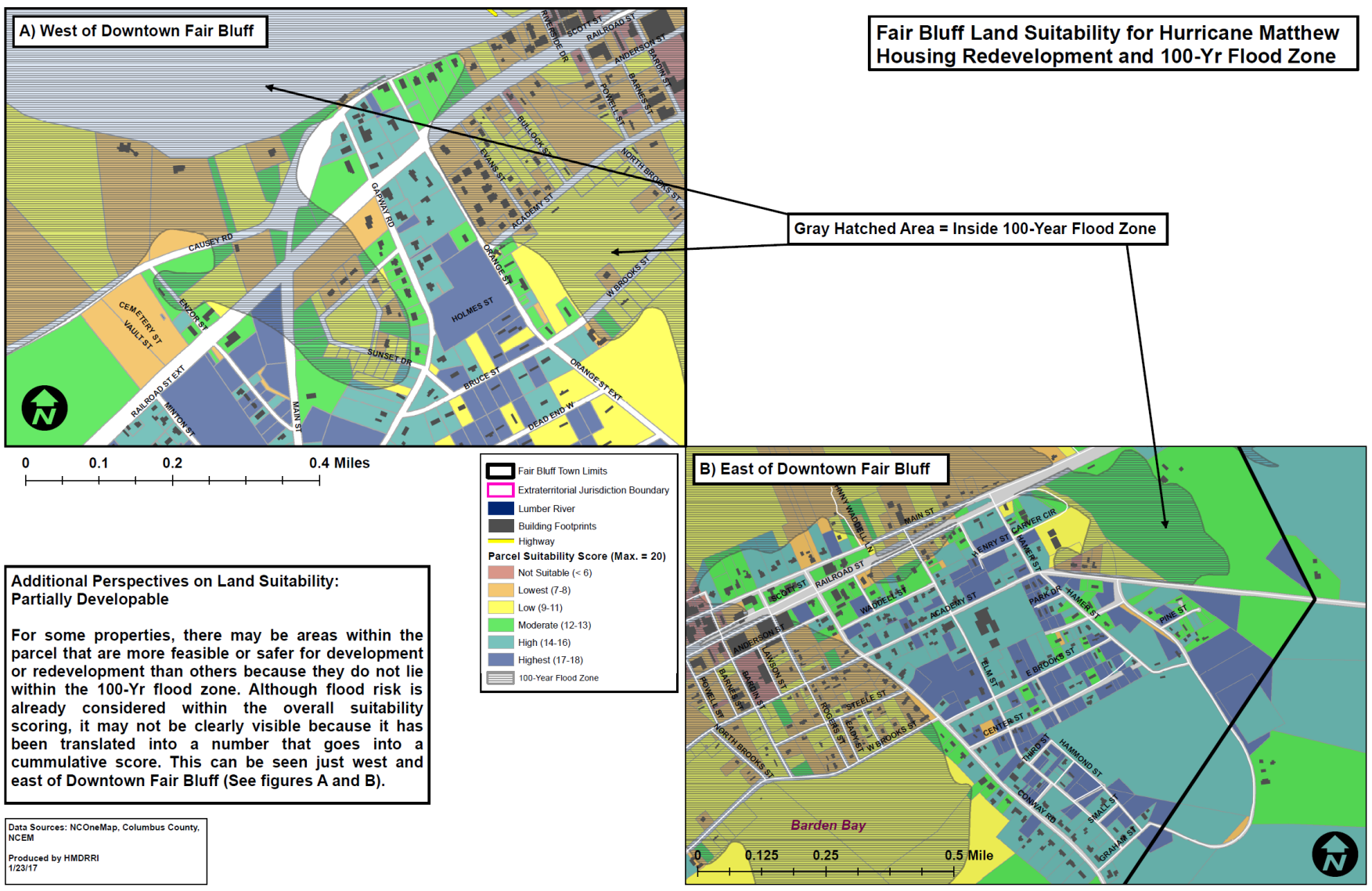


Figure 13A & 13B. Alternate Perspectives of the LSA: Total Suitability and 100-year floodplain



C. Alternate Perspectives of LSA: Partial Developability

Additional maps or portrayals of land suitability were created at a smaller scale, focused on specific areas within the Town to illustrate the parcels that may be considered partially developable based on their intersection or overlap with the 100-year floodplain, shown as cross-hatch pattern in Figures 13A and B. This is important because there are some larger parcels (i.e., south of Academy Street) that received lower scores because of the amount of overlap with the 100-year floodplain (>50%), but contain areas on the property that are at lower risk of flooding and therefore are potentially developable. Figure 13A also show a number of parcels with lower suitability (yellow) interspersed with several parcels with high or highest suitability (blue) which is likely the result of the fact that in the county's parcel boundary data record, each of those properties is legally linked through common land ownership to one of the largest parcels south of Meares St. (scored lower because it's mostly outside of town limits and zoned for low density – agriculture). This is an anomalous occurrence and leads to underestimation of potential high suitability properties.

Ultimately, this enhanced perspective allows the public and decision makers to see one of the key underlying factors of the LSA, the 100-year flood zone, superimposed on top of the general LSA. This could be done with other variables as well (i.e., zoning, infrastructure buffer, or parcel vacancy) to show the nuance involved with the LSA that gets lost or smoothed over when integrated into a composite score. If desired, similar exercises could be done for other variables such as zoning, property owner name, property value, etc.

Chapter 6: Conclusions

The following conclusions are based on the experience of developing the LSA method and performing the analysis during the post-disaster recovery planning process in the Town of Fair Bluff. Recommendations for improved method design and relocation strategy implementation as well as areas for future research are presented in Chapter 7.

A) A GIS-based LSA can be used as an adaptable land use planning tool for identifying the most appropriate locations for post-disaster housing redevelopment.

While recovery from Hurricane Matthew is still ongoing for communities across Eastern North Carolina, the LSA for Fair Bluff provides a meaningful foundation for a more detailed relocation strategy. Using a combination of computer-assisted overlaying techniques, multi-criteria evaluation (MCE), and mix of 'soft' and 'hard' data inputs, the LSA serves as an "informational measure" that provides a clear picture of the areas in town that should be considered for development or redevelopment of safe housing for flood survivors and/or buyout participants. The LSA could also be adapted to show areas suitable for home elevation.

B) There are approximately 100 individual parcels within Fair Bluff's town limits that are considered to have the 'highest' composite suitability and could support multiple types of housing

Located primarily just east and west of Barden Bay, south of downtown, dozens of small-medium size vacant lots exist in areas of reduced flood risk that could support infill development of single family homes. A few larger parcels meet all the same criteria and could support a cluster of single family homes or denser multi-family apartment buildings that would supplement the planned 36-unit development off Rough and Ready Road.

C) LSAs are flexible, interactive decision-support tools that can apply across the 'network of plans' and in other instances involving community displacement and relocation

Various forms of LSAs can be found in all types of local plans (i.e., comprehensive, economic development, natural resource management, etc.). In this case, HMDRRI developed a unique version of a LSA that informs a housing relocation strategy for flood buyout participants. If designed thoughtfully with community stakeholders, the LSA can accomplish multiple objectives and serve as a best practice for effective pre- and post-disaster recovery planning. There are other scenarios beyond major natural hazard events that cause major displacement of people from their homes (i.e., major highway/rail construction, natural resource extraction, etc.) where a relocation strategy, informed by a LSA, could be useful.

D) For LSAs, statistician George Box's phrase "All models are wrong, but some are useful" applies.

There are limitations found in any GIS-based LSA and efforts must be made to minimize them as much as possible. At the same time, limitations must be acknowledged and accounted for when interpreting the results. Data availability and inaccuracy (i.e., water and sewer infrastructure) may influence the overall result, but it shouldn't completely preclude communities from making informed decisions. In smaller communities with limited planning capacity, acquiring hard data, if it exists, can be challenging. Despite some of the limitations identified during the process of conducting a LSA done for Fair Bluff, residents and decision-makers can still apply the results and adapt the process as needed when engaging in future planning efforts.

Chapter 7: Recommendations and Future Research

This series of recommendations are based on the project's findings and aim to describe improvements to the LSA method and implementation process thereby improving the relocation of flood buyout participants. Each set of recommendations is accompanied by key research questions that could inform and advance the effectiveness of the LSA.

I. Improving the LSA Method for Post-Disaster Planning

- **Gather as much of the most accurate 'hard' data as feasible.** Hard data such as the latest flood zone areas or water infrastructure lines are crucial to data processing accuracy. Utilizing information and other plans or policies with a spatial component (i.e. economic development, hazard mitigation, comprehensive, etc.) can insure complimentary design solutions that build resilience and strengthen the network of plans. Hard data includes other disaster response and recovery programs such as FEMA Public Assistance projects, Individual Assistance (IA) data, CDBG-DR, which may be directly or indirectly related to the housing relocation process. These post-disaster data sources include useful information such as the demographics of flood survivors, expected investments in infrastructure repair, and the status of local affordable housing market.

- **Discover 'soft' data through deep community engagement and collaboration.** Indigenous knowledge held by local stakeholders and residents is important particularly in the initial LSA process design and variable identification and weighting. By involving residents and local officials they not only provide information often missed by "outside experts," they are more likely to buy into the results of the analysis, which in this case means they may be more likely to consider moving to areas identified in the LSA. If there's available time and resources, communities should experiment with various methods to co-produce knowledge such as community asset mapping to increase their understanding and ownership of developed strategies. While not completed in time for inclusion to HMDRRI's

LSAs, a comprehensive buyout participant intake survey revealing family characteristics and preferences would allow for more focused objectives for conducting an LSA as part the relocation strategy.

- **Supplement composite suitability score with alternate perspectives.** While the total suitability score is powerful in its ability to synthesize multi-criteria attributes, it can be easy to overlook the individual parts. Portraying single components like the 100-year flood zone on top of the total suitability score illustrates a certain level of nuance that may reveal previously undiscovered opportunities (i.e.' partial developability'). Similarly, variables such as property value and current owner can be displayed as labels with accompanying tables for easier interpretation. The top scoring parcels could also be extracted from larger data set and super-imposed on a variety of other base maps along with other relevant variables (i.e., parks and green space, community assets, zoning overlays, etc.). Top-scoring suitability parcels could also have GIS network analysis performed to determine estimated walk, bike, drive, and bus distances/times from property to various community assets or landmarks.

- **If feasible, explore more sophisticated GIS-based LSA methods such as Ordered Weight Averaging (OWA), Analytical Hierarchy Analysis (AHP), and Artificial Intelligence (AI).** A plethora of methods exist for conducting land suitability analyses and each should be thoughtfully considered based on a community's goals for the analysis, level of in-house expertise, access to outside expertise, time constraints, and financial resources. With a topic as sensitive as post-disaster housing relocation, it may be helpful to use less complex methods due to the greater chance of having the LSA process and results understood, trusted, acted upon by decision-makers and the public, and used to assess other community planning initiatives.

Relevant Research Questions:

1. How have other communities used some form of GIS-based LSA to inform post-disaster housing relocation? Was it created before or after a major event? In either case, have they been used successfully? Is it feasible for smaller communities to do on their own analysis, interpretation, and implementation of the results?
2. What challenges are associated with trying to integrate soft information into a process as complex as an LSA? Are there risks in terms of power imbalance and inequity when stakeholders are deliberating the variables to be included and their relative importance in the model? How might the use of Alternative Dispute Resolution techniques apply?
3. Are LSA methods like AI and neural networks improving or becoming more accessible to the planners and other in the disaster recovery or related field (i.e., climate adaptation, environmental planning)? If so, can they be employed in communities with limited technical capabilities? Are their particular stakeholder groups uniquely suited to assist them, to include universities, professional associations or regional planning organizations?
4. How can recovery partner organizations (state/federal agencies, tribal governments, non-profits, the business community, grassroots organizations, etc.) assist in the development of a successful LSA and subsequent relocation strategy, to include conducting the analysis before the next disaster strikes?

II. Translating Data to Action: Implementing a Relocation Strategy

- **Pair the development of a LSA with design-oriented public engagement activities and work through a local recovery committee.** In alignment with HMDRRI's RS objectives, the LSA can be informed by community design workshops or charrettes that explore geospatial relationships between various community assets and best practices in greenspace design and reuse of buyout properties. LSA design should be an iterative process that includes regular injections of 'soft' information over several meetings or workshops whose focus may be on general recovery issues. An open dialogue should be fostered between residents and other stakeholders involved in the buyout program and

LSA ideas via telephone hotlines, office hours, website updates, social media engagement, print materials, and other methods as identified. Regular consultation from local recovery planning committee members can help maintain familiarity and lead to a more sustained effort, to include the implementation process. If possible, engagement measures should be conducted prior to a disaster when issues of 'speed versus deliberation' and 'time compression' are not present.

- **Engage early on with local community organizations such as community development corporations (CDCs) and other housing stakeholder groups (local/state housing finance agencies, religious groups, non-profits, and private groups like Purpose Built Communities) to explore synergistic programs and funding mechanisms that support holistic housing recovery goals.** Neighborhood associations, CDCs and other preexisting or emergent community groups can be the difference-maker in implementation since they are flexible, can identify and secure resources, provide case management as well as "assume debt, provide grants, loans… and develop property" (Smith 2011, pp 119). Groups like Purpose Built Communities and Habitat for Humanity are in the business of financing the construction and repair of affordable housing as well as facilitating inter-generational wealth building through new homeowner assistance programs.

- **Work with stakeholders who may have an interest in developing or contributing to plans for adaptive reuse of soon-to-be acquired properties as a result of buyout.** Invite natural resource agencies, community land and conservation trusts, local/state/national park agencies, nearby schools, neighboring residents, watershed groups, community gardening organizations, and others interested in green space or vacant lots, to discuss opportunities for adding natural or recreational value to acquired sites.

Relevant Research Questions:

1. Are there good examples of situations where communities purposefully built housing for flood survivors and there were high rates of participation? Were there mandates involved or incentives or both? Given how much uncertainty there is with the timing of buyout programs and the length of time it takes to build new, affordable homes in safe locations, how can a community plan for success?
2. What sorts of organizations similar to CDCs are viable in more rural areas where there are less resources (and potentially enthusiasm) for community development planning or in cases where the region is in economic decline and its population is shrinking and aging? Are regional planning organizations equipped to help all of the smaller towns it's responsible for if the whole region is shocked by a major natural hazard event like a hurricane or flood? If not, what organizations might fill this void?
3. What are the latest and greatest decisions support systems, including new technologies and design software, available to create a more engaging environment for discussing LSAs and long-term planning? Are there specific methods that lend themselves to the complexity of long-term disaster recovery? Could digital humanities, storytelling, and other forms of expression enhance a community's experience and ability to reflect after a disaster?

III. Concluding Thoughts

The record-breaking 2017 hurricane season in the U.S. is a stark reminder of the great challenges we as a civilization face in preparing for, responding to, and recovering from major natural hazard events. For many communities, the rain came down harder, the wind blew faster, and the water levels rose higher than had ever been seen before. Along with recovery from these events, current and future generations are simultaneously trying to understand how to plan and invest more effectively knowing that in an era of climate change, these risks are only expected to increase. Major events like Hurricanes Harvey, Irma, and Maria have produced a set of extremely difficult circumstances for the thousands of people affected. They have also brought people together in amazing ways. The human spirit often shines during response and recovery as

everyday heroes emerge and local officials call for the need to ‘build back better’. However, the physical and emotional trauma that transpires in the aftermath of an event often reveal the disproportionate impact felt by communities of modest wealth and communities of color who were struggling prior to the event. Opportunities to invest in alleviating these disproportionate impacts are limited and at the federal government level, lean towards a reactive instead of proactive approach. Pre-event planning offers another opportunity to create positive change with and for those with the greatest levels of vulnerability.

Every year, more accurate data is collected, analyzed, and visualized through new tools that increase awareness and understanding of our country’s natural hazard risks. Some tools are also getting better at linking together community goals and addressing multiple issues at once. HMDRRI’s approach to the LSA is an example of how a tool can be flexible, yet powerful in its ability to inform a relocation strategy. Supported by the indigenous knowledge of a community, planning approaches like this can be used to guide a more resilient and equitable recovery in the future.

References

Abdulquadri, B., Witt, E., Lill, I. & Bustani, S. (2016). Housing Reconstruction Following the 2012 Nigerian Floods: Was it Built Back Better? Retrieved from: https://www.researchgate.net/profile/Bilau_Abdulquadri/publication/308549903_Housing_Reconstruction_Following_the_2012_Nigerian_Floods_Was_it_Built_Back_Better/links/57e6bd9508ae9227da9d42b8/Housing-Reconstruction-Following-the-2012-Nigerian-Floods-Was-it-Built-Back-Better.pdf

American Planning Association. (2014). Planning for Post-Disaster Recovery Brief Papers: Affordable Housing. Retrieved from: https://planning-org-uploaded-media.s3.amazonaws.com/document/post-disaster-paper-4-affordable-housing.pdf

American Planning Association. (2014). PAS Report 576. Planning for Post-Disaster Recovery: Next Generation. Retrieved from: https://planning-org-uploaded-media.s3.amazonaws.com/publication/online/PAS-Report-576.pdf

Asian Development Bank. (2016). Reducing Disaster Risk by Managing Urban Land Use: Guidance Notes for Planners. Retrieved from: https://www.adb.org/sites/default/files/publication/185415/disaster-risk-urban-land.pdf

Berke, P. (2016). CRC researchers go 'beyond the basics' of hazard mitigation. Coastal Resilience Center. July 27, 2016. Retrieved from: http://coastalresiliencecenter.unc.edu/crc-researchers-go-beyond-the-basics-of-hazard-mitigation/

Berke, P., Newman, G., Lee, J., Combs, T., Kolosna, C., & Salvesen, D. (2015). Evaluation of Networks of Plans and Vulnerability to Hazards and Climate Change: A Resilience Scorecard, *Journal of the American Planning Association*, 81:4, 287-302, DOI: 10.1080/01944363.2015.1093954

Berke., P. & Campenella, T. (2006). Planning for Postdisaster Resiliency. The Annals of the American Academy. Retrieved from: http://journals.sagepub.com/doi/pdf/10.1177/0002716205285533

Berke, P., Kartez, J., and Wegner, D. (1993). Recovery after Disaster: Achieving Sustainable Development, Mitigation and Equity. Disasters, 17: 93–109. doi:10.1111/j.1467-7717.1993.tb01137.x

Bertie County. (2015). CAMA Land Use Plan Update. Section 6: Land Suitability Analysis. Retrieved from: http://www.co.bertie.nc.us/departments/pi/LUP/LUPNov15.pdf

Boustan, L., et al. (2017). The Effect of Natural Disasters on Economic Activity in US Counties: A Century of Data. National Bureau of Economic Research Working Paper No. 23410. Retrieved from: http://www.nber.org/papers/w23410.pdf

Brennan, M. (2011). "The Impacts of Affordable Housing on Education: A Research Summary." Washington, D.C: Center for Housing Policy. Retrieved from: www.nhc.org/media/files/Insights_HousingAndEducationBrief.pdf

Brennan, M., and Lubell, J. (2012). "More than a Roof: Case Studies of Public Housing Agency Initiatives to Increase Residents' Economic Security." Washington, D.C.: Center for Housing Policy. Retrieved from: http://www.nhc.org/media/files/IdeasBrief_AssetBdg_final.pdf

Bukvic, A., & Owen, G. (2017). Attitudes towards relocation following Hurricane Sandy: should we stay or should we go? *Disasters*, *41*(1), 101–123. https://doi.org/10.1111/disa.12186

Burby, R. et. Al. (2000). Creating Hazard Resilient Communities Through Land-Use Planning. Natural Hazard Review. Retrieved from: https://hazards.colorado.edu/archive/workshop/2009/speakers/pubs/olshansky_communities.pdf

Burrough, P. A., et. al. (1992). Fuzzy classification methods for determining land suitability from soil profile observations and topography. Journal of Soil Science, 43: 193–210. doi:10.1111/j.1365-2389.1992.tb00129.x

Cohen, R. (2011). "The Impacts of Affordable Housing on Health: A Research Summary." Washington, D.C.: Center for Housing Policy. Retrieved from: www.nhc.org/media/files/Insights_HousingAndHealthBrief.pdf

Collins, M., Steiner, F. & Rushman, M. (2001). Land-Use Suitability Analysis in the United States: Historical Development and Promising Technological Achievements. *Environmental Management*. 28: 611. https://doi.org/10.1007/s002670010247

Central Florida Regional Planning Council. (2014). Heartland 2060. Affordable Housing Suitability Model. Retrieved from: http://heartland2060.org/download/affordable_housing/housing_suitability_model_2-7-14.pdf

Cleetus, R. (2018). Union of Concerned Scientists Blog: New NOAA Report Shows 2017 Was the Costliest Year or Record for US Disasters. January 8, 2018. Retrieved from: https://blog.ucsusa.org/rachel-cleetus/new-noaa-report-shows-2017-was-the-costliest-year-on-record-for-us-disasters

Environmental Law Institute & UNC Institute for the Environment. (2017). Floodplain Buyouts: An Action Guide for Local Governments on How to Maximize Community Benefits, Habitat Connectivity, and Resilience. Retrieved from: https://www.eli.org/sites/default/files/eli-pubs/actionguide-web.pdf

Federal Emergency Management Agency. (2018). FEMA Releases Draft National Mitigation Investment Strategy for Public Comment. January 11, 2018. Release Number: HQ-18-008. Retrieved from: https://www.fema.gov/news-release/2018/01/11/fema-releases-draft-national-mitigation-investment-strategy-public-comment

Federal Emergency Management Association. (2013). Innovative Floodplain Management. Case Studies: Kinston, North Carolina. Retrieved from: https://www.fema.gov/media-library-data/20130726-1515-20490-7614/kinston_cs.pdf

Freudenberg, R., Clavin, E., Tolkoff, L., & Brawley, D. (2016). Buy-In for Buyouts: The Case for Managed Retreat from Flood Zones. Lincoln Institute of Land Policy & Regional Plan Association. Retrieved from: https://www.lincolninst.edu/sites/default/files/pubfiles/buy-in-for-buyouts-full.pdf

Galloway, G. E. (1994). Sharing the Challenge: Floodplain Management into the 21st Century. Report to the Interagency Floodplain Management Review Committee to the Administration Floodplain Management Task Force. Retrieved from: https://www.floods.org/PDF/Sharing_the_Challenge.pdf

Glavovic, B. and Smith, G. eds. (2014). *Adapting to Climate Change: Lessons from Natural Hazards Planning*. Environmental Hazards. DOI 10.1007/978-94-017-8631-7. ©Spring Science+Business Media Dordrecht.

Hopkins, L. D. (1977). Methods for Generating Land Suitability Maps: A Comparative Evaluation, Journal of the American Institute of Planners, 43:4, 386-400, DOI: 10.1080/01944367708977903

Horney, J. et. al. (2017). Assessing the Quality of Rural Hazard Mitigation Plans in the Southeastern United States. *Journal of Planning Education and Research*. Vol. 27(I) 56-65. DOI: 10.1177/0739456X16628605

Hurricane Matthew Disaster Recovery and Resilience Initiative. (2018). Draft 2017 Fair Bluff Recovery Plan. Coastal Resilience Center, University of North Carolina – Chapel Hill.

Hurricane Matthew Disaster Recovery and Resilience Initiative. (2017). HomePlace – Fair Bluff Community Conversation Guide. Retrieved from: http://coastalresiliencecenter.unc.edu/wp-content/uploads/2017/10/HomePlace-FairBluff.pdf

Hurricane Matthew Disaster Recovery and Resilience Initiative. (2017). HMDRRI Phase One Funding Report (UNC Policy Collaboratory). Retrieved from: http://coastalresiliencecenter.unc.edu/wp-content/uploads/2017/10/HMDRRI-Phase-One-Funding-Report-UNC-Policy-Collaboratory.pdf

Ibrahim, I. et. al. (2015). Suitability Analysis of Resettlement Sites for Flood Disaster Victims in Lokoja and Environs, *World Environment*, Vol. 5 No. 3, 2015, pp. 101-111. doi: 10.5923/j.env.20150503.02.

Jimenez-Magdaleno, K. (2017). FEMA Property Buyouts: Impacts on Land and People. NCGrowth – Kenan-Flagler Institute. Retrieved from: http://www.ncgrowth.unc.edu/wp-content/uploads/2018/01/Buyouts_Impact_LIteratureReview_Final.pdf

Kanako Iuchi (2004) Planning Resettlement After Disasters, Journal of the American Planning Association, 80:4, 413-425, DOI: 10.1080/01944363.2014.978353

Kunreuther, H. (2006). Disaster Mitigation and Insurance: Learning from Katrina. *Annals of the American Academy of Political and Social Science.* Volume 605. Pages 208-227. Retrieved from: http://journals.sagepub.com/doi/pdf/10.1177/0002716205285685

Lyles, W., Berke, P. & Smith, G. (2014). A Comparison of Local Hazard Mitigation Plan Quality in Six States, USA., *Landscape and Urban Planning.* 122 (February): 89- 99.

Malczewski, J. (2014). GIS-based land-use suitability analysis: a critical overview. Prog Plan 62(1):3–65. Retrieved from: http://staff.unila.ac.id/ekoefendi/files/2011/10/Malczewski_2004.pdf

Mallon et. al. (2017). Using GIS Site Suitability Analysis to Identify Vacant Lots for Equitable and Affordable Housing Development in St. Johns. Portland State University. USP 592 GIS II Advanced. Retrieved from: http://web.pdx.edu/~jduh/courses/geog492w17/Projects/08_RutledgeMallonSalzmann_GIS2_W17.pdf

McHarg, I. L. (1969). *Design with Nature.* New York: Natural History Press.

McHarg, I. L. (1992). Green the Earth, Heal the Earth. *Journal of Soil and Water Conservation* 47(1): pp. 39-41.

Multihazard Mitigation Council. (2017). Natural Hazard Mitigation Saves 2017 Interim Report: An Independent Study. Principal Investigator Porter, K.; co-Principal Investigators Scawthorn, C.; Dash, N.; Santos, J.; Investigators: Eguchi, M., Ghosh., S., Huyck, C., Isteita, M., Mickey, K., Rashed, T.;P. Schneider, Director, MMC. National Institute of Building Sciences, Washington.

National Climate Assessment. (2014). 2014 National Climate Assessment. U.S. Global Change Research Program. Heavy Downpours Increasing. Retrieved from: https://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing

National Institute of Building Sciences. (2005). Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. Retrieved from: http://www.nibs.org/mmc_projects#nhms

Naturally Resilient Communities. (2018). Moving People Out of Harm's Way: Property Buyouts. Retrieved from: http://nrcsolutions.org/wp-content/uploads/2017/03/NRC_Solutions_Property_Buyouts.pdf

National Oceanic and Atmospheric Administration. (2018). Billion-Dollar Weather and Climate Disasters: Table of Events. National Centers for Environmental Information. Retrieved from: https://www.ncdc.noaa.gov/billions/events/US/2000-2017

North Carolina Office of the Governor. (2017). One Year Later: North Carolina's Recovery from Hurricane Matthew. Retrieved from: https://files.nc.gov/governor/documents/files/MatthewRecovery-BytheNumbers-OneYearAnniversary.pdf?2Nmgc61K3xqZDcfelclBtIn9_9agzyTJ

Nguyen, M., et. al. (2017). Recovering Affordable Housing in Eastern North Carolina Post-Hurricane Matthew: A Strategy Forward. Hurricane Matthew Disaster Recovery and Resilience Initiative. Retrieved from: http://coastalresiliencecenter.unc.edu/wp-content/uploads/2017/10/Affordable-Housing-Strategy-for-Eastern-NC.pdf

Nelson, M. (2014). Using Land Swaps to Concentrate Redevelopment and Expand Resettlement Options in Post-Hurricane Katrina New Orleans, Journal of the American Planning Association, 80:4, 426-437, DOI: 10.1080/01944363.2014.988167

Olshansky, R. B. (2006). Planning after Hurricane Katrina. *Journal of the American Planning Association*, *72*(2), 147-153. DOI: 10.1080/01944360608976735

Rogers, D. (2016). Rooting for Fair Bluff to bounce back. *The News & Observer.* October 20, 2016. Retrieved from: http://www.newsobserver.com/news/weather/article109459597.html

Sipe, N. & Vella, K. (2014). Relocating a Flood-Affected Community: Good Planning or Good Politics? *Journal of the American Planning Association*, 80:4, 400-412, DOI: 10.1080/01944363.2014.976586

Smith, G. (2011). *Planning for Post-Disaster Recovery: A Review of the United States Disaster Assistance Framework.* Washington, D.C.: Island Press

State of Florida Department of Economic Opportunity. (2018). Statewide Post-Disaster Redevelopment Planning Initiative. Retrieved from: http://www.floridajobs.org/community-planning-and-development/programs/community-planning-table-of-contents/post-disaster-redevelopment-planning

State of North Carolina Department of Commerce. (2017). State of North Carolina Community Development Block Grant – Disaster Recovery Action Plan. April 21, 2017. Retrieved from: https://files.nc.gov/rebuildnc/documents/matthew/hurricane_matthew_nc_cdbg_dr_actionpaln_final.pdf

U.S. Department of Housing and Urban Development. (2017). Community Development Block Grant Disaster Recovery Overview. *HUD Exchange.* Retrieved from: https://www.hudexchange.info/resources/documents/CDBG-Disaster-Recovery-Overview.pdf

U.S. Department of Housing and Urban Development. (2016). CDBG-DR Eligibility Requirement. *HUD Exchange.* Retrieved from: https://www.hudexchange.info/cdbg-dr/cdbg-dr-eligibility-requirements

U.S. Department of Housing and Urban Development. (2016). Community Development Block Grant Disaster Recovery Program. *HUD Exchange.* Retrieved from: https://www.hudexchange.info/programs/cdbg-dr/

Universal Ecological Fund (Fundacion Ecologica Univesral FEU-US). (2017). The Economic Case for Climate Action in the United States. Retrieved from: https://drive.google.com/file/d/0B9whT-2Ezzu7UUNUS3ZielhROFk/view

Wagner, M., Merson, J. and Wentz, E. (2016). Design with Nature: Key lessons from McHarg's intrinsic suitability in the wake of Hurricane Sandy. *Landscape and Urban Planning*, Volume 155, 2016, Pages 33-46, ISSN 0169-2046, https://doi.org/10.1016/j.landurbplan.2016.06.013.

Appendices

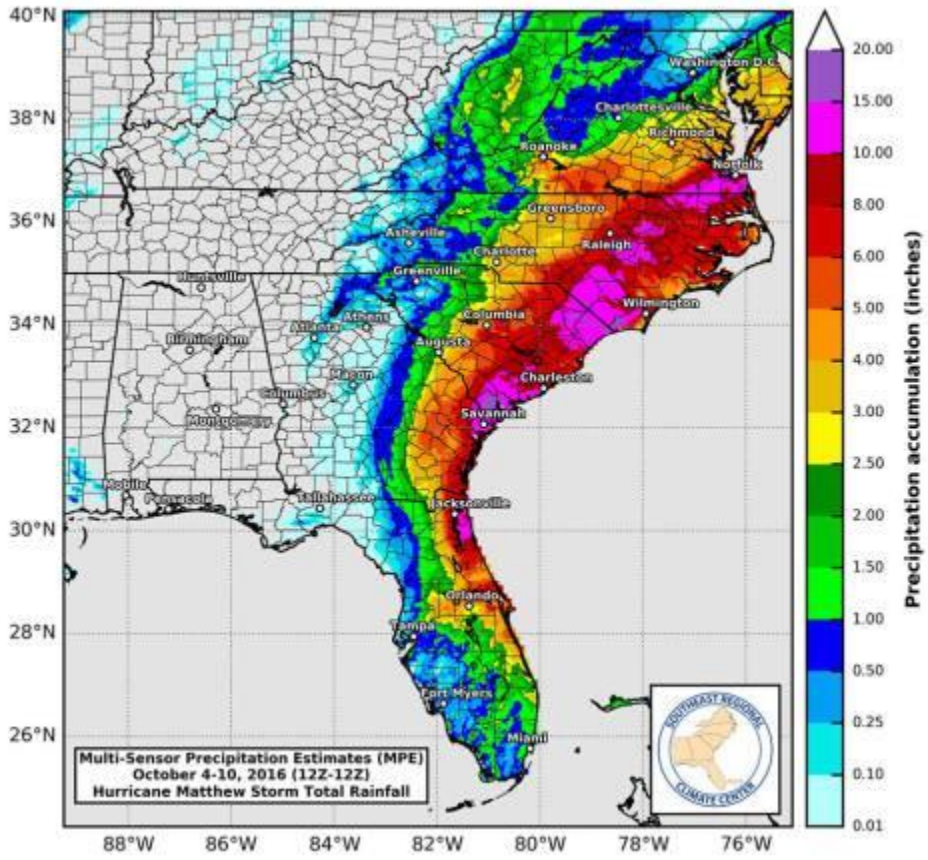


Figure A1. Hurricane Matthew Storm Total Rainfall (Southeast Regional Climate Center, 2017).

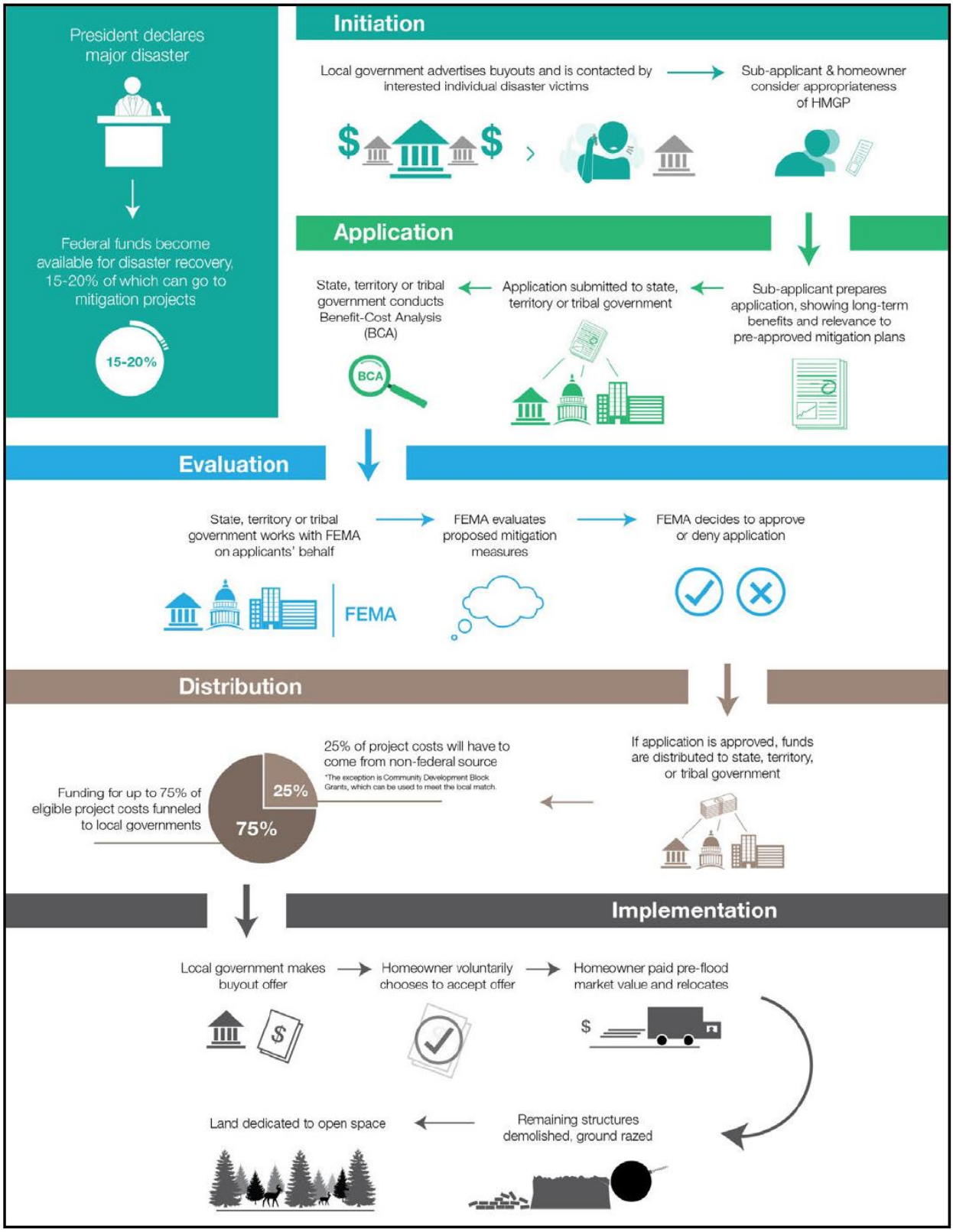


Figure A2. Key Steps in the HMGP Buyout Process (Environmental Law Institute & UNC-IE, 2017).

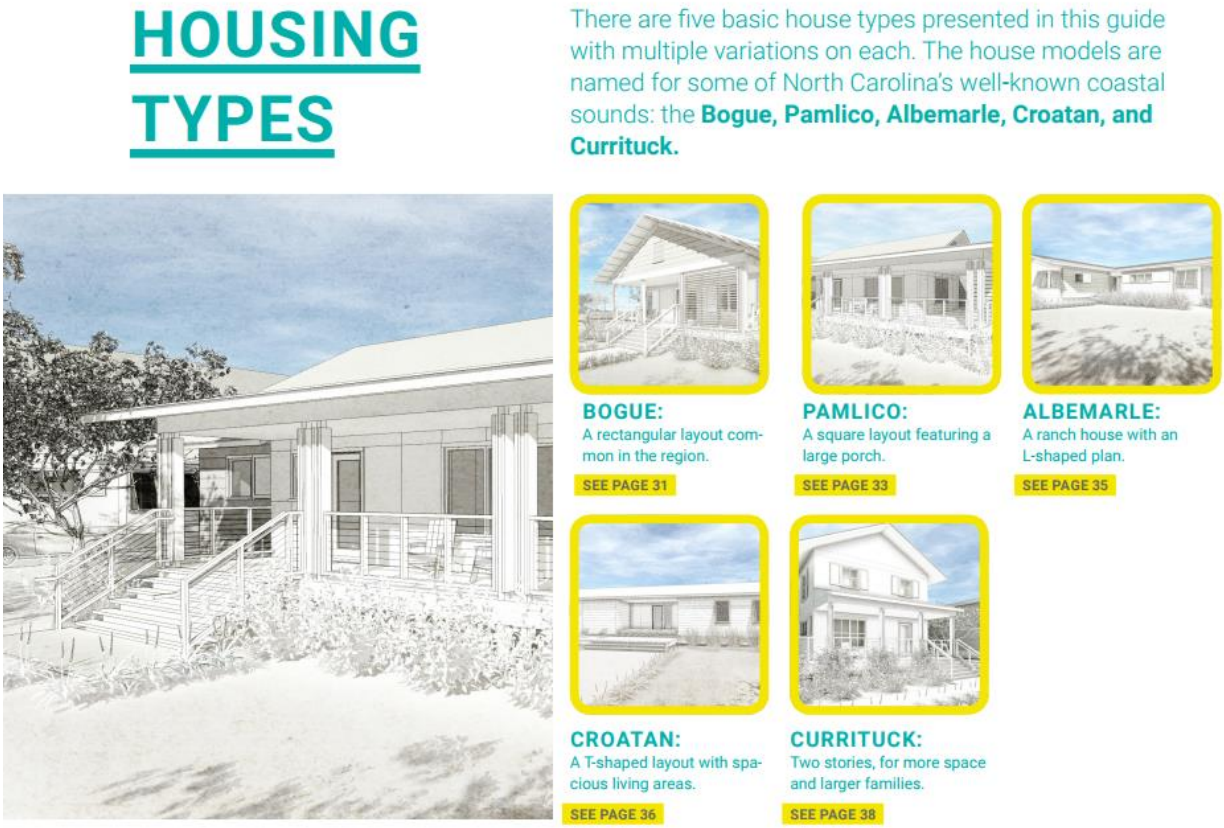


Figure A3. HomePlace Housing types proposed for Relocation Strategy housing redevelopment

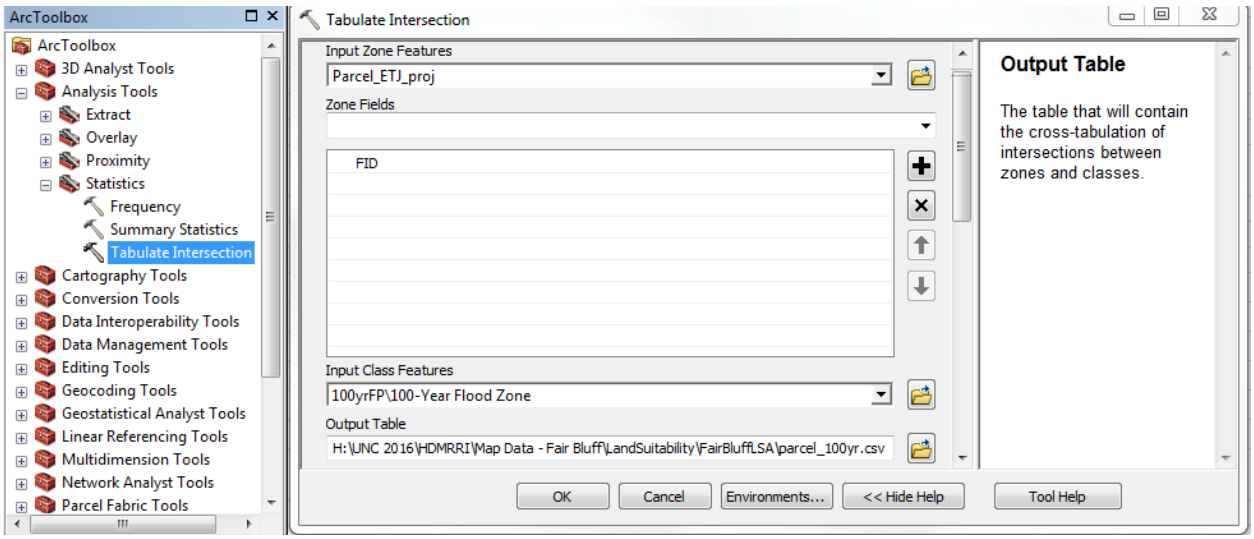
Table A1. Master list of LSA variables considered.

Category	Criteria	Source	Used in LSA
Accessibility of service and facilities	Existing jurisdiction proximity	Census	
	Proximity to commercial area	Local/Plans	
	School proximity (primary, secondary, post-secondary)	Census	
	Hospitals proximity	Census	
	Utility infrastructure connectivity (water, wastewater, electricity, communications)	County/State	
	Park/playground proximity	Local	
Transportation	Bus stop proximity	Local	
	Major highway proximity	Census	
Socioeconomic Factors	Population density	Census	
	Community preference	Survey	
	Renter / owner	Census	
	Neighborhood Type	Local	
	Ratio of less mobile people / disability / aged	Local	
	Land value	Census	
Environment and Safety	100- and 500- Year Flood Zones	State	
	Protective infrastructure integrity	Local	
	Drainage	Survey/Local	
	Reliance on protective infrastructure	Local	
	Proximity to water bodies	State	
	Proximity to known / potential environmentally hazardous waste sites	NC DEQ	
Topography	Slope	USGS	
	DEM	USGS	
	Water table depth	USGS	
	Tidal factors	USGS	
	Soil composition	SSURGO	
	Vegetation composition	State	
	Vegetation density	State	
Planning	Areas of future development (zoning or Future Land Use)	Local	
	Parcel Size	Local	
	Land/Building Vacancy	Local/State	
	Large infrastructure project	Plans	
	Economic development areas	Plans	
Flood Risk	Historical value / significance	Survey	
	FEMA Flood Zones (100- and 500-Year)	NCEM	
	Sea level rise (LiDAR)	NOAA	
	Hurricane Floyd flood extent	NCEM	
	Hurricane Matthew flood extent	NCEM	

Appendix Section A. Step by Step GIS and Microsoft Excel Procedures

1. Collect and vectorize all data
    a. Create base parcel data set that contains all parcels for LSA
    b. Ensure base parcel data set includes parcel related variables (i.e., Zoning, Size (acres or ft^2), Parcel Use, Existence of Structure, etc.)

2. Calculating overlapping area using "Tabulate Intersection" tool and include the following as inputs:
    a. Input Zone: Parcels
    b. Zone Fields: common identifier (i.e., FID or PIN)
    c. Input Class: *variable of interest* (i.e., 100-yr flood zone)
    d. Output: *100yr.csv*



3. Conduct Tabulate Intersection for all variables needing it. Then join the csv. back to parcel shapefile attribute table and after each iteration of "Tabulate Intersection" you are adding 2-3 more fields with the appropriate statistics
4. With each calculation, there was a new comma separated values (csv) table created containing 1) a common identifier (i.e., FID), 2) the calculated area in specified units, and 3) the percentage of overlap for the parcel and data layer of interest.
5. After conducting each Tabulate Intersection, compile results of each table into one excel spreadsheet
6. Rejoined table to the original parcel data file using the common identifier.
    a. After joining, each parcel record will contain data the necessary data to begin calculating scores using the thresholds and weights.
7. export the joined table from ArcMap back into MS Excel,
8. find and replace “<null>” values with “0” assuming that changing value to 0 won’t affect suitability score unintentionally.
9. this is a simple procedure done using a combination of IF and nested IF-AND functions.

   a. Example formula for Proximity to Water Infrastructure: =IF(AND(AH2>0, AH2<50), 0, IF(AND(AH2>50, AH2<101), 1, 0))
   b. Example formula for multiple thresholds variable such as parcel size: =IF(AND(W2>0,W2<3000),0,IF(AND(W2>3000,W2<20000),1,IF(AND(W2>20000,W2<100000),2,0)))
   c. Example formula for text related field such as zoning: IF(AS2="Central Business District",0,IF(AS2="Light Manufacturing - Warehouse",0,IF(AS2="Highway Service- B",1,IF(AS2="Low Density Agriculture",1,IF(AS2="Medium Density Residential",2,IF(AS2="Modular Residential",2,0))))))
10. The result is the joined table with eleven new data fields appended to the end containing the relative scores for each variable.
11. Create one final field for summing the scores creates the total or composite suitability score for each parcel record.
12. Rejoining this now fully scored spreadsheet to the parcel GIS file using the common identifier,
13. Symbolize the total suitability score into six equal interval classes with range of colors (i.e. oranges and reds communicating inappropriate or unsuitable areas and greens and blues denoting higher suitability for development).

*Table A2. Top 30 Highest Scoring Properties from LSA in Fair Bluff, NC**

ID	Property #	Total Score	Total Value	Acres	Sq. Ft.	Zoning	Building/Land Vacancy	Matthew Extent % Overlap	500-Yr % Overlap	Infill Score	Multi-Structure Score	Building/Land Vacancy Score	500-Yr Score	Matthew Extent Score
1	87753	18	$ 19,100	0.76	33,304.43	MED	VACANT - NO FP	1.91	19.33	2	0	3	1	2
2	18139	18	$ 10,300	0.72	31,379.41	MOD	VACANT - NO FP		38.93	2	0	3	1	2
3	17918	18	$ 6,700	0.55	23,974.00	MED	VACANT - NO FP	0.24		2	0	3	1	2
4	18138	18	$ 19,900	1.55	67,621.25	MOD	VACANT - NO FP			2	0	3	1	2
5	17357	18	$ 9,200	0.54	23,400.33	MOD	VACANT - NO FP			2	0	3	1	2
6	17886	18	$ 11,400	0.76	32,898.26	MED	VACANT - NO FP			2	0	3	1	2
7	18271	18	$ 8,200	0.50	21,973.06	MED	VACANT - NO FP			2	0	3	1	2
8	63107	18	$ 17,300	0.58	25,261.77	MED	VACANT - NO FP			2	0	3	1	2
9	82556	18	$ 6,400	1.59	69,298.00	MOD	VACANT - NO FP			2	0	3	1	2
10	82895	18	$ 3,900	0.50	21,799.79	MOD	VACANT - NO FP			2	0	3	1	2
11	85628	18	$ 5,400	0.91	39,640.43	MOD	VACANT - NO FP			2	0	3	1	2
12	92300	18	$ 3,000	0.50	21,799.86	MOD	VACANT - NO FP			2	0	3	1	2
13	93877	18	$ 3,000	0.50	21,799.79	MOD	VACANT - NO FP			2	0	3	1	2
14	95258	18	$ 2,500	0.50	21,799.99	MOD	VACANT - NO FP			2	0	3	1	2
15	96017	18	$ 3,000	0.50	21,799.79	MOD	VACANT - NO FP			2	0	3	1	2
16	96072	18	$ 3,000	0.50	21,801.06	MOD	VACANT - NO FP			2	0	3	1	2
17	17660	17	$ 14,700	0.24	10,401.43	MED	VACANT - NO FP	47.15	18.39	1	0	3	1	2
18	61256	17	$ 3,700	2.10	91,385.37	MED	VACANT - NO FP	47.70	86.61	2	0	3	0	2
19	17459	17	$ 7,700	0.86	37,541.00	MOD	VACANT - FP	13.99	37.80	2	0	2	1	2
20	17639	17	$ 19,000	6.14	267,515.24	MED	VACANT - NO FP	23.26	0.58	0	1	3	1	2
21	17732	17	$ 11,500	0.76	329,94.36	MOD	VACANT - NO FP	49.68	100.00	2	0	3	0	2
22	96489	17	$ 8,400	1.18	51,188.27	MOD	VACANT - NO FP	33.99	100.00	2	0	3	0	2
23	17725	17	$ 5,400	0.48	20,769.42	MOD	VACANT - FP		1.78	2	0	2	1	2
24	17448	17	$ 2,800	0.24	10,369.33	MOD	VACANT - NO FP		1.16	1	0	3	1	2
25	17680	17	$ 8,700	0.67	29,174.35	MOD	VACANT - NO FP		100.00	2	0	3	0	2
26	17686	17	$ 7,600	0.92	39,869.82	MOD	VACANT - NO FP		81.22	2	0	3	0	2
27	17716	17	$ 8,800	0.67	29,248.54	MOD	VACANT - FP		8.55	2	0	2	1	2
28	17891	17	$ 5,200	0.55	23,985.33	MOD	VACANT - NO FP		100.00	2	0	3	0	2
29	18153	17	$ 2,900	0.30	12,958.86	MOD	VACANT - NO FP		1.95	1	0	3	1	2
30	18224	17	$ 3,300	0.23	10,128.64	MOD	VACANT - NO FP		45.43	1	0	3	1	2

*An additional 71 properties had a total score of 17 (highest suitability), meaning properties 17-30 shown above are not necessarily more suitable than the other 71.