Review of Methods and Policies to Slow Flooding Near Jones County, NC

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ABSTRACT

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A flood can be a very costly occurrence. Coastal North Carolina has experienced such events in recent years. Preparing for and preventing major loss from a flood is critical. Many methods have been explored to understand why flooding is occurring more rapidly than ever before. Land use changes, such as urbanization has had an impact, among others. Preventing runoff in the areas where land uses are changing is a growing problem. Clearing rivers and streams of undesirable debris is a constant challenge, particularly after major storm events. New plans such as “Green infrastructure” has become a way to combat the ongoing flooding issues. The “Green infrastructure” is cost effective and makes for a pleasing design. Permeable materials have offered progress in controlling flooding. Continuing forward, policies need to be adopted that would be a guide to action that needs to be taken in the event future disasters occur.

BIOGRAPHY

Kyle Allen Smith was born and raised in Trenton, North Carolina. He received a Bachelor of Science in Agricultural Business Management from North Carolina State University in 2016. After graduation, Kyle moved back to his hometown where he began his career as the Director of Soil and Water Conservation for Jones County. As Director of Soil and Water for Jones County, Kyle has helped many landowners and farmers implement best management practices to preserve water quality. Kyle was recently promoted to Interim County Manager for the County of Jones. While working full-time, Kyle began the Master of Environmental Assessment program in January 2019 and is on track to earn his degree in May 2022.

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TABLE OF CONTENTS

Introduction

Coastal North Carolina has experienced many tropical storms during the last twenty years. The amount of rainfall from major storms across the Southeastern United States has increased 27% over the last 60 years. Three of these storms caused major flooding. These storms, Hurricane Florence of 2018, Hurricane Matthew of 2016, and Hurricane Floyd of 1999 all dumped large amounts of rain causing flooding across many regions of Coast North Carolina. Hurricane Florence dumped 25-35 inches of rain. Hurricane Matthew dumped 18-20 inches of rain, and Hurricane Floyd dumped 17-20 inches of rain, respectively, across Coastal North Carolina (Kurki-Fox, 2018). Additionally, this flooding caused impacts to fisheries habitat and ecological conditions in the Albemarle-Pamlico Sound, which is the second largest estuarine complex in the United States.

Increased precipitation is certainly a major contributor to flooding, but changes in the way the land is used may cause some degree of flooding. Urbanization has had a substantial impact on run-off. The natural soil has been sealed off by parking lots, developing communities, and highways. The development of more river front housing has also had an impact. The open soil has been compacted in these urban areas. Driveways and other paved areas have increased the problem of run-off. As more and more structures are constructed, the runoff enters our drainage ditches and streams at a much swifter rate, overloading a streams capacity to drain to its outlet. Even the conversion from forest to farmland across areas have impaired streamflow. Cultivation and land conversion practices associated with row crop agriculture has increased runoff. These landscape changes have affected flooding in Coastal North Carolina.

Causes of Flooding

Flooding is a natural disaster that can cause heavy damage in affected areas. Flooding is most often caused by heavy precipitation from large storms. Other factors can contribute to flooding. Any change in land use has the potential to increase the risk of flooding in that area. Urbanization is a change in land use that can cause local and regional flooding. Increases in urban runoff, lower infiltration and altered riparian buffers usually result from this land change. Peak streamflow can be affected. Runoff from roads and parking lots adds to the problem. In Eastern North Carolina, the movement toward building housing on or near the riverbank has created a flooding risk. New homes in these areas are constructed on stilts to meet building code requirements to have living areas above 100-year floodplains. Older homes have also been raised to decrease flooding risk. Construction of these communities on the banks of rivers disturbs the natural landscape. Trees are removed, vegetation changed, areas around homes are paved and the land is changed. The impact of this urbanization through runoff increases the risk of floods and erosion (Loperfido, 2014). Urbanization has sealed the natural soils by pavement and surfaces that restrict the natural infiltration which causes runoff. The development of more impervious surface cover due to urban growth has grown tremendously in recent years. Heavy equipment used in developing these areas has also compacted the soil and it becomes an impermeable surface (Qin, 2020).

Changes in land use may have had a direct impact on the rivers and streams in Eastern North Carolina. Land cover changes, irrigation, and changes in land management have contributed to the problem. Clearing lands previously occupied by forests for both agricultural uses such as row crop farming and constructing new infrastructure has contributed to the cause of flooding.

Controlling Flooding and Runoff

Floods are considered to be the most frequent and most damaging of all natural hazards (Karamouz, 2020). Frequent large storm events are requiring North Carolina Coastal communities to develop defensive strategies to respond to flooding events. This review describes those strategies that can be put into place to minimize flooding events. Green infrastructures, clearing and snagging of streams, and comprehensive land management policies are among the strategies discussed.

Green Infrastructures

Green infrastructure is a broad-based term including many techniques such as "green" roofs, water infiltration systems, water collection devices such as ponds, permeable and water retaining pavements, and grass swales to name a few. Green infrastructure has been studied as a method to decrease peak flows and reduce flood impacts. These green infrastructures can offer flood mitigation benefits as well as other environmental and cost benefits. In 2019, Congress enacted the Water Infrastructure Improvement Act, which defines green infrastructure as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface water" (EPA, 2022).

Green roofs incorporate vegetation or non-vegetated control substances such as gravel or stones into roofing systems with the aim of storing water, delaying runoff and reducing peak flows. Green roofs are used to facilitate and reduce urban runoff which could slow flooding probabilities. The water retaining capacity of a green roof would depend on the thickness of the roof layer and the dryness of the roof prior to a major storm event. A vegetated roof does have the ability to retain and slow more water than a non-vegetated roof constructed of gravel or stones (Qin, 2020). Green roofs have been studied among villages in China. Studied data reveals green roofs average 56% more rainwater retention than standard roofing structures. Also recorded, peak flow rates decreased 60-90% with green roof implementation. A deeper substrate layer on a green roof allows for growth of taller plants which was found to retain runoff at an average of 67.5%. However, a deeper substrate layer does require more routine maintenance to the roof and increased implementation costs (Qin, 2020).

Permeable pavements and water retaining pavements are another great example of green infrastructure. The water retaining pavements hold the precipitation and eventually allow the water to infiltrate or evaporate. The permeable pavement allows precipitation to flow through the pavement and back into the soil rather than directly running off to a sewer, stormwater conveyance or water sources such as a stream. A paving block system is another method of green infrastructure which can control runoff. Permeable blocks have high porosity to ensure water can infiltrate, but still provide a hard, drivable surface. Permeable blocks minimize surface runoff from parking lots through the use of an open graded base that serves as a temporary reservoir to hold water before it infiltrates into the sub-soil. Studies of the permeable paving block system has been conducted in Indonesia. Results revealed that the installed system can pass water through the permeable paving blocks at rates higher than 300 mm/hour of rainfall. Studies also show that a sand class soil base in the system can infiltrate 216 mm/hr in comparison to clay base system that only allowed for .36 mm/hr of water infiltration (Suripin, 2021). Thus, confirming the need for a sand lined system below the depths of the paving blocks. The permeable paving blocks used in Indonesia were found to have an infiltration capacity of 360mm/hr. This rate is much higher than any rain event that may occur. The duration of rainfall events is important to determined peak discharge rates. The higher the rain intensity, the higher the peak discharge. Open graded base porosity and system design for total rainfall over an event factor into peak flow capacities of the permeable paving block system design. For a permeable block system with an open graded base of 40% porosity and a design rainfall of 150 mm, the open graded base would need to be 38mm thick (Suripin, 2021). If higher peak discharge limits need to be met, the open graded base should be designed thicker.

Rainwater capture systems such as retention ponds, rainwater barrels or leak tanks collect and hold run-off to allow delay of peak flow and allow for later release and possible increased infiltration. These structures can help store excessive amounts of unwanted waters. Both retention ponds and rainwater barrels are engineered for excessive waters to slowly escape to prevent total structure failure. Studies in China using a rainwater barrel system revealed a reduction of 3-44% water runoff from a traditional roof (Qin, 2020). When full, the rainwater barrel systems do little to slow excessive water runoff from roofs. Thus, owners of rainwater barrel systems are encouraged to keep barrel capacities maximized by lower barrel water levels when possible. Another name for this system would be a leak tank. Qin, 2020 found that peak flow can be reduced by 45% and seized for up to a quarter of an hour when installed leak tanks are in place (Qin, 2020).

Grassy swales have been considered as an option to prevent flooding. These swales detain the runoff and it can then be filtered back into the soil. These swales could also collect runoff from roads, preventing road runoff contaminants from flowing into ditches which leads to streams and then further reducing water quality in streams and rivers (Xie, 2017). Findings have shown that grassy swales have at least a 20-year operation life when properly maintained. Swales can be implemented with drainage pipes beneath their surface to act as an outlet to nearby sewer pipers of drainage ditches during those continual rainfall events. Swales installed with pipes show a 2.7-13 times lower discharge amount, than that of a swale installed without an outlet drainage pipe. The larger the grassy swale, the more retention and precipitation capacity available for subsequent infiltration (Qin, 2020).

In Westchester, New York, a modeled study was conducted after gray infrastructures failed following Superstorm Sandy. To weight the benefits of implemented gray and green solutions to aid in flood mitigation, a modeled control study was performed with the addition to a green levee. The structure modeled was a gray levee, a green levee and a wetland. The study revealed that combined green levee and wetland resulted in an inundation level of .935 meters at Control point one, while inundation levels were higher with a gray levee and wetland. All other Control points revealed positive inundation results with the green levee strategies in place. Construction cost of the green, natural-based strategy showed 40% savings in one zone and 18% savings in other zones studied. Maintenance costs were also noticeable lower for the green, natural strategy. Thus, these “green”, natural solutions are cost-effective and efficient, but cannot act as the only strategy when rare occurring flood event happens (Karamouz, 2020).

Clearing and Snagging of Streams

Stream channel blockages have been recorded to increase both total area and depth of seasonal flooding. Cleaning rivers and streams of undesired debris is a work performed by landowners or resource users to both improve stream navigation and address localized flooding (Linohss, 2012). This process is designed to increase hydraulic capacity and make navigation on the rivers safe. As a flood prevention method, clearing and snagging programs are taking place across the state of North Carolina. In turn, this is helping slow flooding in areas such as Coastal North Carolina.

In this cleaning process, the inclusion and management of natural vegetation is important. Streams which have lost their natural features, including vegetation, have greater flooding risks since water moves faster and causes greater streambank erosion. Therefore, modified clearing and snagging is recommended because that method is less damaging to the environment. Adverse effects to the environment may be avoided or greatly reduced without loss of flood control limiting the type and amounts of debris and vegetation to be removed (Shields Jr, 1984).

In recent years, there have been state and federal funded programs available for communities to remove downed debris from waterways, but there are limitations and regulations in place to follow. The North Carolina Department of Agriculture and Consumer Services (NCDACS) developed Watershed Recovery Efforts centralized around clearing and snagging stream debris that had fallen from major storm events. The Federal government has also issued funding through a program named Emergency Watershed Protection (EWP) available after major flooding events. The goal of this program was for communities to be able to financially address "serious and long-lasting damages to infrastructures to the land" (USDA, 2022). A portion of this program was created to target downed debris in waterways that posed imminent danger to human life by blocking stream channels, road bridges, and/or culverts.

Most recently, a Streamflow Rehabilitation Assistance Program (StRAP) was developed by the NCDACS, allocating a total of 38 million dollars for communities and municipalities. This program aims to reduce flooding statewide, and allocates funding for projects that protect and restore the "integrity of drainage infrastructure" (NCDACS, 2021). Among the project scope of available use of funding is clearing debris and sediments that have blocked streams.

Clearing all significant vegetation and all obstructions from the streams has been done for flood control, but complete snagging and clearing may be damaging to the stream ecosystem.

Because of this, there are regulations in place to prevent ecosystem damages for communities utilizing available clearing and snagging programs such as StRAP.

Studies show that good stream management techniques are important to decreasing flood impacts. According to research by Linohss, 2012 the following strategies are important in proper stream management. Leave stumps on the bank in place unless badly damaged. Remove all vegetation on the banks above a given height. Remove trees that are down on the bank or using vegetation for support. Remove trees within a year. Remove major flow obstacles. Excavate major sediment deposits that have formed upstream or downstream, also additional jams if necessary (Linohss, 2012). The clearing and snagging strategies recognized in Linohss, 2012 are quite similar to requirements established in the StRAP program.

Land Management Policies

Governmental policies can also be effective in reducing flooding events. Governmental policies may include land use restrictions and building codes. Both the Federal and State governments have enacted policies to minimize flooding impacts. The national flood insurance program requires communities to develop minimum building elevations in flood prone areas for new construction and requirements for upgrades to existing buildings undergoing construction renovations. Stricter building codes can be enacted at the State and Local level to prevent rebuilding in hazardous flood prone areas to limit development or land use to types with limited development or land use to types with limited impact due to floods (parks or open spaces). Local governments and communities impacted by flooding events can share ideas and policies to ensure the most effective flood mitigation policies are in place. Data from what has worked in other communities may reduce vulnerability in North Carolina to these flooding disasters. Adopting or amending flood mitigation policies and floodplain ordinances is a simple, low-cost action that communities can take in order to improve resilience to future flooding events (Kurki-Fox, 2018).

Community stakeholders must understand that learning is part of the process of policy making. Any policy developed must be sustainable. Community members must be considered when adopting or amending a flood policy. Community members can contribute past memories of flooding events and present ideas to stakeholders, ensure the most efficient policy is adopted for that their community. Involving community members also allows members of a community to stay involved and knowledgeable of policy changes (Rouillard, 2012). Action should not be mandated by government without considering the effect on the communities. Action for the "here and now" may not be sustainable. Policies that have been adopted in advance to prepare for potential future flooding events allow for protocols and preparations to be more easily followed.

Often missing from the policy making process is the role of memory. Flood memories can help build the platform for lay knowledge (Garde-Hansen, 2017). The impact that floods have on humans, whether socially or economically, or any other way, could provide insight into the process.

Conclusion

Coastal North Carolina has suffered major damage from floods in the last twenty years. With each extreme precipitation event, the problem of flooding in Coastal North Carolina will become more serious. Flooding threatens lives, health, and livelihood. Transportation is challenged. Good and services are interrupted. Communities are still recovering from the last major storms to hit Coastal North Carolina. A serious look at the problem needs to be taken in order to develop methods to reduce loss of property and spoiled water quality. Studying methods used by others may be a guide in developing methods for Coastal North Carolina (Paerl, 2020).

In order for Coastal North Carolina to positively address the problem of continuous flooding a combination of all flooding and runoff control measures must be used. With policies and procedures in place, the fight against Coastal North Carolina flooding can be improved for future storm events.

There are several approaches that can aid in slowing flood waters after major storm events occur. With no approach being superior of another, it's important that Coastal North Carolina areas prone to flooding develop policies and procedures to aid in slowing the threat of flood waters following major precipitation events. No approach mentioned is certain to diminish Coastal North Carolina's flooding problems completely, but with the implementation of the mentioned approaches, overtime, we could anticipate some positive impacts to transpire. Understand that some of the approaches are already in place, but the key to success behind controlling flood waters will be to ensure all mentioned approaches are being utilized across Coast North Carolina communities. Each approach has its own benefits to flood water management, and together the successful impacts are relieving. Using a combination of the methods mentioned can aid in slowing flood waters across communities, thus, revealing positive impacts post storm events in the future.

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