Preface

Building resilience to the threats of climate change is a responsibility that has landed squarely on the shoulders of local and regional authorities in the United States and Europe. Nowhere is this better demonstrated than in the work of cities and towns of the Netherlands and Northern Virginia. To strengthen the response to its own special climate adaptation challenges, the Northern Virginia Regional Commission in 2011 formally kicked-off a long-term effort with the Netherlands oriented to finding, assessing and testing innovative climate adaptation lessons from the Netherlands for suitable application in Northern Virginia. In the summer of 2012 by a senior research fellow, Suzan van Kruchten, from the Province of North Holland, spent five months at the NVRC preparing this report. The report's purpose is to assess the issues and innovations best suited to short or long-term applications to the vast and complex political and environmental landscape of Northern Virginia. This summary of Suzan's initial report was undertaken by Eileen Nakahata, whose contributions were exceptional.

Introduction

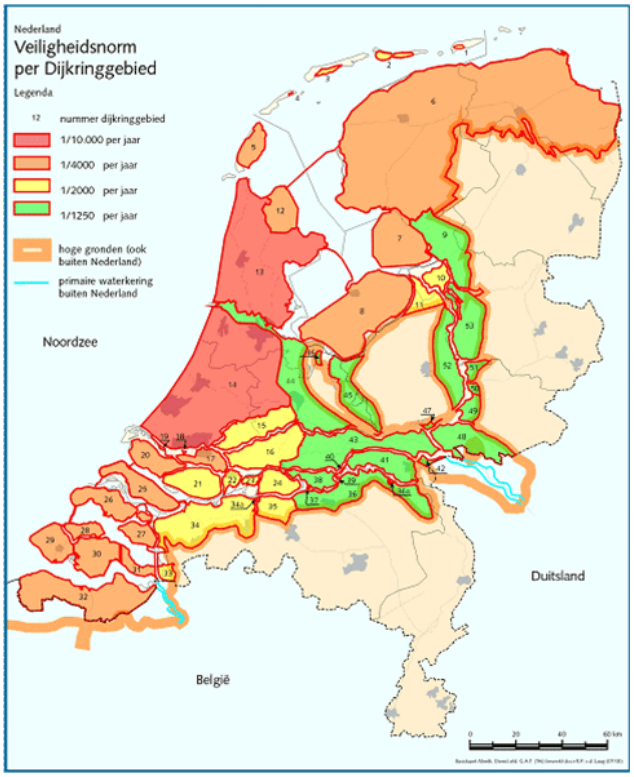
Overview of Water Management/ Flood Prevention in the Netherlands

With nearly three hundred miles of coastline, three major rivers, and nearly a third of the country located below sea level, the Netherlands has been at risk of inundation throughout its history (Haegen 2013, "Dutch Water Program: Room for the River"). The Dutch began combatting this threat in the ninth century by building dikes and by draining and reclaiming a number of low-lying areas ("History of Watermanagement"). These areas of reclaimed land are called polders and make up twenty percent of the Netherlands (Armbruster 1996, 42). Originally, the maintenance work and costs were organized and shared by community groups, who allotted each farmer a section of the dike for which he was responsible ("History of Watermanagement"). These community groups managed water infrastructure until 1255 when the first water board was founded (Haegen 2013). Water boards are independent regional organizations that have maintained and improved Dutch flood defenses from the thirteenth century to the

present day (Haegen 2013, "Dutch Water Program: *Room for the River")*. These water boards have survived many conflicts and changes in government, even though groups in conflict had to cooperate through the water boards for their collective safety (Blom and Lamberts 1999).

Just as the water boards have endured, so has the need for constant vigilance. In 1953, as a result of high spring tides and severe storms, dike failures cause a flood that covered approximately 625 square miles, damaged 40,000 buildings, forced the evacuation of 70,000 people and left 1800 casualties ("Flood Risk" 2008). In reaction to this catastrophe, the Delta Commission was formed that same year to overhaul the Netherlands' coastal protection ("Flood Risk" 2008). Over the next 40 years, the government completed the Delta Works which included building dams across the four major coastal inlets, raising and reinforcing dikes and dunes along the coast and building the Maeslantkering flood surge barrier in the New Waterweg ("Flood Risk" 2008). Thanks to these improvements, the Netherlands has not had a major water-related disaster since 1953 (Haegen 2013). In 1993 and 1995, high rainfall almost caused the Rhine and Meuse rivers to flood, but the dikes managed, barely, to hold up ("Flood Risk" 2008). Nevertheless, the huge economic costs involved evacuating the 250,000 people threatened by these near floods led to the development of a Delta Plan for the major rivers, which utilized new strategies, like those used in the *Room for the River* projects in addition to traditional strengthening and heightening of the dikes("Flood Risk" 2008).

Because of all of these improvements, the Dutch are now prepared to withstand all but a 1250 year flood ("Making Room for the Dutch Approach"). However, the Dutch do not believe they can afford to assume that this guarantees their safety. Sixty five percent of their GDP is produced below sea level and a flood in that area could mean more than 1000 deaths and as much as €100 billion in damages ("Flood Risk" 2008). Additionally, with more intense precipitation, more violent storms and the possibility of 35-85 centimeters (approximately 14-33 inches) of sea level rise over the next century, the Netherlands will be more at risk than ever ("Flood Risk" 2008). To combat this risk the Netherlands continues to invest in flood prevention and climate change adaptation measures and is exploring methods to improve their warning and evacuation procedures as well as to minimize the damage of any floods that do occur.



Flood risk in Northern Virginia

Northern Virginia is not so constantly at risk of flooding. No part of Virginia is below sea level (Choate 2009). However, it is susceptible to a number of severe weather occurrences which lead to flooding

from the Potomac River and its tributaries such as hurricanes, tropical storms and severe thunderstorms. High water caused by severe weather is exacerbated by the tides of the Potomac, an overtaxed stormwater system and development in low-lying areas ("Flood Map" 2012). Alexandria, Fairfax and Prince William County are particularly vulnerable to flooding. For example, Alexandria flooded during Hurricane Agnes in 1972, Hurricane Isabel in 2003, a major storm event in 2006, and Tropical Storm Lee in 2011 ("Flood Map" 2012). Most of these floods are due to overbank flooding from the Potomac. However, Northern Virginia is also susceptible to tidal or storm surge flooding because the Potomac River is tidal. These risks will increase with sea level rise and an increase in downpours and other severe weather events.

Although the global rate of sea level rise is 0.08 inches per year, the Chesapeake Bay rises about 0.14 inches per year because of land subsidence or erosion (Government of the District of Columbia 2010). The Chesapeake Bay is expected to rise 24-48 inches over the next century (Government of the District of Columbia 2010). The Potomac River has risen about one foot in the past century and will continue to rise at an even faster rate for the next hundred years (Metropolitan Washington Council of Governments 2013).

Over the past 100 years, annual precipitation in the Washington metropolitan area has increased by about 0.31 inches per decade and the amount of water that falls in the heaviest downpours has increased by 20% nationwide over the past century, increasing the risk of flash floods (Government of the District of Columbia 2010, Metropolitan Washington Council of Governments 2013). Relative to the previous century, there has also been a 12-20% increase in the number of major weather events in the Mid-Atlantic region (Government of the District of Columbia 2010).

Already twenty percent of Alexandria is mapped as floodplain and there is expected to be a 40-45% increase in flood-prone areas over the next ninety years ("Flood Map" 2012, Metropolitan Washington Council of Governments 2013). In the United States there is a tendency to wait until after disaster strikes to act, but it is safer and more cost-effective to prepare and adapt beforehand.

Opportunities for Northern Virginia to learn from the Netherlands

Although Northern Virginia has begun to address climate change mitigation and adaption at all levels of government, this is a fairly recent development and so Northern Virginia remains mostly in the data-collection and vulnerability assessment stages. The next step for Northern Virginia is planning and implementing adaptive measures and no one has done more work in water control and climate change adaptation than the Dutch. So as Northern Virginia moves from data-collection to implementation it is only logical that it study the policies and technologies that have made Dutch climate adaptation measures so successful.

Key Components of Dutch Climate Change Policies

An Overview of Dutch Programs

Water management, flood prevention, and climate change adaption policies and initiatives in the Netherlands are a result of the collaborative efforts of across all levels of governments as well as between multiple municipal or regional governments.

The European Union

The European Union (EU) issues regulations or directives. Directives set goals that each nation must meet but allow member nations to decide how to achieve that goal. The EU also grants some funding to programs that support an EU policy or general European interest. The EU is passing an increasing number of policies that affect regional water management (Unie van Waterschappen 2010).

EU Flood Directive

This directive enacted in November 2007 applies to all bodies of water across the entire European Union and requires member states to identify areas at risk of flooding by 2011, create flood risk maps by 2013 and establish plans flood risk management plans that address prevention, protection and preparedness by 2015 (European Commission 2012). This directive has helped to promote international collaboration and information exchanges. This assists Dutch efforts to work with their neighbors to control the flow of water into the Netherlands. Through the "FloodResilienCity" and "Adaptive Land Use Flood Alleviation" programs, the EU has made available some financial support for pilot projects in cities of Europe working to support technical exchanges of innovative flood management, urban planning and water storage/discharge practices and policies. Both programs have supported the *Room for the River* in Nijmegen and Overdiep.

Dutch National Government

The national government plays a key role in coordinating the many infrastructural changes that will help the Netherlands adapt to climate change. The Delta Act, effective January 1, 2012, requires the Ministry of Infrastructure and the Environment (the Rijkswaterstaat) propose a Delta Program and its budget to parliament every year on Prinsjesdag (the official opening of Parliament in September) ("Administrative, Legal and Financial Bearings of the Delta Programme"). The Delta Program lays out the plans and provisions for flood safety and water supply for the year ("Administrative, Legal and Financial Bearings of the Delta Programme"). This provides the guiding objectives for safety, timing and funding ("Making Room for Innovation"). The specifics are conceived and implemented by regional authorities ("Making Room for Innovation"). The Delta Act also sets up the Delta Fund in which money is set aside for investments in researching and implementing water management or flood protection projects ("Administrative, Legal and Financial Bearings of the Delta Programme"). From 2020 onwards, at least €1 billion will be put into the fund every year ("Administrative, Legal and Financial Bearings of the Delta Programme").

The national government also usually chooses to provide a "to be determined" amount of compensation equally to all victims of any floods that do occur (Botzen and van den Bergh 2008).

Provincial Governments

The 12 provincial governments in the Netherlands are responsible for spatial planning, recreation, infrastructure and the area's heritage ("Roles and responsibilities of provincial government, municipal governments and water authorities"). The provincial governments are also responsible for translating the guidelines provided by the national government into policies and projects appropriate to the needs of that region ("Roles and responsibilities of provincial government, municipal governments and water authorities"). Each of the provincial governments devises regional plans and zoning guidelines which incorporate climate change adaption and flood prevention plans ("Roles and responsibilities of provincial government, municipal governments and water authorities").

Municipalities

Municipal governments have an important role in implementing policies and guidelines ("Roles and responsibilities of provincial government, municipal governments and water authorities"). In addition to preparing regulations to carry out the policies of national and provincial governments, municipalities also have their own development plan (findsource).

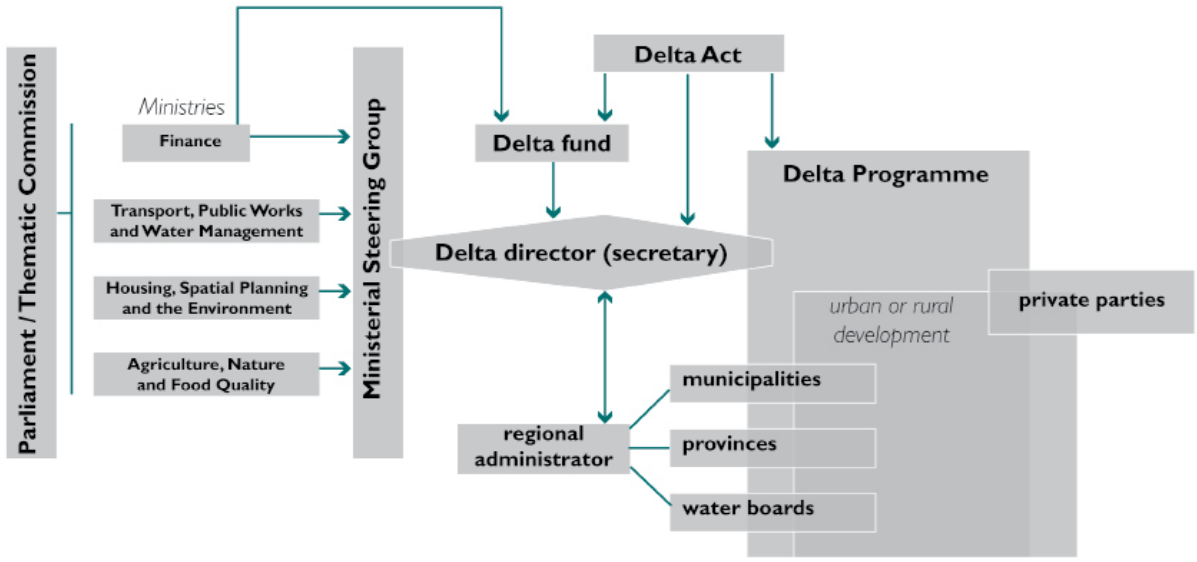
Municipalities often cooperate with other municipalities in order to work more cost effectively. This allows them to share knowledge and assign tasks together.

Water Boards

Water Boards are independent of the national government but have overlapping responsibilities. Water boards are primarily responsible for safeguarding the country against flooding and rising sea level ("Roles and responsibilities of provincial government, municipal governments and water authorities"). Within certain legal boundaries water boards can make binding decisions on citizens' behalf, regulate, issue or refuse permits and levy taxes (Unie van Waterschappen 2010).

Delta Program

The Delta Program is a program led by the national government that annually develops a plan for water management projects in collaboration with provinces, municipalities, water boards, businesses, civic organizations and research institutions.



Intergovernmental collaboration and communication

The Delta Program is divided into nine subprograms: safety, freshwater supply, new construction and restructuring, coast, rivers, IJsselmeer region, Rhine Estuary-Drechtsteden, South-western Delta and Wadden region ("Working Method of the Delta Programme"). Each subprogram is run by one of two ministries, the Ministry of Infrastructure and the Environment or the Ministry of Economic Affairs, Agriculture and Innovation and is staffed by employees of both the central and provincial governments ("Working Method of the Delta Programme"). Each subprogram also develops an action plan which they present to a steering group, composed of delegates from the national and provincial authorities, and then submit it to various social stakeholders for their input ("Working Method of the Delta Programme"). A municipal ambassador is also appointed for every subprogram to serve as a liaison between the national ministries and the municipalities, providing the municipalities with information and support ("Working Method of the Delta Programme"). Once each subprogram has developed their plan it is sent pack to the steering committee for the entire Delta Plan ("Working Method of the Delta Programme"). Once they finish the complete Delta Plan it must be approved by the House of Representatives ("Working Method of the Delta Programme").

Public participation

During the creation of subprogram action plans there are a number of opportunities for public participation. Interest groups are consulted throughout the process ("Working Method of the Delta Programme"). Also, provinces and municipalities typically seek public input on parts of the subprogram plan ("Working Method of the Delta Programme"). If an individual citizen is unhappy with the draft, action plan, or program, they may post their opinions on the Delta Commissioners website or officially submit their views ("Working Method of the Delta Programme").

Case Study: *Room for the River*

This program was initiated in response to the near-floods in the 1993 and 1995 ("Dutch Water Program: Room for the River"). With the collaboration of the Rijkswaterstaat, provincial governments, municipalities, water boards and even the EU, this project develops and promotes innovative, alternative solutions that minimize flood risk by restoring the rivers' natural floodplain and increasing the discharge capacity of the rivers. This will help to keep the risk of flooding low even as climate change spurs more periods of more intense rainfall more water from melting snow and ice ("Making Room for Safety"). As sea levels rise, it will also become harder for rivers to drain, further raising river levels. This strategy of "making room for the rivers" is an alternative to continuing to strengthen the dikes, which would decrease flood risk but increase the potential damage of any flood that did occur ("Making Room for Innovation").

As a result, thirty *Room for the River* projects were initiated in 2007("Dutch Water Program: Room for the River"). They include measures like dike relocation, lowering of floodplains, deepening the riverbed, building diversion channels and creating temporary water storage areas ("Dutch Water Program: Room for the River"). All the projects are scheduled to be completed in 2015 and so far the project is on schedule (except for four projects which are experiencing minor delays) and on budget ("Making Room for Governance"). This kind of success, rare for major governmental projects in the US or the Netherlands, may be thanks to methodology that encourages communication, collaboration and incorporation of additional improvements into the projects.

Intergovernmental Collaboration

National authorities, the Ministry of Infrastructure and the Environment, and the Ministry of Economic Affairs, Agriculture, and Innovation set the guidelines and objectives ("Making Room for Governance"). Local authorities design plans to fit these guidelines and designate the project initiator, which may be a government agency, an NGO, or a member of the private sector ("Making Room for Governance"). The design for each project is then approved by the secretary of infrastructure and the environment ("Making Room for Governance"). This cooperation is laid out in administrative contracts ("Making Room for Governance").

Regional development officials and local development officials cooperate to combine regional and local projects, meaning that local and regional authorities work to carry out development and infrastructural projects in the same area at the same time to increase efficiency, lower costs, and minimize inconvenience ("Making Room for Governance"). The *Room for the River* program greatly accelerates the process of acquiring permits with a coordinating formula that allows the builder to obtain all permits at once ("Making Room for Governance"). *Room for the River* facilitates the sharing of information and innovations between municipalities.

Public Participation

The *Room for the River* method involves residents and businesses as early as the planning stage and throughout the implementation of the project ("Making Room for Governance"). Ensuring their involvement is the responsibility of local authorities, who may develop and propose alternative plans for the project based on the reaction of local parties ("Making Room for Governance"). This not only makes

the projects more popular but it can also make them more effective or speed up the process by eliminating local resistance. For example, the residents of Lent/Nijmegen resisted the *Room for the River* project there for two years due to worries about accessibility and seepage ("Making Room for Innovation"). In response, the local authorities added a cutoff and a temporary bridge to the plan ("Making Room for Innovation").Once their concerns were addressed, the residents not only accepted but really supported the project ("Making Room for Governance").

Maximizing the Benefits

The *Room for the River* program encourages municipalities to combine *Room for the River* projects with other development projects to improve spatial planning. For example, in Gorinchem they combined their *Room for the River* project with the improvement of the Avelingen industrial park, which created more space for businesses on the waterfront and improved water transportation ("Making Room for Innovation"). In Nijmegen, they are improving the city of Lent and creating a new island that will provide a new recreational area for the city ("Making Room for Innovation"). In Millingerwaard, the river foreland excavation offered increased access to nature and the clay excavated was used to produce bricks ("Making Room for Innovation").

Case Study: Building with Nature

The Building with Nature program is carried out by the EcoShape consortium, which is composed of all levels of government, research institutes and members of the private sector, like dredging companies and engineering consultants and co-funded by the Rijkswaterstaat, the European Regional Development Fund and the a variety of local partners (de Vriend and van Koningsveld 2012, 6).

Its objective is to create adaptable infrastructure that works with natural systems rather than against them (de Vriend and van Koningsveld 2012, 9-10). Previously, developers only focused on the primary function of infrastructure but this program encourages the incorporation of opportunities for other functions, such as nature development, recreation or housing (de Vriend and van Koningsveld 2012). Building with Nature also endeavors to work with the public, not only to decrease public resistance but also to take advantage of their expertise on the local area (de Vriend and van Koningsveld 2012, 10).

An example of one of their projects that fulfilled both of these goals is their use of oyster reefs to prevent erosion in the Eastern Scheldt. This project addresses the erosion of tidal flats in the Eastern Scheldt estuary, which resulted from the disruption of tidal dynamics caused by the construction of a storm surge barrier that separates the estuary from the sea and a series of dams that have blocked off several rivers (de Vriend and van Koningsveld 2012, 17). The tidal flats are a protected nature area under Natura 2000 and provide an important habitat for many species (de Vriend and van Koningsveld 2012, 17). The estuary is also a popular recreational area and the location of commercial production of shellfish (de Vriend and van Koningsveld 2012, 17). The tidal flats also help to dissipate wave energy and prevent flooding (de Vriend and van Koningsveld 2012, 17). So to prevent the erosion of these tidal flats Building with Nature has constructed oyster reefs to shelter the flats and catch sediment (de Vriend and van Koningsveld 2012, 18). In response to the concerns of commercial shellfish growers, Building with Nature is also conducting a study to determine whether the oysters in these protective reefs will

interfere with the commercial shellfish beds through competition for food (de Vriend and van Koningsveld 2012, 19).

Another major Building with Nature Project involves raising the wetlands around the Ijsselmeer in order to protect these valuable habitats, home to many important species (de Vriend and van Koningsveld 2012, 29-31). The wetlands must be raised in order to compensate for rising water levels (de Vriend and van Koningsveld 2012, 29-31). The replenishment of these wetlands also protect the dikes against storm surge, which is especially important as rising water levels bring the Ijsselmeer closer to the towns (de Vriend and van Koningsveld 2012, 29-31). This is accomplished by depositing large amounts of sand near the shore and allowing wind, waves, and ice to move it onshore to form dunes (de Vriend and van Koningsveld 2012, 29-31).

Northern Virginia

National Government

Federal Emergency Management Administration (FEMA)

FEMA is a branch of the Department of Homeland Security. According to its website FEMA's mission is to "support our citizens and first responders to ensure that as a nation we work together to build, sustain and improve our capability to prepare for, protect against, respond to, recover from and mitigate all hazards." "All hazards" currently includes both natural disasters and terrorist attacks (Iverson 2012). This ambiguity about FEMA's responsibility has led to sometimes dramatic shifts in focus with changes in administration. Republican administrations typically have taken an approach focused on civil defense, whether against nuclear attack or terrorism (Iverson 2012). Democratic administrations typically focused more on natural disasters and pre-disaster preparedness (Iverson 2012). However, politicians from both sides of the aisle typically come together on disaster relief immediately following a disaster whether natural or manmade.

Although a branch of FEMA, the Federal Insurance and Mitigation Administration, is responsible for hazard mitigation and pre-disaster mitigation of damage, most of FEMA's programs and plans are devoted to dealing with response, relief and reconstruction after disasters.

FEMA also does not have consistent, reliable funding like the Delta Program. Rather it depends on the annual congressional budget and any funding received is under the control of the Department of Homeland Security, which has, in the past, diverted funding from FEMA to counterterrorism efforts. According to a report written by the Democrats of the House Committee on Appropriations, FEMA currently faces more than $1 billion in cuts because of the sequester (Lowey n.d.).

Federal Insurance and Mitigation Administration (FIMA)

FIMA is a subdivision of FEMA. It is responsible for risk analysis, risk reduction, and risk insurance ("Federal Insurance & Mitigation Administration" 2013). Its risk analysis division is charged with

identifying hazards, assessing vulnerabilities and developing risk reduction strategies ("Federal Insurance & Mitigation Administration" 2013).

FIMA's risk reduction division implements a variety of hazard mitigation grant programs that states and local governments may apply for including the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Program, the Flood Mitigation Assistance Program, the Repetitive Flood Claims Program, and the Severe Repetitive Loss Program ("Program Information: Mitigation"). These grants cover a percentage (usually up to 75%) of the cost of the mitigation activity and may cover activities such as mitigation planning, property acquisition and structure demolition or relocation, structure elevation, mitigation reconstruction, dry flood proofing of certain structures, minor localized flood reduction projects, and management costs of the project ("Program Information: Mitigation").

Its Risk Insurance Division runs the National Flood Insurance Program (NFIP) ("Federal Insurance & Mitigation Administration" 2013). The NFIP is an insurance program run by the government with rates set by the NFIP but sold through private insurance companies ("The NFIP Partnership" 2013). It offers coverage for the building as well as the contents and will cover up to 80% of the replacement cost ("Coverage from the NFIP" 2013).

FEMA/FIMA has only just begun, in a report published June 2013, to explore how climate change will affect the NFIP and ways to make NFIP more financially viable as flood risk and population density increase along coasts and rivers (newfemarpt).

U.S. Army Corps of Engineers (USACE)

The USACE has a wide range of responsibilities including the construction and inspection of levees and dams, flood risk management and wetland and estuary preservation. They also help fight floods and respond after disasters.

The USACE is working to "develop practical, nationally consistent and regionally tailored, legally justifiable and cost-effective adaptation measures, both structural and nonstructural, that will reduce vulnerabilities and improve resilience to these challenges" (US Army Corps of Engineers 2012, 2). They are also working to improve interagency cooperation and the sharing of impact and adaptation data between federal, state, local and Department of Defense partners (US Army Corps of Engineers 2012). The USACE is also developing a portfolio of the best practices and guidelines for USACE adaptation activities and investments (US Army Corps of Engineers 2012).

Virginia State Government

The Virginia Department of Environmental Quality is responsible for climate change adaptation among other things and runs the Coastal Zone Management Program. The Virginia Department of Conservation and Recreation is in charge of stormwater management, erosion control, floodplain management and dam safety.

Local Governments

City of Alexandria

The City of Alexandria is working with NVRC through the Sustainable Shorelines program to assess its greatest vulnerabilities (City of Alexandria 2011). It is also examining potential goals and actions, such as educating the public on their risk and vulnerability, integrating the vulnerability assessment into the Hazard Mitigation planning process, increasing freeboard (the height of a watertight portion of a building over a given level of a water in the river) or setback requirements, encouraging the transfer of development rights, creating rolling easements (takes away a landowner's guarantee that the government will try to hold back the sea and instead allows the shoreline to migrate inland), or creating floodplain overlay districts (restricts the type of development that can occur in that zone) (City of Alexandria 2011, Milwaukee River Basin Partnership 2003, NOAA 2011)

Fairfax County

Fairfax County does not have policies that directly address climate change adaption and sea level rise (Northern Virginia Regional Commission 2009). However, it does have a number of related plans and policies. For example, Fairfax County's Floodplain Management Plan lists a number of flood and hazard mitigation and warning measures that help mitigate current risks and will help to prevent more severe damage in the future (Northern Virginia Regional Commission 2009). Fairfax County also has a number of policies such as their Environmental Quality Corridors program, the Tidal Shoreline Erosion Control Measures Ordinance, and General Land Regulations on drainage, floodplains, wetlands, and Resource Protection Areas which also deal with related issues (Northern Virginia Regional Commission 2009).

Intergovernmental programs

Four Mile Run Restoration Project

The Four Mile Run project, although it is not explicitly a project in response to climate changeI has the potential to incorporate multiple lessons from the Dutch experience. The plan aims to transform a stream that has served primarily as a flood control channel since the 1970s and is currently surrounded by concrete, riprap, and walls into an attractive, multi-purpose gathering place for the surrounding communities that still provides the necessary flood protection (Four Mile Run Restoration Master Plan 2006). Additionally this plan was developed through intergovernmental cooperation and public participation.

Intergovernmental Cooperation

The Four Mile Run Project is an example of successful municipal collaboration. This is necessary because the relevant section of Four Mile Run serves as the dividing line between the City of Alexandria and Arlington County. To facilitate this cooperation the two governments created the Joint Task Force (JTF), an eighteen-member commission of citizens from both jurisdictions, and the Agency Coordination Group (ACG), which included staff from a variety of disciplines from both jurisdictions, the NVRC, and the U.S. Army Corps of Engineers (Four Mile Run Restoration Master Plan 2006, 32). The JTF and the ACG organized a series of public outreach efforts and the ACG developed the plan based on the

recommendations of the public and more technical recommendations from the NVRC and the USACE (Four Mile Run Restoration Master Plan 2006, 32-37). The planning process was also funded with aid from the US Environmental Protection Agency and the USACE (Four Mile Run Restoration Master Plan 2006).

Public Participation

The planning of this project offered a number of opportunities for public contributions and involvement. The first of which was the formation of the Joint Task Force which was composed of 18 citizens from the Arlington and Alexandria, most of whom are members of relevant community organizations or civic associations(Four Mile Run Restoration Master Plan 2006). The JTF served as a liaison between members of the community and the ACG, or the agencies that developed the final plan (Four Mile Run Restoration Master Plan 2006). The JTF collected public input through a number of roundtable discussions with community groups, local businesses, civic associations, and members of the Latino community and a visioning workshop (Four Mile Run Restoration Master Plan 2006). At this visioning workshop, attended by 150 members of both communities, participants were provide their opinions on which goals were most important, what they liked and did not like about the stream's current state, and how they thought it could be improved (Four Mile Run Restoration Master Plan 2006). Thanks to this workshop they were able to create a plan that incorporated the public's desire for green corridors, increased connectivity and access, and additional opportunities for recreation and the arts (Four Mile Run Restoration Master Plan 2006).

Funding

Unlike with the Delta Fund, the funding for the Four Mile Run project is not guaranteed once it is approved. Instead it requires additional intergovernmental cooperation in the collection of funding. This project will seek to earn a patchwork of grants from various federal and state agencies as well as private environmental organizations supplemented by funding from both local governments (Four Mile Run Restoration Master Plan 2006).

Coastal Zone Management

The Virginia Coastal Zone Management (CZM) Program is a network of state agencies and local governments ("Overview of Coastal Management"). It also works closely with the National Oceanic and Atmospheric Association (NOAA) which provides more than half of the program's funding as part of its national Coastal Zone Management Program ("Overview of Coastal Management"). Led by the Virginia Department of Environmental Quality (DEQ), it works to protect coastal resources, promote their sustainable use, and coordinate coastal management ("Overview of Coastal Management").

According to the DEQ website, some of their objectives relevant to climate change and intergovernmental cooperation include:

- To reduce or prevent losses of coastal habitat, life, and property caused by shoreline erosion, storms, and other coastal hazards in a manner that balances environmental and economic considerations.

- To reduce or prevent losses of coastal habitat, life, and property caused by shoreline erosion, storms, and other coastal hazards in a manner that balances environmental and economic considerations.
- To ensure sustainable development on coastal lands and support access for water-dependent development through effective coordination of governmental planning processes.
- To avoid and minimize coastal resource use conflicts through research, planning, and a forum for coordination and facilitation among government agencies, interest groups, and citizens.
- To promote informed decision-making by maximizing the availability of up-to-date educational information, technical advice, and scientific data including the use of new tools such as marine spatial planning ("Virginia CZM Program Goals").

The CZM Program has provided funding for a number of climate change adaption initiatives all along the Virginia's coast. In Northern Virginia, CZM has worked with the NVRC to carry out the Sustainable Shorelines Program (Northern Virginia Regional Commission 2009).

Sustainable Shorelines Community Management Project

This project's objective is to regionalize planning efforts for sea level rise and storm surge flooding in Northern Virginia. This project is comprised of three phases: the first includes inventorying data on built and natural resources, assessing vulnerability, collecting and compiling information on relevant local and state policies, and developing a workgroup of local, state and federal government representatives and universities; the second, filling the data gaps revealed by the first phase, by conducting a more detailed vulnerability assessment and beginning the development of adaption planning strategy recommendations; and the third, refining the recommendations and supporting the integration of these recommendations into local policies and planning tools (Northern Virginia Regional Commission 2009). This kind of regional planning with cooperation with state agencies like Virginia Coastal Zone Management Program and the National Oceanic and Atmospheric Administration is similar to the Dutch bottom-up strategy. It also prevents each municipality from having to conduct the same research by themselves and provides a larger context.

Conclusions and Recommendations

Lessons for Northern Virginia

Political and Institutional Barriers to Climate Change Adaptation

Comprehensive climate change adaptation and spatial planning on a national scale as in the Netherlands would be ideal. However, the US has a number of political and institutional barriers that make national level planning difficult. The federal government has limited funds and limited power to implement nation-wide infrastructure planning. In this period of government austerity, budgets for infrastructure and scientific research have been cut severely by the sequester. In the US, we neither have history of severe flooding to motivate us nor a history of agreeing to additional taxes for any reason. Due to their

long history of lethal flooding, the Dutch are willing and accustomed to paying higher taxes for greater protection.

Aside from issues with funding, the US has been suffering from political gridlock on the national level making it difficult for all legislation to be passed. Since there remains a lack of consensus among Americans about the existence of and the cause of global warming, national level climate adaptation legislation is even more unlikely to pass, despite the president's recent support for climate adaptation and mitigation.

Even among the environmental community and local governments, discussion and action more frequently cover mitigation instead of adaptation. So that most environmental legislation that does pass does not adequately address climate change adaptation.

Opportunities for Action and Collaboration on Sub-national Level

In the Netherlands, which is less than half the size of Virginia, planning must happen on a national level to be effective. Whereas in Europe multiple nations must be involved to address a whole watershed, oftentimes watersheds in America may be managed by only a few states. This enables the United States to take action effectively on a regional level.

Northern Virginia's climate change adaptation planning can be enhanced by knowledge sharing with the Netherlands through the sharing of innovations and results in similar projects. The NVRC has a proud history of facilitating these types of connections and information exchanges between Northern Virginia and communities around the world. By establishing this connection, Northern Virginia could utilize Dutch expertise to aid its data collection, vulnerability assessments and the selection and implementation of appropriate policies and technologies and in turn could share its practices, data and innovations with the Dutch.

Opportunities to Implement Dutch Procedural Innovations in Local Projects

Coastal Zone Management Program

Dutch experts could help the Coastal Zone Management by advising them on how best to develop a comprehensive management plan for Virginia's coastline though cooperation with municipalities. Dutch authorities could also provide useful information on the best ways to support and educate municipal and regional officials.

Sustainable Shorelines

NVRC and CZM could also work with Dutch water management and flood control experts to improve the accuracy of the Sustainable Shorelines data collection process and vulnerability assessments. For example, the Dutch could help extend the range of NVRC's projections for flood risk and sea level over a longer period of time.

Northern Virginia's Sustainable Shorelines Project and the Netherlands' Building with Nature Program could share information about techniques of successful beach enhancement and implementation of living shorelines or oyster reefs to prevent erosion. Dialogue between these two programs could also provide the Sustainable Shorelines project with insight into how to more effectively recruit and take advantage of help from universities and the private sector.

Four Mile Run Restoration Project

For the Four Mile Run Project, Northern Virginia could experiment with a more Dutch approach to intergovernmental meetings and planning the funding concurrently with the design. The Netherlands and Northern Virginia could also share techniques for encouraging public participation and their results. Strategies for urban ecological restoration, like those implemented in the Four Mile Run Project and in various *Room for the River* projects could provide another opportunity for information and innovation exchanges.

Delta Cities: Alexandria's Old Town and Bellehaven

Like the Amsterdam neighborhood of Watergraafsmeer, Bellehaven and Old Town Alexandria are low-lying residential areas that are frequently at risk of flooding and that will become ever more vulnerable as the sea level rises. Spatial techniques from *Room for the River*, including "retain, store and drain" could be tested and implemented in Bellehaven and Old Town.

For Future Consideration

There are a number of additional possibilities for more in-depth cross-national exchanges of information between the Netherlands and Northern Virginia.

The Roles of Private and Public Flood Insurance

In the Netherlands, there is no real flood insurance system. In the rare occurrence of a flood, the government chooses at that time whether or not to provide compensation and if so for what percentage of the damages (Botzen and van den Bergh 2008). This compensation is applied equally regardless of how risk-prone the property may have been (Botzen and van den Bergh 2008). Additionally, citizens do not have to pay premiums and so the cost of compensation may result in higher taxes or other economic costs spread across the entire country (Botzen and van den Bergh 2008). Not having to pay higher premiums based on risk and counting on government compensation does not provide incentives for individual property owners to minimize risk (Botzen and van den Bergh 2008). Private insurance companies also did not offer flood insurance (Lloyd's 2013). However, in 2012, one company, Neerlandse, has begun to offer a flood insurance program with premiums based on risk that guarantees up to €75,000 of damage, enough to cover the average damage to a property (Lloyd's 2013). Neerlandse also believes that its insurance program will educate property owners on their risk and encourage them to take measures to minimize that risk (Lloyd's 2013).

In America, flood insurance is an optional government-subsidized program available for purchase through private insurance companies. This flood insurance only guarantees compensation for up to 80% of the loss of both the building and its contents ("Coverage from the NFIP" 2013).

The financial consequences for the Dutch Government if a major flood should occur no doubt help insure continued high standards of flood protection and strict regulations about building in floodplains. However, it removes citizens' responsibility for any decisions they make that increase or decrease their own risk. It would be very interesting to explore how private vs. public insurance systems affect the citizens' and the governments' attitudes to climate change adaptation and hazard mitigation.

Comparing Virginia Soil and Water Conservation Districts with the Water Boards

Additional research into the Water Boards and their closest equivalent in Northern Virginia, the Soil and Water Conservation Districts, might reveal ways in which the Conservation Districts could be better integrated into Virginia's governmental system or to improve collaboration between the Conservation Districts and all levels of government.

Public Participation

NVRC and the Netherlands could also conduct a more in-depth analysis of their various methods of incorporating public participation into the design process. By comparing the techniques involved in and the results obtained by such efforts, the two parties could develop a resource for other regional planning commissions and municipalities for similar adaptation projects.

Expropriation

A more detailed legal investigation could also be conducted to discover why the Dutch seem to have more success expropriating high-flood risk land.

Zoning

More research could be carried out to determine if there are any benefits to having local and regional governments share the responsibility for zoning as it is in the Netherlands, rather than zoning carried out only by local governments, as it is in Virginia.

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