Progressing Policy Towards Planned Adaptation for Flood Risk Management in New Orleans and the Netherlands after Hurricane Katrina

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Abstract

The late Dr. Gilbert F. White of the United States, often known as the Father of Modern Floodplain Management, once mentioned, "Floods are acts of nature, but flood losses are largely acts of man."[19] Hurricane Katrina has been a prime example of this axiom and became a turning point for flood management policy not only for New Orleans but also international flood control leaders, like the Netherlands. Pre-Katrina, both the Americans and Dutch originally held a relatively myopic view of what was necessary to control flooding and manage flood-related risks. It was not until the blatant devastation witnessed in the Hurricane Katrina's aftermath that both countries committed to maturing their flood control policies into the more holistic and integrated approach of flood risk management. The historic inertia and sociopolitical entrenchment of the U.S. Army Corps of Engineers transformed from damage-control reactions post-flooding into prioritizing safety standards and subsequently updating hydraulic requirements over time of vulnerable project to prevent floods in the first place. The Netherlands, despite originally having the more robust flood protection system at the time, also responded to Katrina by establishing its premiere Delta Programme that created a flexible framework of water resource governance to maintain a high baseline level of flood safety for its communities. The U.S. Army Corps of Engineers and the Dutch Water Board have specifically incorporated planned adaptation as a central strategy by taking into account changing climate-related and socioeconomic risks over time to strength and de-risk their flood protection systems. They have worked concurrently and together on this initiative through a process of back-and-forth knowledge transfer that have highlighted overall best practices for floodplain management during the adaptation process—from legal frameworks, stakeholder engagement, funding schemes, interagency partnerships to multi-level governance.

Introduction to Planned Adaptation

Planned adaptation refers, as recorded by the Intergovernmental Panel on Climate Change in 2007, to deliberate policymaking based on an awareness of apparent and/or imminent changes in natural conditions that will likely deviate from a desired state.[23] In regards to water policy and floodplain management, planned adaptation indicates a shift from an almost exclusively flood prevention-based policy to a broader focus on integrated flood risk management. This transition takes into account near and future-term vulnerability assessments and contingency planning for crisis management—highlighting essentially a *risk-based approach* to water policy.

Planned adaptation tends to come in two flavors – a fixed timeline or continuous monitoring approach. A fixed timeline approach refers to updating safety levels and underlying criteria at the end of fixed cycle lengths, for example testing systems every 5 years.[22] All relevant data is analyzed at that time following a set assessment protocol that is also re-evaluated after a fixed cycle timeframe. This methodology for planned adaptation tends to compromise staying up-to-date with safety with being logistically and financially prepared when making required changes to water defense systems after each fixed cycle. A continuous monitoring approach, on the other hand, takes into account the "precautionary principle" where the conditions, based on set thresholds for safety, justify the updates that are made, not just after an assessment cycle is completed.[27] This process tends to be more logistically and financially burdensome, but tends to err more on the side of safety than the fixed timeline approach. Though there are more versions of planned adaptation, these two classifications (and their combination over time) tend to be the most widespread, and often set the tone for the management of floodplains and water defense systems in their respective countries and municipalities.

The following case study on the Netherlands' floodplain management highlights the Dutch's efforts to incorporate planned adaptation into their flood protection systems via a continuous monitoring system (after significant floods) coupled with a fixed cycle approach (in between these natural disasters) that defines the Dutch system over time.[26] The following analysis also chronicles how the Dutch have learned from flood disasters around the world, in particular Hurricane Katrina, that have influenced the improvement of their own systems.

Case Study: Planned Floodplain Management of the Netherlands

The Netherlands has been globally recognized for its "robust" flood protection systems that originated as a result of its unique geography – 55% of its land is severely prone to flooding, which includes 62% of its urban area and 67% of the Dutch population.[8] During the last century, there has been a six-fold increase in urbanization in the food-prone Dutch delta, and future socio-economic projects show a further increase in urbanization between 30% (for low economic growth projections) to 125% (for high economic growth projections) by the year 2100 (with respect to year 2000).[20] Thus, the country will have to continuously rely on stronger and more robust sea defenses and dyke networks for protection. The Dutch have been relatively consistent in recent decades with ensuring the upholding of the following flood risk policies:

1. Achieving a minimum safety standard for each Dutch citizen of 1/100,000 per year chance of flood-related death
2. Societal cost-benefit analysis-based safety standards for Dutch flood defenses
3. Minimizing and counteracting flood-based social disruption
4. Protecting vital and vulnerable infrastructure[26]

But it was not always this way…

Dutch Disaster of 1953

The most recent large coastal flood to hit Europe happened in 1953 when a huge storm surge hit the Netherlands, the east coast of England, Belgium, and Germany killing over 2100 people, more than 1800 of which were in the Netherlands.[21] The Dutch sea defenses at that time could not handle the water pressure from the massive tidal surge coinciding with high tide in the North Sea that night. The water rose suddenly to more than five meters above sea level, causing massive, widespread flooding in embanked regions.[26] Radio stations unfortunately were not broadcast at night and previous adverse weather had disrupted telephone communications, so flood warnings were delayed. As a result, most of the victims were unable to evacuate in time.[21]

Scientists and engineers before the storm had actually foreshadowed such a debacle to occur.[8] The Netherlands had abandoned key reinforcing measures of their substandard water defense systems due to the shift in priorities to World War II in the early 1940s.[21] The Dutch government had set up a "Storm Tide" commission in 1939 to develop a program of flood prevention improvements, [21] but was not able to carry out their recommendations due to the German invasion soon thereafter. Even at the end of the war, the Dutch government focused far more on war-related reconstruction than reconstruction of its ever-deteriorating dykes. Further exacerbating the situation, widespread food shortages in the Netherlands[8] led to the reclamation of even lower lying ground from the sea for crop production, exposing far more regions to flooding.

Dutch Water Policies Post-1953 Flood Disaster

It was not until after the Great Flood of 1953 when immediate and urgent talks began on future flood protection for the country, leading to the implementation of the ambitious "Delta

Works" Project in 1958.[26] The project took a full 40 years until 1998 to complete and aimed at reducing the risk of a disaster, such as the 1953 flood, to a probability of only one in 3000 years.[6]

Before the 1953 flood, water management systems were relatively simple, but in the 1960s, a complex system of reinforcing and heightening river and coastal dikes commenced and increased the complexity of these systems. By the end of the 1960s, the Dutch civil works authorities started emphasizing an integrated water management approach.[8] This transition to a more integrated system of construction led also to an increased coherence of Dutch water management. Subsequently, the First National Water Policy Document was signed and adopted in 1968.[26] This brought about not only a more integrated approach to dyke reconstruction, but also an interconnectedness of roles and responsibilities of all stakeholders from the provincial water authorities to the centralized water management board, delegating responsibility for water management system maintenance at all levels.[8]

From there came a system of updates from the first water policy agreement to several subsequent ones (typically after significant floods were observed or when new policy trends were emerging) that warranted reappraisal of the existing flood protection policies. The second of the national water policy agreements occurred in 1984, which emphasized improving the decision-making process for water system construction, consideration of new use-functions for the water system, and a trend towards its deregulation. The third Policy Document was signed in 1989, and became the first fully integrated water policy plan called the Water Defense Act of 1989. This Act signified a real documented transition towards integrated water management, as it holistically considered the water system and interconnected surface and groundwater policies, in order to optimize the management of the whole water basin. The fourth water policy plan was

instated in 1998, and by that time the Dutch water defense system was internationally regarded as a paradigm for integrated water management.[8]

It was not until 2005, however, when the discussion of *direct safety standards* took the highest priority position in Dutch flood protection policy.[26] This came not as a result of actual Dutch flood problems, but was rather triggered by Hurricane Katrina in Louisiana.

The Catastrophe of Hurricane Katrina

On August 29, 2005, Hurricane Katrina made landfall on the United States Gulf Coast as a Category 3 rated hurricane on the Saffir-Simpson Hurricane Scale.[2] Many cities along the coast were ravaged by the storm surge that grew as high as 9 meters in some regions[16], but it was the low-lying metropolis of New Orleans that experienced the brunt of the devastation. The city's unstable levees and drainage canals were unable to hold up to the pressure of the storm surge, and the weak, unstable underlying soils that anchored the floodwalls expanded and softened, subsequently giving way to the floodwalls in many places, pushing them backwards into the protected polders.[10] Water gushed through neighborhoods and drowned hundreds of people. Eventually, almost 80 percent of the city was submerged.[16]

The flooding killed 1,836 people in New Orleans and the overall devastation from Katrina caused more than $100 billion in damage[4] and affected around 90,000 square miles of the United States.[2] Hundreds of thousands of people in Louisiana, Mississippi, and Alabama were displaced from their homes and these evacuees have been scattered far and wide to almost all of the country's states.[9] The Federal Emergency Management Agency (FEMA) was originally the most criticized for its decision-making and performance before, during, and immediately after Katrina, but it was actually the U.S. Army Corps of Engineers (USACE) that held the legal responsibility for construction and maintenance of the New Orleans flood protection system.[16]

Misinterpretation of Load Tests and Lax Maintenance by the Army Corps of Engineers

A few years prior to Hurricane Katrina, the USACE carried out a full-scale load test of floodwalls in the Atchafalaya Basin just outside of New Orleans. The initially estimated depths at which the flood walls were to be installed was between 31 to 46 feet, yet after this questionable load test on-site, it was determined that the flood walls in the city only needed to be extended to a depth of 17 feet below sea level.[10] The Corps went with the estimates from the load tests, which turned out to be a severe misinterpretation due allegedly to several external factors, including neglect of the essential peat soil structure and mechanics 15-20 below the surface (requiring the pilings to be extended sufficiently below that level to maintain stability)[16] and the existence of a heavy cloth tarp covering a gap between the sheet-pile supports and the ground during the tests.[10] What's more, an external team of engineers from LSU, who investigated the levee failures on behalf of the state of Louisiana after Katrina, discovered that the piling installation extended only to 10 feet below sea level in some areas[18], far shorter than even the 17 feet determined by the (albeit-flawed) load tests.

Additionally, other external peer reviews of the levee failures included a joint investigation by University of California Berkeley and the American Society of Civil Engineers (ACSE) who concluded that several years of lax maintenance practices[18] (based on not only the evidence of faulty levee reinforcements but also on the investigation of actual board meeting minutes of the Army Corps) were likely to have contributed to the levee breaches along some of the outfall canals. Overall, it was revealed that the Army Corps was operating without sufficient oversight, falling short of their flood safety standards, and thus greatly endangering the New Orleans residents they were serving.

Missing External Review Board

The absence of a system of external peer review of the New Orleans flood protection system was heavily criticized by many stakeholders post-Hurricane Katrina. The lack of external peer reviews before Katrina has been considered one of the greatest flaws that contributed to the 2005 disaster in New Orleans.[4] Had the Corps retained an external review board to double-check its flood-wall designs, fewer faulty flood walls would have likely been installed, billions of dollars in property damage could have been prevented, and thousands of lives saved, as concluded by J. David Rogers, a lead author on a Katrina reevaluation study published in a World Water Council report.[9] A External Peer Review (ERP) report issued by the ASCE also highlighted that if the levees and pump stations had not failed "far less property would have occurred and nearly two-thirds of deaths could have been avoided."[16]

Dysfunctional Interaction among Stakeholders

Digging deeper into the issue of what could have been done to prevent the significant devastation from Hurricane Katrina, significant pieces of evidence were found that underscored a slew of inefficiencies resulting from politically polarizing interactions and subsequently delayed actions among flood control stakeholders in New Orleans. It was not only the Army Corps' fault in the design of subpar levee systems and drainage canals, but also the decisions and political pressure from local officials in New Orleans that contributed to the ultimate disaster of Hurricane Katrina.[18] Levee board members and other officials were instrumental in pressuring the corps to build an allegedly less-effective flood protection system (a "high level" option levee system) after several years during which the Corps had planned to build a *potentially* more effective "barrier" option levee system.[10] The decision-making and follow-through for this plan took several decades, however, and many political deliberations delayed its ultimate construction.

Political Gridlock Stalling Renovations of New Orleans' Flood System

New Orleans began the construction of its first complex flood protection system in 1965 after Hurricane Betsy that September ravaged much of the American Gulf Coast and southern Florida[1], causing the U.S. Congress react immediately with mandates to improve hurricane resilience in that region. Congress authorized the Lake Pontchartrain and Vicinity Hurricane Protection Project (LPVHPP)—a massive hurricane protection improvement effort—to enhance hurricane protection for residents of the Greater New Orleans metropolitan area.[10] Most of that responsibility was given to the U.S. Army Corps of Engineers.[16]

The options for the flood system construction came down to two—a "high level" option and a "barrier" option. The "high level" option would consist of constructing very high levees that would prevent flooding/overtopping of storm surge that could result from a "standard project hurricane" (SPH)—a set of generalized hurricane specifications created by the Corps in the 1950s.[10] The SPH model sets a standard for hurricane protection design criteria so as to protect New Orleans from a 200 to 300-year expected extreme hurricane.[23] The "barrier" option includes levee construction but also emphasizes the use of massive gates that would limit excess storm surge from Lake Borgne region in the Gulf of Mexico into the Industrial Canal (New Orleans' main canal waterway) and to Lake Pontchartrain. The canal gates would be closed upon an approaching storm in order to prevent the storm surge to enter the Industrial Canal and flood the city.[8]

Originally, the Corps decided on the "barrier" option[10] as it coupled the use of levees (though not as high as the "high level" option) with a secondary precaution of canal gates to prevent storm surges to hit New Orleans. Upon public disclosure of this plan, however, there was significant public backlash, including a lawsuit by the organization Save Our Wetlands in 1976

that alleged the Corps' environmental impact assessment of the project to be inadequate. Public polls also revealed hesitation by the public towards this "barrier" option plan due to the uncertainty from the effects of opening and closing the canal gates.[16] An injunction[18] on the project was placed in 1976 to allow for further review. It took seven years from the injunction with the "pressuring" of the New Orleans' levee board members and the public, for the Army Corps to abandon the "barrier" project and instead adopt the "high level" option in 1982.[10] A closer look also exposes the "high level" project to be the significantly more economical option.[16] It took about twenty years, just a few years before Hurricane Katrina, for the system to be finally built to completion.

Immediate Aftermath of Katrina: The Army Corps React, Respond & Rebuild

Even with the New Orleans flood protection system finished by the time the Category 3 Hurricane Katrina hit the city on August 29, 2005, the system was not robust enough to contain the storm surges that ensued. The storm breached over 50 levees and surge protection mechanisms in approximately 15 different regions, most notably the levees along the 17th Street Canal, the London Avenue Canal, and the Industrial Canal, which ultimately flooded about 80% of the New Orleans.[2] FEMA, the Coast Guard, and the Army Corps went to work immediately to try to contain and fix the societal and infrastructure damage. The Corps, specifically, started making emergency repairs to the levee breaches and operating a system of pumps to drain the city. Nonetheless, due to the massive amounts of flooding, it took several days and, in some places, even weeks, to pump out the water.[18]

The Corps, during its recovery process of New Orleans after Hurricane Katrina, operated in a three-step process: first, draining the city and assessing the flood protection breaches; second, providing an "interim level" of protection to keep it protected enough to weather the

impending Hurricane Rita and other storms during the 2005 hurricane season; and third, returning the system to pre-hurricane conditions.[10]

Initially, the responses to Hurricane Katrina were inevitably reactionary. Natural disasters warrant immediate attention to the immediate problems that exist in their aftermath. It took over a whole month after Katrina for the damaged canals to be closed, several weeks after September's Hurricane Rita for the city to be fully drained, and the rest of the year to fix all the levee breaches.[2] Yet, even after this initial reactionary phase, the Army Corps was poised to repeat its mistakes from before. After a detailed assessment of around 350 miles of hurricane flood protection mechanisms that led to a comprehensive, prioritized plan to repair them and their pumping stations, even Col. Duane Gapinski, the Corps Task Force Unwatering commander, stressed "The system in its present condition does not ensure that the city will be protected from flooding resulting from storms or hurricanes."[22]

It was not until the following year that the Army Corp began its permanent repairs of the system, and up to five years for adaptive planning for future storms to be considered and put into practice.[23] It was actually the Dutch—still considered at the time to have the most robust flood protection system in the world—to take a closer look at its own system after Hurricane Katrina, and start a process of adaptive planning for future flood considerations, so that the devastation, like that from Katrina, would not happen along its own coastlines.

Dutch Response to Katrina

What is surprising is that despite international recognition of the Dutch dyke system, it was because of Hurricane Katrina that the Dutch started putting greater emphasis on planned adaptation for its floodplain management systems. Fortunately for the Dutch, the legal and political structure of the Netherlands lends itself better to enforcing the adoption of planned

adaptation measures[6] than in the United States, yet even then, it took until after Katrina for the Dutch to incorporate long-term risk management standards into its current civil works planning procedures. Jan Hoogland, the Director of the Dutch Public Water Works, just a month after Hurricane Katrina, made a statement to the US Congress stating how "each flood disaster in the Netherlands – from the 13th century onwards – has brought new lessons to be learned for keeping our country habitable, livable, and attractive to citizens and businesses."[26] This mindset has now been extrapolated to learning also from future predicted disasters.

The Dutch realized rather quickly that, even though they do not experience hurricanes, similar damage and loss of life might occur if a storm of similar strength or flooding of post-Katrina magnitude was to occur in the Netherlands. Despite the acclaimed Dutch dyke system being considered significantly more robust than that of New Orleans at the time, the Netherlands' population density is higher over a larger area with most people relying on public transportation.[12] Therefore, a storm with Hurricane Katrina-like qualities would likely nevertheless affect the region just as severely, with evacuation and rebuilding efforts being more problematic, due to these considerations. With this new perspective after assessing Katrina, the Netherlands' government elevated and became more inclusive with their floodplain risk estimates. These estimates have been the cornerstone for planning, designing, and developing the country's future civil projects.[26] The Dutch government took the cue earlier (within the time New Orleans was still in its aftermath rebuilding phase) to adopt a planned adaptation approach by incorporating these future risks into their current floodplain management strategies.

New Orleans USACE Partnership with the Dutch

The Dutch not only learned and upgraded their resilience efforts from hindsight analysis of Katrina and understanding the devastation in New Orleans from providing relief aid to the

people there, [4] but they also gained keen insight into planned adaptation strategies through direct partnership with the civil works authorities in New Orleans.[9] Dutch engineers were a pivotal contributor in the rebuilding and planning of the new $14 billion New Orleans flood management system, at the behest of the U.S. Army Corps of Engineers.[24] In January 2007, the Army Corps of Engineers traveled to the Netherlands to visit its premiere "Delta Works" levee system that has been the international archetype for robust flood management. Upon the visit, the Army Corp established a partnership with a group of Dutch engineering companies and assigned them a $150 million contract[23] to evaluate, design, and construct a levee and floodwall management system with specific requirements of closure structures to protect communities living near the Industrial Canal, upgraded major pumping facilities, and planned studies for improving flood protection in this region. The United States, through the Army Corps, has pledged a total sum of $14.45 billion investment for this project.[5] With the help from their Dutch contractors, the Army Corps of Engineers and the city of New Orleans have started to adopt best practices from the Dutch flood protection safety standards[6], provided insight to the Dutch[12] on potential flood risks, and have thus *progressed together* to improve both of their systems for greater flood resilience.

Concurrent Upgrading of Floodplain Management Policies to Include Planned Adaptation by the Netherlands and New Orleans

Since Hurricane Katrina, a greater emphasis for planned adaptation to potential flood risks have been adopted by both the Netherlands and New Orleans for their respective communities and coastlines. The Netherlands already had an advantage as it did not have a disaster aftermath to handle, had a more favorable legal system, and a relatively stronger flood control system in place to begin with.[8] Nevertheless, New Orleans also had a big opportunity

window after Hurricane Katrina to rebuild its destroyed flood protection system with the help of federal and international aid[4], and also did not have to worry about technology lock-in considerations to which the Dutch were more susceptible.[27]

Additionally, there was significant public pressure for the Army Corps in New Orleans to build a system that would protect New Orleans from a Category 5 hurricane and provide 500-year storm level protect for urban areas and critical facilities.[5] These considerations as well as legal mandates and lessons from external collaboration[1] led the Corps to implement planned adaptation measures and publish yearly reviews (from 2014 onwards) to continually improve upon its post-Katrina flood protection system.

USACE 2006 – Recognition of Underlying & Increasing Risks

Hurricane Katrina was a wake up call to New Orleans and to the Army Corps that preparing for future storms will require a greater assessment of now and future risks, and thus more structured planned for all likely future conditions that may befall the city, its people and infrastructure. Risk will only increase as the city continues to sink below sea level and protective wetlands in the Gulf of Mexico are further destroyed by development.[3] These risks and those from a changing climate must be taken into account when designing the new flood protection systems.

Before Katrina, the Army Corps focused primarily on "flood control," creating mechanisms to protect against floods based on the current predictions for flooding at the time.[9] This myopic view of planning caused the substandard construction of levees that contributed to the failures during Hurricane Katrina.[2] In June 2006, the Corps' General Strock took responsibility on behalf of the Corps for the levee failures that caused much of the devastation and called the system that was in place "a system in name only."[16] The system was not only

inadequately designed to the standards at the time, but it also did not look far enough into the future for potential risks that may occur during the lifetime of the system.

Since 2006, the USACE has started to expand its original considerations of "flood control" to now take on the more practical and nuanced approach of "flood risk management" by considering how potential flooding risks. They have acknowledged that vanishing wetlands, city sinking, and climate change will change and will subsequently affect floodplains and their management over time. The Army Corps, in 2006, had only just started to consider new knowledge on climate change and how it, in the future, can be incorporated into the Corps' assessments of its Civil Works missions, operations, programs and projects to reduce their vulnerabilities and improve their resilience from flooding.[17]

It was after learning about the Dutch's Delta Programme in 2010[6], however, that the Army Corps decided to follow in the Netherlands' footsteps and create its own structured approach for flood protection review on a regular basis and instating planned adaptation measures at each re-evaluation cycle.

Dutch Delta Programme of 2010

Similarly to the flood risk management practices of the U.S. Army Corps, during the decades prior to Katrina, the Netherlands mostly focused on immediate flood protection[8] when building their flood defense systems. As a direct response to Hurricane Katrina, the Dutch government developed a national safety and security strategy[26] for flooding in 2007 after all relevant actors realized that there were mismatches between actual and required defense mechanisms that very well may grow over time. In order to prevent this from happening, the Dutch government emphasized the creation of a forward-looking flood protection policy that would incorporate knowledge assessment of the changing ecosystem and climate system while

regularly testing the water defense systems, and then update the hydraulic requirements and other safety mechanisms accordingly.[11]

From this new strategy and approach towards flood protection, the Dutch Delta Programme of 2010 was born. The Programme is a national flood protection and freshwater supply program with a multi-level governance structure that includes federal, regional, and local authorities. These decision-making entities work closely with the public, knowledge institutions, and other stakeholders to take into account new knowledge and changing conditions for salient decision-making, implementing measures to prevent current flood risks, and ensuring adequate freshwater supply. The Programme is overall led by a definite government commission and has an annual budget of 1 billion euro.[26]

This approach was a promising start to a new era of Dutch flood protection governance, but it was just the beginning. The government realized it needed to be more agile in adapting policies to current and future flood risks, yet it took a few more years for the government and its stakeholders to consider another critical component to planned adaptation—contingency planning.[20] The 2010 Delta Programme was therefore just the start of new policy changes and planned adaptation measures to come for the Dutch.

USACE 2011 – First Adaptation Report

Just a year after the Dutch established its Delta Programme, the U.S. Army Corps of Engineers published its first annual adaptation report highlighting concrete steps that it and all relevant stakeholders will take to incorporate adaptation measures into its flood control vulnerability assessments.[23] The report introduces the Corps' new strategy of partnering between federal agencies to connect relevant knowledge and skills from these departments to improve decision-making on floodplain management. It also emphasizes developing and implementing

plans for policy and infrastructure adaptation in parallel rather than sequentially, so as to prioritize adaption for the most vulnerable projects.[1] The Corps lays out a plan to pilot test these adaptation methods over the next few years.

The 2011 Adaptation Report by the Corps was also the first time the agency specifically incorporated long-term "adaptive planning" into its policy-making toolbox.[23] It is likely that this was the case because of the introduction of "planned adaptation" as a driver for environmental leadership as highlighted in the Obama Administration's 2009 Executive Order 13514. The Executive Order or "Federal Leadership in Environmental, Energy, and Economic Performance" includes a Federal Adaptation Strategy, which assigns roles to various federal agencies (including the Corps) and includes participation in the federal Climate Change Adaptation Task Force.[1]

To follow through with its roles, the Corps created a Climate Change Adaptation Steering Committee chaired by the USACE Chief of Engineering and Construction, James C. Dalton, and an overall adaptation policy signed by the Corps' Assistant Secretary of the Army for Civil Works, Jo-Ellen Darcy, on June 3, 2011.[23] Through these new initiatives, the Corps has integrated its climate change-related programs to structure adaptive planning among the various departments within the agency. This was a start to the Corps' follow through of making planned adaptation a priority for its civil works projects.

USACE 2014 – Agency Adaptation Policies Adopted

Three years later, the USACE continues to fill in knowledge gaps and develop policies to adapt to climate change and other risks that can affect its extensive floodplain management not only in New Orleans but also around the whole country. During this time, the Corps has updated its adaptation policy statement to include consideration of more risk factors, published

vulnerability assessments on its various projects, and has created models that incorporate planned adaptation measures to help with its civil works decision-making.[24] The Corps has also started to engage with key external stakeholders on critical issues related to climate change risk adaptation domestically. For example, the agency has convened a State, Local, and Tribal Leaders Task Force to make recommendations to "improve climate preparedness and resilience for states, local communities, and tribes."[25]

More federal actions including the release of the Presidential Climate Action Plan (PCAP) in June 2013 and Executive Order 13653 "Preparing the United States for the Impacts of Climate Change" signed in November 2013 helped shape the Corps actions on its planned adaptation strategies. Executive Order 13653 was the federal government's direct response to the rising issue of climate change. It mandates that climate change risks at managed and reduced with "deliberate preparation, cooperation, and coordination."[1] It specifically highlights the need to protect the economy, infrastructure, and environment by planning for future changes due to climate change. This Order aligned very conveniently as the Corps was putting together its strategy for climate change-related planned adaptation.

The Presidential Climate Action Plan reiterated the need for more resilient communities and protection of natural resources while preparing for climate change – activities in which the Corps is uniquely involved. More specifically, the Presidential Plan emphasized how the United States should lead international efforts to prepare for and combat climate change with a requirement for international collaboration.[24] The PCAP gave the Army Corp all the more reason to collaborate with the Dutch to improve their own flood resiliency and even promote its own strategies for floodplain management at an international level. Yet, in 2014, the Corps was still in

planning stages to roll out executable efforts and had several tasks ahead before it can consider itself a leader in planned adaptation approaches to flood management.

Dutch Delta Plan of 2014 – Emphasis on Planned Adaption

While the U.S. Army Corps of Engineers continued to plan its adaptation guidelines from 2011 to 2014, the Dutch, on the other hand, were able to settle on a set of five key water management decisions that were presented to Parliament in 2014, two of which directly addressing flood risk management.[26] These decisions prioritized the allocation of funds and the setting of safety standards to enhance flood protection measures around the country. Higher levels of protection would be placed in areas that would significantly disrupt the whole country, including densely populated regions, places of high economic activity, and those with vital infrastructure.[20] "Regionally differentiated" risk-based safety standards were therefore proposed, yet still ensuring a protection level of 10-5 or higher by 2050 for all Dutch residents living behind dykes and dunes. These standards will then be translated into corresponding hydraulic requirements for these dykes and dunes to be reassessed in 2017.[26] Though the safety standards will stay constant, the requirements necessary to maintain that level of safety will likely increase as climate change intensifies flood risks and causes an estimated sea-level rise of between 25-80 cm from 2011 to 2070. These overall decisions made by the Dutch water authorities are intended to be long term with a time horizon up to 2100.[15]

Lessons Learned by both the U.S. Army Corps and the Dutch Water Authorities

As planned adaptation for flood risk management was essentially carried out concurrently between the U.S. Army Corps of Engineers and the Dutch Water Authorities post-Hurricane Katrina, both governmental agencies can and have learned from each other on superior (and

inferior) practices for incorporating planned adaptation into their national flood protection policies. The Dutch, who started off with the relatively more robust flood protection system, has been working with that same system to upgrade it to planned safety standards and has garnered strong regulatory support for ensuring flood risk protection of the highest caliber.[26] The legal system was already in place when the Dutch started getting more serious about adapting their systems to maintain its safety standards into the future.[6] Additionally, with the introduction of the Delta Programme, an established long-term funding structure has helped the Dutch quickly advance to structured decision-making on how to manage its flood risks over time. Yet, the Army Corps, despite first having to handle the aftermath devastation from Hurricane Katrina, was also able to adopt a planned adaptation approach to future floodplain management strategy and have the chance to start almost from scratch[24], therefore avoiding the problems of technology lock-in that have limited some of the changes that can be made in the Dutch flood defense systems.[11]

There are many ways for a country or region to ensure that its coastlines are safe from storm surges and flooding over time. Yet there are certain policies that can greatly expedite the process of adopting and executing planned adaptation measures for large-scale, long-term and expensive infrastructural projects. Both the Dutch Water Boards and the U.S. Army Corps are in unique geographical and regulatory situations that pose their own set of benefits and costs when it comes to following through with new policymaking on flood risk management. It is nevertheless a typically messy and pluralistic process. Consideration of the legal and regulatory frameworks, funding structures, stakeholder participation, interagency partnerships, and multi-level governance are discussed.

Legal and Regulatory Considerations

When rulemaking concerns value choices, like that for adopting laws and resiliency measures for flood risk management, it is inherently coupled with a complementary legal system. The Dutch, due its centuries-long battle against storm surges along its coastlines, had, early on, made a judgment call that the high risk of flooding justifies the economic investments and strict law adoption to prevent such flooding to occur.[8] The Dutch *mandates* overarching protection from floods[15], while the American flood management system, due to only a small fraction of the country being in flood-prone areas, is subject to the political process[7] where pork-barrel legislation can get in the way of effective protection mechanisms serving the most vulnerable regions that need them the most.

The Netherlands have been building flood protection projects based on estimated risk for a long time, as the government puts a heavier emphasis on disaster avoidance, as compared to the U.S.[6] The U.S. has historically been more effective at disaster management (despite the debacle post-Hurricane Katrina) than disaster avoidance.[12] With planned adaptation, however, the U.S. must become better equipped for disaster avoidance, though as Wim Kuijken, the Dutch government's senior official for overall water control policy, stresses "working to avoid disaster is completely different from working after a disaster."[26]

What's more, not only is the oversight of the U.S. Army Corps minimal to say the least, the Corps cannot even be prosecuted if it does a bad job (like in the case of Hurricane Katrina) due to an immunity clause in the U.S. Flood Control Act of 1928 which protects the federal government from lawsuits over flood control projects.[16] The Netherlands, on the other hand, has a system of checks and balances[26] to ensure that the projects constructed are held to their safety standards.

Critical Role of Long-Term Funding

The Dutch are also a leader in secure funding mechanisms to fund and effectively carry out large civil works projects. The Dutch government currently spends around $1.3 billion per year on water control and allocates funding to local water boards to maintain their dikes, canals, and drainage pumps.[6] The money for New Orleans' levees, however, is only for the short term, and very little has been set aside for more expensive flood defense upgrades in vulnerable communities.[28] When the U.S. Army Corps presented a $21 billion dollar budget for rebuilding the levee system post-Katrina to Congress that was approved and set to the Oval office, President Bush threatened to veto the bill if Congress did not cut its price by a significant margin.[10] For New Orleans alone, estimates show that it would cost $2.5 billion per year and require 10-20 years of construction to create a system to guard against a Category 4 or 5 storm.[9] Yet these critical long-term funding sources have not yet been established.[25] This has been and will probably continue to be a problem for American civil works projects, and could spark another round of reactionary responses when another disaster hits and the flood systems are not ready.

Stakeholder Participation

Another major component for successful implementation of planned adaptation for flood risk management goes hand in hand with funding—that is, the managing and participation of stakeholders. The Dutch have been very successful in this regard through the Delta Programme which has involved a joint, socially and broadly-based decision-making process by a variety of stakeholders. Unique but integrated roles were allocated at each level of the tiered stakeholder model from the centralized water authority all the way to the decentralized municipal Dutch Water Boards that have lead to a streamlined civil works management system. An independent coordinator (the Delta Commissioner) leads the Programme and oversees the Delta Committee,

comprised of multiple governmental stakeholders, on their decisions for upgrading civil works projects. The Delta Committee works closely with the Dutch Steering Committee for National Safety and Security (that was created in 2012) and that has acted as a national sounding board for public concerns to be considered by the Committee.[26] Through efforts by the Delta Committee, the Delta Act of 2011 was established, with unanimous acceptance by the Dutch Senate[26], to allocate necessary funds for the independent, yet regulated, Dutch Water Boards to follow through with their maintenance and upgrades of public water utilities and civil works projects.

This stakeholder division system was put in place for efficiency and to appease the Dutch government that its flood-prone country is prepared for its "own Hurricane Katrina." The system has overall succeeded in increasing the awareness of national risks to Dutch cities, improved capacities for disaster relief and recovery (DRR), and strengthened a public-private network for DDR and planned adaptive measures for future flood risk.[12]

The U.S. Army Corps, on the other hand, did not have a system already in place historically to easily transition to planned adaptive policies for their civil works projects. Instead, there has been a lack of thorough communication between stakeholders and inertia to changing the Corps' policies with new information on risks and cost-benefits.[16] The Corps has a history of reluctance and agnosticism in setting priorities for its projects [18], and oftentimes have left it to Congress to determine which projects should be funded over others, without advising Congress on which proposed projects are more the more critical, despite the price tag.[16] This disjointed stakeholder participation model has fared neither well for the Corps and its projects nor Congress.

Agency behavior and policies have become entrenched within the Corps as the agency has operated so many water projects without conflict for so long.[10] It was not until intense

political pressure from a horrified public witnessing the devastation after Hurricane Katrina did the dial start moving and the Corps start placing more emphasis on safety and long-term risk management. The Corps have historically tended to appease multiple interest groups, resulting many times in pork-barrel legislation and continuing existing operations[16], rather than altering their procedures for greater utility and safety. Even today, the Corps is still in the process of planning for better stakeholder engagement with Congress and the communities they serve.[25] They have looked to the Dutch Water Authority and other international agencies with similar functions[24] to gain better understanding of how to optimize engagement between various stakeholders in the short and long term.

Interagency Partnerships

Despite the historic entrenchment of the Corps' policies and operating procedures internally, the U.S. federal agency has made significant progress in its adaptive planning efforts through key interagency partnerships. Immediately after Hurricane Katrina hit, Corps officials worked directly with the Orleans Parish and Louisiana Department of Transportation officials and private industrial partners to fix breaches in the canal levees.[9] Additionally, there was deliberate coordination between the Corps and FEMA to protect New Orleans citizens and maintain a baseline level of levee system protection during Hurricane Rita just a month after Katrina.[2] Years after Hurricane Katrina, the Corps have continued to strengthen their partnerships among federal and state-level agencies. The Corps have created a long-term planning partnership with FEMA to do long-term extensive safety-related states of their large flood protection systems and to create new 100-year flood elevation maps that take into account not only the flooding from Katrina but also future baseline sea level and additional storm surge benchmark levels over the long term.[25]

Particularly the Corps has been obtaining valuable insight and expertise from these collaborations so that its progress on adaptation efforts clearly reflects the best available knowledge and science.[24] The Corps has partnered with the National Oceanic and Atmospheric Association (NOAA) and the U.S. Geological Survey (USGS) to screen existing coastal projects for climate change vulnerability. From this joint examination process, it was determined that about a third of the 1400 assessed projects will potentially be impacted by sea level changes.[3] From this knowledge, the Corps set out to create a Sea Level Calculator tool to help them assess what changes may come about and what measures are required to adapt to them.[25]

The Corps has also reciprocated and helped guide other land and water resource agencies through disseminating science-based adaptation strategies. The Corps is one of the primary key stakeholders in the Federal Interagency Climate Change and Water Working Group (CCAWWG) since its inception in 2008, and through its involvement has provided vertical datum and hydrology guidance to their partner agencies based on their own knowledge from hurricane recovery efforts.[24] The Corps has also been instrumental in creating useful models and decision-making tools to promote resiliency efforts at the federal, state, and local levels. For example, the Sea Level Rise Tool created by the Corps is also being currently used in New York and New Jersey for post-Hurricane Sandy relief efforts.[25]

Multi-Level Governance

The Dutch have a history of consensus government, and through that process have been able work at multiple governmental levels. From its central Water Authority to its multiple municipal Water Boards, management of the Dutch national flood protection systems can happen at many levels and has been ultimately successful in maintaining high standards. The U.S. Army Corps, on the other hand, despite strong federal interagency collaborations, has limited resources

to make decisions at state and district levels[6] where the actual approved projects are being carried out. The legal system in the United States also does not favor a multi-level governance structure for the operation of civil works projects. Very few state laws can influence or affect Corps operations because federal laws in the United States take precedence over state laws.[10] Nevertheless, the US Army Corps can take a note from the Dutch's robust multi-level governance structure of states setting the safety standards for primary flood defenses; regional water boards responsible for dike maintenance; provinces directing spatial planning; and municipalities, police, fire fighters and health authorizes being responsible for contingency planning and crisis management.[26] This structure has served the Dutch well in ensuring effective communication between stakeholder groups, streamlining decision making, and following through with long-term adaptive measures. Despite the current legal restrictions, the U.S. Army Corps can still learn from the Dutch's governance system so as to achieve their own similar goals for floodplain risk management.

Next Steps for Flood Risk Adaptation in the Netherlands

The low-lying country of the Netherlands has become an international leader in flood risk management because it has no choice—more than 60% of its very densely populated land mass is vulnerable to flooding.[13] For more than a thousand years, the Dutch have used a system of dykes to fight back water from inhabited regions and seven centuries have passed since the first pumping systems have been put into place.[8] As sea levels continue to rise and yearly storms intensify over time, the Netherlands must continue to maintain a level of flood safety for the protection of its people.

The main way the Dutch introduced planned adaptation into their flood management portfolio was through a system of knowledge gathering (which also included influence from Al

Gore's *Inconvenient Truth*) lead by water authorities within the Dutch government that was tasked to understand the implications of climate change and societal growth to its flood protection systems.[20] Without planned adaptation, the safety of the Dutch water defense systems would likely become inadequate over time and could cause unforeseen devastation from future flooding and natural disasters, similar to that seen after Hurricane Katrina. With the introduction of the Delta Programme in 2010 and a stable €1 billion per year Delta Fund from 2013,[26] the Dutch have created a strong foundation to continue improving its flood protection systems in the wake of natural and societal factors that make resiliency more challenging.

Half of the Netherlands lies within 1 meter above of sea level, with an eighth lying below sea level.[12] Scientific estimates show sea levels to rise at increasing rates over time, which will drastically affect the Netherlands' geography and habitability. The current Dutch storm surge barriers and much of the country's 3,700 km of dykes, dunes, and dams are not resilient enough in the face of future sea level rise.[11] Particularly the most vulnerable areas, including the Rhine River, the River Maaas, and the Ijsselmeer region are likely to receive the greatest amount of flooding[14], and due to the high economic development in those regions, their protection is vital to the country. Thus, flood risk standards have shifted focus to minimizing societal disruption. Policies have subsequently been tailored to flexibly adapt to keep up with the pace of these changes. These risk-based safety standards and policies will ultimately be translated into stricter hydraulic requirements for the 2017 re-assessment cycle.[27]

The Dutch have shown leadership in its effective approaches towards integrated flood risk management over the years. They have created a legitimate framework of water resource governance; secured funding for decades ahead; explored future scenarios, thus creating a set of adaptive measures; and elegantly implemented these measures into their civil works projects.

Although there is still a lot of work ahead to continually adapt to climate risks and economic growth, the Dutch have a solid foundation yet a flexible approach to manage their systems effectively as new risks and uncertainties manifest over time.[20]

Next Steps for Adaptation for the Army Corps in New Orleans

Before the U.S. Army Corps of Engineers' first Climate Change Adaptation Report in 2011, the agency had a myopic view on how it would adapt its water management practices over time. The Corps had been relying on pre-existing models and analysis of storm strength and damage predictions and base off their infrastructure on them, without factoring in for climate and societal factors that could influence these predictions.[16] Because of this short-term focus, much of the agency's responses to consequences of climate change and other flood risk factors have been reactionary, with much of its operation modifications and decision making afterwards being forced by congressional actions and court decisions.[1] Before 2011 and even (to a degree) today, the Corps leadership has been operating under externally driven influences and political pressure[3] without garnering the motivation within the organization to incorporate changes in its civil works projects and operating procedures. The Corps' historically entrenched interests and inertia to change ultimately led to the failure of the levee system in New Orleans during Hurricane Katrina.[4] From that point on, however, after a reactionary phase of immediate rebuilding, the Corps has taken a closer look at its standard operating procedures and construction protocol to plan for and permanently improve its safety standards and resiliency for both the short and long term.[10]

As highlighted above in previous sections, the USACE has incorporated planned adaptation into its policy toolbox since 2011, with a documented emphasis since 2014, and have partnered with the Dutch since Katrina to implement long-term risk management strategies into

their civil works planning. This year, in 2015, the Corps has released an updated Adaptation Report, working off of the progress made in 2014, to emphasize next steps for the Corps and celebrate its successes. In this new Adaptation Report, the Corps adopts the an adaptive approach to resiliency as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."[25] It strongly emphasizes the need to plan for and adapt to adverse events like super storms and changing conditions like sea level rise, with similar protocol and adaptation efforts as the Netherlands.

As can be seen through its Dutch partnership, the Army Corps has also leveraged knowledge gained through external collaborations in order to conduct pilot tests on new adaptation measures.[23] These tests have helped the Corps assess efficacy and gather further knowledge to create more detailed assessments on climate change impacts on their infrastructure projects. For example, since 2009, the Corps has conducted several pilots to test methods for balancing river sedimentation.[24] A national assessment is currently underway to identify civil works projects that are at risk of increased sedimentation and how that relates to the hydrology in those regions.[25] This will ultimately drive decision making on how to handle sedimentation for Corps flood projects in the future. Yet, other factors might need to be assessed in parallel to gain a broader understanding of underlying consequences of sedimentation, so that actions taken are not in isolation.

The USACE has made significant efforts in adopting planned adaptation into its policymaking and taking the lead in creating interagency and international partnerships for effective knowledge transfer, to guide decision making on its flood risk management solutions. Yet the Corps still in the planning stages, and still has concrete decision-making to be made in the near future. Yet, despite the uncertainty that climate change and other risk factors may bear

on these complex decisions, the Corps has learned from Hurricane Katrina and hast he potential to create a resilient flood protection system based on adaptive planning and consistent project monitoring. The agency has the resources to thrive under uncertainty, with an experienced staff of water resource engineers, managers, and military persona, many of whom were instrumental in carrying out relief and rebuilding efforts after Hurricane Katrina. The Corps is also now well aware of the costs of short term action[23] and are therefore poised to take on the future challenges of ruggedizing their civil works projects, engaging all stakeholder groups, and taking on any and all anticipated flood risks for years to come.

Conclusion

Hurricane Katrina was not only a tragic disaster that highlighted the levee and infrastructure problems of New Orleans. The catastrophe also catalyzed the reassessment of flood protection systems all over the world, particularly by the internationally regarded leaders of flood management—the Netherlands. From initial focus on basic flood control to a new mindset on adaptive planning for future flood risks, both the Dutch Water Boards and the U.S. Army Corps of Engineers have become proactive with their approaches to new projects and establishing systems to protect their communities. Through forward-looking modifications in engagement, governance structures, legal actions, and new policies, these governmental agencies are preparing themselves to consider and adapt for all impending risks to their flood protection infrastructure. Time will tell whether these new systems are actually followed through and whether they will lead to protection against future flooding disasters. Nevertheless, Hurricane Katrina has taught an important lesson—without planning for future flood-related risks, the safety and resilience of communities that depend on these systems will be in jeopardy.

References

[1]Adaptation Policy and Plan. US Army Corps of Engineers. (2015, November 12). Retrieved from http://www.corpsclimate.us/adaptationpolicy.cfm

[2]Bourget, P. (2005). Hurricane Katrina: Dimensions of a Major Disaster. *Environmental Hazards Management, Vol. 334.* Retrieved from http://www.gwu.edu/~icdrm/publications/PDF/EMSE334_Katrina.pdf

[3]Flatt, V., & Tarr, J. (2011). Adaptation, Legal Resiliency, and the U.S. Army Corps of Engineers: Managing Water Supply in a Climate-Altered World. *North Carolina Law Review.* Retrieved from http://www.nclawreview.org/documents/89/5/flatt.pdf

[4]Grunwald, M. (2007, August 2). Katrina Anniversary: The Threatening Storm. TIME Magazine. Retrieved from http://content.time.com/time/specials/2007/article/0,28804,1646611_1646683_1648904-2,00.html

[5]Hebert, J. (2015, August 25). The resilience strategy: What threats will New Orleans be facing in 50 years' time? *The Guardian.* Retrieved from http://www.theguardian.com/cities/2015/aug/25/katrina-new-orleans-resilience-strategy-jeff-hebert-flooding-climate-change-sea-level-rise

[6]Higgins, A. (2012, November 14). Lessons for U.S. From a Flood-Prone Land. *The New York Times.* Retrieved from http://www.nytimes.com/2012/11/15/world/europe/netherlands-sets-model-of-flood-prevention.html?_r=0

[7]History.com Staff. (2009). Hurricane Katrina: 10 Years Later. Retrieved from http://www.history.com/topics/hurricane-katrina

[8]Jan Oosthoek, K. (2006, January 21). Dutch river defences in historical perspective. Retrieved from https://www.eh-resources.org/dutch-river-defences-in-historical-perspective/

[9]Kates, R., Colten, C., Laska, S., & Leatherman, S. (2006). Reconstruction of New Orleans after Hurricane Katrina: A research perspective. *The National Academy of Sciences of the USA, Vol. 103* (No. 40), 14653-14660. doi:10.1073/pnas.0605726103

[10]Kysar, D., & McGarity, T. (2006). Did NEPA Drown New Orleans? The Levees, the Blame Game, and the Hazards OF Hindsight. *Duke Law Journal, Vol. 56:179*, P.179-235. Retrieved from http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1297&context=dlj

[11]McKinney, V. (2007, May 1). Sea Level Rise and the Future of the Netherlands. Retrieved from http://www1.american.edu/ted/ice/dutch-sea.htm

[12]McQuaid, J. (2007, August 28). What the Dutch Can Teach Us About Weathering the Next Katrina. Retrieved from http://www.motherjones.com/environment/2007/08/what-dutch-can-teach-us-about-weathering-next-katrina

[13]McVeigh, T. (2014, February 2). The Dutch solution to floods: Live with water, don't fight it. Retrieved from http://www.theguardian.com/environment/2014/feb/16/flooding-netherlands

[14]Panel of Federal Experts Discuss Impacts of Sea Level Rise & Coastal Erosion. Silver Jackets. Retrieved from http://silverjackets.nfrmp.us/Get-Involved/More-Information/Silver-Jackets-Newsletter/The-Buzz-Spring-2015/Federal-Experts-Discuss-Impacts

[15]Peterson, A., & Bloemen, P. Planned Adaptation in Design and Testing of Critical Infrastructure: The Case of Flood Safety in The Netherlands. *International Symposium for Next Generation Infrastructure Conference Proceedings.* Retrieved November 26, 2015, from http://discovery.ucl.ac.uk/1469402/

[16]Robertson, C., & Schwartz, J. (2015, May 23). The New York Times. Decade After Katrina, Pointing Finger More Firmly at Army Corps. Retrieved from http://www.nytimes.com/2015/05/24/us/decade-after-katrina-pointing-finger-more-firmly-at-army-corps.html?_r=5

[17]Serbu, J. (2014, November 13). Army Corps of Engineers embraces uncertainty in planning for climate change. Federal News Radio. Retrieved from http://federalnewsradio.com/defense/2014/11/army-corps-of-engineers-embraces-uncertainty-in-planning-for-climate-change/

[18]Stoltz, M. (2015, August 24). Flood damage after Katrina could have been prevented, S&T expert says. Retrieved from http://news.mst.edu/2015/08/flood-damage-after-katrina-could-have-been-prevented-st-expert-says/

[19]Sullivan, P. (2006, October 9). Gilbert F. White; Altered Flood-Plain Management. The Washington Post. Retrieved from http://www.washingtonpost.com/wp-dyn/content/article/2006/10/08/AR2006100801035.html

[20]Ten Brinke, W., Kolen, B., Dollee, A., Van Waveren, H., & Wouters, K. (2010). Contingency Planning for Large-Scale Floods in the Netherlands. *Journal of Contingencies and Crisis Management, Volume 18* (Issue 1), P.55-69. doi:10.1111/j.1468-5973.2009.00594.x

[21]The Dutch Flood Disaster of 1953. (2002). Retrieved from http://www.holland-at-home.com/en/the-dutch-flood-disaster-of-1953

[22]Thomas, E., & Turner, T. (2010). Climate Change and Emergency Management: Adaptation Planning. *American Bar Association*. Retrieved from http://www.americanbar.org/content/dam/aba/publications/state_and_local_law_news/sl_34_3_thomas_turner.authcheckdam.pdf

[23]USACE Climate Change Adaptation Plan and Report 2011. (Department of the Army, Corps of Engineers, Civil Works Strategic Plan 2011-2015) as approved by the Executive Office of the President's Council on Environmental Quality (3 Jun 2011). Retrieved from http://www.corpsclimate.us/docs/usace_climate_change_adaptation_report_03_june_2011.pdf

[24]USACE June 2014 Climate Change Adaptation Plan. As presented by the USACE Climate Preparedness and Resilience Steering Committee (June 2014). Retrieved from http://www.usace.army.mil/Portals/2/docs/Sustainability/Performance_Plans/2014_USACE_Climate_Change_Adaptation_Plan.pdf

[25]USACE June 2015 Climate Change Adaptation Plan. As updated by the USACE Climate Preparedness and Resilience Steering Committee (June 2015). Retrieved from http://www.corpsclimate.us/docs/USACE_Adaptation_Plan_12-NOV-2015_hires.pdf

[26]Van Haegen, M., & Wieriks, K. The Delta Plan revisited: Changing perspectives in the Netherlands' flood risk reduction philosophy. *Water Policy. 2015 Supplement,* Vol. *17*, p41-57. doi:10.2166/wp.2015.003

[27]Yeo, S. (2014, July 3). Netherlands to upgrade flood defences to cope with climate change. Retrieved from http://www.climatechangenews.com/2014/03/04/netherlands-to-upgrade-flood-defences-to-cope-with-climate-change/

[28]Zevenbergen, C. (2013). Taming global flood disasters. Lessons learned from Dutch experience. *Natural Hazards, Volume 65* (Issue 3), P.1217-1225.