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Institutional inertia and critical junctures in water management: A case study of New Orleans, LA

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Summary

Climate change is bringing with it a number of growing threats to vulnerable urban areas around the globe, and cities in coastal, deltaic areas are facing both acute and chronic impacts. With global migration trends seeing people moving towards these densely populated coastal zones, those impacts are threatening a growing number of people and properties. This trend appears in the United States, with the Gulf Coast region in particular representing the fastest growing region in the country from 2000 to 2017 according to the U.S. Census Bureau. Location on coastlines vulnerable to sea-level rise, combined with growing frequency and intensity of tropical storm events, more intense seasonal storms, and more frequent high-river events, leaves these urban areas increasingly vulnerable to climate change-related damages. Combined, these represent major threats to current water management systems and practices in cities.

New Orleans, Louisiana, in the United States Gulf Coast region was chosen as a case study for this research due to its history of catastrophic flooding events, vulnerability to climate change, extensive subsidence, predominant social inequities, and its heavy reliance on hard infrastructure solutions to water management.

This paper seeks to uncover the most important factors causing institutional inertia in the water management sector, a socio-institutional phenomenon that is backed by academic research. Additionally, this paper seeks to illuminate the phenomenon of critical junctures in the period of study for New Orleans (1893-present) to understand their causes, results, and path-dependent legacies. Incremental changes to systems, structures, and institutions are increasingly attributed to institutional inertia in the water management sector; critical junctures are brief moments in time that are capable of breaking inertia, providing opportunities for institutional change.

Desk research of both primary and secondary sources, as well as semi-structured interviews, were conducted for data collection and analysis. The main findings of the case study research were that all contributing factors identified through a thorough a literature review (costs, uncertainty, path dependence, power/legitimacy, and complexity) did in fact promote institutional inertia in the New Orleans water management sector. Further, a process tracing historical analysis of the period of interest illuminated critical junctures that largely have failed to break the flood resistance paradigm that has dominated New Orleans water management since the system's inception.

Keywords

Institutional inertia, critical juncture, water management, flood control, New Orleans

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LONG LIVE NOLA!

Foreword

This thesis was written in the pursuit of completing the Master of Science in Urban Management and Development at the Institute for Housing and Urban Development Studies at Erasmus University Rotterdam. Within this program, I completed the specialty of Urban Environment, Sustainability, and Climate Change, in which this thesis topic fits well. As a lifelong resident of New Orleans, LA, as well as a student of civil engineering, public administration, and now urban management and development, this topic of research is relevant and suited to my background.

Abbreviations

IHS	Institute for Housing and Urban Development Studies
IV / DV	Independent variable / Dependent variable
R1, R2, …, R10	Respondent 1, Respondent 2, etc.
MR&T	Mississippi River and Tributaries Project
LPVHPP	Lake Pontchartrain and Vicinity Hurricane Protection Project
USACE	United States Army Corps of Engineers
SPH	Standard Project Hurricane
SWBNO	Sewerage and Water Board of New Orleans
DPW	Department of Public Works
NFIP	National Flood Insurance Program
FIRM	Flood Insurance Rating Map
FEMA	Federal Emergency Management Agency
HSDRRS	Greater New Orleans Hurricane and Storm Damage Risk Reduction System
SELA	Southeast Louisiana Urban Flood Damage and Reduction Project

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1.0 Introduction

1.1 Background information and problem statement

Climate change poses an increasing threat to urban areas across the globe, and cities in coastal, deltaic areas are facing both acute and chronic impacts. Coastal zones have historically been attractive places for settlement and urban expansion due to their abundance of available resources, their logistical importance for trade and defense, as well as their socio-cultural significance (Neumann, Vafeidis, Zimmermann, & Nicholls, 2015). Global migration trends see people moving to coastal zones, where population density is higher than that found inland. Further, a majority of the world's megacities are found in coastal areas, especially in delta regions (for the aforementioned reasons), leaving those developed areas vulnerable to sea-level rise and other climate change threats (Neumann, et al., 2015).

According to the United States Census Bureau (as cited in Cohen, 2019), in 2017 approximately 94.7 million people (29.1%) of the U.S. population lived in counties along the coast. Of all the coastline regions, the Gulf Coast (along the Gulf of Mexico) was the fastest growing between the years 2000 and 2017, with 15.8 million residents in 2017 (up more than 3 million, or 26.1%, since 2000) (U.S. Census Bureau 2017 Population Estimates, as cited in Cohen, 2019). Location on coastlines vulnerable to sea-level rise, combined with growing frequency and intensity of tropical storm events, more intense seasonal storms, and more frequent high-river events, leaves these urban areas increasingly vulnerable to climate change-related damages. Combined, these represent major threats to current water management systems and practices in cities.

There is a mounting awareness (backed by empirical research) that there is an imbalance between climate change projections and institutional response, especially at the local government level (Lorenz et al., 2017, as cited in Munck af Rosenschöld & Rozema, 2019). Further, there is a growing understanding in the academic sphere that this discrepancy (lack of sustainable innovation, built-in adaptive capacity, resilience to flooding) is linked to socio-institutional aspects of water management systems rather than a lack in technological advancement (Taylor, 2014; Brown & Farrelly, 2009).

Slow changes to water management systems, structures, and institutions are increasingly attributed to the phenomena of "institutional inertia," what Munck af Rosenschöld, Rozema, and Frye-Levine (2014) define as the "stickiness" of institutions, or "how they resist change" (p. 640). They argue that stickiness can be seen as a "defining trait of institutions, as they embody stability and predictability to a considerable extent" (Munck af Rosenschöld et al., 2014, p. 640). Brown and Farrelly (2009) echo this argument in the context of water management, suggesting that water system "capacity deficits are pervasive and cannot be easily addressed through simple project, programme or champion interventions" (p. 844). Understanding the factors that contribute to institutional inertia within the water management sector, thus, is the primary goal of this thesis paper.

New Orleans, Louisiana, in the United States was chosen as an especially pertinent case study for a number of reasons. Significant research and data support its vulnerability to climate change, subsidence, social inequities, and its heavy reliance on hard infrastructure solutions to water management (Section 4.1 for more details). With that in mind, tackling its history of institutional inertia and critical junctures could prove useful for experts both inside and outside of the city.

Within this paper, the most important variables contributing to institutional inertia in water management in the city of New Orleans, Louisiana, in the United States are identified. Further, through a thorough process tracing analysis beginning with the inception of the city's drainage system in 1893, critical junctures in the past (and potential for the future) will be identified as markers of lowered barriers to change (i.e., breaks in this institutional inertia) with the potential for transformational shifts in the current system (Munck af Rosenschöld & Rozema, 2019).

1.2 Relevance of research topic

A study of water management institutions as an impediment to reasoned adaptation is relevant according to the research of several authors. Munck af Rosenschöld & Rozema (2019, p. 6) argue that "formal institutions induce capacity or resource constraints;" Saleth and Dinar (2005) (as cited in Brown & Farrelly, 2009) contend that water management institutions are "subjective, path dependent, hierarchical and nested both structurally and spatially, and embedded within the cultural, social, economic and political context" (p. 840). Taylor (2014) and Brown and Farrelly (2009) both identify institutions as barriers to change, citing several different factors in that conclusion including: coordinating relevant actors, short-term vision, unclear responsibilities, little public or political salience, and lack of appropriate resources, to name a few. Institutional inertia, thus, is a variable that explicates "1) why fundamental organizational change is infrequent 2) why many organizations fail to change, 3) why fundamental change is not enough to overcome inertial effects and 4) why organizations will have problems with adapting and maintaining newly implemented constructs" (Aksom, 2021, p. 19).

Expanded on within this paper, the effects of institutional inertia can be overcome (at least for relatively short periods of time) through critical junctures. Capoccia and Kelemen (2007) define critical junctures as "relatively short periods of time during which there is a substantially heightened probability that agents' choices will affect the outcome of interest" (p. 348). In this thesis, a process tracing method is utilized to identify critical juncture periods that have punctuated institutional inertia in the water management sector in New Orleans, Louisiana.

The selection of New Orleans as a case study was particularly relevant. In the context of climate change, Cigler (2007) cites high river conditions, high (and growing) rates and intensities of strong hurricanes, wetland degradation and subsidence, increasing intense seasonal storm events, and ground subsidence within the city as specific impacts New Orleans is facing. The last phenomenon, worsened by continuous pumping action and no institutional groundwater monitoring, is astounding: by 2005 when Hurricane Katrina passed over the city, 62 percent of New Orleans was below sea level – up to 10 feet below in some areas – when just a century earlier, there were only little portions of the city below sea level (Horowitz, 2020; Cigler, 2007). There is social, cultural, and economic interest to protect and preserve the city as it currently stands; however, current institutional, structural, and political arrangements are not resilient enough nor are they sufficient for the increasing impacts climate change is manifesting. Therefore, this paper will address a gap in academic research concerning institutional inertia in water management in New Orleans. Further, with data collected through desk research and semi-structured interviews of key informants, a discussion on critical junctures in the city is included.

1.3 Research objectives

Due to the recognized research gap of socio-institutional factors causing institutional inertia in the realm of water management institutions (Brown and Farrelly, 2009; Taylor 2014), this paper seeks to utilize a particularly suitable case study in New Orleans, Louisiana, to contribute to this academic field. By operationalizing key variables including institutional inertia, costs, uncertainty, path dependence, power and legitimacy, complexity, and critical junctures, key factors contributing to institutional "stickiness" will be identified via secondary data and expert interviews (Munck af Rosenschöld, Rozema, and Frye-Levine, 2014; Munck af Rosenschöld & Rozema, 2019).

To complete this, a historical analysis via careful process tracing of the history of water management and governance in New Orleans (from the establishment of the drainage system until present) will inform the identification and prioritization of factors contributing to institutional inertia in this arena. The paper will also include details on past critical junctures in New Orleans that may form a pattern of causes, results, and prevailing water management paradigms, important to planning for the next opportunity. These tasks will be achieved through application of theory and operationalization of variables along with input from key expert interviews.

The ultimate purpose of this paper is to uncover the most important and pressing factors contributing to institutional inertia as it pertains to water management in New Orleans. Additionally, insight into critical juncture periods capable of moving the city towards sustainable transformation increases its relevance and applicability for the city in the future. Much research thus far has been concentrated on technological innovation to combat the effects of climate change, but there are relatively little concerning socio-institutional contributions (Wong, 2006, as cited in Brown & Farrelly, 2009; Munck af Rosenschöld & Rozema, 2019). In this way, this paper will add to the academic literature concerning the role of institutions and governance in climate change (specifically water management) actions. Further, conclusions reached through data analysis may be transferrable to other coastal, deltaic urban areas around the globe (but especially in applications within the U.S.) facing similar threats as New Orleans.

1.4 Research questions and sub-questions

Main Questions:

- What factors have contributed most to institutional inertia regarding water management in New Orleans, Louisiana?
- Why have critical junctures in that period failed to break institutional inertia?

Sub-questions:

- o What have institutions, actors, and management systems looked like from 1893 until present?
- o What periods of time can be classified as critical junctures (1893-present) and what were the results of those periods?
- o How do the identified factors interact with one another?

2.0 Literature review

Chapter 2 includes state of the art theories, as well as a literature-informed conceptual model, that are detailed for variables and concepts of interest. Institutional inertia is the dependent variable (DV) of interest, with five contributing independent variables contributing to inertia (costs, uncertainty, path dependence, power and legitimacy, and complexity, following. Lastly, the concept of the critical juncture is explored as an independent variable capable of disturbing the prevailing institutional inertia. Definitions from published academic literature, as well as their associations to climate change and the water management sector, are presented.

2.1 State of the art theories / concepts of the study

2.1.1 Institutional inertia

To begin the discussion on institutional inertia, first institutions themselves must be defined and discussed in the urban context. North (1990) defines institutions famously as societal "rules of the game," or rather constructed limits that "shape human interaction" and exchange incentives politically, socially, and economically (p. 3). Mahoney and Thelen (2010) argue that institutions are "relatively enduring features of political and social life (rules, norms, procedures) that structure behavior and that cannot be changed easily or instantaneously" (p.4, as cited in Munck af Rosenschöld & Rozema, 2019, p. 3). Not to be confused with organizations and actors, institutions are established and codified (formally and informally) as a means of stability, reducing uncertainty for societal agents that work within the recognized institutional framework (North, 1990). This stability, an axiomatic quality of institutions, gives rise to the phenomenon of institutional inertia that is the dependent variable in this paper.

Aksom (2021) defines the phenomenon of institutional inertia as one that "1) resists, 2) obstructs and 3) forces organizations towards a reversal back to old routines even after a change is accomplished" (p. 16). Munck af Rosenschöld, Rozema, and Frye-Levine (2014) similarly refer to institutional inertia as the 'stickiness' of institutions, or their resistance to change (p. 640). Pierson (2000) both echoes and expands on this definition, arguing that inertia is a result of an established increasing returns process (to be discussed later) that reaches a single equilibrium point, which again, is resistant to change.

Institutional inertia is present in the climate change adaptation, as well as the urban water, sectors. Formal institutions in this context are "the rule systems that guide policy action in addressing adverse effects of climate change" (Munck af Rosenschöld & Rozema, 2019, p. 5). Institutions generate (or limit) resource availability and capacity-building to address climate change impacts (Munck af Rosenschöld & Rozema, 2019). More specific to the topic in the paper, institutional inertia is recognized as an effective barrier to change in the urban water sector, though there is little research and understanding on how to overcome these barriers (Brown and Farrelly, 2009). Brown and Farrelly (2009) state this is the case because:

> *"these types of capacity deficits are pervasive and cannot be easily addressed through simple project, programme or champion interventions. Rather these barriers can only be addressed through programmes of change targeted at the systemic and embedded cultures, structures and relationships of current institutions of urban water management (Brown and Farrelly, 2009, p. 844).*

Therefore, a focus on institutional inertia within the water management sector is both relevant and necessary. Specifically, identifying the factors that contribute to inertial forces (socio-institutional, rather than technocratic) is a crucial first step towards later identifying solutions. The former is the purpose of this research.

Munck af Rosenschöld et al. (2014) identified five factors that they argued contributed to institutional inertia: costs, uncertainty, path dependence, power, and legitimacy. Taylor (2014) compiled six "governance barriers," similar to inertial forces, from extensive literature review including:

- *"securing political commitment for climate adaptation;"*
- *"operating within an organizational culture that stifles innovation, collaboration and learning;"*
- *"competing short-term priorities and interests;"*
- *"coordinating and allocating responsibilities between local, regional and national levels of government;"*
- *"coordinating and collaborating between government, private and civil society actors;" and*
- *"reorienting existing funding and resources or accessing new financial flows for climate change adaptation" (Berkhout, 2012; Biesbroek et al., 2014; Burch, 2010; Clar et al., 2013; Ekstrom and Moser, 2013; Funfgeld, 2010; Granberg and Elander, 2007; Measham et al., 2011; Pasquini and Shearing, 2014; Roberts, 2008; Runhaar et al., 2012; Satterthwaite, 2011; Storbjork, 2010; Uittenbroek et al., 2013, 2014; Winsvold et al., 2009; as cited in Taylor, 2014, p. 195-196).*

Brown and Farrelly (2009), following their hypothesis that socio-institutional factors are preventing strategic and synchronized adaptation in urban water management, identify twelve barriers (p. 842):

- *"Uncoordinated institutional framework;*
- *Limited community engagement, empowerment & participation;*
- *Limits of regulatory framework;*
- *Insufficient resources (capital and human);*
- *Unclear, fragmented roles & responsibilities;*
- *Poor organisational commitment;*
- *Lack of information, knowledge and understanding in applying integrated, adaptive forms of management;*
- *Poor communication;*
- *No long-term vision, strategy;*
- *Technocratic path dependencies;*
- *Little or no monitoring and evaluation, and*
- *Lack of political & public will."*

Boston and Lempp (2011) isolate four "asymmetries" that have contributed to little or no action on climate change: "the voting asymmetry, the cost-benefit asymmetry, the interest group asymmetry and the accounting asymmetry" (p. 1002). In order these refer to (1) an imbalance in political accountability to the voting population and a short-term focus; (2) the steep costs of climate change adaptation in the present to benefit future generations; (3) an imbalance of power and influence in politics at the expense of much of the public; and (4) a lack of representation of natural capital and ecosystem services in the current economy (Boston and Lempp, 2011). Salet, Bertolini, and Giezen (2013) point towards path dependencies, uncertainty, complexity, and the inherent political and financial risks in adapting to climate change at current to prepare for the future as factors contributing to a slow change of pace. Van Buuren, Ellen, and Warner (2016) expand on the path dependent variable, arguing there are "technical, cultural, financial, and institutional" elements to path dependency that must be considered in water management (p. 1).

To distil the arguments by these researchers, it can be stated that institutional inertia in many respects hinders change or only allows incremental change over time (North 1990; Boston and Lempp, 2011; Tayor, 2014; Brown & Farrelly, 2009; Munck af Rosenschöld et al., 2014; Munck af Rosenschöld & Rozema, 2019; Salet, Bertolini, and Giezen, 2013; Van Buuren, Ellen, and Warner, 2016; Aksom, 2021). In the pursuit of concise yet informed variables for analysis within this paper, five factors have been identified contributors to institutional inertia: costs, uncertainty, path dependence, power/legitimacy, and complexity. Each will be expanded upon in the following sections.

Following those, literature concerning the concept of critical junctures will be discussed. This concept is regarded as essential to the institutional inertia discussion within this research as points of opportunity, defined as "the trigger events that set processes of institutional or policy change, in motion" (Hogan & Doyle, 2007, p. 885). Again, this concept will be discussed further in detail in Section 2.1.7.

2.1.2 Costs

The first factor contributing to institutional inertia to be discussed in this paper is costs. There are two cost categories that are relevant to this variable in the water management sector: costs associated with climate adaptation and defense actions, as well as transaction costs.

Costs associated with adapting to climate change are contributors to institutional inertia in a number of ways. Boston and Lempp (2011), as mentioned previously, point to a cost-benefit asymmetry: "the costs and the benefits of policies to mitigate climate change are significantly different with respect to the crucial dimensions of time, certainty, visibility, and tangibility" (p. 1005). To implement plans and projects – not to mention research, data collection, monitoring and evaluation, and maintenance – demands immediate investments that must be paid for by the current generation for the benefit of subsequent ones (Boston and Lempp, 2011). Munck af Rosenschöld and Rozema (2019) reason that the significant costs associated with present adaptation limit "change processes" and act as barriers to "transformational responses to climate change," especially at the level of local government due to competing priorities that may or may not take precedent (p. 10). There remains a clear correlation between availability of funding at the local level and propensity to act on climate change mitigation and adaptation (Munck af Rosenschöld & Rozema, 2019).

There are other costs contributing to inertial forces beyond investment in the construction of projects themselves. Political costs, though intangible, are strong limiting forces. To invest heavily in climate adaptation at present, utilizing tax monies or other public funds, without clear and immediate payoff is not politically salient and thus is disincentivizing (Boston and Lempp, 2011; Munck af Rosenschöld & Rozema, 2019; Taylor, 2014). Additionally, should adaptation or mitigation projects require the construction of new institutions themselves, these "often entail high fixed or start-up costs, and they involve considerable learning effects, coordination effects, and adaptive expectations" (Pierson, 2000, p. 255). Therefore, there are incentives to work within current administrative environments, regulations, and rules, which may or may not be conducive to innovative planning for the future (Van Buuren, Ellen, and Warner, 2016).

To conclude discussion on the variable of costs, transaction costs are also frequently mentioned in literature (Munck af Rosenschöld et al., 2014; Pierson, 2000; Van Buuren, Ellen, and Warner, 2016). Within the current operating environment of existing institutions, coordinating systematic and strategic interventions for climate change is regularly wrought with inefficiencies (Munck af Rosenschöld et al., 2014). Betsill (2001) maintains that "the capacity for local governments to take action against climate change is restricted by the high costs of coordinating the work between local departments as well as general budgetary constraints" (as cited in Munck af Rosenschöld et al., 2014, p. 641). Put in another way, "Transaction costs… are a direct result of inefficiencies in communication and negotiation required to change the status quo of coordination action toward resolving a complex problem" (Brennan, 2009; Neyapti, 2013; as cited in Munck af Rosenschöld et al., 2014, pp. 642). Pierson (2000) asserts that dependence on complex political and administrative procedures "undermines transparency," thus increasing transaction costs (p. 260). Not only does this hinder system improvements, but it also prolongs sub-optimal service provision and prevents timely and necessary fixes to the system (Pierson, 2000).

2.1.3 Uncertainty

Uncertainty is the second variable promoting institutional inertia to be discussed. Uncertainty includes unknowns regarding exact climate change impacts into the future, as well as regarding institutional/actor responsibility for associated climate adaptation actions. Contributing to the unwillingness to invest in large-scale transformative adaptive measures, uncertainty regarding climate impacts to any given locale continues to delay action due to the significant political and financial risks associated with making the wrong investments (Salet, Bertolini, and Giezen, 2013). Munck af Rosenschöld et al. (2014) deem this "regret potential," as investments may prove to be unnecessary should climate impacts not manifest themselves as currently predicted (p. 642). Uncertainty in projections, thus, is a major basis of inertial forces for institutions. This uncertainty can certainly have political ramifications, as well, pitting urgent scientific projections against political salience (Taylor, 2014; Munck af Rosenschöld et al., 2014; Munck af Rosenschöld & Rozema, 2019). It is important to note that while there remains substantial uncertainty regarding climate impact projections especially to local areas, uncertainty in adaptation project efficacy also persists (Boston and Lempp, 2011). In this way, the politics of requiring substantial investment in measures with unproven viability are difficult to navigate (Boston and Lempp, 2011).

Uncertainty in language, communication, roles, and responsibilities as it pertains to climate adaptation efforts causes institutional inertia, as well (Munck af Rosenschöld et al., 2014; Taylor, 2014; Brown and Farrelly, 2009; Munck af Rosenschöld & Rozema, 2019). Munck af Rosenschöld et al. (2014) argue that a "lack of clear definitions, or a common language, that help make sense of the problem at hand constitutes a significant obstacle to achieving institutional change" (p. 642). Brown and Farrelly (2009) echo this argument, citing poor communication, uncoordinated institutional frameworks, poor organizational commitment, and unclear roles and responsibilities all as socio-institutional barrier types (p. 842). Ziervogel and Parnell (2012, as cited in Taylor, 2014) identify ambiguity in assigned roles and responsibilities as barriers to climate adaptation. As a result, siloed approaches between levels of government and intra-governmentally at the local level "undermines coordination and collaboration and thereby the efficacy with which holistic and robust responses to addressing climate risks and vulnerabilities can be implemented" (Ziervogel and Parnell, 2012, as cited in Taylor, 2014, p. 205).

2.1.4 Path dependence

Path dependence cannot be separated from the phenomenon of institutional inertia. Especially in a water management context, path dependency has shaped the pervasive trends globally in how urban governments deal with the threats of too much or too little water (Brown and Farrelly, 2009; Van Buuren et al., 2016; Hanger-Kopp, Thaler, Seebauer, Schinko, & Clar, 2022). First, a discussion on authors' varying definitions on path dependency will be provided as a foundation for its prominence in inertial forces. Following that, its prominence in water management will be included, as well.

Pierson (2000) is the predominant author concerning path dependence and its impact on institutions. He argues that there are a few essential assertions concerning path dependence: "Specific patterns of timing and sequence matter; starting from similar conditions, a wide range of social outcomes may be possible; large consequences may result from relatively 'small' or contingent events; particular courses of action, once introduced, can be virtually impossible to reverse; and consequently, political development is often punctuated by critical moments or junctures that shape the basic contours of social life" (Collier and Collier 1991; Ikenberry 1994; Krasner 1989; as cited in Pierson, 2000, p. 251). The notion of "increasing returns" has been utilized in several other authors' discussions on path dependence, in the sense that once a decision is made (though its temporal context is crucial) it triggers "self-reinforcing or positive feedback processes" (Pierson, 2000, p. 251). Pierson (2000) argues that specifically in the realm of politics, increasing returns processes are prominent given the stability institutions, power asymmetries, and the opacity of governance structures and rule-making. What path dependence processes cause is a process that, once a decision has been made regarding a track to follow and the more time passes, the costs of switching tracks are very high (many times prohibitively so).

Though Pierson (2000) is cited by many authors in his discussion of path dependence, others have added to its definition, as well. Arthur (1994) cites four characteristics of increasing returns (and thus path dependency): unpredictability, inflexibility, nonergodicity, and potential path inefficiency (as cited in Pierson, 2000). Bennett and Elman (2006) identify four elements of path dependence: (1) causal possibility (more than one alternative path to choose from with alternative outcomes); (2) contingency (random factors influence direction of events); (3) closure (some paths are less possible or impossible due to influence); and (4) degree of constraint (i.e., "actors are tied to the path that is chosen or would face high costs in moving off this path once it is established") (Bennett and Elman, 2006, p. 252).

In the climate change and water management context, path dependencies have dominated urban decision-making. Saleth and Dinar (2005) state that in a water management context, institutions are "subjective, path dependent, hierarchical and nested both structurally and spatially, and embedded within the cultural, social, economic and political context" (as cited in Brown and Farrelly, 2009, p. 840). Munck af Rosenschöld et al. (2014) speak about 'technological lock-in,' where certain decisions regarding responses to climate change impacts are so embedded in political and technical life that there is little or no support for change. Brown and Farrelly (2009) saw in their extensive review of urban water literature that technocratic path dependencies were prevalent, causing "urban water industry's conservatism and reliance on traditional, highly visible solutions rather than attempt new 'ways-of doing'" (p. 844). Van Buuren et al. (2016) point to the reliance on 'hard' engineering measures for flood protection as a path dependent phenomenon in the Dutch water management context, citing sunk costs in hard infrastructure, political actors' reliance on hard measures, and citizen trust in those hard measures rather than innovative, soft measures.

Hanger-Kopp et al. (2022) echo this reliance on structural measures from flood risk management as path dependency, arguing that these measures exhibit lock-in and sub-optimality which are characteristics intrinsic in path dependency.

2.1.5 Power and legitimacy

Power and legitimacy are discussed as distinct variables in literature, as is demonstrated in Munck af Rosenschöld et al. (2014) and Munck af Rosenschöld and Rozema (2019). However, through reviews of other sources (Boston and Lemmp, 2011; Taylor, 2014; Brown and Farrelly, 2009; Van Buuren, Ellen, and Warner, 2016), there is significant support for the notion that these variables indeed should be discussed together.

Power suggests that political and economic actors and institutions in positions of influence can stimulate or delay change (Munck af Rosenschöld et al., 2014). Many times, this manifests itself with those in power supporting incumbent actors and systems, while "insubordinate" groups with opposing or different ideas are suppressed (Munck af Rosenschöld et al., 2014). In congruence with the definition of power is legitimacy defined: "substantive and procedural fairness and to the extent to which decisions are acceptable to stakeholders and participants in policy processes" (Tennekes et al. 2013, p. 242, as cited in Munck af Rosenschöld & Rozema, 2019, p. 9). Though these researchers classify power and legitimacy as distinct, they, too, state in several instances how these variables are related:

- *"Depending on the interests of powerful actors, legitimacy can be used to both constrain and encourage institutional change" (Munck af Rosenschöld et al., 2014, p. 644)*
- *"The definition of what conduct should be considered legitimate or 'appropriate' is enacted by actors with sufficient resources to do so. Institutions that are in active exchange with the broader social system, entangled in larger power webs, provide them with legitimacy" (Munck af Rosenschöld et al., 2014, p. 644)*
- *"In other words, legitimization processes are dependent on existing power relationships. Furthermore, power and legitimacy link up to path dependence, as the historical choice for a particular path is legitimized by powerful actors" (Munck af Rosenschöld et al., 2014, p. 644)*

Boston and Lempp (2011) describe the connection between power and legitimacy in a different manner, using multi-lateral agreements in the pursuit of coordinated action against climate change to do so. In order to reach consensus on these agreements, there must exist "strong, active leadership by the major powers," yet in most cases actors and institutions are neither powerful nor considered legitimate enough to hold this responsibility (Boston and Lempp, 2011, p. 1001-1002). In turn, this promotes inertia in addressing climate change (Munck af Rosenschöld et al., 2014). Boston and Lempp (2011) also consider how power and legitimacy affect plan and project implementation and accountability, arguing selected projects are in fact backed by powerful lobbyist groups and special interests – many times at the expense of the public. Climate adaptation plans and strategies that lack this backing – i.e., require creative or widespread funding sources with more equitable benefits – find themselves subjected to inertial forces as their champions are not powerful enough and/or the plans are not seen as legitimate (Inderberg, 2011, as cited in Munck af Rosenschöld & Rozema, 2019)

In a water management context, power and legitimacy are very influential together contributing to institutional inertia. In their extensive literature review of urban water related literature to uncover socio-institutional barriers, Brown and Farrelly (2009) found that the second-most prevalent barrier was "limited community engagement, empowerment, and participation," citing that community members were not viewed as legitimate decision-makers; therefore, community participation – and by proxy community power – is limited (p. 843). In this same review, the third most prevalent barrier was the limits of existing regulatory frameworks which included "lack of authority/ power of operational organisations to implement SUWM alternatives, often resulting in organisations being more reactive rather than reinforcing a proactive operational culture" (Brown and Farrelly, 2009, p. 843).

In the study context of the Dutch delta, Van Burren et al. (2016) identify where power asymmetries exist and where legitimacy has stifled prominent innovation in some cases. Power asymmetries rely on "core players," limit institutional adjustment, and attempt to fit new policy ideas within existing, legitimized structures (Van Burren et al., 2016). Legitimacy in this context is exemplified in the heavy expert and public reliance on and trust in structural defense measures for flood protection (Van Burren et al., 2016). As innovative methods for water management surface, frequently they are fitted within hard infrastructure water management rather than a new policy paradigm on their own (Van Burren et al., 2016). The result: "the impact of this cautious learning process in terms of institutional change is still minor" (Van Burren et al., 2016, p. 8).

2.1.6 Complexity

Complexity is the final variable included in this paper contributing to institutional inertia. To define complexity is a difficult exercise, though there are two definitions in literature that are concise and relevant to its application in this context. Head (2008) defines complexity as interactions between "elements, subsystems and interdependencies" that are not contained within political boundaries, making decisions, responsibilities, and coordination difficult to achieve (p. 103). Zellner et al. (2008) expands on the facets of complexity, namely "interactions among social, financial, and cultural attributes, and information, energy, and material stocks and flows that operate on different temporal and spatial scales" (p. 474).

With these definitions in mind, it becomes apparent that complexity and inertial forces are closely linked. Within the realm of urban planning and climate adaptation, several authors point to this relationship. Pierson (2000) contends that because politics and the evaluation of public performance is so complex, self-correction is limited. Inertia stems from inability to pinpoint inefficiencies in the system, inhibiting appropriate adjustments in a timely manner (Pierson, 2000). Complexity in the policy and planning realm is rampant in environmental and urban water management. Briassoulis (2004, as cited in Brown and Farrelly, 2009) argues that this complexity is indeed attributed to this institutional setting it arises from; Mitchell (2005, as cited in Brown and Farrelly, 2009) concurs with this assessment in a water management application, calling for institutional change to make implementation activities more efficient. As for water management measures that are forward-looking, meaning accounting for climate change impacts, the complex nature of administrative and legal standards – not to mention the nature of the problem itself – frequently dissuades stakeholders from changing the current status quo (Van Buuren, Ellen, and Warner, 2016; Brown and Farrelly, 2009). Additionally, complex governance arrangements can cause "poor feedback of knowledge pertaining to the problem (local climate impacts) and the implementation of solutions (prioritized adaptation measures) from subordinate units to the central authority" (Winsvold et al., 2009, as cited in Taylor, 2014, p. 206).

Lessening complexity to decrease its inertial impact is, somewhat obviously, not an easy feat according to literature (Taylor, 2014; Salet, Bertolini, and Giezen, 2013; Van Buuren, Ellen, and Warner, 2016; Pierson, 2000). Taylor (2014) cites conflicting "technical and political processes of decision-making," the "multi-sectoral nature of urban climate adaptation," and the reliance on external expertise to advise local governments as areas to be investigated (p. 207). Legal adjustments to current standards and practices are complex points of contention for many actors, as well (Van Buuren, Ellen, and Warner, 2016). When implementing new standards, rather than creating new methods or pathways within governing institutions, authorities will attempt to integrate them into current standards as much as possible to avoid complex interactions and expensive maneuvers (Van Buuren, Ellen, and Warner, 2016). Sorensen (2018) argues that "complex, multi-level governance systems" contribute to institutional inertia "by introducing complexity in governance processes where significant degrees of consensus are encouraged or required, and veto-points proliferate" (p. 629)

Notably, transparency, equity, and accountability can be sacrificed within these complex institutional arrangements (Siders, 2019; Pierson, 2000; Brown and Farrelly, 2009). Complex systems and decision-making can act as effective barriers to efficient problem-solving and public participation in the planning and evaluation process (Pierson, 2000; Siders 2019; Brown and Farrelly, 2009). When a complex system malfunctions, issues determining root cause and parties responsible abound (Pierson, 2000). Siders (2019) contends that transparency "allows people affected by government decisions to know the facts and processes involved in making those decisions" (p. 244). Without proper and consistent oversight, those measures meant to protect the public and make urban areas more resilient and sustainable could very quickly become inequitable and outdated (Siders, 2019; Brown and Farrelly, 2009).

2.1.7 Critical Juncture

The final variable of interest in this paper is the critical juncture. Crucial to the discussion of institutional inertia, critical junctures are defined famously by Capoccia and Kelemen (2007) as:

> *"characterized by a situation in which the structural (that is, economic, cultural, ideological, organizational) influences on political action are significantly relaxed for a relatively short period, with two main consequences: the range of plausible choices open to powerful political actors expands substantially and the consequences of their decisions for the outcome of interest are potentially much more momentous. Contingency, in other words, becomes paramount" (Capoccia & Kelemen, 2007, p. 343).*

This definition supports the notion that critical junctures are periods of time in which institutional inertia can be disrupted, allowing changes to occur in the institutional setting. Changes are not, however, a requirement of critical junctures; rather, if alternatives were considered but ultimately rejected, a critical juncture may still have occurred (Capoccia & Kelemen, 2007). Capoccia and Kelemen (2007) qualify "relatively short periods of time" by stating that this period is short relative to the "path dependent process it instigates;" further, they argue that "the probability that agents' choices will affect the outcome of interest must be high relative to that probability before and after the juncture" (p. 348).

Moving beyond the work of Capoccia and Kelemen (2007), there are several authors that offer additional insights into the relationship between critical junctures and institutional inertia. Sorensen (2018) states that critical junctures occur during the "destabilization of an existing institutional order," and this destabilization often occurs due to exogenous shocks to the institutional order (p. 619). The presence of permissive and productive conditions can make critical junctures more feasible and apparent. Permissive conditions "represent the easing of the constraints of structure and make change possible," while productive conditions provide the structure for institutional change, e.g., "antecedent conditions that shape perceptions of what change is appropriate and possible, existing institutional capacities and biases, the key actors mobilizing to generate change (including differences in their relative power and influence), and the rules structuring change processes and roles in the introduction and establishment of new institutions" (Soifer, 2012, as cited in Sorensen, 2018, p. 619; Sorensen, 2018, p. 619).

Literature concerning critical junctures often argue that the result of such a period is the establishment of a new path-dependent pathway (Sorensen, 2018; Hogan & Doyle, 2007; Capoccia and Kelemen, 2007). Hogan and Doyle (2007) regard the significance of critical junctures as "pointing to the importance of the past in explaining the present" (p. 886). Essential to the study and identification of critical junctures is the concept of contingency, which Vergne and Durand (2010, p. 755) define as "unpredictable, non-purposive, and seemingly random" (as cited in Hanger-Kopp et al., 2022, p. 619). Hanger-Kopp et al. (2022) attempt to operationalize contingent events as "decisions made as a consequence of circumstances that are unusual, surprising for the planning process and often not anticipated in that particular organizational, governance, and institutional setting–as compared to the explanatory capacity of a theory or discipline" (p. 3). Within a context of institutional inertia, contingency implies that there are a set of possible options that may or may not induce wide-scale change during a critical juncture period.

In a climate change and water management context, critical junctures have frequently occurred as a result of a natural disaster or flood event (Hanger-Kopp et al., 2022; Gawronski & Olson, 2013). These disasters are seen as contingent events that overload "current risk management capabilities and therefore brings about a shift in institutional paradigms and responsibilities" (Kuhlicke et al., 2020, as cited in Hanger-Kopp et al., 2022, p. 4). Gawronski and Olson (2013) write about the connection between disasters and critical junctures, notably stating that they are capable of triggering decisions putting institutions on inertial, path-dependent trajectories:

> *"Indeed, our interest in disasters and critical junctures focuses on those very alternatives, or "choice points," because during the emergency response phase of a disaster - but usually more significantly during recovery and reconstruction - decisions and choices among alternatives are often stark in their consequences. More specifically, disasters create windows of opportunity for policy changes, and the resulting choices affect a range of outcomes and, to borrow Capoccia and Kelemen's phrasing, thus have "the potential to trigger a path-dependent process that constrains future choices" and are "qualitatively different from the 'normal' historical development of a nation-state (2007, 348)" (p. 134).*

It must be stated that Gawronski and Olson (2013) qualify their argument by asserting, "no disaster, by itself, can ever be a critical juncture" (p. 143).

2.2 Conceptual framework

This section includes a conceptual framework that necessarily follows the previous one, as it is meant as "as both the result and focus of a literature review" (Van der Waldt, 2020, p. 4). A conceptual framework is defined as a "visual representation of a study's main theoretical tenets or concepts" with a key focus on "identifying keywords (i.e., key concepts and related concepts as these appear in the title) and the visual mapping of the interrelationship between these elements" (Miles and Huberman (1994), Jacard and Jacoby (2010) and Ravitch and Riggan (2017) as cited in Van der Waldt, 2020, p. 2; Van der Waldt, 2020, p. 3). The result is a schematic diagram that clearly showcases key concepts and how they relate to one another.

Below is the conceptual framework that represents the relationships of the variables analyzed in this thesis (Figure 1):

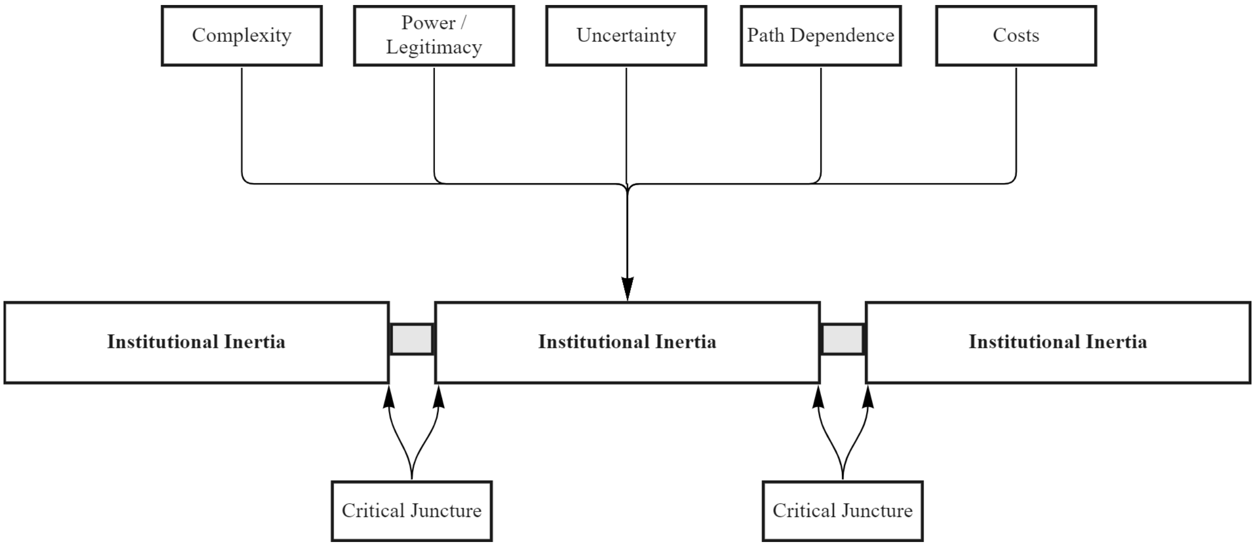


Figure 1: Conceptual framework

There are five independent variables (IV) contributing to the dependent variable (DV) institutional inertia: complexity, power and legitimacy, uncertainty, path dependence, and costs. Additionally, there is a sixth IV, critical juncture, that is capable of punctuating institutional inertia. Critical junctures are necessarily separated from the five IVs represented at the top of the conceptual framework because while the latter contribute to the continuation of institutional inertia, the former is frequently manifested as an exogenous shock resulting in "relatively short periods of time during which there is a substantially heightened probability that agents' choices will affect the outcome of interest" (Capoccia & Kelemen, 2007, p. 348).

3.0 Research design, methodology

3.1 Description of the research design and methods

3.1.1 Research strategy: case study, process tracing, and desk research

A case study of New Orleans, Louisiana, was selected for analysis due to its long-standing water management sector and the complexity of problems it faces. There is an urgent need to examine institutional inertia and critical junctures as it pertains to water management in New Orleans as climate change impacts are increasingly threatening the current institutions and systems in place that were established more than a century ago. As there is significant primary and secondary data to analyze, to be supplemented by expert working actors' input, the city poses an excellent case to scrutinize.

The method of case study research is particularly suited to the analysis of the research questions posed in this paper. Case study research offers "richly detailed and extensive descriptions of the phenomenon under study," and in some cases a researcher can "arrive at an explanation of the research subject" (Van Thiel, 2014, p. 87). Though specific to one unique case, research findings can sometimes be "regarded as representative for other situations in the same research domain" (Van Thiel, 2014, p. 89). To make data collection, results, and analysis more reliable and valid, triangulation is utilized via a mixed method research design, including analysis of primary and secondary documents and semi-structured interviews of content experts. To complete the former, desk research was utilized as the foundation of information for variable selection, operationalization of those variables, and the historical analysis. Desk research is "an efficient and cost-effective strategy" that is "ultimately suitable for research of an historical nature (describing developments over time)" (Van Thiel, 2014, p. 102-106).

A process tracing case study design is utilized in this paper. Collier (2011) presents a recognized definition of process tracing: "the systematic examination of diagnostic evidence selected and analyzed in light of research questions and hypotheses posed by the investigator. Process tracing can contribute decisively both to describing political and social phenomena and to evaluating causal claims" (p. 823). Temporal sequencing is essential in process tracing:

> *"First, interaction effects, in the sense that it is not the simple sum of the causal strength of two or more causal factors which makes them strong enough to produce an outcome, but their co-existence which accelerates (or moderates) their causal power; second, the idea that specific causal factors (sometimes confusingly called causal mechanisms) work only within specific contexts; and third, the idea that the working of a first causal factor is a necessary precondition for the activation of the second in a later stage" (Blatter and Blume, 2008, p. 322).*

Process tracing, in the analysis of both institutional inertia and critical junctures, is also particularly suitable given it "gives close attention to sequences of independent, dependent, and intervening variables" (Collier, 2011, p. 823). This paper seeks to verify that the selected independent variables (costs, uncertainty, path dependence, power/legitimacy, and complexity) influence the dependent variable (institutional inertia) in the water management sector in New Orleans. Further, using process tracing, it seeks to identify past and future critical junctures that are capable of punctuating this institutional inertia. There exists a highly descriptive component to process tracing case studies, which is vital to uncovering causal links between variables and phenomena of interest, along with, importantly to the study of critical junctures, counterfactuals and contingent events during the time period of interest (Blatter and Blume, 2008; Collier, 2011; Capoccia and Kelemen, 2007; Gawronski & Olson, 2013). Capoccia and Kelemen (2007) argue in favor of a process tracing case study method in the study of critical junctures: "researchers must not stop with simply identifying the critical juncture but must instead deepen the investigation of the historical material to identify the key decisions (and the key events influencing those decisions) steering the system in one or another direction, favoring one institutional equilibrium over others that could have been selected" (p. 369). Ultimately, the process tracing case study research design is most suited to identify and verify variables and causal mechanisms present in the water management sector in New Orleans, especially due to its complex historical development.

3.1.2 Data collection methods (primary and secondary)

For the purposes of this paper's research questions, primary and secondary data are essential to fulfilling a process tracing analysis with a high level of detail, sequencing of events, analysis of critical junctures, and the identification of variable influences on the phenomenon of interest – institutional inertia.

Secondary data refers to "earlier research findings (data) which can be used anew in another study on the same or a related subject," including statistical data and "written conclusions from earlier studies" (Van Thiel, 2014, p.104-105). Examples of the latter are "scientific articles, books, or research reports" that are used to inform and answer the research questions (Van Thiel, 2014, p. 105). As secondary data includes data targeting different research questions (another purpose) than those explored in this paper, there lies an operationalization problem that can be addressed through identifying and applying information relevant to the study's purpose and ensuring data triangulation (for data reliability and validity) (Van Thiel, 2014).

Primary data is defined as "information that has been collected by the researcher him- or herself" which includes "information that has not been produced for research purposes, or which has not been used for research before" (Van Thiel, 2014, p. 102). Examples primary data include "written or printed sources, such as annual reports, the minutes of meetings, company records, business correspondence, policy documents, legal papers, brochures, newsletters, periodicals, annual budgets, covenants, pledges, coalition agreements, results statistics, management reports, speeches and so forth" (Van Thiel, 2014, p. 102).

Primary and secondary data collection for the desk research and process tracing portion of the case study focuses on public governmental reports, factual news sources, research papers, and historical books concerning the history of the water management sector in New Orleans. The majority of these sources were found via database searches, though expert recommendations informed some selections.

Primary data in the form of semi-structured interviews of key experts is utilized for this analysis. A semi-structured interview is used "to generate answers from participants that were spontaneous, in-depth (Dearnley 2005, Baumbusch 2010), unique (Krauss et al. 2009) and vivid (Dearnley 2005)" (as cited in Kallio, Pietilä, Johnson & Kangasniemi, 2014, p. 2959). As a deductive study, the interview guide developed for the questioning of these experts is based on the operationalization of variables (see Section 3.2) (Van Thiel, 2014). A semi-structured interview design was selected to cover information not found in primary or secondary sources (i.e., "opinions, relationships, or perceptions"), as well as for data corroboration for triangulation (Van Thiel, 2014, pp. 94-95). The interview guide outlines confidentiality, the purpose of the study, and the specific questions to be asked of each respondent. Three interview guides were created for this study to best target respondents and their respective expertise. The interview guides are included in this paper (Appendix 2) to ensure feasible replicability of this research. The semi-structured interview guide was created following the framework developed by Kallio, Pietilä, Johnson, and Kangasniemi (2014) (Appendix A.1).

3.1.3 Description of sample

Primary and secondary data was collected, considered, and analyzed for this thesis. Documentation utilized for analysis included:

- Federal, state, and local government publications (reports, Congressional proceedings, research studies, meeting minutes, and task force proceedings)
- Academic journal articles
- Periodical articles
- Policy briefings
- Historical publications (books, archival excerpts)

There were ten interviewees included as a supplement to these published materials, chosen via purposive sampling that included 'elite' (organization leaders), 'informant' (organization employees), and 'independent expert' respondents (Van Thiel, 2014, p. 97). These interviewees were organized into three respondent groups, depending on their organizational affiliation: (1) government officials, (2) subject matter experts, and (3) community member proxies. The latter group was selected in place of community member surveys due to time limitations. Interview guides were created for each respondent group (see Appendix 2). Respondents were selected based on their experience with the water management system, their organizational affiliation, and the likelihood of availability. Their names will remain anonymous as explained in the introduction of the interview guide (see Appendix B.1) to allow for open, truthful, and detailed responses to the interview guide questions. Since the data from these interviews was considered supplementary to the historical analysis process tracing portion of this study (see Section 3.1.3), ten respondents were deemed sufficient for data triangulation purposes.

In the interest of anonymity and response confidentiality, respondent names are not included in this paper. Instead, respondents are numbered, categorized, and described in general terms as to give brief explanations behind their inclusion in this research (Table 4).

Table 1: Respondent designation and experience

Respondent	Respondent category	Experience
R1	Subject matter expert	Ground subsidence and climate resilience expert
R2	Community proxy / government actor	SWBNO community engagement specialist
R3	Community proxy / subject matter expert	Climate resilience and community engagement expert
R4	Subject matter expert / government actor	Climate resilience expert, extensive previous experience working within local government
R5	Subject matter expert / government actor	Climate resilience expert, board member of SWBNO

R6	Subject matter expert	Civil engineer, extensive experience with flood resilient projects in New Orleans
R7	Government actor	SWBNO planning specialist
R8	Subject matter expert / government actor	Engineering consultant, extensive experience working at all levels of SWBNO as a principal engineer
R9	Subject matter expert / government actor	Engineering consultant, extensive experience working at all levels of SWBNO as an engineer and deputy director
R10	Subject matter expert	Water NGO executive director in New Orleans

3.1.4 Data analysis

The data collected via desk research and interviews is analyzed jointly to support conclusions drawn in the results and conclusions sections of this paper. To perform analysis, the qualitative research program "Atlas.Ti" is utilized to store relevant documents and transcriptions. It is important to note and explicate the reasoning behind the joint analysis of both relevant desk research documents and semi-structured interview data. As the research conducted for this paper is classified as a case study, it is essential to ensure data triangulation to counter issues pertaining to data reliability and validity (Van Thiel, 2014). Therefore, combining primary and secondary sources found through desk research alongside transcription data from expert interviews allows the researcher to more reasonably support valid, reliable conclusions drawn from the study.

The deductive nature of this study is clear in the operationalization of variables prior to data analysis. Accordingly, codes are developed that correlate to the variables and associated indicators of interest that can be found in operationalization table in Section 3.2. Deductive research is useful when the researcher is trying "to answer the question of whether the effects predicted (by the hypotheses) are indeed observed in reality" (Van Thiel, 2014, p. 148). In the case of this research, operationalization and the research questions are essential to data analysis, as they "help to decide what is relevant to the study, and what is not" (Van Thiel, 2014, p. 143).

Codes are utilized as a "brief summary of the main attributes or features of the unit" through careful scrutinization of the selected, relevant documents, as well as the interview transcriptions (Van Thiel, 2014, p. 143). For a detailed view of the selected codes in this research, see the operationalization table in Section 3.2. For example, the independent variable "Costs" is split into five indicators (e.g., "Transaction costs") and further into 10 codes (e.g., "Transaction costs: negative," "Transaction costs: positive," etc.) to be applied to documents. A sentence fragment, full sentence, or group of sentences can be selected at one time, and one or more pertinent codes is applied to that selection.

An example from a coded interview transcript for the following statement: "There are definitely specific bureaucratic issues that hold the organization back from being effective." This sentence was coded with the following indicators: "Perc.: insti. change: high resistance" and "transaction costs: negative." The respondent was describing the result of a heavily bureaucratic institution that is resisting change in the pursuit of efficiency due to heavily entrenched institutional norms and values.

Once fully coded, analysis is performed. For this study, the Atlas.Ti "Co-Occurrence Table" function is used to support the conclusions located in the Results and Conclusions chapters of this paper. In this function, codes that are applied in concert with one another on the same (or overlapping) section of document are counted and displayed in table form. Additionally, a co-occurrence coefficient is included as a marker of indicator relationship strength with a range of zero to one. The stronger the relationship between two indicators, the higher the number of co-occurrences and the closer to one the coefficient is within the analysed texts. Though these results are discrete numerical indicators of relationship strength, they are utilized as a starting point in uncovering relationships between variables rather than outright conclusions of relationship strength. This is due to the researcher's recognition that some important relationships may be embedded in a small number of co-occurrences that are not always apparent upon first glance.

For this analysis, indicators relating to "institutional inertia" are compared with indicators relating to the five IVs found to influence inertia in literature (costs, uncertainty, path dependence, power/legitimacy, complexity). Additionally, the DV "institutional inertia" is compared to the last IV "critical juncture" to uncover the relationships between those distinct variables, as well. The quote pulled above used as an example of coding proves also to be a good example of co-occurrence. In that case, the two codes "Perc.: insti. change: high resistance" and "transaction costs: negative" are co-occurring, representing potential relationships between those codes themselves and the variables they are indicators of (in this case, "institutional inertia" and "costs," respectively).

Co-occurrence tables used for analysis are found in Appendix A.7.

3.2 Operationalization

Table 2: Operationalization of variables - definitions

Variable	Definition
Institutional Inertia	"Institutional inertia refers to the 'stickiness' of institutions, or to how they resist change. Arguably, this can be seen as a defining trait of institutions, as they embody stability and predictability to a considerable extent" (Pierson, 2004, as cited in Munck af Rosenschöld, Rozema, and Frye-Levine, 2014, p. 640)
Costs	Costs associated with climate adaptation and defense actions, as well as transaction costs
Uncertainty	Unknowns regarding exact climate change impacts into the future, as well as regarding institutional/actor responsibility for associated adaptation actions
Path dependence	"The notion of path dependence is generally used to support a few key claims: Specific patterns of timing and sequence matter; starting from similar conditions, a wide range of social outcomes may be possible; large consequences may result from relatively "small" or contingent events; particular courses of action, once introduced, can be virtually impossible to reverse; and consequently, political development is often punctuated by critical moments or junctures that shape the basic contours of social life (Collier and Collier 1991; Ikenberry 1994; Krasner 1989, as cited in Pierson, 2000, p. 251).
Power/Legitimacy	Those institutions and actors in positions of influence support "incumbent" actors and systems; "insubordinate" groups with opposing ideas are suppressed (Munck af Rosenschöld, Rozema, and Frye-Levine, 2014) "Current practices are sustained, as they are considered appropriate by actors" (Munck af Rosenschöld, Rozema, and Frye-Levine, 2014, p. 645)
Complexity	Interactions between "elements, subsystems and interdependencies" that are not contained within political boundaries, making decisions, responsibilities, and coordination difficult to achieve (Head, 2008, p. 103) "interactions among social, financial, and cultural attributes, and information, energy, and material stocks and flows that operate on different temporal and spatial scales" (Zellner et al., 2008, p. 474)
Critical Juncture	"relatively short periods of time during which there is a substantially heightened probability that agents' choices will affect the outcome of interest" (Capoccia & Kelemen, 2007, p. 348)

Table 3: Operationalization of variables – institutional inertia

Variable	Indicator descriptions	Indicator (code) names	Data collection method(s)	Literature sources
Institutional inertia	1. Change in water management practices post-critical juncture 2. Change in institutional actors post-critical juncture 3. Perception of resistance to institutional change 4. Perception of resistance to new practices and paradigms regarding water management	1.1 No change: practices 1.2 Some change: practices 1.3 Significant change: practices 2.1 No change: actors 2.2 Some change: actors 2.3 Significant change: actors 3.1 Perc.: inst. change: low resistance 3.2 Perc.: inst. change: high resistance 4.1 Perc.: innovation: low resistance 4.2 Perc.: innovation: high resistance	Secondary data Semi-structured interviews Target interviewees: • Government officials • Water experts • Non-governmental actors	Munck af Rosenschöld, Rozema, and Frye-Levine, 2014 Taylor, 2014 Brown and Farrelly, 2009 Munck af Rosenschöld & Rozema, 2019 Van Buuren, Ellen, and Warner, 2016 Pierson, 2000 Aksom, 2021
Costs	1. Costs of proposed adaptive actions / projects 2. Cost-benefit of proposed plans 3. Transaction costs (e.g., Number of bureaucratic / nongovernmental actors to coordinate; Red tape) – negative indicates mal-impacts; positive indicates beneficial impacts 4. Cost-benefit perception	1.1 Cost of projects: positive 1.2 Cost of projects: negative 3.1 CBA: positive 3.2 CBA: negative 4.1 Transaction costs: positive 4.2 Transaction costs: negative 4.1 Perc.: project benefits: positive 4.2 Perc.: project benefits: negative	Secondary data Semi-structured interviews Target interviewees: • Government officials • Water engineers and scientists	Munck af Rosenschöld, Rozema, and Frye-Levine, 2014 Brown and Farrelly, 2009 Taylor, 2014
Uncertainty	1. Climate impacts to NOLA for the future 2. Delegation of responsibility for climate actions	1.1 Cl. Imp.: low uncertainty 1.2 Cl. Imp.: medium uncertainty 1.3 Cl. Imp.: high uncertainty 2.1 Responsibility: low uncertainty 2.2 Responsibility: medium uncertainty 2.3 Responsibility: high uncertainty	Secondary data Semi-structured interviews Target interviewees: • Government officials • Water engineers and scientists • Non-governmental actors	Munck af Rosenschöld, Rozema, and Frye-Levine, 2014 Brown and Farrelly, 2009 Boston and Lempp, 2011 Cigler, 2007 Taylor, 2014 Salet, Bertolini, and Giezen, 2013

Path dependence	1. Investment costs into water management system components 2. Legal embeddedness of current water management system / institutions 3. Public perception of water management measures (i.e., trust in current system, openness to other - soft engineering - water management options) 4. Reality of innovations making NOLA safer and more resilient to flooding hazards	1.1 Investment costs: all-time 1.2 Investment costs: annual 2.1 Legal requirements: strict 2.2 Legal requirements: lax 3.1 Perc.: Public trust: low 3.2 Perc.: Public trust: high 4.1 Imp. innovation: low 4.2 Imp. innovation: medium 4.3 Imp. innovation: high	Secondary data Semi-structured interviews Target interviewees: • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • Water experts and engineers	Pierson, 2000 Munck af Rosenschöld, Rozema, and Frye-Levine, 2014 Brown and Farrelly, 2009 Salet, Bertolini, and Giezen, 2013 Van Buuren, Ellen, and Warner, 2016 Sorensen, 2018 Bennett & Elman, 2006
Power/Legitimacy	1. Decision-making authority hierarchy 2. Perception of improvements to water management system 3. Perception of ability to change institutional structure / decision-making process for water management 4. Perception (public/expert) of legitimacy in decision-making regarding drainage operation	1.1 Authority: low 1.2 Authority: high 2.1 Perc.: System improvement low 2.2 Perc.: System improvement high 2.3 Perc.: System improvement none 3.1 Perc.: Agency in decision-making: low 3.2 Perc.: Agency in decision-making: high 4.3 Perc.: Legitimate decision-making: low 4.4 Perc.: Legitimate decision-making: high	Secondary data Semi-structured interviews Target interviewees: • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • Government officials • Non-governmental actors • Water experts	Munck af Rosenschöld, Rozema, and Frye-Levine, 2014 Munck af Rosenschöld & Rozema, 2019 Brown and Farrelly, 2009 Siders, 2019

Complexity	1. Complexity of problem 2. Complexity of institutional/actor arrangements	1.1 City area 1.2 City area below sea level 1.3 Demographics: median age 1.4 Demographics: race 1.5 Demographics: mean household income 1.6 Demographics: flood insurance coverage 1.7 Demographics: spatial distribution 1.8 Urban flooding impact 1.9 Level of public understanding of risk: low 1.10 Level of public understanding of risk: medium 1.11 Level of public understanding of risk: high 1.12 Level of political actor understanding of risk: low 1.13 Level of political actor understanding of risk: medium 1.14 Level of political actor understanding of risk: high 2.1 Decision-making accessibility: high 2.2 Decision-making accessibility: low 2.3 Public participation requirements for system improvements / additions 2.4 Perc.: Clarity in decision-making: high 2.5 Perc.: Clarity in decision-making: low 2.6 Perc.: Clarity in responsibilities: high 2.7 Perc.: Clarity in responsibilities: low	Secondary data Semi-structured interviews Interviewee targets: • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • Government officials • Non-governmental actors	Head, 2008 Zellner et al., 2008 Siders, 2019 Brown and Farrelly, 2009

Table 4: Operationalization of variables – critical juncture

Variable	Sub-variables	Indicator descriptions	Indicator (code) names	Data collection method(s)	Literature sources
Critical Juncture	Contingency	1. Presence of more than one alternative for actors to decide upon (with path dependent legacy) 2. Perception of 'design moments' post-disaster	1.1 CJ: Alternatives present 1.2 CJ: Alternatives not present 2.1 Design moment: positive 2.2 Design moment: negative	Secondary data Semi-structured interviews Interviewee targets: • Government officials • Non-governmental actors • Water experts • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • New Orleans history experts	Capoccia & Kelemen, 2007
	Agented choice	1. Perception that decisions made within certain time period would have lasting impacts (i.e., path dependent legacies) 2. Perception that "agents' choices will affect the outcome of interest" relative to that probability before and after a certain time period (Capoccia & Kelemen, 2007, p. 348)	1.1 Perc.: Decision impact: positive 1.2 Perc.: Decision impact: negative 2.1 Perc.: Decision weight: positive 2.2 Perc.: Decision weight: negative	Semi-structured interviews Interviewee targets: • Government officials • Non-governmental actors • Water experts • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • New Orleans history experts	
	Permissive and productive conditions	1. Government budget for drainage system 2. Government budget for operation and maintenance of levee/pump/canal system 3. Timing of institutional change post-disaster	1.1 Govt. funding improvements: positive 1.2 Govt. funding improvements: negative 2.1 Govt. funding O&M: positive 2.2 Govt. funding O&M: negative 3.1 Perc.: Timing: positive 3.2 Perc.: Timing: negative	Secondary data Semi-structured interviews Interviewee targets: • Government officials • Non-governmental actors • Water experts • Public perception proxies will be utilized: members of NGOs and community organizations with close ties to members of the public • New Orleans history experts	

3.3 Expected challenges and limitations

When performing remote desk research, there is both an overwhelming amount of information and still not enough of information tailored to the research purpose. Selecting relevant data from searches yields sufficient material for analysis, yet there are inevitably some data sources that are left out. Additionally, there were some limitations regarding the availability of some historical information, especially considering the entirety of the research for this paper was performed remotely from New Orleans, therefore eliminating the opportunity of in-person data gathering from local sources. Performing data triangulation via the selection of various data sources and types along with interview data helps to overcome the uncertainty of some forfeited information, enhancing data reliability and validity.

Objectivity concerns may lie in the fact that the researcher is a native of New Orleans, where frequent nuisance flooding occurs in proximity to personal residence. Maintaining a clear research focus on the questions and objectives posed in Chapter 1 provides structure to data gathering and analysis. Also, triangulation is a “highly suitable means of countering problems that might arise with respect to reliability and validity” in this case, as well (Van Thiel, 2014, p. 91).

Regarding the interview process, privacy and confidentiality concerns may influence respondent answers. These concerns are addressed through clear articulation of data usage, storage, and disposal post-submission. Another limitation within the interview process is the decision to interview community member proxies, rather than a survey of New Orleans residents. This decision was a result of time constraints and the remote nature of this research process. Community perception responses, thus, are noted with this caveat.

Finally, within case study research, it is “difficult, if not impossible, to generalize findings to other situations, either because the case is unique or because results only apply to the particular context that has been examined” (Flyvbjerg, 2006, as cited in Van Thiel, p. 87). Thus, there is a limitation in external validity. However, making clear the methodology (case study process tracing and semi-structured interview guide) followed by the researcher, along with triangulation of information, aids in ensuring replicability, validity, and credibility (Blatter and Blume, 2008; Van Thiel, 2014).

4.0 Results, analysis, and discussion

4.1 Description of case study: New Orleans, Louisiana

The case study selected for this research is the city of New Orleans, Louisiana, in the United States. It presents an especially relevant case for study for a number of reasons, summarized below.

4.1.1 Subsidence

The majority of the city's population currently lives below sea level (Horowitz, 2020). However, in 1895, 95 percent of the city was above sea level; in 1935, that number was 70 percent above sea level; and by 1960, only 48% of the city remained above sea level (Campanella, 2018a). New Orleans is now built over an area that is on average between six and seven feet below, but up to over ten feet below sea level, in a series of "topographic bowls" caused by anthropogenic actions that have been implemented especially in the 20th century (Cigler, 2007; Campanella, 2018a) (Figure 2).

Figure 2: LIDAR elevation model of New Orleans. Areas above sea level in red, below sea level in yellow/blue. Range from +15ft to -10ft. (Adapted from FEMA data, Campanella, 2018a).

Horowitz (2020) brings this phenomenon into the present: "Since the 1960s, metropolitan New Orleans had sunk nearly two feet relative to the water around it" (p. 131). This was both a result of rising sea levels and subsiding land (Horowitz, 2020; Andersen et al., 2007).

The large-scale expansion of the city beyond the natural Mississippi River ridge above sea level in the twentieth century was the result of engineering feats in swamp/marsh-drainage and largely federally subsidized. The city is built on soils that are no longer connected to a sediment source, the Mississippi River, and thus are prone to natural subsidence via consolidation and organic material decay (Andersen et al., 2007). Further contributing to the problem is local groundwater pumping, a system which only expanded throughout the twentieth century as more marsh land was drained and developed for urban expansion (Andersen et al., 2007). According to United States Geological Survey data measured primarily in Orleans Parish from 1951 to 1995, "subsidence has been estimated to occur at an average rate of about 0.15 to 0.2 inches per year, although rates in excess of 1 inch per year occur in some locations" (Andersen et al., 2007, p. 8).

The federal government played a role in New Orleans urban sprawl, thus aiding development in vulnerable geographic and topographic locations and hastening subsidence via separation from sediment deposition. Horowitz (2020) expands on this idea by highlighting federally supported programs and projects that brought New Orleans to where it is today:

> *"Beginning during the 1930s and continuing for the rest of the century, federal policies – and millions of dollars in federal funds--directed Louisianians away from the high ground near the Mississippi River, and into drained swamps near Lake Pontchartrain. Even as the goals of federal housing policies changed over the decades, their geographical effect in metropolitan New Orleans remained remarkably consistent. When the Home Owners' Loan Corporation bailed out homeowners during the Great Depression in the 1930s, the federal government downgraded old neighborhoods by the river and favored new neighborhoods by the lake. When the GI Bill of Rights subsidized mortgages for veterans of World War II in the 1940s and 1950s, the federal government discouraged rehabilitating older buildings at the city's core and urged new construction in lower-lying areas on the metropolitan periphery. When the National Flood Insurance Program began offering homeowners economic protection from flood damage beginning in the late 1960s, the federal government wrote the rules in ways that effectively subsidized development in flood-prone areas. When the Army Corps of Engineers constructed the Lake Pontchartrain and Vicinity Hurricane Protection Project in the 1970s and 1980s, the federal government justified the cost of the enormous levee system with the prospect of hundreds of thousands of people moving to previously uninhabitable parts of the region" (Horowitz, 2020, p. 70).*

4.1.2 Vulnerability to climate change impacts

Impacts due to climate change are threaten New Orleans and its water management system. There is substantial research supporting growing intensity, frequency, and duration of tropical storm events (Coastal Protection and Restoration Authority, 2017). The Third U.S. National Climate Assessment (2014, as cited in Coastal Protection and Restoration Authority, 2017) "showed that the intensity, frequency, and duration of North Atlantic tropical storms, as well as the frequency of major hurricanes (Category 3-5), have all increased since the early 1980s" (p. 2). Already, major hurricanes (Category 3-5) occur at a disproportionally higher rate on the Gulf Coast than any other U.S. region threatened by tropical storm events (Cigler, 2007). It is expected that Louisiana will "experience a decrease in the number of tropical depressions, tropical storms and Category 1 and 2 hurricanes, but an increase in the frequency of Category 3-5 hurricanes in the coming years" (Coastal Protection and Restoration Authority, 2017, p. 13). The state of Louisiana leads the U.S. in flood losses per capita and repetitive loss claims, and this phenomenon is expected to worsen as global temperatures continue to rise, as research conducted by Holland and Bruyere (2013) supported that "found an increasing trend in the proportion of Category 4-5 hurricanes of 40% per degree Celsius SST rise that is directly attributed to anthropogenic global warming" (as cited in Coastal Protection and Restoration Authority, 2017, p. 2; King, 2005, as cited in Cigler, 2007).

Importantly, not just tropical storm events threaten the city, but also intense rainfall events that occur semi-frequently in New Orleans and cause widespread nuisance flooding (and even sometimes damages to property). These heavy rainfall events are capable of overwhelming the drainage system, and are expected to increase in both frequency and intensity due to climate change (Waggoner & Ball, 2013).

4.1.3 Social vulnerability

New Orleans, similar to other U.S. cities, can trace much of its social vulnerability to racist redlining practices that were exercised during the 20th century. Outcomes impacted include economic disparity and unequal and inequitable access to quality housing, quality education, public transportation, health outcomes, and generational wealth (Mitchell, 2018; Habans et al., 2020; Barrios, 2011; City of New Orleans & Housing Authority of New Orleans, 2016). Historic disinvestment and lack of socioeconomic opportunity has led to high-poverty and majority-minority (mainly African American), segregated neighborhoods that have grown in concentration since the 1970s into the present (Habans et al., 2020; Fussell and VanLandingham, 2010; City of New Orleans & Housing Authority of New Orleans, 2016). "Before [Hurricane] Katrina, New Orleans had enormous disparities in social vulnerability. It was 67.3 percent African American. Of the 28 percent of residents who were poor, 84 percent were African American" (Cigler, 2007, p. 65).

The Data Center (2020), utilizing data from the U.S. Census Bureau, highlights that the median age of the New Orleans metropolitan area has increased to 39 years in 2020 from 34.8 years in 2000. Figure 3 shows racial trends in Orleans Parish from 2000 to 2020, as well, taken from the Data Center (2020).

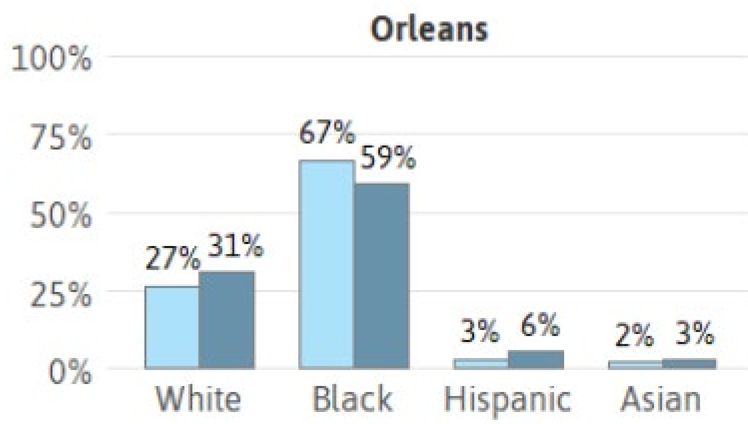


Figure 3: Racial demographics of Orleans Parish (U.S. Census Bureau data from Census 2000 and Population Estimates 2020, as cited in the Data Center, 2020)

Finally, New Orleans has a median household income of $45,615, substantially lower than the country's median of $65,712 (U.S. Census Bureau American Community Survey, 2019, as cited in The Data Center, 2020).

4.1.4 Reliance on flood resistant infrastructure

Inertia in the water management sector in New Orleans has largely manifested in actors' and institutions' reliance on flood-resistant infrastructure design rather than flood-resilient infrastructure design for the city. Fields, Thomas, and Wagner (2017) provide definitions for these phrases in terms of urban scale and management paradigm, found in Table 4.

Table 5: Definitions of flood-resistant and flood-resilient design, taken from Fields et al., 2017, p. 310

Term	Urban Scale	Management Paradigm
Flood-resistant design	"Levees, floodwalls, pipes, canals, and structural means to resist the entrance of water into the city and to remove it as quickly as possible."	"'Flood Defense' – Policies that support, promote, or require flood-resistant infrastructure, buildings, and communities, such as floodwalls with the goal of keeping water out"
Flood-resilient design	"Modified structural systems, integration of green and blue infrastructural solutions with the assumption that flooding will happen."	"'Living with Water' – The adaptation of policies, laws, and plans to allow for investment in new systems based in resilience. Treats the reduction of flood risk as an opportunity to create new amenities, active living, and ecological urbanism. Adapts city infrastructure to let water into the city through urban and landscape design."

As a result of that reliance on flood-resistant, hard infrastructure, New Orleans now has an extensive flood control and drainage system consisting of levees, floodwalls, pumps, and canals. The system's main components can be found detailed in Section 4.2.2.1, while the institutions that manage them are explained in Sections 4.2.2.2 to 4.2.2.4.

4.2 Results and analysis

4.2.1 What have institutions, actors, and management systems looked like from 1893 until present?

In order to contextualize institutional inertia in the New Orleans water management sector, it is essential to identify the institutions, actors, and systems that are integral to its functions. This section works to do just that, while emphasizing temporal entry and authority hierarchies. First, the evolution of the system itself is briefly covered, then the actors are expounded upon.

4.2.2.1 Drainage and flood control system

For flood control on the Mississippi River, a 'levees-only' policy (later adapted with floodways, channel improvements, and improvements to tributary basins in the Flood Control Act (also known as Jadwin Plan of 1928 – see Section 4.2.2.2) adopted in the 19^{th} century remains the predominant method of river flood control on the Mississippi River (Rogers, 2006). The Mississippi River and Tributaries (MR&T) Project, authorized by Congress in the Flood Control Act of 1928, authorized the "Mississippi River Commission (created in 1879) controlled by the Corps of Engineers to provide for flood protection along the Mississippi River between Cape Girardeau, MO and Head-of-Passes, LA," and remains largely intact today (Rogers, 2006, pp. 8-9). Essential to understanding inertia in this arena, Barry (1997) notes that "The Mississippi River Commission never became a scientific enterprise. It was a bureaucracy. The natural process of a bureaucracy, by contrast, tends to compromise competing ideas. The bureaucracy then adopts the compromise as truth and incorporates it into being… The commission took positions and the positions became increasingly petrified and rigid" (as cited in Gordon & Little, 2009, p. 6). As of post-Katrina, "3,714 miles of flood control levees have been authorized for construction under the Mississippi River & Tributaries Project" (Rogers, 2006, p. 13).

The system of levees, control structures, and floodwalls for the rest of the city were designed and constructed in the mid-to-late 20th century, following the authorization of the Lake Pontchartrain and Vicinity Hurricane Protection Project (LPVHPP) in 1965. "The project generally included earthen levees with floodwalls along Lake Pontchartrain, the 17th Street Canal, the Orleans Canal, the London Avenue Canal, and the Industrial Canal" (Andersen et al., 2007, p. 18). The United States Army Corps of Engineers (USACE) was authorized by Congress to design and construct the project to "safeguard more than 150 square miles of metropolitan New Orleans" (Horowitz, 2020, p. 86). Congress "directed USACE to design the hurricane protection system for "the most severe combination of meteorological conditions that are considered 'reasonably characteristic' of the region"," otherwise known as the Standard Project Hurricane (SPH) (Andersen et al., 2007, p. 20). The criteria for the SPH, which informed the design of the LPVHPP, was based on historic hurricanes from 1900 to 1956. Notably, even with updated criteria for the SPH and a new "probable maximum hurricane" that included more recent data (including Hurricane Betsy that hit New Orleans in 1965), USACE did not update SPH criteria (thus system design measurements) at any point prior to Hurricane Katrina in 2005 (Andersen et al., 2007). Levees on both the river (24.5 feet mean gulf level) and lake (13.5 feet mean gulf level) sides of the city are much higher than the average elevation of the city (Figure 4).

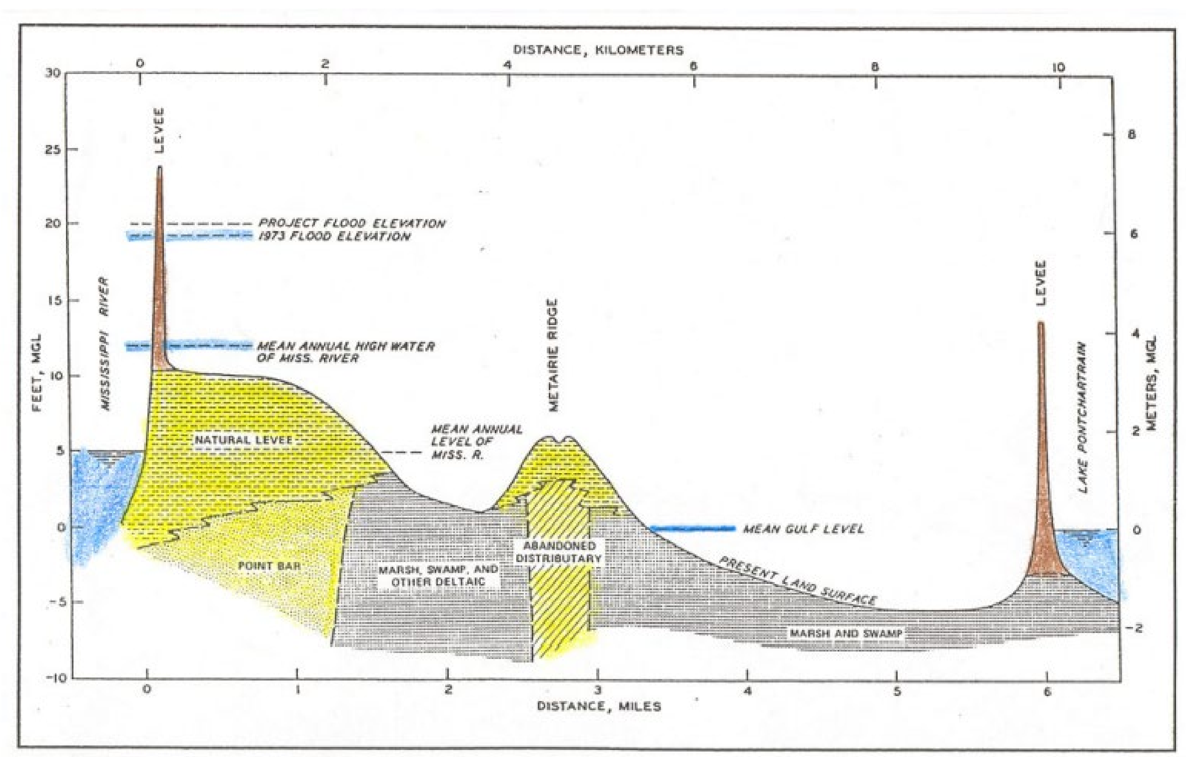


Figure 4: Cross section of New Orleans (Kolb and Saucier, 1982, as shown in Rogers, 2006, p. 12)

Once constructed by USACE, control of the LPVHPP (i.e., operations and maintenance) was transferred to the Orleans and Jefferson levee boards and the SWBNO (see Appendix 1.3 for breakdown of agencies and organizations responsible for the water management "protection" system in New Orleans prior to Hurricane Katrina, from Andersen et al., 2007). Levee districts were tasked with maintaining the canals, while SWBNO operated pump stations and controlled drainage canal discharges (Rogers, 2006). The LPVHPP highlighted institutional problems in the decades preceding Hurricane Katrina:

> *"Federal appropriations and the USACE construction schedules never reflected a high priority for completing the work. Without sufficient funds and a sense of urgency from the responsible government agencies, construction lagged behind schedule, causing further cost escalation and thus wider funding shortfalls. Local cost sharing was slow to materialize and even in-kind contributions for maintenance were not made. For example, following Katrina, the Orleans Levee Board was roundly criticized for spending most of its time on commercial real estate ventures rather than its core levee maintenance mission. In addition, as noted earlier, encroachment near the floodwalls by local property owners made critical remedial work identified by the USACE difficult or impossible to undertake. Despite these seemingly obvious omissions and shortfalls, everyone involved in the project, from the U.S. Congress, the USACE, the Levee Districts, city government, and individual homeowners, acted as if a fail-safe flood protection system were in place" (Gordon & Little, 2009, p. 8).*

In summary, "the pressure for tradeoffs and low-cost solutions likely compromised quality, safety, and reliability" (Andersen et al., 2007, p. 72). Additionally, due to the separation of responsibilities for design and maintenance of system elements, "the levees were not always maintained properly" and "the group of agencies did not work together to ensure that the New Orleans area was protected from hurricane damage" (Andersen et al., 2007, p. 70). Consequences of decided upon institutional arrangements and unclear responsibilities are stark according to Andersen et al. (2007): "As the hurricane protection system for New Orleans was being designed and debated amongst the USACE and state and local stakeholders, compromises were made based on cost, land use, environmental issues, and other conflicting priorities. Protection of the public's safety was not always the outcome of these compromises" (p. 74).

As for the drainage system, "The foremost constraint was the necessity of designing a system that would drain land below sea level, and convey the drained water to a discharge point at or above sea level… There were only three possible outlets for the water. All of them were located at elevations higher than the land to be drained" (United States Army Corps of Engineers, New Orleans District, 1999, p. 79). In New Orleans, water runoff is drained then pumped into Lake Pontchartrain, Lake Borgne, or other close bodies of water through major canals (Figure 5).

Figure 5: Map of New Orleans waterways (Andersen et al., 2007)

A summary of the city's drainage system today, courtesy of the SWBNO:

> *"The drainage system boasts 99 major drainage pumps, 21 constant-duty pumps to manage groundwater intrusion in its canals, 24 pump stations, 200 miles of canals, and another 1,500 miles of underground drainage pipes. Uniquely, the Sewerage and Water Board produces its own power to run the majority of water and drainage pumps that are essential to the city's system" (Sewerage and Water Board of New Orleans, 2022, p. 10).*

Regarding the nearly 100 pumping stations in the New Orleans area, some are recently constructed and some are almost 100 years old (Andersen et al., 2007). As for their power source, approximately 60 percent of the power for the pump stations "has to be generated locally, at their own 20 MW generator stations. Unfortunately, all of these generating stations are located below mean gulf level and subject to shut-down by flooding" (Snow, 1992, as cited in Rogers, 2006, p. 33).

The SWBNO drainage system is primarily supported by property millages (taxes), with relatively minor additions from bonds (Sewerage and Water Board of New Orleans, 2019b). Importantly, a 2011 Bureau of Governmental Research analysis showed "about 43% of the taxable value of properties in New Orleans are exempt either because they are owned by government or some non-profit organization, or the property's assessment is too low to pay the millages when accounting for the homestead exemption. As a result, many large generators of runoff, such as parking lots, churches, schools, and hospitals pay nothing for drainage service—inequitably placing a burden on the homeowners and businesses who pay for drainage through their real estate taxes" (Sewerage and Water Board, 2019, p. 10). Historic and continued lack of funding has forced SWBNO to delay system maintenance, cut operating costs, and postpone or sparingly select capital projects (Sewerage and Water Board of New Orleans, 2022).

Funding for the city's responsibility of the minor drainage system (drainage pipes smaller than 36 inches in diameter and all drainage basins) comes from the city's general fund in the annual budgeting process (Sewerage and Water Board, 2022).

4.2.2.2 Sewerage and Water Board of New Orleans

The Sewerage and Water Board of New Orleans (SWBNO) was established by the Louisiana Legislature in 1899 to "construct and operate water, sewerage, and drainage works to be funded by a voter-approved property tax" (Gordon & Little, 2009, p. 2). In 1903, the Drainage Commission merged with SWBNO, consolidating responsibility of drainage, water, and wastewater operations under one entity for efficiency (Sewerage and Water Board of New Orleans, 2022; Rogers, 2006; United States Army Corps of Engineers, New Orleans District, 1999). SWBNO remains an independent municipal agency as "one of 10 "unattached" boards and commissions placed under the executive branch by New Orleans' home rule charter, meaning it's not attached to a specific department of the city government" (Howard, 2018, p. 1).

Importantly, funding for each division – drainage, water, and sewerage – must be kept separately by law, meaning each division has its own dedicated source; however, a two-thirds Board vote can divert funds between divisions in case of emergency (Sewerage and Water Board of New Orleans, 2019b). To increase millages dedicated to finding drainage operations, maintenance, and improvements, increases must be set by the City Council and approved by citizen voters (Sewerage and Water Board of New Orleans, 2019b). This arrangement gives the city government substantial control over SWBNO funding through levying taxes (Howard, 2018). Significantly, in 1991, "voters refused to renew a 2-mill tax that supported the drainage system. No funding source came to the City with its new responsibilities" (Howard, 2018, p. 2). This transferred responsibility of the minor drainage system to the city's Department of Public Works (DPW) (see Section 4.2.2.4).

At present, "SWBNO has drawn down its reserves, borrowed money that it cannot repay, is nearly $40 million in arrears on contractor payments, and has imperiled its ability to issue further bonds. Additional funding is critical for continued operation" (Sewerage and Water Board of New Orleans, 2019b, p. 11).

4.2.2.3 United States Army Corps of Engineers (USACE) and the federal government

The federal government, through its legislative powers, USACE, funding powers, and some of its programs, has a critical role in flood control in New Orleans. The U.S. Congress authorizes USACE projects and responsibilities in the city, and has control over the "purse-strings" for project funding. "As a federal agency, the USACE and its projects are funded by the federal government, with a share of the costs borne by the local sponsor. Every year, the USACE requests funding. Through the federal budget-setting process, the Executive Branch (via the Office of Management and Budget) and the United States Congress authorize a project and allocate funding, but not necessarily at the same dollar amounts as requested or required" (Andersen et al., 2007, p. 72). Federal money remains one of, if not the largest, source of funding available for infrastructure investments on the state and local scales (Fields, Thomas, & Wagner, 2017). The Congressional funding power in the New Orleans flood control context resulted in irregular funding, thus a hurricane protection system that was constructed piecemeal, "with an overall lack of attention to 'system' issues" (Andersen et al., 2007, p. 72). In the case of the LPVHPP, a project was projected to be complete by 1978 in 1971, on January 1, 2005, it was only 80 percent complete – with disastrous consequences to come in August 29th of that year during Hurricane Katrina (Horowitz, 2020).

Specific to New Orleans, USACE became responsible for Mississippi River levees through the MR&T project in 1928 following the passage of the Flood Control Act of 1928. USACE became profoundly involved in the design and construction of drainage canals, floodwalls, and additional levees through a federal study that began in 1955 and culminated in the LPVHPP in 1965 following

Hurricane Betsy (see Section 4.3.3.3) (Horowitz, 2020; Rogers, 2006). USACE acts as "engineer" for levee districts, though local sponsors must approve of designs and actions (Andersen et al., 2007). "For instance, following Hurricane Betsy, the USACE proposed providing hurricane protection along the Lake Pontchartrain lakefront instead of along the canals. This proposal was strongly opposed by the Sewerage and Water Board of New Orleans and by the Orleans Levee District, and ultimately dropped by the USACE" (Andersen et al., 2007, pp. 70-71).

Though entrusted with the research and study behind engineering decisions made in New Orleans, "External peer reviews were conducted on very few, if any, of New Orleans's hurricane protection system projects," and, as a result, "questionable engineering decisions were made… Margins of safety were too low in designing the levees. Improper datums were used in construction. The standard project hurricane was not updated" (Andersen et al., 2007, p. 71). The greater engineering community was not utilized for review, and USACE committed grave errors in judgement in some design decisions (see Section 4.3.3.4 for further detail) (Andersen et al., 2007).

Finally, it is essential to mention the National Flood Insurance Program (NFIP) when discussing relevant federal programs for the New Orleans context. Created in 1968 under the National Flood Insurance Act, the NFIP attempted to discourage building in flood prone areas through creating specific flood insurance rate maps (FIRMs) as a prerequisite for community eligibility for the program, land use regulations to prevent development in hazardous FIRM areas, and by withholding subsidies for new construction in flood prone areas (Horowitz, 2020). Prior to 2005, "the NFIP was self-sufficient, had minimal borrowing authority, and for the most part was able to pay small principal repayments and accompanying interest expenses" (Cannon, Gotham, Lauve-Moon, & Powers, 2020, p. 2). By 2005, 67 percent of New Orleans carried flood insurance compared to a national rate of 5.4 percent (Horowitz, 2020). However, in 2018, that number had fallen to just 20.74 percent (FEMA, 2018, as cited in Cannon et al., 2020).

The NFIP was $20.5 billion in debt as of December 31, 2017, even after a $16 billion debt cancellation, from accumulation of debt since 2005 (Cannon et al., 2020). "As designed and implemented, the current program is unable to repay this debt. In FY 2018 alone, the NFIP paid over $375 million of interest expenses" (FEMA, NFIP, 2018, as cited in Cannon et al., 2020, p. 2). In the near future, the NFIP must come up with a way to maintain fiscal sustainability, even in the face of growing threats due to climate change, else risk losing the "ability to borrow money from the Treasury or issue new contracts" (Cannon et al., 2020, p. 3).

4.2.2.4 City of New Orleans government and levee districts

The city's Department of Public Works (DPW) is responsible for the minor drainage system, including 72,000 catch basins and almost 1,200 miles of drainage pipes (Sewerage and Water Board, 2019). The city took on this role in 1991, when voters voted down a renewal of the 2-mill tax meant to support the drainage system (Howard, 2018). "DPW is responsible for more than 80% of all drainage lines (including canals) in New Orleans" (Howard, 2018, pp. 1-2). Separate from DPW, it is also important to note that the city government through the City Council has significant control over SWBNO funding via its tax levy power. Further, SWBNO "must obtain the approval of both the City Council and the Board of Liquidation before issuing bonds or (with a limited exception) raising sewer and water rates" (Howard, 2018, pp. 2-3). Lastly, with the mayor on the Board of Directors, there is an inextricable link between SWBNO governance and politics.

The Orleans Levee District was established by the Louisiana legislature in 1890, responsible for "the operation and maintenance of levees, embankments, seawalls, jetties, breakwaters, water basins, and other hurricane and flood-protection improvements surrounding the City of New Orleans, including the southern shores of Lake Pontchartrain and along the Mississippi River" (Gordon & Little, 2009, p. 2). Critical to the understanding of public discontent with levee districts is their governing boards: "appointed by the governor, the levee districts were meant to oversee the process of managing the state-owned lands, using the proceeds to build levees or construct drainage schemes, as Congress had intended four decades earlier" (Horowitz, 2020, p. 25). Criticism of levee boards was evident in Congressional House hearings and reports post-Katrina, where studies and testimonies brought up lack of warning systems, responsibilities in times of crisis, inter-district communication, and fixation on assets meant to help pay for levee improvements rather than the maintenance work itself ("Hurricane Katrina," 2005; H. Rep. No. 109-377, 2006; Andersen et al., 2007).

Following these Congressional hearings post-Katrina, and as a result of public and political actor discontent with levee district arrangement pre-Katrina, levee districts were reorganized by the Louisiana state legislature in 2006. The levee district responsible for the majority of Orleans Parish now is the Southeast Louisiana Flood Protection Authority-East.

4.2.2 What periods of time can be classified as critical junctures (1893-present) and what were the results of those periods?

This section will identify and explore the periods of time that can be classified as critical junctures in the context of water management in New Orleans (see Section 2.1.7 for definition). Important to reiterate, critical junctures, though capable of disrupting and destabilizing institutional inertia, do not necessarily result in changes to the institutional setting (Capoccia & Kelemen, 2007; Sorensen, 2018). As showcased in the Conceptual Framework (Section 2.2), critical junctures frequently are followed by another period of institutional inertia, whether that period be on the same path-dependent pathway or a different, path-dependent, one. Specific to the New Orleans context, as will be detailed in this section, critical junctures in the city have largely failed to break the flood-resistant paradigm and approach to water management adopted by actors and institutions in the city since the drainage system's inception.

Each description of identified critical junctures in this section will be structured as follows: period of occurrence, description of juncture, result of juncture, and inferences on why they failed to break institutional inertia.

4.2.2.1 Drainage system inception (1893-1903)

Prior to the construction of the modern drainage system that began in 1896, development in New Orleans was confined to the area closest to the Mississippi River – a natural ridge created by sediment deposition following riverine floods – with mostly swamp lands on the lake side of the city (United States Army Corps of Engineers, New Orleans District, 1999). The United States Army Corps of Engineers New Orleans District (1999) paints a picture of the drainage system at that time:

> *"Most of the inhabited area of the city was close to the river, and drainage consisted of open ditches extending from the slightly elevated land near the river to the swampy area behind the city. The available pumping machines appeared similar to riverboat paddlewheels and pushed the rain water into outfall canals. Drainage was slow, and the flow very polluted because there was no treatment of sewage. Flooding was frequent, and the area below lake level could not be developed. Such was the general situation when the New Orleans Mayor and City Council decided that something should be done to dramatically improve drainage" (p. 79).*

Though there had been attempts to create a government entity assigned the task of drainage in New Orleans prior to 1893 (i.e., the establishment of the drainage advisory board tasked with creating a drainage plan for the city), those efforts had failed for a variety of reasons: lacked public official backing, no government funds for plans, and/or public opposition (United States Army Corps of Engineers, New Orleans District, 1999).

The period of 1893 to 1903 presents itself as a critical juncture in the water management sector in New Orleans. Arguably the most important juncture in its history, this period saw the development of a comprehensive drainage system (plan finished in 1895, with construction beginning in 1896), much of which "is still operational today, utilizing the major plan features and operating principles of the 1895 plan" (United States Army Corps of Engineers, New Orleans District, 1999, p. 79).

Critical to the idea that this period was indeed a critical juncture were a few elements that present. First, civic leaders and the public recognized at this time that New Orleans could not develop any further (thus not expand economically) without a concentrated effort to design and construct drainage and sewerage systems. These sentiments culminated in City Council's decision to bring together a Drainage Advisory Board in 1893, which it "provided $700,000 to gather the necessary topographic and hydrologic data, study the situation, and make recommendations on how the problems might be solved" (Rogers, 2006, p. 28). The Board consisted of engineering experts from public, private, and academic sectors, and its plan was submitted to the City Council in 1895 (Rogers, 2006; United States Army Corps of Engineers, New Orleans District, 1999).

The Louisiana State Legislature created the Drainage Commission of New Orleans in 1896, and this entity was tasked with designing and implementing drainage projects in the city along with exploring how to fund this major undertaking (Rogers, 2006). "Construction, begun in 1896, received an additional impetus in 1899 when voters—including some women, who were able to vote in this referendum through their ownership of property—overwhelmingly approved a two-mill property tax to fund the Sewerage & Water Board of New Orleans" (Campanella, 2018).

The SWBNO was established via the Louisiana State Legislature in 1899 due to revenue from this millage, and it was tasked with the responsibilities to "to furnish, construct, operate, and maintain a water treatment and distribution system and sanitary sewerage system" in the city (Rogers, 2006, p. 29). As construction continued into the 20th century, the SWBNO was merged with the Drainage Commission in 1903 to make operations managing water in the city more efficient, an institutional arrangement that remains today (Rogers, 2006). Figure 6 shows the drainage system as it stood in 1903.

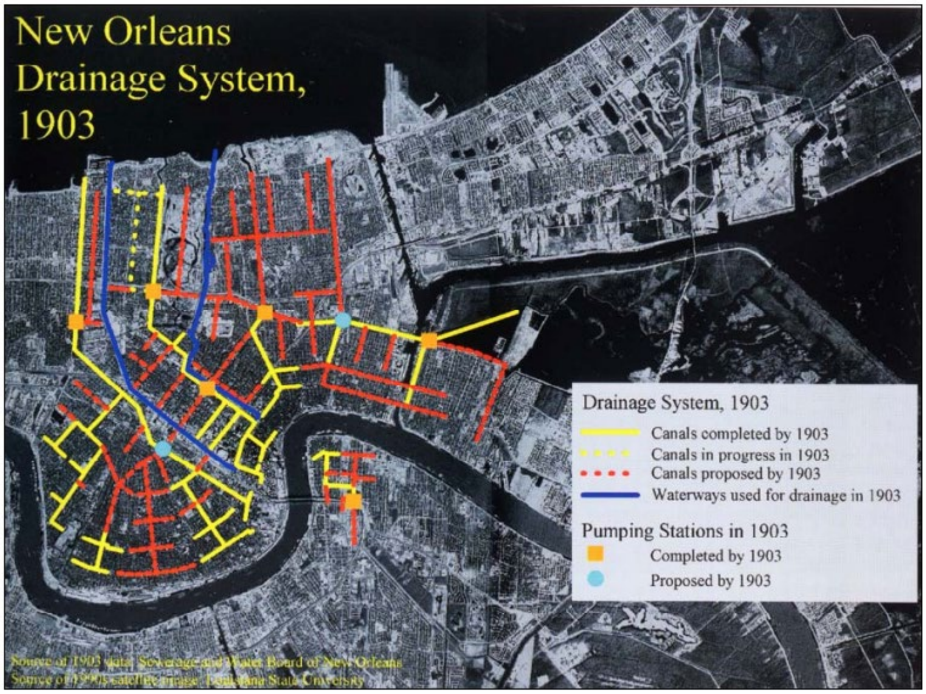


Figure 6: Drainage system infrastructure in 1903 (Rogers, 2006, p. 29, as taken from Campanella, 2002)

Results of construction of this new system were relatively immediate and significant. Between 1900 and 1914, the assessed values of property in the city grew almost 80 percent (United States Army Corps of Engineers, New Orleans District, 1999). Additionally, "tax coffers skyrocketed as swamps became subdivisions; malaria and typhoid cases decreased tenfold, and death rates plunged with improved sanitation" (Campanella, 2018).

This first critical juncture separates itself from the following ones in that its impacts accomplished breaking from the institutional norm that preceded its period. Governmental institutions were established where there were not any prior, and the drainage system (along with separate drinking water and sewerage systems) altered the city's landscape (and its development possibilities) with consequences felt at present day. Importantly, this moment congregated public official and resident sentiments in favor of designing, implementing, and critically paying for this system. Furthermore, the path-dependent pathway that was established during this period was characterized by flood-resistant infrastructure in which water was viewed as a "problem to be solved, rather than a condition to be managed" and thus construction of elements that were "aimed at removing as much water as possible through mechanization" throughout the city (Campanella, 2018).

4.2.2.2 Historic Mississippi River flood (1927-1928)

The Mississippi River flood of 1927 was historic in its volume, flooding effects across the Mississippi River states, and policy consequences. There had been four river floods in Louisiana prior to 1927, each with more damages than the one before (Rogers, 2006; Horowitz, 2020). Though the 1927 river flood had no flooding impacts on New Orleans – the last time that occurred was in 1859 – it remains a critical juncture for the city due to its institutional and political flood control consequences (Rogers, 2006).

A levees-only flood control policy became established for the Mississippi River throughout the 19th century, guided via influence by the USACE. Local entities began constructing levees along the river, sometimes with help from the federal government, in the 1800s to prevent riverine flooding that occurred semi-frequently with varying consequences. As more levees were built along the river, river stage increased and thus volume of water held back by those structures also increased. The levee system also had two other significant impacts: first, it disconnected the Mississippi River Delta from its sediment source; second, it fomented a false belief in citizens connected to the river that they "no longer had to fear the Mississippi" (Horowitz, 2020, p. 35).

The 1927 river flood remains the largest ever recorded on the lower Mississippi River valley (Rogers, 2006). Rogers (2006) details its consequences for the valley: "The levees that were supposed to protect the valley broke in 246 places, inundating 27,000 square miles of bottom land; displacing 700,000 people, killing 1,000 more (246 in the New Orleans area), and damaging or destroying 137,000 structures" (p. 7). The flood coincided with a record precipitation storm in New Orleans, which dumped 18 inches of rain on the city in a 48-hour period in March of 1927, overwhelming the drainage system and flooding much of the city (Rogers, 2006). Flooding associated with the river caused "more than $400,000,000 in losses; 92,431 businesses were damaged and 162,017 homes flooded… In Louisiana alone, 10,000 square miles in 20 parishes went underwater" (Bradshaw, 2011).

Politicians in Louisiana and New Orleans faced a difficult choice during the flood when the river reached critical heights near the city threatening its valuable property. Bradshaw details this point in time:

> *"The threat continued to worsen, however, and state government officials believed the levees would inevitably break. If the break happened below New Orleans, it would relieve pressure and spare the city from massive flooding. An upstream break, on the other hand, would send a disastrous flood into New Orleans. Despite strenuous objections from people living downstream, Governor O. H. Simpson and his advisors acquiesced to a plea from New Orleans civic leaders to blast a breach in the levee. This would give the flood a shortcut to the sea and drop the river level at New Orleans, at the cost of flooding further south. Engineers chose a westward loop in the river at Caernarvon and began blowing the levee apart on April 29. Over the next ten days they used thirty-nine tons of dynamite to open a channel that released 250,000 cubic feet of water per second from the river" (Bradshaw, 2011).*

Residents in these areas impacted south of New Orleans were evacuated, left without homes and livelihoods once the breaches were achieved, and only a few would ever receive some relatively paltry compensation for their losses (Bradshaw, 2011). "Adding to their anger, a natural breach of the levees subsequently eased pressure on the New Orleans levee; the blasting had been unnecessary" (Bradshaw, 2011).

The levees-only policy of flood control for the Mississippi River was exposed as an inadequate solution in the 1927 river flood; as a result, the federal government was forced to evaluate and update its flood control policy, culminating in the Flood Control Act of 1928 (Bradshaw, 2011; Rogers, 2006). The United States Congress authorized the Mississippi River and Tributaries (MR&T) Project in the Flood Control Act of 1928, authorizing the Mississippi River Commission (est. 1879) – controlled by the USACE – to "provide for flood protection along the Mississippi River between Cape Girardeau, MO and Head-of-Passes, LA" (Rogers, 2006, pp. 8-9). The MR&T Project became known at the time as the "Jadwin Plan," as Major General Edgar

Jadwin was the Army's Chief of Engineers as it was authorized (Rogers, 2006). The Jadwin Plan consisted of four major elements, explained by Rogers (2006):

> *"1) levees to contain flood flows wherever practicable, or necessary to avoid razing large sections of existing cities and transportation infrastructure; 2) bypass floodways to accept excess flows of the river, passing these into relatively undeveloped agricultural basins or lakes; 3) channel improvements intended to stabilize river banks, to enhance slope stability and commercial navigation; and 4) improvements to tributary basins, wherever possible. This category included dams for flood storage reservoirs, pumping plants, and auxiliary channels" (p. 9).*

In essence, the authorization of the MR&T project signalled a shift in river flood control by the federal government, moving away from levees-only management into a more varied approach. That said, for New Orleans, levees and floodwalls along the Mississippi River remain steadfast protection elements that would be devastating if brought to failure. MR&T elements that ease threats via the river include strengthened levees upstream and downstream, the Bonne Carre Spillway and Morganza Floodway upstream of New Orleans, along with the Old River Control Structure that diverts 1,500,000 cubic feet per second of river water from the Mississippi into the Atchafalaya River (Figure 7). Construction on projects did not start until 1931, when federal funds were first appropriated by Congress (Rogers, 2006).

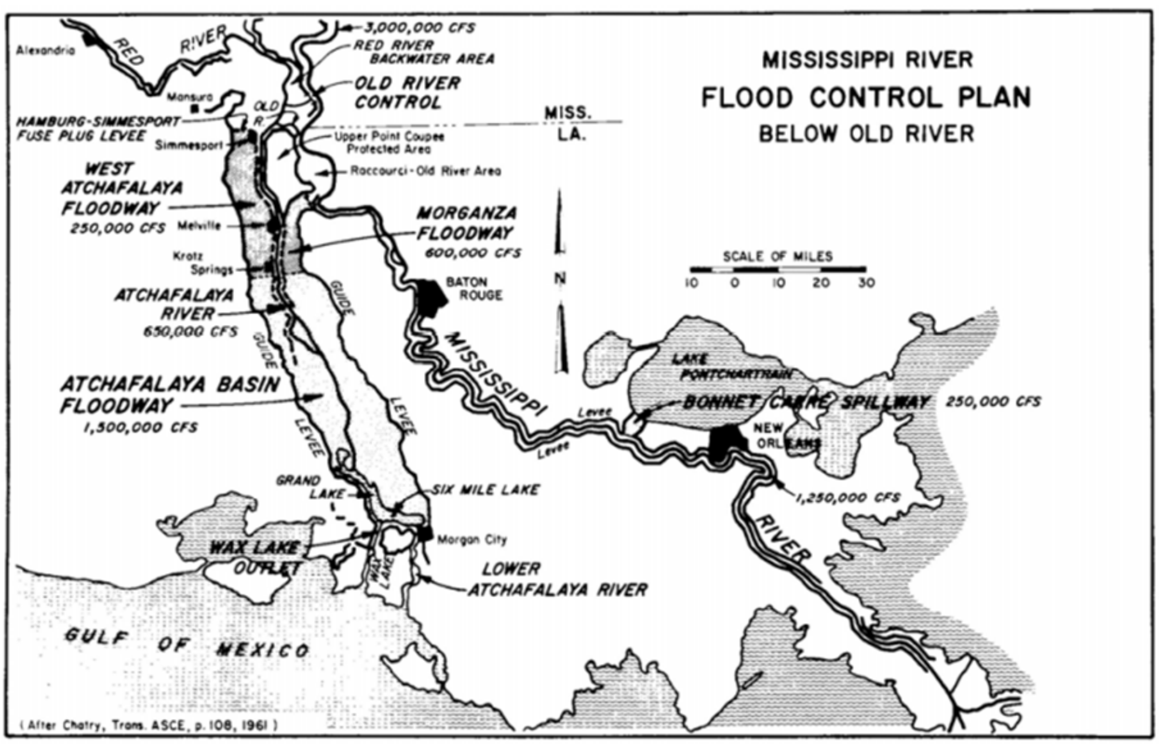


Figure 7: MR&T elements in Louisiana (from Chatry, 1961, as cited in Rogers, 2006)

Though adjustments were made to the implemented methods of flood control on the Mississippi River in this period – setting a path-dependent pathway of this heavily regulated, government-maintained system – the flood-resistant paradigm remained strong. Thus, while this period opened a “range of plausible choices” to “powerful political actors,” and the “consequences of their decisions for the outcome of interest” were particularly impactful, changes came in the form of system strengthening an diversification of hard infrastructure along with the cementing of the federal government’s role in flood control on the river (Cappocia & Kelemen, 2007; Rogers, 2006; Bradshaw, 2011).

4.2.2.3 Hurricane Betsy (1965)

The critical juncture period begun by Hurricane Betsy in 1965 requires political context that preceded its moment in time that was characterized by quick, decisive decision-making following the storm. Importantly, this critical juncture period contained two significant elements with impacts to flood control and water management in the city of New Orleans: increased federal involvement within city limits for hurricane protection and drainage (specifically the city’s drainage canal system, separate and different from its role on the MR&T system), and the authorization of funds and construction of the Lake Pontchartrain and Vicinity Hurricane Protection Project (LPVHPP) in 1965 (Rogers, 2006; Horowitz, 2020; Gordon & Little, 2009).

In 1955, the U.S. Congress approved a USACE study considering hurricane protection for the city of New Orleans, culminating in the completion of the LPVHPP study in 1962. Rogers (2006) describes what the USACE studied during this period:

> *“The Corps studied the problems posed by the drainage canals, which had settled as much as 10 feet since their initial construction in the mid-19th Century. This settlement had necessitated two generations of heightening following hurricane-induced overtopping in 1915 and 1947. Each of these upgrades likely added something close to three additional feet of embankment height to keep water trained within the drainage canals and provide sufficient freeboard to prevent storm surges emanating from Lake Pontchartrain from overtopping the canal levees. The maximum design capacity of the three principal drainage canals (17th Street, Orleans, and London Avenue) was about 10,000 cfs, but this figure was being reduced by settlement and sedimentation problems” (pp. 35-36).*

Following the completion of the study in 1962 and following three years of “various bureaucratic reviews and approvals,” the USACE provided the plan to Congress; specifically, the LPVHPP study “arrived at the Committee on Public Works in July 1965, less than two months before Hurricane Betsy made landfall” (Horowitz, 2020, p. 86).

Hurricane Betsy made landfall on September 9, 1965, as a Category 4 storm on the Saffir-Simpson scale (Appendix A.4 for scale). Storm surge caused by the storm overwhelmed the city’s levee protection system, causing widespread flooding and damage. Rogers (2006) details that Betsy caused the worst flooding in the city since another hurricane in 1947 – “Winds gusts up to 125 mph were recorded in New Orleans along with a storm surge of 9.8 ft, which overwhelmed both sides of the Inner Harbor Navigation Canal (IHNC), flooding the Ninth Ward, Gentilly, Lake Forest, and St. Bernard Parish areas, as well as all of Plaquemines Parish” (p. 16). It is estimated that almost 100,000 houses in New Orleans sustained damages during the storm (13,000 with major damage) (Horowitz, 2020). Hurricane Betsy became the first natural disaster in the US with over one billion dollars in damages across the affected areas. Apart from damages to property, there were 81 fatalities (53 in Louisiana) from the storm (Rogers, 2006).

Following Hurricane Betsy and the damages and loss of life it incurred, “the authors of the Committee on Public Works’ report asserted that the levee system the Corps had proposed, ‘would have eliminated the flooding of developed areas in the city of New Orleans [and] the Chalmette area of St. Bernard,’ decreasing the cost of damages by $85 million and ‘greatly reduc[ing]’ the number of deaths” (Horowitz, 2020, p. 86). Congress authorized construction of the LPVHPP in late October of 1965, one of the largest and most ambitious civil works projects in the country’s history (Horowitz, 2020; Rogers 2006). Rogers (2006) explains what the LPVHPP entailed:

> *“In October 1965 Congress approved a $2.2 billion public works bill that included $250 million for Louisiana projects and $85 million down payment for a system of levees and barriers around New Orleans. This work included raising the Lake Pontchartrain levee to a height of 12 ft above Mean Gulf Level (MGL) in response to the flooding caused by Betsy. The Orleans Levee Board also let contracts to pound steel sheetpile walls along the crests of their drainage canal levees to increase their effective height, so storm surges on Lake Pontchartrain would not overtop the drainage canals (which had occurred in 1915, 1947, and 1965, but without catastrophic loss of the canal levees). The uncased sheetpiles were intended to be a temporary measure, awaiting a permanent solution that envisioned placement of concrete flood walls using the sheetpiles as their foundations, funded by the Federal government” (p. 17)*

With the federal government now involved more heavily in flood control in the city, responsibilities for actors in the sector were designed as follows: “The USACE was charged with designing and building improved levees, the Orleans and Jefferson Parish Levee Districts with levee maintenance, and the S&WB with operation and maintenance of the pumping stations” (Gordon & Little, 2009, p. 2).

Though the federal government had been studying the possibility of hurricane protection for the city of New Orleans since it began its study in 1955, Hurricane Betsy provided a moment in time “in which the structural (that is, economic, cultural, ideological, organizational) influences on political action are significantly relaxed for a relatively short period” (Capoccia & Kelemen, 2007, p. 343). Legislation for the city had been dragging in Congress prior to the natural disaster yet following its devastation it was quick to act. For the federal government – and essential to the continued development and residency in New Orleans – the authorization of the LPVHPP signalled a view that the costs of the new hurricane protection system were outweighed by its benefits. Explicitly, Horowitz (2020) notes that the “scale tipped in favor of the project based on the growth it would support” (p. 87).

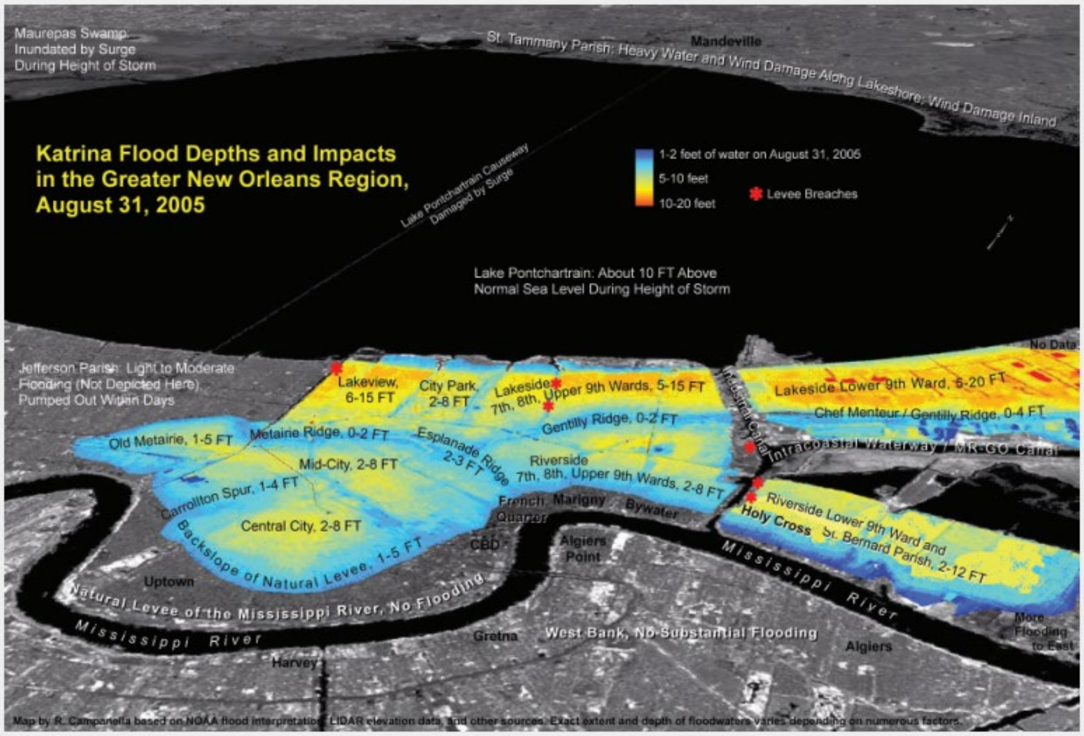
Seemingly in a good place, thus, with the commitment of the federal government to design and build the LPVHPP, it confounds that 40 years later, Hurricane Katrina brought with it so many devastating impacts – many of which are now deemed a result of engineering failures of the system. Accordingly, prior to the discussion of Hurricane Katrina (Section 4.2.2.4), it is prudent to offer some additional context for that period (see Appendix A.2 “Significant Congressional, Judicial, and USACE Decisions Related to the LP&VHPP” for a detailed timeline). “Although Congress had hurried to authorize the LPVHPP after Betsy, it made appropriations in a piecemeal fashion--and the Corps undertook a series of new studies to update its designs- so the Corps did not show meaningful progress on the new system for several years” (Horowitz, 2020, p. 88). New concrete floodwalls on the Industrial Canal and over 40 miles of new levees in New Orleans East and Chalmette had been completed by 1974 (Horowitz, 2020). However, construction on the Lake Pontchartrain barrier, the “linchpin of the system,” had not begun by 1975 (Horowitz, 2020). “In 1971, the Corps had projected that the system would be complete by

1978; in 1976, it revised its projection to 1991. The estimated cost had increased to over $350 million. In the meantime, the LPVHPP became subject to the new regulatory regime heralded by the National Environmental Policy Act of 1969 and the Clean Water Act of 1972" (Horowitz, 2020, p. 88). By January of 2005, USACE reported that the LPVHPP was only 80 percent complete (Horowitz, 2020).

4.2.2.4 Hurricane Katrina (2005)

Hurricane Katrina was a tropical cyclone that reached Category 5 strength but weakened to a strong Category 3 storm before landfall in Louisiana on August 29, 2005. It remains the costliest storm in U.S. history, with total damages reaching $186.3 billion (adjusted to reflect the 2022 Consumer Price Index cost) (NOAA National Centers for Environmental Information, 2022). "Approximately 80 –85% of New Orleans flooded not from a direct hit by the hurricane, but because of a series of errors in the design, construction, and maintenance of the levees, floodwalls, and canals that comprised the federal hurricane protection system on 29 August 2005" (Steinberg, 2006, Seed et al., 2006, Houck, 2006, as cited in Wagner & Frisch, 2009, p. 237). Andersen et al. (2007) found that "approximately two-thirds of the flooding attributed to water flowing through [levee] breaches. The remainder was attributed to overtopping and significant rain from the hurricane" (p. 31).

Flood depths reached up to 20 feet in some areas of the city, causing both catastrophic property damages and loss of life (Figure 8). Further, due to the city's position below sea level and the destruction of pump capacities and levees/canals due to flooding, floodwaters remained in parts of the city for 43 days (Horowitz, 2020).



As the levee breaches flooded the metropolis, the few feet of elevation that differentiated the topography of New Orleans imperceptibly to the naked eye now dramatically spelled the difference between survival or destruction of entire neighborhoods. While most of the areas shaded blue in this map will probably be salvaged, those areas in yellow are in question, and those areas in brown and red will likely be partially bulldozed. *Map and analysis by author.*

Figure 8: "Katrina flood depths and impacts in the Greater New Orleans Region, August 31, 2005" (Campanella, 2006, p. 399)

Recall from Section 4.3.2.3 that the LPVHPP remained unfinished come 2005, resulting in an appalling USACE post-storm confession that the hurricane and flood protection system by the time of Hurricane Katrina "was a system in name only" (Horowitz, 2020, p. 129). Horowitz (2020) contends that its incomplete state was a result of "plodding bureaucracy and piecemeal federal appropriations" in the 40 years since the LPVHPP was authorized (p. 129). Andersen et al. (2007) goes further, stating that in addition to piecemeal appropriation and construction, "there were pressures for tradeoffs and low-cost solutions that compromised quality, safety, and reliability" (Andersen et al., 2007, p. vii). When strong storm surge brought by the storm hit the flood control system in place in 2005, it proved unable to hold them back, forcing levee breaches/failures in numerous areas around the city (Figure 9). In more detail, "The massive, destructive flooding of New Orleans was caused by ruptures at approximately 50 locations in the city's hurricane protection system. Of the 284 miles of federal levees and floodwalls — there are approximately 350 miles in total — 169 miles were damaged" (Andersen et al., 2007, p. 25).

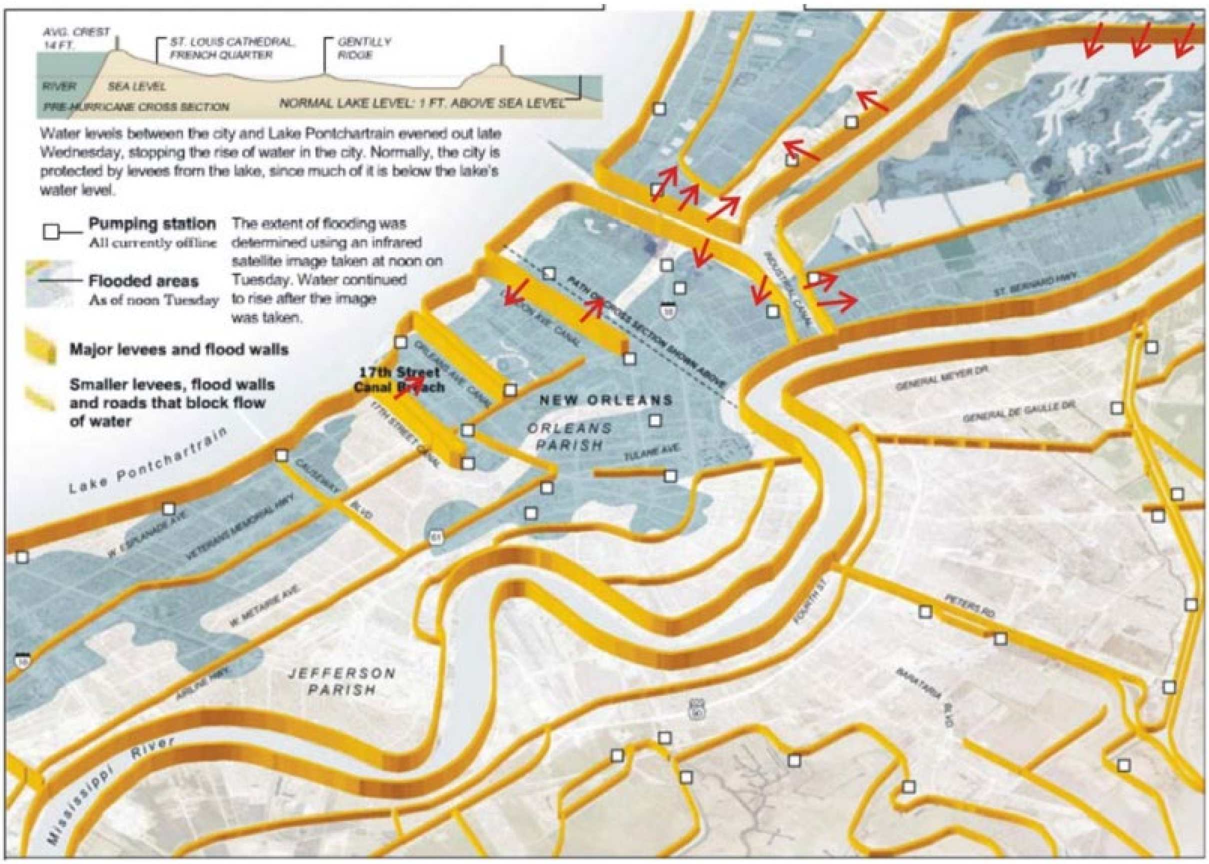


Figure 9: Levee and floodwall protection system in New Orleans (red arrows denote levee failures) (image by the New York Times, as cited in Rogers, 2006, p. 40)

In a forensic engineering review of the levee failures throughout the city, research conducted by Andersen et al. (2007) supported the following conclusions:

> *"There were two direct causes of the levee breaches: collapse of several levees with concrete floodwalls (called I-walls) because of the way they were designed, and overtopping, where water poured over the tops of the levees and floodwalls and eroded the structures away. Furthermore, the many existing pump stations that could have helped remove floodwaters were inoperable during and after the storm" (p. v).*

It is now clear that there were severe study result misinterpretations and miscalculations that resulted in engineering decisions with a too-low margin of safety for the city and for the protection of life (Andersen et al., 2007; Miller, Jonkman, & Van Ledden, 2015). Particularly these gross errors were relevant in the design and implementation of the I-walls in the drainage canals throughout the city that were meant to supplement canal levee strength and height along with levees built around the city that were not designed for overtopping (Andersen et al., 2007). The result of these errors – went largely unchecked due to a vested lack in external peer reviews that allowed these poor engineering decisions – manifested in:

- Toppled I-walls due to geotechnical failure to account for a water-filled gap (causing failure before pressures met design standards): "The engineering design did not account for the variability in the strength of soft soils beneath and adjacent to the levees. The designers failed to take into account a water-filled gap that developed behind the I-walls as they bowed outward from the forces exerted by the floodwaters" (Andersen et al., 2007, p. vi; Rogers, 2006)

- Improperly designed levees: "the levees were not armored or protected against erosion — an engineering choice of catastrophic consequences because this allowed the levees, some constructed of highly erodible soil, to be scoured away, allowing water to pour into New Orleans" (Andersen et al., 2007, p. vi) and "Levee builders used an incorrect datum to measure levee elevations — resulting in many levees not being built high enough. Some levees were built 1 to 2 feet lower than the intended design elevation. Furthermore, despite the acknowledged fact that New Orleans is subsiding (sinking), no measures were taken into account in the design to compensate for the subsidence by monitoring the levees and raising them up to the pre-subsidence design elevation" (Andersen et al., 2007, p. vi).
- Ultimately: "The hurricane protection system was designed for meteorological conditions (barometric pressure and wind speed, for example) that were not as severe as the Weather Bureau and National Weather Service listed as being characteristic of a major Gulf Coast hurricane" (Andersen et al., 2007, p. vi).

Also significant, uncovered in studies of the disaster, was that no single agency was in charge of hurricane and flood protection in New Orleans (Andersen et al., 2007; Horowitz, 2020; Yim et al., 2007; "Hurricane Katrina," 2005) (for more detail, see Appendix A.3). It became clear that lack of inter-agency coordination caused inefficiencies and miscommunication that led to serious consequences during and directly after the storm (Andersen et al., 2007; "Hurricane Katrina," 2005). Andersen et al. (2007) highlight the consequences:

> *"No single agency or organization is empowered to provide the much-needed system-wide oversight or focus on the critical life-safety issues. No formal coalition of agencies is directed to provide strategic direction, definition of roles and responsibilities, and coordination of critical construction, maintenance, and operations. Indeed, it appears that no agency or group of agencies ever defined clear, mutually agreed-upon expectations of what the hurricane protection system was really intended to achieve" (p. 68).*

The combination of the above-mentioned elements and the impacts brought by Hurricane Katrina had devastating consequences for the city and its residents. There were over 1,000 fatalities associated with the disaster in Louisiana, an estimated 767 of which were in the city of New Orleans (Markwell & Ratard, 2012, as cited in Fields et al., 2017). An estimated 124,000 jobs were lost, value of residential property in the region fell by 25 percent, value of non-residential properties fell by 12 percent, there was significant damages to public infrastructure totalling in billions of dollars for repairs, and long-term loss of electricity provided even more complications to recovery efforts (Andersen et al., 2007).

Further, demographic differences in impact were clear. Extreme poverty, majority African American segregated neighborhoods suffered the worst impacts from the storm (Fussell and VanLandingham, 2010). Research from the Brookings Institution (2005, as cited in Cigler, 2007) found that "areas occupied by poor and immobile populations suffered disproportionate inundation during the hurricane. It was known that about 15 percent of New Orleans residents would rely on public transportation to evacuate — about 70,000 people — but such provision was not made" (p. 68). Further, approximately 52 percent of the fatalities associated with the storm were African American (compared to 40 percent white), and 60 percent of all deaths were people over the age of 70 (Andersen et al., 2007) (see Appendix A.5). Finally, "Of the more than 14,000 units of public housing that once stood in New Orleans, 7,379 remained standing in 2005, and only 5,146 were occupied. All but a very few of the residents were African American" (Horowitz, 2020, p. 158).

Had the levees not failed and the pumps operated at full capacity, it is estimated that "nearly two-thirds of the deaths would not have occurred" and "less than half the actual property losses… would have occurred" (Andersen et al., 2007, p. 39). The USACE estimated that if the LPVHPP had been constructed and maintained properly, flooding would have been reduced by two-thirds and economic damages by half (Horowitz, 2020).

It prudent to shift the discussion to Hurricane Katrina's impact as a critical juncture for the water management sector. Returning from the storm seemingly gave urban planners the opportunity to dramatically shift the geographic footprint of the city, not to mention its water management paradigm. Recalling the definitions of critical junctures set forth in Section 2.1.7, Hurricane Katrina becomes likely the most modern critical juncture in the period of study. Gawronski and Olson (2013) in particular discuss disasters as contingent events likely to set off a critical juncture period, where "decisions and choices among alternatives are often stark in their consequences" (p. 134).

Following Hurricane Katrina, there was a overwhelming evidence that the city was facing a large design moment: "In New Orleans the discussion of this physical aspect began with the fundamental discussion about the viability of the city and whether or not all or parts of it should be rebuilt" (MacQuarrie, 2005, Dionne, 2005, Bourne, 2007, Manaugh & Twilley, 2008, as cited in Wagner & Frisch, 2009, p. 239). There were several alternatives present to planners, as laid out by Wagner and Frisch (2009):

> *These ideas have included completely moving or relocating the city, the construction of 'super-levees' around the city or internal levees within it, raising the city on fill, building a floating city or an 'American Venice', reducing the city's urban footprint, and reconstructing the city around more functional systems of bayous, canals and waterways, also known as 'New Orleans meets the Dutch'" (Rose, 2008, Urban Planning and Water Safety Workshop, 2008, as cited on p. 239).*

Ideas presented represented four main concepts for the city: "city abandonment, city shrinkage, land-use changes, and design for sustainability" (Wagner & Frisch, 2009, p. 244). As these alternatives were presented to the larger public, it became clear that the public itself had largely not been a consulted in the creation of the ideas. Further, many of these plans saw the demolishing of majority-African American neighborhoods viewed as 'vulnerable' to make space for open, stormwater retention parks, making alternatives appear racist in their intent even if that was not always so (Horowitz, 2020) (see Appendix A.6 for example of a failed alternative, the 'Green Dot Plan'). Once published, there was significant public outcry related to several options that suggested shrinking the overall footprint of the city or dramatically changing its landscape (Wagner & Frisch, 2009). Ultimately, "Advocating their commitment to home and selfdetermination, an African American- and labor-led coalition of neighborhood-based groups forced City Hall to authorize and enable their vision of rebuilding the whole city" (Horowitz, 2020, p. 147).

"Despite these grand claims, the rebuilding and redesign of New Orleans has been more of an incremental process of small-scale interventions, of restoration and demolition on a piecemeal basis, rather than widespread clearance and planned reconstruction" (Wagner & Frisch, 2009, pp. 241-242). Directly after the storm, President Bush advocated for Category 5 storm surge levels of hard-infrastructure protection for the city; in December of 2005, Congress directed the USACE to produce a plan for this level of protection within two years (Horowitz, 2020). However, the USACE produced its plans late, three and a half years post-storm, and found that Category 5 risk reduction would have a price tag of between $59 to $139 billion (Horowitz, 2020). The peer review team for this publication criticized the USACE "for not offering a plan at all, but rather a vast list of options, thousands of pages of alternatives, without a path for action." (Horowitz, 2020, p. 177). Ultimately, Congress would only appropriate $120.5 billion, of which $75 billion was dedicated to emergency relief, and which was split between five states including Louisiana (Horowitz, 2020).

The return to the city, and the water management paradigms associated with safe return, were largely dependent on infrastructure in place that would satisfy flood insurance requirements for city coverage. No flood insurance coverage would mean "New Orleanians would be unable to secure mortgages, no homes would be rebuilt, and any possible recovery would stop in its tracks" (Horowitz, 2020, pp. 177-178). To satisfy insurance requirements, the region had to be protected against a 100-year storm. The Federal Emergency Management Agency (FEMA) agreed to maintain NFIP coverage in the city temporarily, even through the 2006 hurricane season with unfinished repairs to the system, with the promise from the federal government of a stronger hurricane protection system to be built (Horowitz, 2020). The "Bush administration officials began to hedge on their initial commitment to Category 5 protection. Instead, they offered support only for the 100-year protection necessary for the city to remain in the NFIP" and in "November 2007, Congress lowered the standard of protection for metropolitan New Orleans from the 200- to 250-year level it had authorized after Hurricane Betsy, to the 100-year level. The Corps had called its post-Betsy public works a 'hurricane protection system,' but it described its post-Katrina project as a 'risk reduction system'" (Horowitz, 2020, pp. 177-178).

The Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS), with a Congress-appropriated $14.43 billion price tag, contained some elements that were new (yet still hard infrastructure) (Horowitz, 2020, p. 178):

- *"A $1.1 billion, 1.8-mile long, 25-foot-tall concrete wall stretched across the Mississippi River-Gulf Outlet and the Gulf Intracoastal Waterway, designed to prevent storm surges from funneling into the city from the east."*
- *"A sixteen-foot tall floodgate was designed to prevent storm surges from entering the Industrial Canal from Lake Pontchartrain. Similar floodgates crossed the 17th Street Canal, the Orleans Avenue Canal, and the London Avenue Canal, designed to prevent storm surges from entering the*

drainage canals; large pumps at Lake Pontchartrain were designed to enable the city to continue to drain rainwater from within the city, even when the gates were closed."

- *"The Army Corps "armored" levees across the region, covering them with grass, concrete, and other materials designed to keep them from being scoured away and collapsing, even if they were overtopped."*

Yet, the water management paradigm largely remained the same – flood resistant infrastructure was repaired and strengthened. Further, many experts recognized that a 100-year level of flood protection wan inadequate for a major city (Horowitz, 2020). That said, FEMA certified the HSDRRS as meeting the NFIP standard in 2014, even with a caveat that some neighborhoods remained extremely vulnerable to flooding impacts. When FEMA announced that neighborhoods deemed "Special Flood Hazard Areas" would have to carry flood insurance to secure mortgages, the city appealed; by 2016, "FEMA announced that flood insurance would not be required in most of New Orleans. The next year, more than 3,000 policy holders in New Orleans dropped their flood insurance coverage" (Horowitz, 2020, p. 179).

It is important to note that there were some agency changes following the storm that in some ways marked a punctuation in institutional inertia: 1) the Coastal Protection and Restoration Authority was created in 2005 as a state agency dedicated to work on coastal restoration and hurricane protection, and 2) new levee district arrangements saw the Southeast Louisiana Flood Protection Authority-East created and designated control over the majority of Orleans Parish on the east bank of the Mississippi River (along with some of Jefferson and St. Bernanrd Parishes) by the State Legislature in 2006.

Additionally, it cannot be understated the social impact of Hurricane Katrina. It so clearly highlighted social vulnerabilities in New Orleans but did not necessarily change the city's course regarding addressing those vulnerabilities. Current patterns reflect similar trends to that before the storm. "In the eleven years following the storm, neighborhoods that were majority Black and in low-lying areas of the city became even more Black (e.g., New Orleans East, sections of Gentilly). In contrast, areas that were majority Black that were in higher elevations are increasingly becoming significantly whiter" (City of New Orleans & Housing Authority of New Orleans, 2016, p. 32). From 2015 U.S. Census Bureau statistics, the African American population in New Orleans appears to have decreased by 28 percent since 2005 (compared to a decrease of 7 percent in the white population (as cited in Horowitz, 2020). A Keen Independent Study (2018) found current "unequal access to home equity and home mortgages for people of color in the New Orleans metropolitan area" (p. 7). Again, from 2015 Census data, median white family income was $62,074, compared to an African American median family income of $26,819 (as cited in Horowitz, 2020). Horowitz (2020) continues on to highlight the racial disparities in quality of life ten years after the storm:

- *"Compared to white people, African Americans were far more likely to describe themselves as "very worried" that their children would not be able to get a good education, that the levees would not protect their neighborhoods, that they would not be able to find a good job, that they could not afford a decent place to live, or that they would be a victim of violent crime" (p. 196)*

- *"White people were more than twice as likely as African Americans to say that their quality of life had improved since the flood, while African Americans were more than three times more likely than white people to report that their lives had gotten worse" (p. 196)*

4.2.2.5 Tipping points

The discussion on critical junctures is not complete without mentioning some moments in time that were significant, yet did not fulfil wholly the definition of a critical juncture. Capoccia and Kelemen (2007) distinguish the two concepts: "In accounts that involve long-term, cumulative causes, there may be a tipping point—a point at which the cumulative cause finally passes a threshold and leads to a rapid change in the outcome —but a tipping point is not a critical juncture" (p. 351). This section describes two such tipping points that came up both in reviews of primary and secondary sources, as well as in supplementary interviews: the storms of May 1995 that preceded the authorization of the Greater New Orleans Hurricane and Storm Damage Risk Reduction System in 1996, and the August 5th, 2017 heavy precipitation event that caused widespread flooding throughout the city and the beginning of a local government reckoning with stormwater.

In the twentieth century there were several heavy precipitation events to strike the city outside of tropical cyclones; as the city became more developed in more vulnerable areas, the impacts these storms caused to property in the city increased. One such event that is the tipping point of note in this section was a historic precipitation event in May of 1995 that overwhelmed the drainage and pumping system in the city, with 4 to 12 inches of rain hitting across the city (Rogers, 2006). Between May 8 and 9 of 1995, in 40 hours of duration, the storm "damaged 44,500 homes and businesses, causing $3.1 billion in damages. This was the costliest single non-tropical weather related event to ever affect the United States" (Rogers, 2006, p. 21). This storm acted as a tipping point: in 1996, the U.S. Congress authorized "the design and construction of the Southeast Louisiana Urban Flood Damage and Reduction Project (SELA) in Section 108 of the Fiscal year 1996 Energy and Water Development Appropriations Act, and Section 533 of the Water Resources Development Act (WRDA) of 1996" (Sewerage and Water Board of New Orleans, 2019a). Through this legislation, the USACE and SWBNO (with a cost sharing agreement of 75%/25%, respectively) cooperated to design and construct new pumping stations and better drainage canals throughout the city (Sewerage and Water Board of New Orleans, 2019a). Respondent 9 explains the thought process behind this program when it was enacted:

> *"The logic behind SELA was that flood insurance is federally insured, is a federally funded program. And so, when they had, you know, May of 95, and we had 20 inches of rain, and everybody flooded, they all filed a claim, and the federal government had to write a check. And it was, you know, $50,000 for you, and $50,000 for you, and $50,000 for you, but it added up to billions of dollars, right. And then there was another flood event, and it was the same type of thing. And then another one is the same type of thing. And the logic here is, instead of spending $2 billion every time it floods, to put everything back the way that it was, why don't you give us the $2 billion in advance, okay, and will, it will expand the drainage system, so that when we get that kind of rain event, it's not going to flood? Right? And so by spending the $2 billion now, you're gonna save the $2 billion in every storm thereafter. Right. So that's the logic for how for how the SELA program came to be. The big term was repetitive flood claims."*

The May 1995 storms served as a tipping point rather than a critical juncture because the range of decisions open to decision-makers following the flooding were not expanded substantially, nor were influences on political action relaxed. Rather, they provided an opportunity for local officials to request for federal assistance in addressing stormwater management in the city (both in funding and in expertise) (Sewerage and Water Board of New Orleans, 2019a). R8 and R9 both expressed the importance of federal funding assistance in this arena: "the Corps of Engineers has always played a vital role because of the levees, but over the last 30 years with the with the SELA program, all of the improvements, well, not all of the improvements, but the vast majority of the improvements have been have been directly related to drainage system" "…most of [SWBNO's] drainage funds are trying to keep pace with, their discretional spending, is spent trying to keep up with SELA."

The second tipping point of note is the most recent event discussed in this paper, a thunderstorm in August of 2017 that dropped up to nine inches of rain in some parts of the city in four hours (Craig, 2017). "The ensuing flood overwhelmed the city's pump system and covered much of central New Orleans in several feet of water, taking 14 hours to drain and prompting 200 'life-threatening' emergency calls, according to city records" (Craig, 2017). The impacts of the storm forced several officials at SWBNO to leave or be fired due to public discontent as well as allegations of leadership missteps (Craig, 2017). Viewing this storm event as a tipping point, Respondent 5 states:

> "So, for example, there was a there was a juncture which were the floods of – the August floods that happened… 2017, right. Yeah. That was a moment in time of kind of a Band-Aid was ripped off. The first Band-Aid was Katrina. This was the second Band-Aid. And that's when everything changed. And there was a deep examination of the SWBNO and just all you know, the systems in general, including public works cause it's not, you know SWBNO isn't 100% alone in all of this."

Though most interview respondents agreed that the public and even the majority of public officials were not too educated on and aware of the water management system in New Orleans, the 2017 floods brought the issue of stormwater management to the forefront of people's minds. Awareness continues to grow about the limits to system capacity, SWBNO has even introduced new public information campaigns to begin to address water management education in the city (R3, R7). The 2017 represent a tipping point rather than a critical juncture. The flooding did not relax the structural influences on political action, there was a lack of plausible choices open to political actors, and no path-dependent pathways were triggered as a result of any decisions made of note (Capoccia and Kelemen, 2007; R5; R7).

4.2.3 How do identified factors interact with one another?

In the final portion of analysis, the results of the significant coding analysis are presented to showcase illuminated relationships found from the collected primary and secondary data. As described in Section 3.1, documentation and interview transcripts were coded via the coding scheme presented in Section 3.2 (Operationalization). The results of those efforts are rendered in this section, i.e., presenting where strong co-occurrences appear and what variables are involved. Strong relationships will be mentioned in the following sections, and co-occurrence tables showing both count and coefficients are included in the Appendix. It is critical to note that "strong relationships" were defined by the researcher as a count of greater than 5 and/or a coefficient of 0.05 or greater. These values were selected following examination of coding results at the discretion of the researcher to capture relationships via two measures.

4.2.3.1 Institutional inertia and costs

From the co-occurrence analysis comparing institutional inertia and costs, there are a few indicators with high co-occurrence counts and relatively high coefficients that suggest relationships (Appendix A.7.1).

Perceptions, guided in this research by both documentation and expert interviews, are essential markers of indicator (and thus variable) relationships. For costs and institutional inertia, the coding scheme supports that when projects/programs are perceived as having positive benefits for the water management system, there is a lower resistance to innovative management paradigms (i.e., flood resiliency) and lower resistance to institutional change. These relationships were particularly strong for the cost factor, yielding the highest co-occurrence coefficients of all strong relationships.

Positive project benefit perception, as well as a positive cost-benefit rating, produced some change in water management practices according to the analyzed sample. Related conversely, when the cost of projects was substantial (i.e., "negative," an impediment to swift payment and action), there was a clear perception that institutions resisted change, perpetuating inertia.

Most apparently, it is clear that transactional costs are one of, if not the primary, contributors to institutional inertia in New Orleans water management. High co-occurrence relationships with transactional costs included: no change in water management practices, high institutional resistance to change, high resistance to innovation, and only some change in practices. Transactional costs were manifested as a number of phenomena seen in the water management sector: limited intra- and inter-agency communication, fragmented communication with non-governmental actors and the public, political ramifications, and bureaucracy (especially Civil Service). These results are in line with what was outlined in the literature review (Boston & Lempp, 2011; Munck af Rosenschöld & Rozema, 2019; Munck af Rosenschöld & Rozema, 2014; Taylor, 2014; Van Buuren et al., 2016; Pierson, 2000). Interviewees echoed the impact of these phenomena, as well.

- R2: "Minimum three, four, to five months to get something taken care of through the bureaucratic red tape. Civil services is a tough one too, especially for staffing because their rule is that you may not even advertise for that vacant position until a month after that person is left. So, there's no cross training, there's no overlapping of the same position. It's just hopefully your manager knows how to do your job and can train your or your coat if you have co-workers that you all kind of share responsibilities, then you lack each other in, but there's no there can be no overlapping."
- R5: "I think that I find it interesting that the city of New Orleans can get all this money to do all these projects, but having such a hard time getting the projects done and I think that has to do with just communication breakdowns within the City and Sewerage and Water Board, like not talking to each other, you know. So I do see the bureaucracy really as a hindrance to getting some of this stuff done. I don't think it's like a maybe they just don't have enough employees to handle it or they just don't really. I think the problem is that they don't have enough trained employees."

- R7: “Just like the nature of the way that the [civil service] system is structured, it’s resistant to change because their roles are extremely defined and protected. And so, any change to that is a threat to their livelihoods and a threat to their daily life. And so, I do think that that poses a big challenge in terms of implementing change.”

4.2.3.2 Institutional inertia and uncertainty

Institutional inertia and uncertainty yielded relatively weak relationships in the co-occurrence analysis compared to other variables, with counts maxing out at 7 and coefficients only reaching 0.05 (Appendix A.7.2). Nevertheless, co-occurrences of note are related to institutional inertia indicators of no change. There was no observed change in actors (inertial indicator) with uncertainties in climate impact and with clarity in actor/institution responsibilities. Data supports that roles and responsibilities are especially clear post-Katrina, at least to those agencies responsible for water management, entrenching institutional arrangements in the city. Medium uncertainty regarding climate impact has resulted in little to no change in water management practices to date. Though interviewees and reviewed literature sources recognize that there will be significant climate change impacts to the city (Section 4.1.2), the magnitude, timing, and severity of those impacts were brought up as the source of uncertainty.

- R6: “You know, like the magnitude is uncertain, but I think that the impacts are known. I think that everybody's aware that storm intensity and frequency is increasing and that as sea level rises, that means the lake levels also rise. And so, all of our drainage goes to the lake. And so that just affects the outfall canals because they're all the same, you know, connected hydraulically so. So, I don't think that there's been any, you know, I think everybody sees it and it's trying to prepare for it. And nobody knows the magnitude obviously, but none of us know how fast things are gonna change or will exactly what the consequences are going to be.”

4.2.3.3 Institutional inertia and path dependence

For this comparison, path dependence contained five indicators that yielded the strongest counts and coefficients: (1) investment costs: all time, (2) legal requirements: strict, (3) perception of public trust: low, (4) perception of trust: high, and (5) impact innovation: high (Appendix A.7.3). These results support stronger relationships with these path dependence indicators to the variable of institutional inertia.

First, significant investment in the current water management infrastructure over the course of the drainage and flood control system’s history in New Orleans has resulted in a few, sometimes conflicting, conclusions. There were strong relationships between all-time investment and all three practice codes (i.e., significant, some, and no change in practices). Thus, sample analysis indicates that investment into the water management system is not an indicator of change in water management practices. In contrast, it is clear that all-time investment has not resulted in a change in water management actors. In other words, investment in the water management system through its history has been for flood-resistant system improvements, with few exceptions, and no significant changes in institutional actor arrangements.

Legal embeddedness of the water management system, coded as “Legal requirements: strict,” has led to a perception of high resistance to innovation and institutional change, yet some change in practices. The latter may be explained in legal restructurings of water management practices and institutional arrangements, as exemplified in Section 4.2.2.4 in the discussion of levee district rearrangements and flood control system bolstering. Though some changes may have been publicized and newsworthy, they were essentially maintaining the institutional status quo of flood-resistance.

Indicators of perceived high levels of public trust have resulted in perceived low resistance to institutional change and innovation. Conversely, low public trust perceptions yielded high resistance to innovation and institutional change according to sample analysis. This phenomenon was brought up on a number of occasions with interviewees, who indicated that gaining public trust in present day is one of the most important steps in instituting changes to the water management system.

- R3: “And there's widespread perception of mismanagement of technological and bureaucratic failures and the string of urban flooding, problems and disasters have happened since [2017]. I think that's reflected in both mainstream media reporting social media accounts and how people day-to-day talk about and bash, Sewerage and Water Board, and in every possible way.”
- R9: “I mean, there's a lot of people who don't have any trust for the Sewerage and Water Board at all. So, a drainage fee is going to say, hey, you know, you were gonna get $25 million more a year for the drainage fee, and we'll be able to address drainage. Well, you're not doing a good job with what I gave you. Why should we give you more?”

Following the disasters described in Section 4.2.2, it is apparent to all in the water management sector that the public has, accordingly, lost faith in established institutions to execute their jobs to a high standard. Interestingly, experts interviewed maintained that though trust is low, so is knowledge concerning how the drainage and flood control system works. In turn, governmental institutions are largely withdrawn from the public, offering some public engagement opportunities with little tangible changes from public input. This is a significant area requiring improvement and research, namely how governments should approach gaining public trust back through engagement opportunities to better co-create solutions to wicked problems.

Finally, high innovation impact has resulted in a perceived lower resistance to more innovation, low resistance to institutional change, and significant changes to water management practices. These results are uplifting, as sample analysis is essentially supporting the notion that with continued proof of flood resilient infrastructure success, institutions are more open to expanding implementation – possibly even on a system-scale. Implicit in this conclusion, however, is that flood resilient infrastructure must be implemented somewhere to prove its viability as a flood management option. Especially in New Orleans, interviewees noted that SWBNO has historically had significant requirements for even considering – not to mention implementing – innovative projects. Respondent 9 revealed “But on a large scale, you know, you had to show us [SWBNO] that, that you you've been working for it's been working successfully for five years, or you know, or 100,000 feet or both, or something like that. We weren't we weren't interested in being a test a guinea pig.”

4.2.3.4 Institutional inertia and power/legitimacy

Sample analysis of institutional inertia and power and legitimacy support several strong relationships between indicators (Appendix A.7.4). First, recognized institutions and actors of high authority are not clearly related to changes in actor arrangements, yet they have some impact on changes in practices. This may support the conclusion that powerful actors in New Orleans, once their roles and responsibilities were defined and authorized, have remained in place through critical junctures and disasters alike, for the most part (Sections 4.2.1 and 4.2.2).

With perceptions of high system improvement, there was a perceived lowering of resistance to innovative ideas and institutional change. Further, in the case of high perception of system improvement, there is evidence that change to practices in water management is more possible. On the contrary, when there is a perception that the system has improved little or not at all, there is a higher perceived level of resistance to innovation and institutional change. This phenomenon is interesting given that little perceived improvement of an inefficient and malfunctioning system has fostered further investment and development of the same system elements.

When the perception of ability to change institutional structures and/or the decision-making process for water management is high, there is a perceived low resistance to innovation and institutional change. When that agency is perceived low, innovation is resisted and resistance to institutional change is high.

Finally, when the perception of legitimacy in decision-making regarding water management operations (on the part of the public or experts in the field) is high, there is a perceived low resistance to institutional change. That said, the analysis showed a stronger relationship for the corollary opposite: when perception of legitimate decision-making is low, there is a high perceived resistance to institutional change.

4.2.3.5 Institutional inertia and complexity

Though complexity had the most indicators of all variables, there are relatively little relationships of note between complexity and institutional inertia according to data analysis (Appendix A.7.5). In fact, the highest count was 5 while the highest co-occurrence coefficient was 0.06. That said, some relationships are highlighted.

Notable is the effect of public and political actor understanding of the water management system (and risks) on changes to actors and practices. When the level of political actor (including water management experts) understanding of the system, its capacities, and risks, is high, there seems to be little to no change in actors or practices. In contrast, when the public has a higher level of understanding, there is evidence to support a higher level of actor and practice changes. This phenomenon could be a topic of study in its own right, namely the impact of educated and engaged communities on institutional change.

When decision-making accessibility is low, there is a perceived high resistance to institutional change. This perhaps points to the impact of largely internal decision-making within governmental organizations charged with water management and flood protection in New Orleans. Difficulties working with local governmental actors/officials tasked with water management and flood protection were clear in interviews with experts outside of government:

- R5: “So I do think that this information in my experience information is not shared well like then departments or you know, the Office of Resiliency is doing one thing and the Department of Public Works doesn't know what's happening. You know, like, as far as your model, you know, if you're modeling a certain area to see what improvements we can make in the drainage system, you know, like there's just not a lot of awareness, like interdepartmental awareness.”
- R10: “In the NGO space, we are impacted deeply by government. Because the government's not getting along, we don't get along if government is not moving, we can't move.”

When there is a vested interest and investment in public participation and engagement, there appears to be some ability to change the actors associated with water management in New Orleans.

> R3: "And when people understand the cycle of pumping and subsidence, every single person was, like, holy cow, what are we doing? Why do we do that? And so I think that desire is deep because the current system is failing on its own merits in terms of flood control and risk reduction, but it's a question of politics and imagination that that to me is actually the challenge, not a design for not whether or not there's a desire for change."

Perhaps public input guides the selection of more representative actors, or, in another scenario, public discontent with current operations may force changes to personnel, as well (see discussion on 2017 August flooding tipping point for example). Finally, with urban flooding impacts to the city, there sometimes comes changes to water management practices – though this is not a rule, nor is it at a fast pace.

4.2.3.6 Institutional inertia and critical junctures

Finally, the last variables of comparison were institutional inertia and critical junctures (Appendix A.7.6). Notably, this comparison yielded the greatest number of significant results, with 32 relationships of note.

First, in a critical juncture (or juncture-adjacent) scenario, there seems to be no correlation between when alternatives were present for powerful actors to choose from and a change in actors or practices. There were equally strong relationships between presence of alternatives and no, some, and significant changes in actors and practices. In other words, having alternatives present does not determine a change or a lack of changes on either of those fronts.

During design moments in the period of study, indicator analysis suggests that there is no robust relationship to changes in water management and flood control actors and practices. There are strong indicator relationships in the analysis between the "design moment: positive" indicator and all levels of actor and practice change. In non-design moments, the analysis shows that the possibility of significant actor re-arrangement or changes remained strong.

According to analysis results, there is not a significant relationship between design moments and perceived resistance to institutional change (i.e., strong relationships with perceived low and high resistance indicators).

When government was unable to fund improvements to the water management system, there was a high perception of resistance to institutional change. Conversely, when government was able to contribute funding to system improvements, there was a slew of indicator relationships (or lack thereof) revealed. When funding was made available by government, there was a perceived low resistance to innovation. Government ability and commitment to fund improvements yielded little no changes in actors in the water management sector. For practices, government funding yielded results for all levels of change (i.e., no, some, significant), indicating that there cannot be significant conclusions drawn from those relationships.

Mentions of inadequate government contributions to operations and maintenance (O&M) costs of water management and flood control projects yielded a perceived high resistance to institutional change. When O&M costs were made available, analysis indicates a low perceived resistance to institutional change and the possibility of significant changes to water management practices.

With no perception that decisions made within certain period would have lasting impacts (i.e., path dependent legacies), there was a resultant perceived high resistance to institutional change. When decision impact was perceived, there was a perception of low resistance to innovation, institutional change, and the possibility of significant changes to water management practices.

Similar to the decision impact indicator, with a perception that "agents' choices will affect the outcome of interest" relative to that probability before and after a certain period (Capoccia & Kelemen, 2007, p. 348), there was a perceived low resistance to innovation, institutional change, and the possibility of significant changes to water management practices.

Lastly, timing of institutional change post-disaster yielded a few relationships to institutional inertia indicators. When the timing of change post-disaster was perceived as inadequate (i.e., too slow), there was a perceived high resistance to institutional change. In contrast, when the perception of timing of institutional change was positive, there was a perceived low resistance to innovation and institutional change. The latter result could be attributed to the critical juncture period (a design moment), many of which were discussed for New Orleans in Section 4.2.2. It is important to note here, however, a point that Fields et al. (2017) highlights regarding post-disaster timing:

> *"The drawback of relying on postdisaster planning and investment, however, is that it happens in a highly constrained timeline where an incredible number of decisions must be made quickly and amid conflicting needs and mandates…Moreover, "fast forward" of postdisaster planning can be further constrained by regulations that dictate both the flow of federal funds and the purposes for which they can be utilized. The result of these factors is often an uneven recovery process of "crisis driven redevelopment" (Gotham and Greenberg 2014) and the challenge of implementing an equitable redevelopment process" (Blackwell 2005; Vazquez 2005)" (p. 311).*

Respondent 4 made a similar point regarding timing of change post-disaster:

> *"So part of the paradox of disaster recovery, and I'm sure there are people who have written about this is that it is both this moment when people are open to change because they it's been such a huge impact that they don't ever want that to happen again, and they also want things to go back to normal as quickly as possible. And those two and it's so it's actually not the best time when people are traumatized and shaken up to make massive changes…So is timing important? Absolutely. But I think it's also timing relative to how far away you are from the event now. The other problem though that you have is that the further away you get from an event, the more people forget about it and get comfortable again with the way things are and are less interested in big shifts and then more interested in incremental changes."*

4.3 Summary of results

Chapter 4 presented the results of the extensive process tracing historical analysis and subsequent coding results. In summary, there is evidence from this analysis that all five factors depicted as contributors to institutional inertia in the conceptual framework (Section 2.2) do, in fact, act as contributors in the case study of interest, New Orleans. Further, the presence of multiple critical junctures throughout New Orleans' water management history is consistent with definitions presented in Section 2.1.7 (Sorensen, 2018; Hogan & Doyle, 2007; Capoccia and Kelemen, 2007; Hanger-Kopp et al., 2022; Gawronski & Olson, 2013). Therefore, this case study is not a departure from what is suggested in literature regarding institutional inertia, contributing variables, and punctuating critical junctures.

Relationships illuminated in the coding co-occurrence analysis may indicate that not each variable contributes to institutional inertia with the same level of significance. However, the ability of critical junctures to disrupt institutional inertia – with or with path-dependent legacies resulting – was evident in the reviewed sample and subsequent analysis. Table 6 showcases the results of the coding analysis in a simplified form, highlighting the differences between variable relationships. Note: variable ratios are ranked largest to smallest.

Table 6: Strong variable relationships with institutional inertia

Variable	# Indicators	# Possible relationships with institutional inertia	# Strong relationships with institutional inertia	Ratio strong/possible
institutional inertia	10			
critical juncture	14	140	32	0.2286
path dependence	9	90	16	0.1778
power / legitimacy	9	90	12	0.1333
costs	8	80	9	0.1125
uncertainty	6	60	3	0.0500
complexity	21	210	7	0.0333

The table of variables above is useful, but it employs basic functions that do not represent a robust statistical analysis. For this reason, it should only be utilized as a first marker of relationship strength for analysis and this case study, rather than a commentary on relationship strength in all applications.

With that said, in the initial ranking from Table 6, the analysis supports that some variables (notably path dependence, power / legitimacy, and costs) are more strongly related to institutional inertia than others (uncertainty, complexity). To be clear, all variables were shown to have at least some impact on institutional inertia, which is consistent with available literature.

The process tracing historical analysis of critical junctures in the New Orleans water management sector illuminated a heavily path dependent history of flood resistance with few course corrections. Though some junctures brought new actors into the city – whether that be for flood control, hurricane protection, or improvement of drainage systems – the system of hard infrastructure meant to keep water out of the city still dominates institutional missions and work. Therefore, though alternatives may have presented themselves during these junctures to alter the predominant institutional paradigm, those opportunities have not been selected or utilized. Recent nuisance floods since Hurricane Katrina may act as a tipping point in this arena, signalling discontent with the current status quo and modus operandi. When the next critical juncture presents itself, it is clear that extensive research, planning, and prioritized projects prior to that moment will dictate whether or not systems change is possible.

5.0 Conclusions

Chapter 5 concludes this research paper by answering the main research questions, answers that are guided by the results and analysis presented in Chapter 4. The main research questions are as follows:

- *What factors have contributed most to institutional inertia regarding water management in New Orleans, Louisiana in the period 1896 to present?*
- *Why have critical junctures in that period failed to break institutional inertia?*

In addition, Chapter 5 summarizes research validity, importance, and relevance, as well as provides recommendations for further research.

The purpose of this study was to utilize a case study of the New Orleans water management sector to uncover the most important factors contributing to institutional inertia in this arena. Additionally, a historical analysis was conducted to illuminate critical junctures during the history of the city's water management sector in the period of study. The purpose of the latter was to expose potential periods of transformational change and their outcomes in the hopes of informing best practices for the next juncture opportunity to push for paradigmatic, systems change (i.e., a shift towards flood resiliency as opposed to flood resistance).

5.1 Answering the research questions

5.1.1 What factors are contributing most to institutional inertia regarding water management in New Orleans, Louisiana, in the period 1893 to present?

Research in this paper indicates that all five identified contributing factors – costs, uncertainty, path dependence, power/legitimacy, and complexity – are indeed contributors to institutional inertia in the water management sector in New Orleans.

First, the effects of path dependency on institutional inertia in water management in New Orleans are clear, consistent with the reviewed sample and interviewees, and with literature. As exemplified in Sections 4.2.1 and 4.2.2, institutions that were established at the beginning of the period of study are largely still present today. Not just institutions, but the hard infrastructure elements of levees, floodwalls, pumps, etc., are prevalent in the city as the flood resistant water management paradigm has dominated, again, since the system's inception at the very end of the 19^{th} century. It seems that Bennett and Elman's (2006) "closure" and "degree of constraint" elements of path dependence are particularly evident in New Orleans, with the former dominated by political actors and the public alike dependent on flood resistant infrastructure and the latter explained by early and continued investment in such hard infrastructure. "Technological lock-in" (Munck af Rosenschöld et al., 2014), 'technocratic path dependencies' (Brown and Farrelly, 2009), and a reliance on hard engineering (Van Buuren et al., 2016; Hanger-Kopp et al., 2022) is evident. Clear also is that employees themselves of important institutions embody path dependency in their insistence on "the old way of doing things."

Power and legitimacy proved to be a strong contributing variable to institutional inertia in the New Orleans water management sector, consistent with literature (Munck af Rosenschöld et al., 2014; Munck af Rosenschöld and Rozema, 2019; Boston and Lemmp, 2011; Taylor, 2014; Brown and Farrelly, 2009; Van Buuren, Ellen, and Warner, 2016). There certainly remains a relatively closed group of agencies and organizations responsible for water management in the city, and some of their guiding rules and regulations (e.g., Civil Service and bureaucratic red tape) maintain institutional inertia. Van Buuren (2016) expands this point, calling on power asymmetries that stifle innovation and limit institutional judgement, implicitly limiting outside input and agency. That said, substantial growth in water management NGOs, as well as a growing acceptance of flood resilient ideas (i.e., blue-green infrastructure) should be noted. Boston and Lempp's (2011) discussion on "strong, active leadership" is relevant, given government actors are not perceived as trustworthy nor adequate at their roles. Brown and Farrelly's (2009) emphasis on limited community engagement strikes true in New Orleans, as community members by-and-large are not perceived as legitimate decision-makers by higher authorities. As the data sample illuminated an ostensible lack of targeted community engagement for creative solutions to water management in New Orleans, institutions were in turn viewed with lower legitimacy (a point represented in Brown and Farrelly, 2009, and Munck af Rosenschöld et al., 2014). Finally, the phenomenon of little perceived progress to the currently inefficient (sometimes ineffective) water management system – despite apparent innovations available for improvement – was illuminated through this analysis.

Costs, especially transactional costs (including those associated with bureaucracy) have limited innovation and supported flood resistant design in New Orleans. The enormous costs associated with system improvement, operations, and maintenance are apparent contributors to institutional inertia in New Orleans, both for flood resistant infrastructure and the price tag associated with flood resilient infrastructure. This is consistent with what was prescribed in literature (Boston and Lempp, 2011; Munck af Rosenschöld & Rozema, 2019; Taylor, 2014). Separate from funding, transactional costs (e.g., number of bureaucratic / nongovernmental actors to coordinate; Red tape; civil service requirements) are key barriers to institutional change in the city. Before flood resilience can be implemented in the city, there are institutional communicative and workforce barriers, particularly within governmental actors, that must be addressed. The impact of transaction costs on institutional inertia is well documented in literature (Munck af Rosenschöld et al., 2014; Pierson, 2000; Van Buuren, Ellen, and Warner, 2016), and is clearly present in New Orleans.

Even as the last ranking of contributing variables, uncertainty and complexity still very much indicate essential drivers of institutional inertia. It is particularly uncertainties regarding climate impact magnitude and timing that may explain water management inertia, consistent with "regret potential" by Munck af Rosenschöld et al. (2014) and similar theorizing by Salet, Bertolini, and Giezen, 2013. Especially since Hurricane Katrina, there seems to be little uncertainty regarding the roles and responsibilities of established institutions – for better or worse – though siloed arrangement and poor communication markers are certainly present in this case study, found in literature (Munck af Rosenschöld et al., 2014; Taylor, 2014; Brown and Farrelly, 2009; Munck af Rosenschöld & Rozema, 2019). Complexity remains an important factor contributing to inertia in that the problems New Orleans faces in water management are too complex to nail down one catch-all solution. Pierson's (2000) contention that the complex nature of politics and evaluation of performance limits self-correction is relevant for New Orleans, where the city government is inextricably tied to funding and operations of the drainage system. Inefficiencies and complexities in administrative and legal standards (Van Buuren, Ellen, and Warner, 2016; Brown and Farrelly, 2009) certainly act as barriers to public engagement and feedback, but even other expert stakeholders. Lastly, it cannot be understated that the water management sector problems (and future solutions) are inextricably tied to social vulnerabilities and racism present in the city's planning and development. Complex institutional arrangements in the city, unclear to most in the public as well as some public officials, has limited transparency, equity, and accountability, which is affirmed by literature (Siders, 2019; Pierson, 2000; and Brown and Farrelly, 2009).

5.1.2 Why have critical junctures in that period failed to break institutional inertia?

It is clear that indicators of critical junctures are capable of disrupting institutional inertia within the case study of New Orleans water management. Consistent with what was stated literature, as well as what was represented in the conceptual framework, critical junctures in New Orleans were largely a result of exogenous shocks to the institutional order that forced the "destabilization" of the existing one (Sorensen, 2018). From the historical process tracing analysis, as similarly found by Gawronski and Olson (2013), "disasters create windows of opportunity for policy changes, and the resulting choices affect a range of outcomes" (p. 134).

The results of critical junctures were not always a dramatic shift in the water management paradigm, nor did they cause large changes to actors, institutional arrangements, or practices. However, as represented in the conceptual framework, they were periods that were capable of breaking institutional inertia in which "the range of plausible choices open to powerful political actors expands substantially and the consequences of their decisions for the outcome of interest are potentially much more momentous" (Cappocia & Kelemen, 2007, p. 343).

The historical analysis results presented in Section 4.2.2, as well as results from the coding analysis, may indicate a few reasons behind critical juncture failure to break institutional inertia in New Orleans (and thus the prevailing water management practices and paradigms aligned with flood resistance).

First, funding for both disaster recovery and large infrastructure projects still largely remains tied to the federal government. This has two consequences: 1) implementation takes time depending on the scale of projects and the speed of appropriations, and 2) monies are designated for specific uses, most of which have historically been for doubling down on (expanding, strengthening, promoting) hard water management infrastructure (not flood resilient innovations) in New Orleans, many times for insurance purposes. Fields et al. (2017) presents hope on this front: "Over the last decade, federal guidance has been altered to enhance the potential for these funding mechanisms to be used for green infrastructure," especially in a post-disaster scenario (pp. 313-314). Unfortunately for New Orleans on this front, "During the immediate years of rebuilding [after Hurricane Katrina], before the wave of policy innovations that followed Superstorm Sandy, neither HUD [United States Department of Housing and Urban Development] nor FEMA provided explicit guidance regarding investing in green and blue infrastructure or climate resilience generally" (Fields et al., 2017, p. 314).

Secondly, there is significant devoted expertise, improvement, and investment required for improved community engagement in New Orleans. An engaged public, one that is understanding of the water management and flood control system capacity and risks, are more able to make educated decisions for themselves, their livelihoods, and ideally for this application, the officials and issues they trust to make their lives better. As it stands, the public trusts the government little to implement the most cost-effective, scientifically backed, and equitable solutions to the vast array of water management problems the city is facing. Additionally, limited public knowledge of the system and its elements limits engagement with and pushback on actors/institutions in charge of systems changes. Co-creation of solutions that work on a systems-scale is only possible with governmental institutions that value public input and respond to their concerns, ideas, and visions for the future. To get there, extensive investment in public education and awareness should continue to be a priority for institutions in charge of water management and the city government itself.

5.2 Research validity, importance, and relevance

Research conducted in this paper followed methodology informed by literature, supported conclusions regarding the research questions and sub-questions, and contributed to the academic field it is nested within. Section 3.1 describes the research strategy, data collection methods, description of data sample, and how data was analyzed, all of which were informed by literature. With case study research, it is critical to ensure data reliability and validity through triangulation (Van Thiel, 2014. For this study, this was accomplished through combining primary and secondary sources found through desk research alongside semi-structured interview data.

As a concise restatement of Section 1.2, the topic of study is relevant and important to add to existing literature on topics of water management institutional inertia and critical junctures. There is a recognized research gap on the socio-institutional factors contributing to institutional inertia (Brown and Farrelly, 2009; Taylor 2014; Munck af Rosenschöld & Rozema, 2019). Further, the application of institutional inertia and critical juncture lenses on the history of water management in New Orleans is novel, making it particularly poignant for city planners and water management institutions planning for the next disaster.

New Orleans remains a relevant and important case study due to its geographic location and context, its positioning with climate change, and those additional reasons cited in Section 4.1 (subsidence, vulnerability to climate change impacts, social vulnerability, and reliance on flood resistant infrastructure). Conclusions drawn from this research may help to inform pre-disaster research, design, and planning for the city in the hopes that the next critical juncture could offer an opportunity for systems change with a prepared plan of action. Lessons learned in this research about New Orleans may also act as a foundation for further research into other localities in the United States facing similar inertia and climate threats.

5.3. Recommendations for further research

Recommendations for further research suggested themselves throughout the study process, both in desk research and in interviews. First, applications of both the institutional inertia and critical juncture lenses to other localities and their water management sectors could be useful in corroborating or refuting results and conclusions presented in this paper.

Next, it could be prudent to conduct comparative research between the United States and another country (or countries) of interest looking into levels of confidence in both entrusted actors/institutions and their engineered structures. What became quite clear in this research was that in the U.S., there exists a unique over-confidence in the engineered structures that have been the predominant flood control policies since the 19th century, for better or worse. The implications of that overconfidence (or lack thereof in other jurisdictions) could prove to be leverage points for future planning and/or institutional arrangements.

Research in cultivating and promoting an engaged public (including how to overcome deeply rooted public distrust in government) would be prudent not only for the co-creation of solutions to water management problems in New Orleans, but also for applications in other localities and for other urban issues.

Finally, tracking federal funding appropriation and results for flood resilient infrastructure, especially in a post-disaster situation, will prove useful for New Orleans and a growing number of cities facing sea-level rise and increasing, intense storms.

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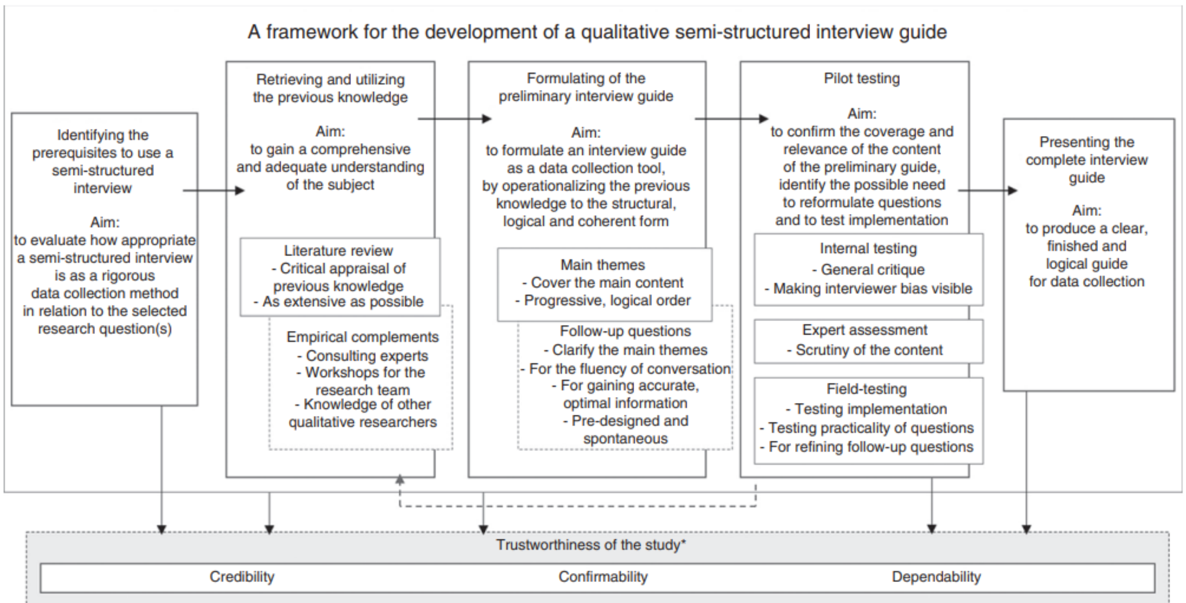
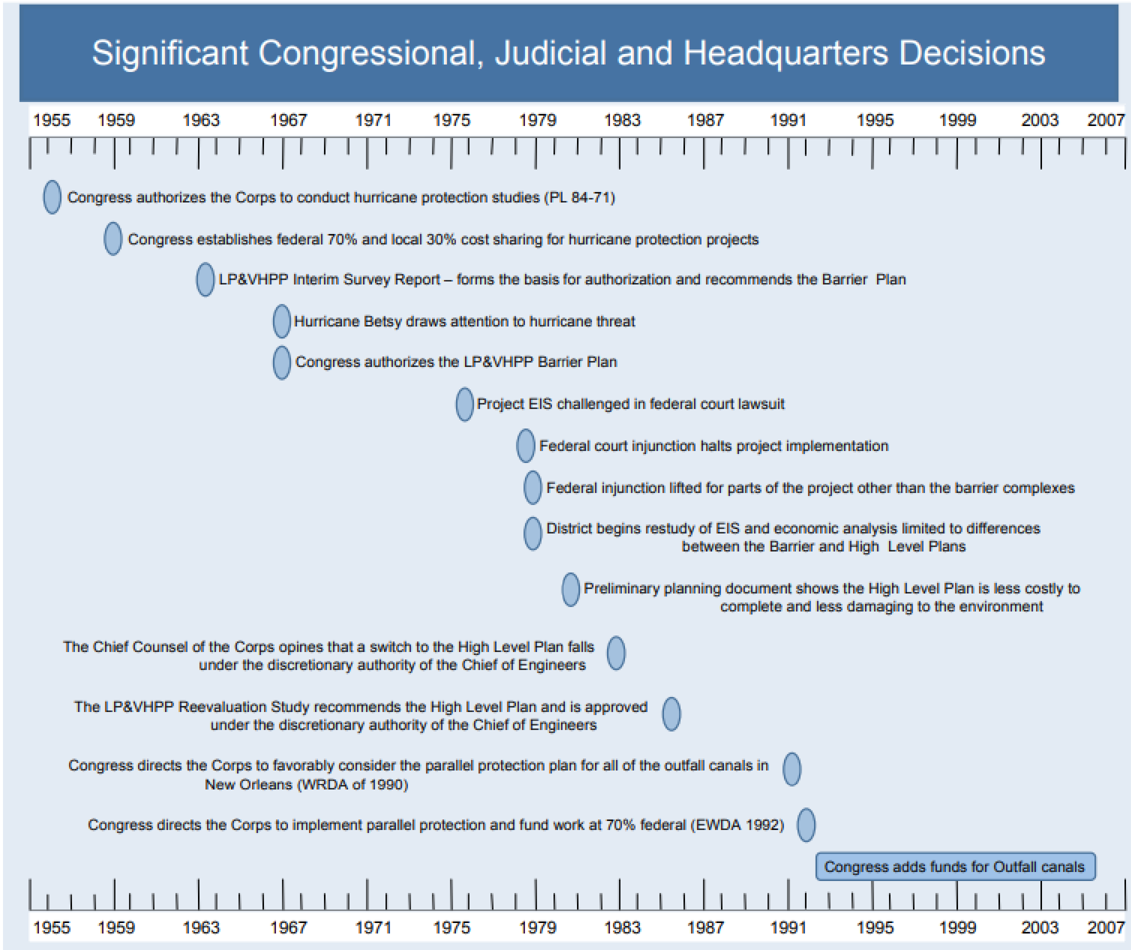
Appendix 1: Important supplements

A.1: Semi-structured interview guide framework (Kallio, Pietilä, Johnson, and Kangasniemi, 2014, p. 2962)



A.2: "Significant Congressional, Judicial, and USACE Decisions Related to the LP&VHPP" (Woolley & Shabman, 2008, as cited in Gordon & Little, 2009, p. 4)



Source: Woolley, D. and L. Shabman. Decision-Making Chronology for the Lake Pontchartrain & Vicinity Hurricane Protection Project. Final Report for the Headquarters, U.S. Army Corps of Engineers; Submitted to the Institute for Water Resources of the U.S. Army Corps of Engineers, March 2008.

A.3: "Agencies and Organizations Responsible for Portions of New Orleans's Hurricane Protection System" (Andersen et al., 2007, pp. 68-70)

AGENCY	ROLE AND RESPONSIBILITY
UNITED STATES CONGRESS	Authorization and funding.
USACE HEADQUARTERS	USACE guidance and oversight.
USACE ENGINEER RESEARCH AND DEVELOPMENT CENTER	Research to support new design approaches.
USACE NEW ORLEANS DISTRICT	Design and construction oversight as the "Engineer" for each of the five independent levee districts in the New Orleans metropolitan area.

AGENCY	ROLE AND RESPONSIBILITY
EAST JEFFERSON LEVEE DISTRICT	Maintenance and operation of the flood protection levee system around the east bank portion of Jefferson Parish to protect the citizens of East Jefferson from Lake Pontchartrain and Mississippi River flooding.
LAKE BORGNE BASIN LEVEE DISTRICT	Maintenance and operation of 13 miles of the Mississippi River Levee, 26 miles of back protection levee, 23 miles of the Lake Pontchartrain and Vicinity Hurricane Protection Levee, the Bayou Dupre Control Structure, 12 flood gates, the Violet Freshwater Siphon, 55 miles of drainage canals, and eight major drainage pumping stations.
ORLEANS LEVEE DISTRICT	Maintenance and operation of the hurricane and flood protection improvements for the City of New Orleans on the southern shores of Lake Pontchartrain and along the Mississippi River, including inspection and maintenance of 129 miles of levees and floodwalls, 189 floodgates, 97 flood valves, and two flood control structures.
PONTCHARTRAIN LEVEE DISTRICT	Maintenance and operation of the hurricane and flood protection improvements for St. Charles Parish, including the southern shores of Lake Pontchartrain, the Bonnet Carré Spillway, and along the Mississippi River, including inspection and maintenance of associated miles of levees and floodwalls.
WEST JEFFERSON LEVEE DISTRICT	Maintenance and operation of hurricane and flood protection improvements for the west bank of Jefferson Parish, including the levee system east and west of the Harvey Canal, along each side of the Harvey Canal, and along the Mississippi River, including inspection and maintenance of more than 50 miles of levees and floodwalls and associated floodgates.
DRAINAGE PUMP STATIONS DEPARTMENT OF JEFFERSON PARISH	Administration, direction, coordination, and implementation of major drainage and flood control programs and direct construction, operation, and maintenance of 340 miles of canal waterways, drainage ditches, cross drains, culverts, and internal levee systems; 1,465 miles of street subsurface drainage systems; and operation and maintenance of 52 drainage pump stations.

AGENCY	ROLE AND RESPONSIBILITY
SEWERAGE AND WATER BOARD OF NEW ORLEANS	Administration, direction, coordination, and implementation of major drainage and flood control programs and direct operation, construction, and maintenance of 90 miles of open canal waterways, drainage ditches, cross drains, and culverts; 90 miles of street subsurface drainage systems larger than 36 inches in diameter; and operation and maintenance of 22 drainage pump stations. The Sewerage and Water Board also operates and maintains all drainage pump stations in Orleans Parish, east and west banks, and is responsible for waterways' trash pick-up and grass cutting.

A.4: Saffir-Simpson Hurricane Scale

Table 3.2 The Saffir-Simpson Hurricane Scale

CATEGORY	WIND SPEED (mph)	TYPICAL STORM WATER SURGE (ft)
1	74 - 95	4 - 5
2	96 - 110	6 - 8
3	111 - 130	9 - 12
4	131 - 155	13 - 18
5	> 155	> 18

Figure 10: Saffir-Simpson hurricane scale (table from Andersen et al., 2007, p. 12)

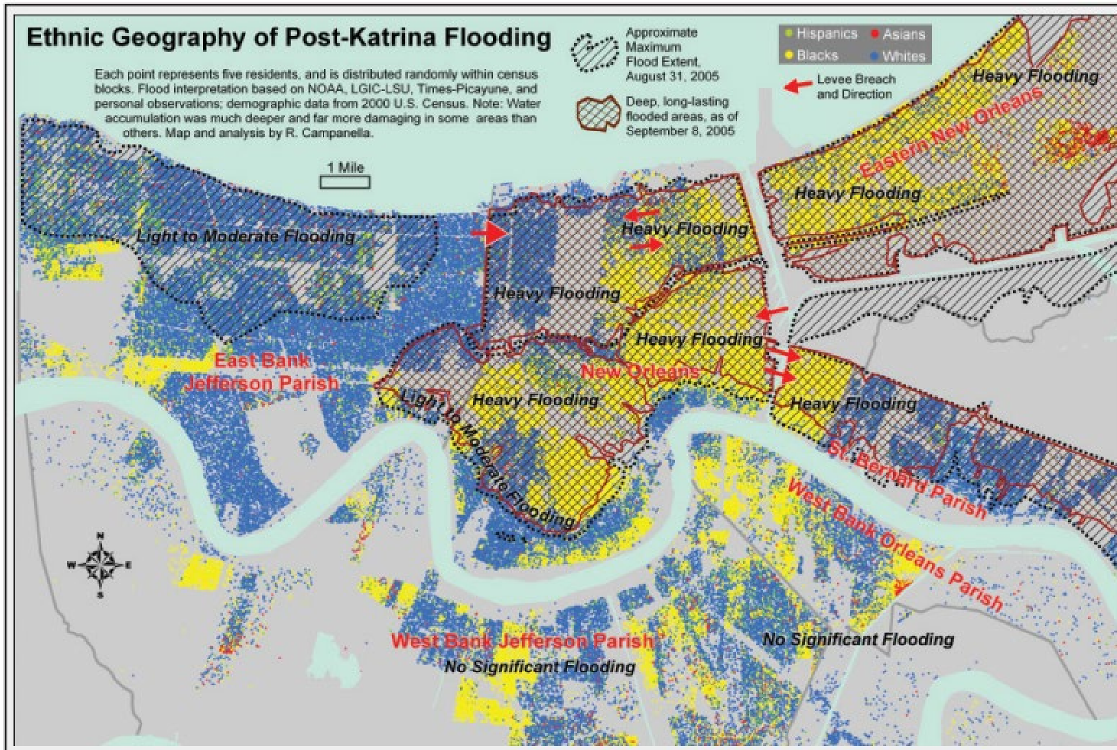
A.5 Demographic supplements – Post-Katrina

Table 7: Ethnic geography of post-Katrina flooding (Campanella, 2006, p. 401)

Ethnic Geography of Post-Katrina Flooding

New Orleans Metro Area Group	Initially Flooded Population: Residential population of homes with regard to maximum spatial extent of flood, August 31, 2005.		Persistently Flooded Population: Residential population of homes with regard to areas still flooded on September 8, 2005.	
	Flooded	Not Flooded	Flooded	Not Flooded
All Residents (988,182)	574,798 (58%)	413,384 (42%)	397,048 (40%)	591,134 (60%)
Whites (500,672)	256,123 (51% of whites)	244,549 (49% of whites)	121,262 (24% of whites)	379,410 (76% of whites)
Blacks (429,902)	286,391 (67% of blacks)	143,511 (33% of blacks)	257,375 (60% of blacks)	172,527 (40% of blacks)
Asians (25,552)	14,578 (57% of Asians)	10,974 (43% of Asians)	9,240 (36% of Asians)	16, 312 (64% of Asians)
Hispanics (49,342)	28,450 (58% of Hispanics)	20,892 (42% of Hispanics)	11,830 (24% of Hispanics)	37,512 (76% of Hispanics)

Figures represent urbanized portions of Orleans, Jefferson, and St. Bernard parishes on both banks, excluding Rigolets and rural south Jefferson. Sum of ethnic-group totals exceeds total population because of double-counting among groups. All percentages are with respect to total for that group. Figures may vary depending on criteria used to identify lightly flooded areas. Analysis by R. Campanella based on 2000 Census and flood estimates by NOAA, FEMA, LSU, and other sources.



Although ethnic and racial diversity characterized the human geography of the flooded regions, certain groups suffered disproportionately. Of those residences in the tri-parish metropolis (which was 44 percent black in 2000) that flooded immediately after the storm, 50 percent of the pre-Katrina occupants of those households were black. Of those that remained flooded ten days later, 65 percent were black, indicating that the deepest and most persistently flooded areas were predominantly, though not overwhelmingly, African American. *Map and analysis by author.*

Figure 11: Map - "Ethnic geography of post-Katrina flooding" (Campanella, 2006, p. 400)

A.6: Post-Katrina planning alternative – ‘Green Dot Plan’

Immediately following Hurricane Katrina, the Bring New Orleans Back Commission (BNOBC) was established to consider plans for the city moving forward (Horowitz, 2020; Fields et al., 2017). One such plan presented to the BNOBC came to be known as the “green dot plan,” as “conceptual renderings of park space in the form of ‘green dots’ were superimposed on existing, low-lying neighborhoods… presented at a time when most citizens were not ready or able to participate in postdisaster planning, were perceived by many as signposts for wholesale abandonment of neighborhoods and conversion to parks” (Fields et al., 2017, p. 313). Though not originally the intent of the green dot plan, fears surrounding racist recovery efforts, abandonment of whole neighborhoods for water retention purposes, a return to a city that did not resemble home, and little community engagement in the creation of these plans spelled the disposal of these ideations (Horowitz, 2020; Fields et al., 2017).

A.7: Co-occurrence tables

A.7.1 Institutional inertia and costs

Table 8: Institutional inertia and costs co-occurrence

	• CBA: negative Gr=33		• CBA: positive Gr=57		• Cost of projects: negative Gr=112		• Cost of projects: positive Gr=2		• Perc.: project benefits: negative Gr=4		• Perc.: project benefits: positive Gr=44		• Transaction costs: negative Gr=241		• Transaction costs: positive Gr=14	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
• No change: actors Gr=30	0	0.00	3	0.04	1	0.01	0	0.00	0	0.00	1	0.01	4	0.01	0	0.00
• No change: practices Gr=41	1	0.01	1	0.01	3	0.02	0	0.00	0	0.00	0	0.00	6	0.02	0	0.00
• Perc.: innovation: high resistance Gr=26	1	0.02	0	0.00	5	0.04	0	0.00	0	0.00	1	0.01	11	0.04	0	0.00
• Perc.: innovation: low resistance Gr=26	0	0.00	3	0.04	1	0.01	0	0.00	0	0.00	17	0.32	1	0.00	0	0.00
• Perc.: insti. change: high resistance Gr=63	1	0.01	0	0.00	14	0.09	0	0.00	1	0.02	3	0.03	29	0.11	0	0.00
• Perc.: insti. change: low resistance Gr=14	0	0.00	3	0.04	1	0.01	0	0.00	0	0.00	6	0.12	0	0.00	0	0.00
• Significant change: actors Gr=29	0	0.00	1	0.01	1	0.01	0	0.00	0	0.00	0	0.00	5	0.02	1	0.02
• Significant change: practices Gr=22	0	0.00	3	0.04	0	0.00	0	0.00	0	0.00	2	0.03	1	0.00	0	0.00
• Some change: actors Gr=21	0	0.00	1	0.01	2	0.02	0	0.00	0	0.00	3	0.05	4	0.02	1	0.03
• Some change: practices Gr=62	2	0.02	8	0.07	5	0.03	1	0.02	0	0.00	8	0.08	6	0.02	0	0.00

A.7.2 Institutional inertia and uncertainty

Table 9: Instutional inertia and uncertainty co-occurrence

	● Cl. Imp.: high uncertainty Gr=11		● Cl. Imp.: low uncertainty Gr=27		● Cl. Imp.: medium uncertainty Gr=67		● Responsibility: high uncertainty Gr=21		● Responsibility: low uncertainty Gr=109		● Responsibility: medium uncertainty Gr=72	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
● No change: actors Gr=30	0	0.00	0	0.00	5	0.05	0	0.00	7	0.05	0	0.00
● No change: practices Gr=41	0	0.00	0	0.00	5	0.05	0	0.00	4	0.03	0	0.00
● Perc.: innovation: high resistance Gr=26	0	0.00	0	0.00	0	0.00	1	0.02	0	0.00	0	0.00
● Perc.: innovation: low resistance Gr=26	0	0.00	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00
● Perc.: insti. change: high resistance Gr=63	1	0.01	0	0.00	0	0.00	1	0.01	0	0.00	1	0.01
● Perc.: insti. change: low resistance Gr=14	0	0.00	1	0.03	0	0.00	0	0.00	1	0.01	0	0.00
● Significant change: actors Gr=29	0	0.00	0	0.00	0	0.00	0	0.00	4	0.03	3	0.03
● Significant change: practices Gr=22	0	0.00	0	0.00	2	0.02	0	0.00	1	0.01	2	0.02
● Some change: actors Gr=21	0	0.00	0	0.00	0	0.00	0	0.00	3	0.02	0	0.00
● Some change: practices Gr=62	0	0.00	0	0.00	4	0.03	0	0.00	3	0.02	2	0.02

A.7.3 Institutional inertia and path dependence

Table 10: Institutional inertia and path dependence co-occurrence

	Imp. Innovation: high Gr=37		Imp. Innovation: low Gr=6		Imp. Innovation: medium Gr=7		Investment costs: all-time Gr=95		Investment costs: annual Gr=8		Legal requirements: lax Gr=7		Legal requirements: strict Gr=148		Perc.: Public trust: high Gr=8		Perc.: Public trust: low Gr=64	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
No change: actors Gr=30	0	0.00	0	0.00	0	0.00	6	0.05	0	0.00	0	0.00	2	0.01	0	0.00	2	0.02
No change: practices Gr=41	0	0.00	0	0.00	0	0.00	6	0.05	0	0.00	0	0.00	2	0.01	0	0.00	1	0.01
Perc.: innovation: high resistance Gr=26	1	0.02	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	8	0.05	0	0.00	7	0.08
Perc.: innovation: low resistance Gr=26	3	0.05	0	0.00	2	0.06	3	0.03	1	0.03	0	0.00	5	0.03	3	0.10	0	0.00
Perc.: insti. change: high resistance Gr=63	1	0.01	0	0.00	1	0.01	3	0.02	0	0.00	0	0.00	13	0.07	0	0.00	15	0.13
Perc.: insti. change: low resistance Gr=14	3	0.06	0	0.00	0	0.00	4	0.04	1	0.05	0	0.00	1	0.01	3	0.16	0	0.00
Significant change: actors Gr=29	1	0.02	0	0.00	0	0.00	3	0.02	0	0.00	0	0.00	5	0.03	0	0.00	0	0.00
Significant change: practices Gr=22	4	0.07	0	0.00	0	0.00	8	0.07	0	0.00	0	0.00	2	0.01	1	0.03	0	0.00
Some change: actors Gr=21	0	0.00	0	0.00	0	0.00	3	0.03	0	0.00	0	0.00	4	0.02	0	0.00	0	0.00
Some change: practices Gr=62	1	0.01	0	0.00	1	0.01	15	0.11	0	0.00	1	0.01	10	0.05	0	0.00	3	0.02

A.7.4 Institutional inertia and power/legitimacy

Table 11: Institutional inertia and power/legitimacy co-occurrence

	• Authority: high Gr=171		• Authority: low Gr=4		• Perc.: Agency in decision-making: high Gr=8		• Perc.: Agency in decision-making: low Gr=11		• Perc.: Legitimate decision-making: high Gr=2		• Perc.: Legitimate decision-making: low Gr=37		• Perc.: System improvement: high Gr=15		• Perc.: System improvement: low Gr=44		• Perc.: System improvement: none Gr=7	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
• No change: actors Gr=30	10	0.05	0	0.00	1	0.03	1	0.03	0	0.00	1	0.02	0	0.00	2	0.03	0	0.00
• No change: practices Gr=41	4	0.02	0	0.00	1	0.02	1	0.02	0	0.00	2	0.03	1	0.02	3	0.04	1	0.02
• Perc.: innovation: high resistance Gr=26	0	0.00	0	0.00	0	0.00	3	0.09	0	0.00	2	0.03	1	0.03	8	0.13	0	0.00
• Perc.: innovation: low resistance Gr=26	0	0.00	0	0.00	3	0.10	0	0.00	1	0.04	0	0.00	5	0.14	1	0.01	0	0.00
• Perc.: insti. change: high resistance Gr=63	5	0.02	0	0.00	0	0.00	5	0.07	0	0.00	13	0.15	1	0.01	18	0.20	5	0.08
• Perc.: insti. change: low resistance Gr=14	0	0.00	0	0.00	3	0.16	0	0.00	1	0.07	0	0.00	5	0.21	0	0.00	0	0.00
• Significant change: actors Gr=29	7	0.04	0	0.00	1	0.03	0	0.00	0	0.00	1	0.02	0	0.00	0	0.00	0	0.00
• Significant change: practices Gr=22	4	0.02	0	0.00	1	0.03	0	0.00	0	0.00	0	0.00	2	0.06	0	0.00	0	0.00
• Some change: actors Gr=21	5	0.03	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
• Some change: practices Gr=62	9	0.04	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	1	0.01	1	0.01	0	0.00

A.7.5 Institutional inertia and complexity

Table 12: Institutional inertia and complexity co-occurrence

	• City area Gr=38		• City area below sea level Gr=92		• Decision-making accessibility: high Gr=5		• Decision-making accessibility: low Gr=48		• Demographics: flood insurance coverage Gr=27		• Demographics: mean age Gr=5		• Demographics: mean household income Gr=17		• Demographics: race Gr=47		• Demographics: spatial distribution Gr=64		• Level of political actor understanding of risk: high Gr=54	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
• No change: actors Gr=30	1	0.01	1	0.01	0	0.00	3	0.04	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	0.05
• No change: practices Gr=41	1	0.01	3	0.02	0	0.00	2	0.02	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	5	0.06
• Perc.: innovation: high resistance Gr=26	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	1	0.01	1	0.01	0	0.00
• Perc.: innovation: low resistance Gr=26	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Perc.: insti. change: high resistance Gr=63	0	0.00	0	0.00	0	0.00	5	0.05	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.02
• Perc.: insti. change: low resistance Gr=14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Significant change: actors Gr=29	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	3	0.04
• Significant change: practices Gr=22	2	0.03	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.02	2	0.03
• Some change: actors Gr=21	0	0.00	0	0.00	1	0.04	2	0.03	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
• Some change: practices Gr=62	1	0.01	3	0.02	2	0.03	2	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.03

	• Level of political actor understanding of risk: low Gr=32		• Level of political actor understanding of risk: medium Gr=24		• Level of public understanding of risk: high Gr=24		• Level of public understanding of risk: low Gr=44		• Level of public understanding of risk: medium Gr=40		• Perc.: Clarity in decision-making: high Gr=14		• Perc.: Clarity in decision-making: low Gr=14		• Perc.: Clarity in responsibilities: high Gr=32		• Perc.: Clarity in responsibilities: low Gr=25		• Public participation requirements Gr=23		• Urban flooding impact Gr=158	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
• No change: actors Gr=30	0	0.00	1	0.02	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	1	0.02	0	0.00	0	0.00	0	0.00
• No change: practices Gr=41	0	0.00	1	0.02	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Perc.: innovation: high resistance Gr=26	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Perc.: innovation: low resistance Gr=26	0	0.00	1	0.02	1	0.02	0	0.00	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Perc.: insti. change: high resistance Gr=63	3	0.03	0	0.00	0	0.00	4	0.04	2	0.02	0	0.00	1	0.01	1	0.01	1	0.01	1	0.01	0	0.00
• Perc.: insti. change: low resistance Gr=14	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
• Significant change: actors Gr=29	2	0.03	0	0.00	3	0.06	1	0.01	0	0.00	0	0.00	0	0.00	1	0.02	1	0.02	0	0.00	0	0.00
• Significant change: practices Gr=22	1	0.02	0	0.00	2	0.05	1	0.02	0	0.00	0	0.00	0	0.00	0	0.00	1	0.02	0	0.00	1	0.01
• Some change: actors Gr=21	0	0.00	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	0	0.00	2	0.05	2	0.01
• Some change: practices Gr=62	0	0.00	0	0.00	0	0.00	2	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	6	0.03

A.7.6 Institutional inertia and critical junctures

Table 13: Institutional inertia and critical junctures co-occurrence

	• CJ: Alternatives not present Gr=4		• CJ: Alternatives present Gr=104		• Design moment: negative Gr=9		• Design moment: positive Gr=110		• Govt funding improvements: negative Gr=79		• Govt funding improvements: positive Gr=92		• Govt funding O&M: negative Gr=56		• Govt funding O&M: positive Gr=6		• Perc.: Decision impact: negative Gr=10		• Perc.: Decision impact: positive Gr=21		• Perc.: Decision weight: negative Gr=4		• Perc.: Decision weight: positive Gr=23		• Perc.: Timing: negative Gr=96		• Perc.: Timing: positive Gr=19	
	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient	count	coefficient
• No change: actors Gr=30	0	0.00	6	0.05	0	0.00	10	0.08	1	0.01	7	0.06	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.02	0	0.00
• No change: practices Gr=41	0	0.00	6	0.04	1	0.02	9	0.06	2	0.02	6	0.05	2	0.02	0	0.00	1	0.02	0	0.00	0	0.00	1	0.02	4	0.03	1	0.02
• Perc.: innovation: high resistance Gr=26	0	0.00	2	0.02	0	0.00	2	0.01	3	0.03	2	0.02	1	0.01	1	0.03	1	0.03	0	0.00	0	0.00	0	0.00	3	0.03	1	0.02
• Perc.: innovation: low resistance Gr=26	0	0.00	4	0.03	0	0.00	4	0.03	2	0.02	6	0.05	0	0.00	1	0.03	0	0.00	4	0.09	0	0.00	4	0.09	2	0.02	2	0.05
• Perc.: insti. change: high resistance Gr=63	0	0.00	4	0.02	0	0.00	6	0.04	9	0.07	2	0.01	7	0.06	1	0.01	5	0.07	0	0.00	1	0.02	2	0.02	11	0.07	2	0.03
• Perc.: insti. change: low resistance Gr=14	0	0.00	4	0.04	0	0.00	6	0.05	0	0.00	4	0.04	0	0.00	1	0.05	0	0.00	4	0.13	0	0.00	4	0.12	0	0.00	3	0.10
• Significant change: actors Gr=29	0	0.00	6	0.05	2	0.06	5	0.04	0	0.00	4	0.03	1	0.01	1	0.03	1	0.03	1	0.02	1	0.03	1	0.02	0	0.00	1	0.02
• Significant change: practices Gr=22	0	0.00	10	0.09	0	0.00	10	0.08	0	0.00	9	0.09	0	0.00	2	0.08	0	0.00	3	0.08	0	0.00	3	0.07	0	0.00	1	0.03
• Some change: actors Gr=21	0	0.00	2	0.02	0	0.00	3	0.02	0	0.00	5	0.05	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00	1	0.02	1	0.01	0	0.00
• Some change: practices Gr=62	0	0.00	14	0.09	0	0.00	18	0.12	2	0.01	16	0.12	2	0.02	1	0.01	0	0.00	1	0.01	0	0.00	1	0.01	3	0.02	2	0.03

Appendix 2: Interview guides

B.1 Interview guide introduction

Hello, my name is Allison Olsonoski. I am a master's student at the Institute for Housing and Urban Development at Erasmus University Rotterdam in the Netherlands. I am currently working on my master's thesis, in which I am researching institutional inertia and critical junctures in the water management sector using a case study in New Orleans, Louisiana. Having completed thorough background research and analysis of the water management sector in New Orleans since 1896 (creation of established drainage authority in NOLA), it is prudent to expand on my findings with expert input and insights. Therefore, this interview aims to supplement my research thus far. Specifically, I am seeking input on perceptions of factors contributing to this inertia from your expert background, as well as a conversation on the city's future in water management.

Your input will be treated as highly confidential: data gathered in this interview will not be seen or utilized by anyone other than the present interviewer (Allison Olsonoski). Additionally, your name and answers will remain anonymous. If you have any questions regarding this interview during or after we finish, please feel free to reach out to me.

<u>Background Information:</u>

- Background – expertise, education
- Current role

B.2 Interview guide for community engagement proxies

1. What do you gage as the public's level of trust in the current water management system? Qualify/expand if needed.
   - o High level of trust
   - o Medium level of trust
   - o Low level of trust
2. What is the public's level of understanding regarding the water management system? Qualify/expand if needed.
   - o High
   - o Medium
   - o Low
3. Do you believe the public is open to soft engineering water management options?
   - o If not, why not?
4. Do you believe the government is open to soft engineering water management options?
   - o If not, why not?
5. Is decision-making in the water management sector perceived as legitimate by the public? By experts?
   - o Talk about drainage operations
   - o Talk about accessibility to decision-making regarding innovations and current institutions
6. What are the public participation requirements for system improvements / additions?
7. What is the level of public engagement regarding the water management sector?
8. How has the water management system in New Orleans changed (i.e., improved) since Hurricane Katrina?
   - o What else do you believe could be done?
9. Is the institutional structure of water management in New Orleans capable of change?
   - o Why or why not?
10. What is the future of water management in New Orleans?
    - o In a discussion of critical junctures, will the future be abandonment or institutional change?

B.3 Interview guide for government actors

1. Are climate change impacts to New Orleans uncertain? What is your perception:
    - Low uncertainty
    - Medium uncertainty
    - High uncertainty
2. What is your perception of governmental actor understanding of risks associated with water management system:
   Qualify/expand if needed.
    - High level
    - Medium level
    - Low level
3. Are roles and responsibilities for each actor in the water management sector clear? Are they uncertain? What is your perception, and qualify as necessary:
    - Low uncertainty
    - Medium uncertainty
    - High uncertainty
4. Is the decision-making process in the water management sector clear? What is your perception, and qualify as necessary:
    - High clarity
    - Medium clarity
    - Low clarity
5. Do current legal structures / requirements for the water management sector act as a barrier to change? Is the current system legally embedded?
6. Is the government budget for the drainage system adequate (improvements, O&M)?
7. Do you see transaction costs (e.g., Number of bureaucratic / nongovernmental actors to coordinate; Red tape) as a barrier to institutional change? Explain.
8. In your opinion, how has timing affected institutional change post-disaster?
    - What moments in time have given you the impression that that “agents' choices will affect the outcome of interest” relative to that probability before and after a certain time period (Capoccia & Kelemen, 2007, p. 348)?
9. In your experience after disasters (from recollection or experience), have alternatives for water management change presented themselves in a path dependent manner? (i.e., did you have an understanding that decisions made within a certain time period would have long-lasting impacts, difficult to deviate away from as time passed?)
10. After great disasters, what do you recall as significant changes to the water management system? This can include practices/ system elements/ actors.
    - Has the water management system been improved since Hurricane Katrina? What more needs to be done, if anything?
11. Is there resistance to institutional change in the water management sector? (i.e., is there an openness to innovation and systematic changes to the way we manage water?)
12. If not destructive and disruptive hurricanes, what other event do you believe could trigger a “critical juncture” or “design moment”?
13. What is your perception of new practices and paradigms regarding water management (e.g., Greater New Orleans Urban Water Plan)?
14. Do you see a benefit in implementing new ways of managing water in New Orleans? If not, why? If so, how?

  - Is it realistic to expect these innovations are capable of making New Orleans safer and more resilient to flooding hazards?

15. What is the future of water management in New Orleans?
    - In a discussion of critical junctures, will the future be abandonment or institutional change?

B.4 Interview guide for subject experts

1. Are climate change impacts to New Orleans uncertain? What is your perception:
    - Low uncertainty
    - Medium uncertainty
    - High uncertainty
2. What is the public's level of understanding regarding the water management system? Especially as it pertains to the risks associated with living in New Orleans. Qualify/expand if needed.
    - High
    - Medium
    - Low
3. What is your perception of governmental actor understanding of risks associated with water management system: Qualify/expand if needed.
    - High level
    - Medium level
    - Low level
4. Are roles and responsibilities for each actor in the water management sector clear? Are they uncertain? What is your perception, and qualify as necessary:
    - Low uncertainty
    - Medium uncertainty
    - High uncertainty
5. Is the decision-making process in the water management sector clear? What is your perception, and qualify as necessary:
    - High clarity
    - Medium clarity
    - Low clarity
6. Do current legal structures / requirements for the water management sector act as a barrier to change? Is the current system legally embedded?
7. Is the government budget for the drainage system adequate (improvements, O&M)?
8. Do you see transaction costs (e.g., Number of bureaucratic / nongovernmental actors to coordinate; Red tape) as a barrier to institutional change? Explain.

9. In your opinion, how has timing affected institutional change post-disaster? Positive or negative?
    - What moments in time have given you the impression that that "agents' choices will affect the outcome of interest" relative to that probability before and after a certain time period (Capoccia & Kelemen, 2007, p. 348)?
10. In your experience after disasters (from recollection or experience), have alternatives for water management change presented themselves in a path dependent manner?
    - (i.e., did you have an understanding that decisions made within a certain time period would have long-lasting impacts, difficult to deviate away from as time passed?)
11. After great disasters, what do you recall as significant changes to the water management system? This can include practices/ system elements/ actors.
    - Has the water management system been improved since Hurricane Katrina?
    - What more needs to be done, if anything?
12. Is it feasible to change the institutional structure / decision-making process for water management in New Orleans?
    - Is it necessary?
13. Is there resistance to institutional change in the water management sector? (i.e., is there an openness to innovation and systematic changes to the way we manage water?)
14. If not destructive and disruptive hurricanes, what other event do you believe could trigger a "critical juncture" or "design moment"?
15. What is your perception of new practices and paradigms regarding water management (e.g., Greater New Orleans Urban Water Plan)?
16. Do you see a benefit in implementing new ways of managing water in New Orleans? If not, why? If so, how?
    - Is it realistic to expect these innovations are capable of making New Orleans safer and more resilient to flooding hazards?
17. What is the future of water management in New Orleans?
    - In a discussion of critical junctures, will the future be abandonment or institutional change?

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