

University of Vermont

ScholarWorks @ UVM

UVM Honors College Senior Theses

Undergraduate Theses

2017

Cultural Heritage and Rising Seas: Water Management, Governance, and Heritage in Venice and Amsterdam

Katherine D. Mitchell

Follow this and additional works at: <https://scholarworks.uvm.edu/hcoltheses>

Recommended Citation

Mitchell, Katherine D., "Cultural Heritage and Rising Seas: Water Management, Governance, and Heritage in Venice and Amsterdam" (2017). *UVM Honors College Senior Theses*. 161.
<https://scholarworks.uvm.edu/hcoltheses/161>

This Honors College Thesis is brought to you for free and open access by the Undergraduate Theses at ScholarWorks @ UVM. It has been accepted for inclusion in UVM Honors College Senior Theses by an authorized administrator of ScholarWorks @ UVM. For more information, please contact donna.omalley@uvm.edu.

Cultural Heritage and Rising Seas

Water Management, Governance, and Heritage in Venice and Amsterdam

Katherine Mitchell



A thesis submitted
in partial fulfillment of the requirements
for the degree of Bachelor of Arts

Environmental Program
College of Arts and Sciences
Honors College

University of Vermont

May 2017

Advisors

Kelley DiDio, PhD, University of Vermont

Brendan Fisher, PhD, University of Vermont

Abstract

Global climate change poses threats, including sea level rise, that will affect cultural heritage. Cultural heritage is “the legacy of physical artifacts and intangible heritage attributes of a group or society that are inherited from past generations, maintained in the present, and bestowed for the benefit of future generations” (UNESCO Office in Cairo, 2016). Venice and Amsterdam are two cities with cultural heritage sites and vulnerability to flooding as a result of geography and rising sea levels. This research is organized into two case studies that examine the history, water management strategies, current challenges, and governance of these two cities as it relates to protection of their cultural heritage in the face of flooding caused by sea level rise.

Keywords: cultural heritage, water management, flooding, sea level rise.

Acknowledgements

I would like to express my gratitude, first and foremost, to my advisors, Brendan Fisher and Kelley DiDio. To Brendan for his time and support from the beginning of the proposal process all the way through my final thesis, and to Kelley for all of her advice and her Honors College sophomore seminar *Art and Its Destruction*, which sparked my love for art history and inspired this thesis.

I would like to thank my defense committee members, Rachelle Gould and Anthony Grudin, for generously giving their time. This project would not have been possible without the assistance of UVM research librarians Laurie Kutner and Daisy Benson, who offered their expertise and helped me to find stacks of books and hundreds of articles.

There are not enough ways to thank my parents, Tom and Christine Mitchell, for their endless support throughout my college career and thesis process and especially for their willingness to read numerous proposal and thesis drafts.

I would also like to thank my friends for commiserating and letting me ramble about Venetian Renaissance Architecture and ancient Dutch water management over dinner, I couldn't have done it without you!

Table of Contents

Introduction.....	5
Case Study: Venice.....	13
History.....	13
Historical Water Management.....	29
Site Overview.....	34
Challenges and Threats.....	35
Governance.....	46
Case Study: Amsterdam.....	49
History.....	49
Historical Water Management.....	62
Site Overview.....	68
Current Challenges.....	69
Modern Water Governance.....	76
Conclusion.....	79
References.....	82

Introduction

Global climate change poses threats to cultural heritage, many of which are not well understood. Most current research in this area involves case studies of threatened sites, suggestions of general risk assessment and management strategies, and calls to action. Threats to cultural heritage are increasingly being documented at the site level but there are still gaps in the literature around adaptation to and mitigation of these threats both at specific sites and on a national and global level.

Cultural Heritage

Defining cultural heritage. Cultural heritage is defined most concisely by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as “the legacy of physical artifacts and intangible heritage attributes of a group or society that are inherited from past generations, maintained in the present, and bestowed for the benefit of future generations” (UNESCO Office in Cairo, 2016). Cultural heritage is divided into three broad categories recognized and utilized by UNESCO: monuments, groups of buildings, and sites. The term encompasses tangible (physical) heritage, both movable and immovable (including underwater heritage), and intangible heritage, which includes oral traditions and rituals (O'Brien, O'Keefe, Jayawickrama, & Jigyasu, 2015; Yahaya, 2006). Cultural heritage is important to the people living in the area, as well as domestic and foreign tourists and the broader global community (O'Brien et al., 2015). In 1972 UNESCO adopted the definitions of the three categories of heritage that are in use today. Sites are defined as “works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view” (UNESCO, 2008; Yahaya, 2006).

Heritage tangible value. All categories of cultural heritage hold value, both tangible and intangible, to the local and global communities. This value is not always immediately evident, especially when compared to the value of other infrastructure (D. C. Harvey & Perry, 2015). Cultural heritage holds tangible, economic value by providing employment and as a major attraction for tourists (Howard, 2013; O'Brien et al., 2015; Phillips, 2015). An estimated fifty percent of tourism is driven by cultural heritage and five percent of the world's Gross Domestic Product (GDP) comes from tourism. Tourism as a whole also supports one in twelve jobs globally and is a major export (source of income) for many countries (O'Brien et al., 2015). Because heritage has this economic value in driving tourism and providing employment, one argument for preservation of heritage is that future generations should be afforded the same economic benefits (Phillips, 2015). Where at-risk or threatened heritage sites are concerned, tourism is a threat and also a source of income (F. Harvey, 2016).

Heritage intangible value. Cultural heritage also holds intangible value. Arguments have been made that heritage is essential to human existence and experience, and as such it can be a driver of resilience in the face of disasters (O'Brien et al., 2015). As cities developed, so did cultural heritage sites, such as government buildings and places of worship, that provided a location for the daily political, economic, and religious activities of the inhabitants (O'Brien et al., 2015). These sites and buildings hold an emotional attraction for both local people and visitors, as familiar views that provide a link to the past (Nettley, DeSilvey, Anderson, Wetherelt, & Caseldine, 2014; O'Brien et al., 2015). The sense of place and associated cultural landmarks of a city are essential to local identity (Howard, 2013; O'Brien et al., 2015; Phillips, 2015; Smith, Messenger, & Soderland, 2010) and should be passed on to future generations as well (Colette, 2007; Smith et al., 2010).

Climate Change, Sea Level Rise, and Flooding

Cities in the United States, such as Miami Beach, Florida; New Orleans, Louisiana; New York, New York; Charleston, South Carolina; Norfolk, Virginia; Tybee Island, Georgia; and Fort Lauderdale, Florida, are already experiencing flooding due to rising sea levels (Gillis, 2016; Kolbert, 2015). For example, yards, driveways, and roads in Miami Beach flood at high tide and the city has already spent hundreds of millions of dollars on flood defenses and damage repair (Kolbert, 2015). New York's response to Hurricane Sandy shows that it is likely the city best prepared for sea level rise in the United States, though the country as a whole is only in the earliest stages of responding to climate change (Pilkey, Pilkey-Jarvis, & Pilkey, 2016).

Concentrations of carbon dioxide in the atmosphere are higher now than at any time in the past 800,000 years (United Nations Environment Program, UNESCO, & Union of Concerned Scientists, 2016). Global temperatures have warmed one degree Celsius since 1880 (United Nations Environment Program et al., 2016). Current oceanic and atmospheric warming, rising sea levels, and diminished snow and ice are unprecedented (United Nations Environment Program et al., 2016). As global temperatures continues to increase, so will the rate of sea-level rise (United Nations Environment Program et al., 2016).

Scientific research suggests that given present global temperatures, a certain amount of sea level rise is now guaranteed (Pilkey et al., 2016; Rice, 2016). Sea level rise predictions by the end of the century range from 3 to 6.5 feet (between 0.9 and 1.9 meters) (Kolbert, 2015; Ward, 2010), and some geologists think there is a possibility of a 10 to 30 foot (3 to 9 meter) rise in the next one hundred years (Hinkel et al., 2014; Kolbert, 2015). The range of predictions is due to different assumptions of the rate of ice sheet melting, which could hold steady or increase with

time (Kolbert, 2015). The rate of subsidence, or sinking of the land, could also exacerbate sea level rise in certain areas (Hinkel et al., 2014).

Coastal areas offer easy access to the ocean, which brings economic benefits such as shipping, transportation, and industries like fishing, tourism, and recreation (Pilkey et al., 2016). Most of the largest cities and nearly half of the world's population are on or near coasts and are, to varying degrees, threatened by rising sea levels (Kolbert, 2015; Pilkey et al., 2016). An estimated one hundred million people live within three feet of mean high tide and another hundred million live within six feet (Kolbert, 2015). Storm surges, predicted to be increasingly destructive, could impact hundreds of millions more (Kolbert, 2015). Cities will have to adapt and come up with creative and innovative solutions mostly on their own because each city is in a unique situation and no how-to guide exists (Kolbert, 2015). Predicted sea level rise would cause annual losses of between 0.3% and 9.3% of global GDP and both flood protection and damages would cost billions of dollars (Hinkel et al., 2014).

The majority of scholarship on the subject of climate change preparedness and heritage threats accepts climate change as human-caused, with the exception of a few sources that are more than thirty years old. Disagreement comes on what the best response is (Hinkel et al., 2014; Kolbert, 2015; Pilkey et al., 2016; Rice, 2016). Some experts and scholars argue that retreat from the coasts and abandonment of low-lying areas is, or will soon become, the only option, others hope to use technology to mitigate risks and adapt.

Threats to Heritage

Cultural heritage has always been at risk from a range of factors that includes natural disasters and conflict (O'Brien et al., 2015). Throughout history works of art have been destroyed by a variety of means: intentionally, as a result of conflict or natural disasters, or simply by being

ignored or forgotten (Gamboni, 2005). There are modern examples of iconoclasm, the motivated destruction of art, which often accompanies domestic and international conflicts. The giant statues of Buddha destroyed by the Taliban in Bamiyan, Afghanistan and the Twin Towers in New York are both examples of heritage, valued by the local and international community, that have been targeted and lost (Gamboni, 2005; Latour, 2002). Whether movable or not, cultural heritage objects have legal protection, but a lack of legal recognition from the local government or acknowledgement of importance from the international community can lead to neglect and less investment in preservation (Gamboni, 2005).

Climate-related threats. Climate change has emerged as a new threat that will continue to threaten cultural heritage in a variety of ways and requires further study (Cassar, 2005; O'Brien et al., 2015; UNESCO World Heritage Centre, 2007, 2008). Natural processes, which stand to shift due to climate change, threaten archeological remains both above and below ground (Howard, 2013). Groundwater pollution and salt precipitation can damage stone buildings, as well as their sculptural decoration (Gazquez, Rull, Medina, Sanz-Arranz, & Sanz, 2015). Air pollution is also a threat to buildings and sculpture. Airborne particles can degrade the surfaces of materials, altering their appearance and obscuring decoration and details (de la Fuente, Vega, Viejo, Diaz, & Morcillo, 2011, 2013).

Rising global temperatures are changing freezing patterns and melting permafrost in some areas. Fewer freezing events in certain areas can be positive for heritage because freezing and thawing cycles put pressure on historic stone. However, many archeological remains, including human bodies, are preserved in permafrost and might be damaged or lost if they are no longer kept at a constant temperature (Grossi, Brimblecombe, & Harris, 2007). Disappearing

permafrost can also cause the foundations of buildings to shift and may lead to more frequent landslides that could obscure archeological sites (Grossi et al., 2007).

Climate change can also affect the indoor environment, particularly in historic buildings with little insulation. This can result in changes in both temperature and humidity which can cause damage to heritage objects housed in the buildings (Huijbregts, Kramer, Martens, van Schijndel, & Schellen, 2012). Human activity in response to climate change can also be destructive, particularly to the archeological record in areas where humans attempt to move and fill land where it is lost to erosion and rising sea levels (Howard, Challis, Holden, Kincey, & Passmore, 2008).

The Statue of Liberty, Stonehenge, and the Galapagos Islands are all examples of UNESCO World Heritage sites at risk from climate change (F. Harvey, 2016). Climate change may lead to milder winters in the United Kingdom that could lead to population growth among burrowing mammals, in turn destabilizing the stonework at Stonehenge (Guarino, 2016). Drought in California has exposed archaeological sites that have been submerged under lakes, rivers, and reservoirs for hundreds of thousands of years, leaving the sites vulnerable to looting (Brown, 2015). Both the Louvre and the Musee d'Orsay, art museums in Paris, were shut down in June 2016 after days of rain caused both museums to enact emergency plans to evacuate works of art to higher floors to protect them from flood threats (Stapley-Brown, 2016). With moveable heritage, such as paintings, protection is simpler because the works can be moved out of harm's way (Stapley-Brown, 2016).

UNESCO published a report in May 2016 entitled *World Heritage and Tourism in a Changing Climate*. Climate change is quickly becoming one of the most significant risks for world heritage (United Nations Environment Program et al., 2016). Current and future climate

change could threaten the outstanding universal value (OUV), integrity, and authenticity of world heritage sites (United Nations Environment Program et al., 2016). This is a threat to the economies and communities that depend on tourism (United Nations Environment Program et al., 2016). The report states that there is an “urgent need to better understand, monitor and address climate change threats to World Heritage sites” (United Nations Environment Program et al., 2016).

Climate change will increase vulnerability of sites to other stressors, such as tourism and infrastructure development, and create challenges for preservation (United Nations Environment Program et al., 2016). Visitor safety is also an issue at some sites (United Nations Environment Program et al., 2016). Cultural heritage sites lose some of their significance if they are moved, which is usually not possible, and cannot be recovered if lost (United Nations Environment Program et al., 2016). Inadequate management plans, issues with legal frameworks, and lack of funding or resources can all be barriers to management and protection (United Nations Environment Program et al., 2016). Policy changes and financial investments are needed for effective adaptation and could take decades to put in place (United Nations Environment Program et al., 2016). Adaptive capacity depends in part on the financial situation of the country as it dictates ability to prepare for natural disasters (United Nations Environment Program et al., 2016).

Sea level rise as a threat. Sea level rise is particularly worrisome for the preservation of cultural heritage because much of the world’s cultural and archeological heritage lies along coasts (Erlandson, 2008; Marzeion & Levermann, 2014). Using mapping of heritage sites and projected sea level rise, one study found that of the 720 cultural and mixed (sites with both natural and cultural) heritage sites on the UNESCO World Heritage List, 109 sites will be

threatened by rising sea levels with current warming trends. Without intervention, global temperatures are expected to rise exponentially which would impact at least an additional 27 sites (Marzeion & Levermann, 2014).

Protecting Cultural Heritage

Protecting cultural heritage from the stresses of climate change will require responses at both the national and local levels (UNESCO World Heritage Centre, 2007). UNESCO and other international conventions can provide recommendations to countries and request information but generally are not in a regulatory role (UNESCO World Heritage Centre, 2007). In most cases in which heritage is threatened, legal action can be taken to protect it, however policies cannot protect heritage from natural processes (D. C. Harvey & Perry, 2015). Because of the complexity of the issue, any management at the global level will require collaboration and will likely focus primarily on communication and education (UNESCO World Heritage Centre, 2007). Given the diversity of threats, most management will need to happen at the local level and with community involvement (Cassar, 2005; UNESCO World Heritage Centre, 2007).

There is currently considerable ongoing research on the impacts of climate change, but there is a lack of research on the impacts of climate change on heritage and on cultural heritage in particular (UNESCO World Heritage Centre, 2008). Public and political support are needed for both research and threat management (Cassar, 2005; UNESCO World Heritage Centre, 2008). Potential economic losses and their impact on society need to be examined through socio-economic research (UNESCO World Heritage Centre, 2008).

UNESCO reports, independent scientific studies, and scholarly articles indicate that site-level assessment and site-specific management are needed due to the variation in climate-related threats at each site (Cassar, 2005; Colette, 2007; Nettley et al., 2014; Reeder-Myers, 2015;

UNESCO World Heritage Centre, 2007, 2008; Westley, Bell, Renouf, & Tarasov, 2011).

Working with communities and leveraging citizen scientist programs may be an effective way to gain public support, complete assessments, and implement management programs at the site-level (D. C. Harvey & Perry, 2015). Studies and reports have proposed frameworks for assessing vulnerability or outlined the development of such frameworks and decision-making processes (Daire et al., 2012; Huijbregts et al., 2012; Nettley et al., 2014; O'Brien et al., 2015; Phillips, 2015; UNESCO World Heritage Centre, 2007).

Rising seas and the issue of world heritage and climate change have been receiving recent news coverage, especially in the wake of the 2016 UNESCO report, which may help raise awareness (Abel, 2017; Davidson, 2016; Guarino, 2016; F. Harvey, 2016). Overall there has been a call for more research and for informed decision-making and strategies regarding the management, adaptation, and protection of cultural heritage sites in the face of climate-related threats (Grossi et al., 2007; Howard, 2013; Marzeion & Levermann, 2014; UNESCO World Heritage Centre, 2007, 2008).

Case Study: Venice

Origins

Venice was founded in the fifth century CE, the exact year is frequently identified as 421 CE (Ferraro, 2012; Norwich, 1982; Plant, 2002), more than one hundred years after the capital of the Roman Empire was moved to Constantinople (Ferraro, 2012). Legend holds that the city was founded on March 25, which coincides with the feast of the Annunciation, the legendary foundation of Rome, and the vernal equinox (Ackroyd, 2009; Ferraro, 2012; Norwich, 1982).

Over the following centuries, Venice was built on the islands and marshes of what is now known as the Venetian lagoon (United Nations Environment Program et al., 2016).

The Venetian lagoon lies where the rivers from mainland Italy empty into the Northern Adriatic Sea. Here, salt and freshwater mix and a line of islands made up of sand and other materials dumped by the rivers help to form a barrier between the lagoon and the sea (Ackroyd, 2009; Norwich, 1982). Myths surrounding the city's founding have existed since its beginnings and include links to the Trojans that gave the Venetians classical ancestry coveted during the Renaissance (Ackroyd, 2009; Ferraro, 2012; Norwich, 1982).

Venice's original settlers were fishing people who escaped to the lagoon to avoid the aggressive tribes that were invading and colonizing northern Italy as the Roman Empire was crumbling (Ackroyd, 2009; Ferraro, 2012; Madden, 2012; Norwich, 1982). They arrived in the lagoon by boat and settled the area in huts constructed on stilts above the mud flats (Ackroyd, 2009; Ferraro, 2012). Life in the area was precarious from the beginning as the land was shaped by the tides and constantly shifting (Ferraro, 2012).

For the first half century, most people who fled to the lagoon saw the situation as temporary and returned to their homes and lives on the mainland as each wave of invasions passed (Norwich, 1982). The flow of refugees to the lagoon increased in the late fifth century with the invasion of the Huns and again in the sixth century with the Lombard invasion of northern Italy (Ackroyd, 2009; Ferraro, 2012; Norwich, 1982). Larger numbers of permanent inhabitants fundamentally changed the nature of the lagoon (Ackroyd, 2009; Ferraro, 2012). The people that migrated to the lagoon stayed grouped by the city they had migrated from, settling on separate islands (Ackroyd, 2009).

Despite being close to the former centers of Roman civilization, the area was remote and secluded (Ackroyd, 2009). Their geographic isolation allowed the Venetians to stay uninvolved in the upheavals that shook mainland Italy after the fall of the Roman Empire and provided safety for the lagoon's inhabitants (Ackroyd, 2009; Norwich, 1982; United Nations Environment Program et al., 2016). The early settlers were joined by nobles and craftsmen who brought with them traditions linked to the Etruscans, Greeks, and other Mediterranean civilizations (Ferraro, 2012). They also crossed paths with Gauls and Celts who left traces of their own cultures on the area (Ferraro, 2012).

By the sixth century, the beginnings of sea power and commerce, which would later be the foundations of the Venetian maritime empire, were already established (Ackroyd, 2009; Norwich, 1982). Early inhabitants of the lagoon took advantage of the wildfowl and marine life abundant in the area, and they harvested and traded salt (Ackroyd, 2009; Norwich, 1982). They were also known for their maritime skills and frequently transported people and goods between mainland ports, to Byzantium, and along the rivers of northern Italy (Ackroyd, 2009; Ferraro, 2012; Norwich, 1982). These early Venetians were involved in trade with Greece (Ackroyd, 2009) and had military and political links with the Byzantine Empire (Norwich, 1982).

In the ninth century, troops led by Charlemagne's son Pépin attacked Venice from the Adriatic, leading the inhabitants to move to a group of islands in the middle of the lagoon (Keahey, 2002). This set of islands were known as the Rivoalto, or high bank, and eventually became the Rialto, the central marketplace of the city (Ackroyd, 2009). The position of these islands in the center of the lagoon made them a safer location for the capital of an empire in later years because they are protected by sandbars and channels that were nearly impossible for potential invaders to navigate (Norwich, 1982).

In 466, representatives of each island community met to form a loose system of self-government that involved each of them selecting a tribune annually and all of the tribunes working together for the common good. This was the first sign of unity between the island communities and foreshadowed the eventual foundation of the Venetian Republic with its constitutional system (Ackroyd, 2009; Norwich, 1982). Venice elected its first Doge, the word for Duke in the local dialect (Ferraro, 2012), around the start of the eighth century and the title was passed down successively for more than a thousand years (Ferraro, 2012; Norwich, 1982).

The ducal system in Venice followed the Byzantine model of monarchy, but the position was primarily ceremonial between the ninth and thirteenth centuries (Ferraro, 2012). During this time, competing wealthy families maintained their independence and shaped events as they rose in status with wealth acquired through banking or trading (Ferraro, 2012). At the end of the twelfth century, an electoral council made up of both old and new powerful families was established to elect the Doge (Ferraro, 2012). The precarious nature of life in Venice because of the challenging environment required continuous cooperation and, along with the shared commercial interests, fostered social and political unity (Ferraro, 2012).

From the ninth through the fifteenth century, Venetian independence, power, and wealth grew in parallel with the gradual decline of major powers, including the Byzantine empire (Ferraro, 2012; United Nations Environment Program et al., 2016). The city-state expanded and became a powerful and rich trade state (United Nations Environment Program et al., 2016). In 828, Saint Mark the Evangelist became the patron saint of the city after the Venetians pirated his body from Alexandria and brought it to Venice (Ferraro, 2012). Saint Mark's symbol, the lion, became a symbol of the city and its expanding power and his body became a relic essential to Venetian civic identity (Ferraro, 2012).

The city became wealthy as a link between Europe, the Adriatic coast, Greece, Constantinople and the Black Sea, Egypt, and the Holy Land, especially as a result of the Crusades (Ferraro, 2012). Venetian ships offered passage by sea to the Holy Land, which helped with the opening of new trade routes in the southern and eastern Mediterranean (Ferraro, 2012). Venice benefitted from its secluded and central position, aligning itself with either West or East, either Catholic or Orthodox Christianity, depending on the situation (Ackroyd, 2009). Its independence and alliances with both the Franks and Byzantines allowed Venetian ships to sail freely to both the East and West. Venice became a predominantly merchant city (Ackroyd, 2009).

Commercial Hub and Empire

The city of Venice served as the capital of an independent Republic until 1797 (Fletcher & Spencer, 2005), its strategic position as a connection between the Middle East and continental Europe allowed the Republic to rise in power (Ferraro, 2012; Fletcher & Spencer, 2005). By the thirteenth century, Venice was one of Europe's largest cities, the center of a Mediterranean maritime empire, and a principle force in the Mediterranean world (Ferraro, 2012; Madden, 2012; Strathern, 2013). Venice's rise was slowed in the fourteenth century by a European banking collapse, two earthquakes, and several outbreaks of the Bubonic Plague (Strathern, 2013). Following this series of disasters, the city's trade was quickly revived in large part due to the state-run ship building enterprise and the Venetians became involved in the Black Sea slave trade, which was opened up following labor depletions across Europe because of the plague (Strathern, 2013).

Beginning in the late fourteenth century and throughout the fifteenth century, Venice was a commercial hub and the primary European trading partner of the Ottoman Empire (Ching, Jarzombek, & Prakash, 2011; Ferraro, 2012), as well as ports in the eastern Mediterranean that

were depositories for goods from Europe and from India, Persia, and China (Ferraro, 2012). Venice's power peaked in the fifteenth century thanks to control of maritime trade routes and continued to thrive in the sixteenth century (Ching et al., 2011; Ferraro, 2012). Venice had a monopoly over trade between Europe and the East, all goods brought overland from the Middle East and China were transported on Venetian ships and then distributed throughout Europe (Ferraro, 2012; Keahey, 2002), giving the city influence across the continent (Ching et al., 2011). In addition to transporting goods, Venice established a series of naval bases and colonies around the eastern Mediterranean in order to control production of finished goods (Ferraro, 2012). During this time, the islands of the Rialto became essentially a giant warehouse for the rest of Europe for products from around the known world (Ferraro, 2012). For centuries, the Venetian Republic had a monopoly on the spice market in the Mediterranean (Ghosh, 2016). Spain and Portugal first undertook exploration in the hopes of finding a route to the places in the Indian Ocean where spices were produced that bypassed Venice and the Middle East (Ghosh, 2016).

In the early fifteenth century, some focus shifted to developing trades within the city, such as dyeing and glass working (Strathern, 2013). Venice's image of stability and ability to maintain its independence even after mainland Italy was invaded by France and Spain at the end of the fifteenth century perpetuated the myth that the city had always existed and would endure forever, protected by God and Saint Mark (Ferraro, 2012). Venice is considered the birthplace of modern capitalism and was a free republic thriving on commerce for centuries while the rest of Medieval Europe was still governed by monarchs and the feudal system (Madden, 2012).

Art and Architecture Before the Renaissance

The wealth of the Venetian commercial empire caused an increase in building in the city and Venice's contact with other cultures through trade is evident in architecture from this period

(Ferraro, 2012). By the early ninth century, the ducal palace had been built along with the ducal chapel (Ackroyd, 2009), originally modeled after the Church of the Holy Apostles in Constantinople (Ferraro, 2012). This chapel burned down and was replaced in the mid eleventh century with a Greek-style basilica modeled again on the Church of the Holy Apostles and on the Hagia Sophia, also in Constantinople (Ferraro, 2012). The powerful families of Venice also built waterfront residences in the immediate area to be close to the center of power (Ackroyd, 2009; Ching et al., 2011). Constructing stone residences with large towers like those in most Italian cities was impossible on the unstable land in Venice, instead, the homes of wealthy Venetian merchants were waterfront palaces with their own docks and storerooms (Ferraro, 2012). The Venetians did not need defenses for their homes because of the peace that was characteristic of life in the Republican city (Ferraro, 2012; Madden, 2012).

Because of the Republic's frequent contact through trade with the Islamic world and northern Africa and its position straddling East and West, the architecture of the city is an eclectic mix of styles (Ferraro, 2012; Madden, 2012). Parts of the city plan are borrowed from the Islamic world and the skyline is reminiscent of major Islamic cities, the large public spaces mirror those in cities in northern Africa and Southwest Asia, and other features, like the footpaths and Grand Canal, appear similar to other cities in the Mediterranean and Middle East (Ferraro, 2012). Venetian contact with Constantinople and Alexandria is also evident in the Basilica of San Marco in which biblical stories are told in Byzantine gold mosaics probably produced by Greek artists between the twelfth and fourteenth centuries (Ferraro, 2012; Madden, 2012). The floor of San Marco is a marble mosaic that resembles an Asian carpet and contains images that resemble typical Byzantine images in their stillness (Ferraro, 2012; Madden, 2012). The exterior of San Marco is modeled after the Great Umayyad Mosque in Damascus and the

Dome of the Rock in Jerusalem with colorful mosaics and gold background instead of the plain brick exterior typical of Byzantine churches (Ferraro, 2012).

Due to Venice's rise in power, changes occurred to both the basilica of San Marco and the adjacent square during the twelfth and thirteenth centuries as Byzantine, Islamic, and Gothic features inspired by the travels of Venetian merchants were incorporated (Ferraro, 2012). The square was doubled in length, offices were constructed for public administrators, and the Basilica was topped with low domes that were characteristic of Byzantine churches (Ferraro, 2012). Other architectural forms, both Islamic and Arabic, were added during the thirteenth century as well as ornamentation and decorations, much of which was acquired as a result of war and the crusades (Ferraro, 2012; Madden, 2012). The most famous souvenir was from the Fourth Crusade, four horses were removed from the Hippodrome in Constantinople in 1204 and placed on the roof of the basilica (Ferraro, 2012).

During the thirteenth century, members of the Dominican, Franciscan, and Augustinian orders began to arrive from central Italy and built churches in the Gothic style, though with flat roofs instead of vaulted ceilings due to the instability of the soil in the city (Ferraro, 2012). The waterways, lack of space, and instability of the earth in Venice challenged architects to come up with creative ways to expand the homes of rich merchants (Ferraro, 2012). Building taller was not an option because of the soil, so homes were expanded over the streets instead (Ferraro, 2012). By the end of the fourteenth century, much of Venice's overall design was in place, the foundation for the city today, and its architectural fabric and material culture had been defined (Ferraro, 2012). In the fourteenth century, the Venetian Gothic style, a combination of French Gothic and Islamic architecture, had formed (Madden, 2012). This style can be seen in many

private palaces and in the Ducal Palace, characterized by pointed arches and other designs along an open façade (Madden, 2012).

Renaissance

In the early sixteenth century, Venice was a major regional Italian state because of its mainland possessions (Ferraro, 2012). Conflict and persecution were common across Europe in the fifteenth and sixteenth century, and the freedom in the Venetian Republic, as well as the strong economy, made Venice a popular place for immigrants (Ferraro, 2012). Venice became a world city, home to foreigners, tourists, and refugees who all contributed to the hybrid culture that came to be known as “Venetian” (Ferraro, 2012). Fifteenth century contact between Venice and mainland Europe contributed greatly to the development of Renaissance culture in the city during the sixteenth and seventeenth centuries (Ferraro, 2012). Over the course of the fifteenth and sixteenth centuries, the European trading economy shifted away from the Mediterranean and became concentrated in new centers on the Atlantic coast (Rietbergen, 1998), especially as other Europeans followed the Portuguese in discovering their own routes to Asia (Rietbergen, 1998). By the mid seventeenth century, Venice’s economic power had faded due to competition with the French, English, Dutch, and German ships that were all prominent in the Mediterranean by 1625 (Ching et al., 2011; Ferraro, 2012).

As its maritime and commercial power waned after 1630, Venice became instead one of Europe’s cultural capitals (Ferraro, 2012; Strathern, 2013), exhibiting the Venetians’ ability to adapt to changing circumstances by transforming their civic identity through the arts (Ferraro, 2012). Due in large part to the nearby University of Padua, Venice was also a center of learning and research during this period, attracting many notable Renaissance-era scholars (Strathern, 2013).

Renaissance art and architecture. The Italian Renaissance began in Florence during the fourteenth century and quickly made its way to Venice (Madden, 2012). The term Renaissance, meaning rebirth, refers to the return to classical models of architecture, sculpture, and literature during this time (Madden, 2012). The wealth acquired primarily through trade fueled the demand for art in Renaissance Venice and the peace in the city attracted skilled craftsmen who had trouble conducting business during the wars that were common on the mainland (Madden, 2012).

Venice was home to many Renaissance artists, including Jacopo, Gentile, and Giovanni Bellini, Giorgione, Titian, and later Tintoretto and Veronese (Ferraro, 2012; Madden, 2012; Strathern, 2013). They had a wide variety of talents and styles and their work became famous both within the city and across Europe (Ferraro, 2012; Madden, 2012). Venetian Renaissance painting, which reached its height in the second half of the sixteenth century, emphasized color and light rather than form and mass as central Italian painting did (Ferraro, 2012). Jacopo Bellini was one of the first Renaissance artists in Venice and his family workshop influenced the shift in Venetian art from fresco to oil paintings on canvas, which Jacopo had been introduced to in Bruges and which lasted better in the salty, humid climate (Madden, 2012).

When Venetian focus moved to local industries around the fifteenth century, both private homes and public buildings were transformed by increased spending (Ferraro, 2012). There was also a desire to display ties to Rome in architecture elements, such as arches, and building decoration (Ferraro, 2012). Following the sack of Rome by the troops of the Holy Roman Emperor Charles V in 1527, artists and architects who had been living in Rome for the Pope's patronage fled the city and some, including Jacopo Sansovino moved to Venice (Ferraro, 2012; Madden, 2012). This coincided with work on the part of Venetian nobles to redefine and Romanize the public image of the city (Ferraro, 2012). Sansovino was commissioned by Doge

Andrea Gritti to update the area around San Marco and transform it into a beautiful open space as part of his plan, implemented between 1537 and 1554, to turn Venice into a second or new Rome (Ferraro, 2012; Madden, 2012). During this time, Sansovino also redesigned parts of the Ducal Palace, notably the staircases, and designed several churches around the city as well as the Library of Saint Mark (Madden, 2012).

Architect Andrea Palladio moved to Venice in 1540 and was active after Sansovino's death, he used classical models in church architecture and the villas he designed for Venetian nobles (Ferraro, 2012; Madden, 2012). His architectural style, called the Palladian style, was influential in Western architecture for centuries and spread across Europe and to North America during the enlightenment, it can be seen in several of the government buildings in Washington, D.C. (Madden, 2012). Palladio changed the look of Venice, he built new classical facades for existing medieval buildings and designed new buildings (Madden, 2012). However, after a fire destroyed much of the Ducal Palace in 1577, the decision was made to rebuild the lost sections in the Gothic style, exactly as they were before the fire to represent the stability and longevity of the Venetian Republic (Ferraro, 2012; Madden, 2012).

Venice's most famous bridge, the Rialto Bridge, was built in the sixteenth century and was the only bridge to cross the Grand Canal before modern times (Madden, 2012). A permanent bridge was built during this period because sailing ships docked at warehouses and no longer needed to be able to sail down the canal (Madden, 2012). Many great architects, including Palladio and Michelangelo, submitted designs but the final design, that of Antonio da Ponte, combined beauty with function (Madden, 2012). It had three separate pathways to move traffic efficiently and market stalls that the government could rent out to make a profit (Madden, 2012).

By the beginning of the eighteenth century, Venice looked much like it does today, demonstrated by the cityscape paintings of the Venetian painter Canaletto from the mid eighteenth century (Madden, 2012; Strathern, 2013). After tourism started up again when Venice became part of Italy, Foreign and local artists painted the city, including Turner, Monet, Sargent, Manet, Whistler, and Renoir (Ferraro, 2012; Madden, 2012). New buildings built in the nineteenth and early twentieth century changed some of the historic image of the city (Ferraro, 2012).

Foreign Rule

By the eighteenth century, Venice's Golden Age had ended (Plant, 2002). Venice was praised for its antiquity and stable republic by enlightenment thinkers from France and England in the seventeenth and eighteenth centuries (Madden, 2012). Following the American and French revolutions, the political climate in Europe changed (Strathern, 2013). Little change was needed in Venice because the Republic had embraced enlightenment concepts long before the rest of the continent (Madden, 2012). Venice still remained on the geographic and political fringes of the continent, where repression was widespread, though a decline in tourism led to economic hardship and unrest (Strathern, 2013).

The French Revolution began in 1791 and was followed immediately by the Reign of Terror, which ended in 1794 (Madden, 2012). At this point the French set out to bring liberal revolution to the rest of the world (Madden, 2012). In early 1796, Napoleon Bonaparte was appointed commander in chief of the Army in Italy with the assignment to free northern Italy from Hapsburg rule and then move towards the Hapsburg capital in Vienna (Madden, 2012). Venice had adopted a strict neutrality policy, which it clung to as the Austrians and French

fought in northern Italy and even as the Venetian Republic lost parts of its mainland empire (Madden, 2012).

In early 1797, the last city in northern Italy fell to the French, and the Austrian troops retreated over the Alps (Madden, 2012). French troops remained in Italy to maintain peace and oversee the establishment of new republics (Madden, 2012). Napoleon believed that Venice was fighting against him by helping the Austrians and saw the Venetian Republic as a medieval, tyrannical state (Madden, 2012). Napoleon became determined to wipe the Venetian Republic off the earth, and after French and Venetian ships fired on each other in the lagoon, he delivered an ultimatum to the senate that included abolishing the Venetian Republic (Madden, 2012). The Great Council voted to dissolve the republic at the suggestion of Doge Lodovico Manin (Madden, 2012). Ironically, as Europeans were busy constructing new republics based on Ancient Rome, the Venetian Republic, established as Rome was falling and therefore the last link to the Roman empire, came to an end (Madden, 2012).

Venice fell to Napoleon in May 1797 (Ferraro, 2012; Plant, 2002; Strathern, 2013). By the time the city fell, its glory had long since started to disappear (Ferraro, 2012) and it had been in political and economic decline for at least two centuries (Norwich, 1982). Venice was ceded to Austria in October 1797 (Ferraro, 2012; Madden, 2012) and Austrian troops entered the city in January 1798 (Ferraro, 2012). Venice changed hands a few times between the French and the Austrians in the early nineteenth century (Madden, 2012; Plant, 2002), and the city continued to undergo decline under foreign rule (Ferraro, 2012). Under French control, visual representations of the Doge were removed from around the city and important artifacts were brought to Paris, though most were returned when French control ended (Ferraro, 2012). The city also entered an

economic recession under French rule, which improved somewhat under Austrian rule (Ferraro, 2012).

Unified Italy

In 1861, Italian nationalist troops formed a unified Italian state (Ferraro, 2012; Madden, 2012) that included all but Rome, still ruled by the Pope, and Venice, still under Austrian control (Madden, 2012). Venice was united with Italy in 1866 (Ferraro, 2012; Madden, 2012; Plant, 2002) after the Third Italian War of Independence (Madden, 2012). The city and its industries were revitalized during this period as projects were undertaken to restructure the city in order to increase its commercial and industrial potential to make it the capital of an Italian province (Ferraro, 2012).

During the second half of the nineteenth century, foreign visitors returned to Venice (Madden, 2012). Among them was English art critic John Ruskin, who alerted the world to Venice's precarious position through recording the crumbling city in need of restoration (Madden, 2012). He believed that Venice was a treasure that belonged to the whole world and that the Venetians did not understand the danger their city was in as "they undertook restorations that were in reality just demolitions" (Madden, 2012, p. 391).

In July 1902, the twelfth century Campanile of San Marco collapsed (Madden, 2012). In the age of newspapers, images of the scene triggered worldwide calls for restoration (Madden, 2012). It was rebuilt by 1912, identical on the exterior but with a modern frame (Madden, 2012). Throughout the twentieth century, the debate about whether to preserve or modernize the city would affect Venice (Madden, 2012).

World War I impacted the Venetian economy by limiting both tourism and shipping (Madden, 2012). The Austrians blockaded the lagoon and bombed Venice, however many of the

explosives dropped failed to explode (Madden, 2012). The Venetians had prepared for the possibility of bombing; artistic treasures like the horses of San Marco and Renaissance paintings and sculptures were removed from their usual locations and hidden or taken to the mainland, and churches were protected using padding and old mattresses (Madden, 2012).

Following the war, the Porto Marghera, a massive, modern port and industrial zone, was constructed to establish Venice as a modern commercial center (Ferraro, 2012; Keahey, 2002; Madden, 2012). The Fascist government under Mussolini worked to modernize Italy, which in Venice included the expansion of the city of Mestre near the port (Keahey, 2002), construction of a new bridge connecting the Rialto to the mainland, a new square with bus stands and a parking garage (Madden, 2012), and new public buildings (Ferraro, 2012). Little new housing was constructed in the historic city center during this time, and increasing numbers of workers began to commute from the mainland, causing the city on the lagoon to become more of a museum (Ferraro, 2012).

The city itself was not bombed during WWII because of its historical and cultural importance, though it did not escape other impacts of the war such as hunger and deportations of the Jewish population (Ferraro, 2012). The Allies were determined to preserve cultural treasures in Italy, and Venice's artistic and architectural treasures made it a relatively safe place during the war (Madden, 2012). Venice saw very few fatalities during World War II, the biggest cause of death was people falling into the canals during blackouts (Ackroyd, 2009)

Historical Tourism

Venice's tourism industry began during the Crusades when the city provided lodging for crusaders stopping between Europe and the Holy Land (Ferraro, 2012). Starting in the sixteenth century, visitors came to see relics, churches, palaces, paintings, and scenery, as well as for

carnival season (Ferraro, 2012). In addition to art and architecture, the city was known for music and opera (Ferraro, 2012). Reasons for travelling had shifted by this time, Europeans traveled to see unusual, interesting, and beautiful things rather than for commerce or religious reasons (Madden, 2012).

In the seventeenth century, the biggest draw for tourists was the art and diversity of architecture, as well as the festivals, and the number of tourists increased dramatically during Carnival and Sensa (Madden, 2012). Sensa celebrated the Venetian marriage to the sea on Ascension Day, government officials boarded a decorated ship and rowed to the edge of the lagoon, where the Doge threw a golden ring into the sea (Madden, 2012). Carnival was the festival that led up to lent, most European cities had some kind of celebration and Venice's became very popular (Madden, 2012). The Venetians devised ways to make both festivals draw more visitors, which included extending the duration and making both larger and more lavish (Madden, 2012).

In the eighteenth century, Venice was an obligatory stop on the Grand Tour undertaken by wealthy Europeans as part of their cultural education (Ferraro, 2012; Strathern, 2013). By this time, the city had become a tourist destination and was both a vibrant city and a museum (Madden, 2012). The Piazza San Marco with the Byzantine church of San Marco and Gothic Ducal Palace stood at its center and were the main attractions (Madden, 2012). The arrival of wealthy visitors from mainland Europe was welcome in a city that had lost its traditional sources of income (Madden, 2012).

In the mid-nineteenth century, tourism was down from eighteenth century levels and the Venetian economy was struggling (Madden, 2012). The Austrian government initiated several projects to modernize the city, including gas lighting and a proposed railroad bridge (Madden,

2012). The railroad opened travel up to a whole new class, it was no longer so expensive that it was limited to just the elite (Madden, 2012). After unification with Italy, Venice's future would rely on tourism (Madden, 2012). With the new Italian state came the return foreign visitors to Venice, including Americans traveling with greater ease due to the rise of steamships (Madden, 2012).

By the end of the nineteenth century, tourists came to Venice not for the entertainment but to see the city (Madden, 2012). Carnival was revived in the 1880s (Ferraro, 2012). The Lido, the longest of the barrier islands between the lagoon and the Adriatic (Ackroyd, 2009), was just a sand bar until the early twentieth century when it was transformed into a modern destination for wealthy tourists with the construction of resorts, high-end housing, and shops (Madden, 2012). The streets were wide, straight, and tree lined and allowed for cars, making the Lido the opposite of Venice, representing all things new instead of old (Madden, 2012). Following World War II, rising affluence in the United States and reliable air travel brought more and more Americans to Venice (Madden, 2012). Large numbers of tourists continue to visit Venice today.

Historical Water Management

Venice is made up of 118 separate islands inside a protected lagoon, in which the canals take the place of streets (UNESCO World Heritage Centre, 1987). The lagoon is a crescent, approximately thirty-five miles (fifty-six kilometers) in length and seven miles (eleven kilometers) in width, along the coast of northeastern Italy (Ackroyd, 2009). It is neither land nor sea, created about six thousand years ago from the mud, silt, and other debris carried to the area by the the Brenta, Sile, and Piave rivers flowing from the Alps (Ackroyd, 2009; Norwich, 1982). Much of the lagoon is shallow (Norwich, 1982) and the area is constantly shifting and shaped by

the tides (Ackroyd, 2009). A long, narrow bank of sand, divided into islands by three channels, protects the lagoon from the sea (Ackroyd, 2009).

All coastal lagoons will eventually transform into either land or open sea (Fletcher & Spencer, 2005). The Venetian lagoon would have become dry land about five hundred years ago if not for human intervention, today it is becoming increasingly deeper and more salty as the lagoon slowly returns to the sea (Ackroyd, 2009). The city of Venice and its history were built on altering the lagoon (Plant, 2002). Water management, careful maintenance, and daily use of waterways over the centuries have transformed the lagoon into an artificial landscape that is habitable by humans and that utilized the surrounding canals and water as walls to keep out enemy armies (Ackroyd, 2009; Fletcher & Spencer, 2005).

The flight from the Lombards in the sixth century led to the true emergence of Venice (Ackroyd, 2009). There is archaeological evidence from this time not only of human habitation, but also of work to reclaim land and manage the lagoon (Ackroyd, 2009; Ferraro, 2012). Starting in the ninth century, institutions were created and people appointed to oversee reclamation of land, defense against the sea, and dredging of canals (Ackroyd, 2009; Norwich, 1982). The earliest defenses were wooden stakes holding up wickerwork, later, rivers were diverted and stone walls and dams were built to keep out the water (Ackroyd, 2009). The central zone of the city and the most important settlements, the Rialto and San Marco, grew first (Ferraro, 2012) and strengthened the capital city of the growing republic (Norwich, 1982)

During the ninth and tenth centuries, each of the islands making up the city was a separate parish with its own church, central square, and patron saint (Ferraro, 2012). These island parishes used the canals for transportation and communication, and those that were closest together were also connected by bridges (Ackroyd, 2009; Ferraro, 2012). Each island could only

be reached by water and the two modes of transportation were by water or by foot via bridges and footpaths (Ferraro, 2012). There was usually a wharf on the canal near the church to bring in goods (Ferraro, 2012). During these few centuries marshes were drained, swampland reclaimed, dykes and dams built, and a ferry system of gondolas was established (Ackroyd, 2009).

Water and the natural flow of the tides were vital to life in Venice, serving as both transportation for goods and materials and the city's sewage system (Ferraro, 2012). The island parishes continued to evolve somewhat in form because of continuous silt deposition. The city was expanded further via landfills around the edges, resulting in Venice resembling a fish or a Byzantine mosaic in which canals separate irregular plots of land (Ferraro, 2012).

Each of the islands in the lagoon was gradually expanded, making the waterways that divided them, what have become today's canals, more narrow (Keahey, 2002). From the beginning, the construction of the city was a technological feat that relied on reclaiming land and filling in what had once been water with consolidated soil, dirt, gravel, and trash (Ferraro, 2012). Where buildings were constructed on the edge of what was once water, the parts of the foundations on the filled land often settled at a faster rate than the rest of the building, resulting in leaning towers and skewed buildings (Keahey, 2002). Canals were excavated and mud used to raise the level of the land and the city expanded by adding new landfills around its edges (Ferraro, 2012). Early Venetians dealt with rising water by raising the pavement around buildings or by demolishing the buildings, building up the ground, and creating new structures, as demonstrated by the five levels of older pavements that have been found beneath St. Mark's Square (Keahey, 2002).

Between 1250 and 1350, the Rialto was transformed into an international emporium, canals were dredged and watercraft circulation was improved (Ferraro, 2012). The island of

Rialto became a market providing Venetians with products from around the known world and a giant warehouse for all of Europe (Ferraro, 2012). It was linked to the port via the Grand Canal (Ferraro, 2012).

Between the fourteenth and eighteenth centuries, rivers were diverted through a process of trial and error to prevent silt buildup in the lagoon (Fletcher & Spencer, 2005; Keahey, 2002; Zanda, 1989). In 1534 a massive dike (St. Mark's Dike) was completed to protect the lagoon from the periodic floods of the Piave River (Keahey, 2002). In the mid seventeenth century the Venetians built marble seawalls along the Adriatic side of the barrier islands Lido and Pellestrina to further protect them and the lagoon from the sea (Fletcher & Spencer, 2005; Keahey, 2002). Throughout this period, the Venetians monitored the dynamics of the water closely and made changes to the lagoon as necessary (Fletcher & Spencer, 2005; Zanda, 1989).

Scholarship on the history of the relationship between Venice and the sea refers to the sea as an enemy of the people, one with which they are engaged in a constant battle, and the city as insecurely or precariously placed (Ackroyd, 2009). The lagoon, and life in it, are constantly shifting (Ackroyd, 2009). This fight against the sea and the precarious nature of life call for community effort and create a common purpose (Ackroyd, 2009). The sense of communal life led the Venetians to be the first in Italy to create a communal palace and civic square (Ackroyd, 2009). Venice was also among the first cities to benefit from some kind of city planning, which in this case included zoning of industries along the edges of the city (Ackroyd, 2009).

Proximity to the sea has always been a fact of life in Venice, bringing floods and fear as well as wealth (Ackroyd, 2009). The Venetians maintained the lagoon because it was necessary for survival and to protect their way of life (Ferraro, 2012; Keahey, 2002). The tides, flowing into the city and back out again twice each day, removed waste from the lagoon, preventing

outbreaks of illnesses and infections like malaria and taking the place of a sewer system (Keahey, 2002; Zanda, 1989). The Venetians understood the importance of the lagoon and the tides and during the Republic there were strict laws regarding water (Keahey, 2002). The lagoon also provided the city with a natural defense and buffer from medieval Italy that allowed it to become a commercial and military power (Ferraro, 2012; Zanda, 1989). Waterways were vital for transportation, trade, food, and protection (Ferraro, 2012). The importance of the connection between the city and the sea was emphasized by the ritual Marriage with the Sea (Ferraro, 2012).

The waters were given the same reverence as walls of a city, anyone that dared to damage them was seen as an enemy (Fletcher & Spencer, 2005). Early on, the city recognized the need to protect the water from pollutants, including the saltwater that was designated to be used for waste (Ferraro, 2012). Ordinances were put in place to protect the lagoon from pollutants such as cloth dyes and spoiled meat (Ferraro, 2012).

Venice's environment and proximity to the sea, and therefore connection with foreign lands, made it unique among medieval Italian cities (Ferraro, 2012). Removed from the conflicts of the mainland and with the sea for protection, the Venetians could focus on creating a commercial empire instead of on warfare (Ferraro, 2012). The government grew as the empire expanded and special magistracies were established to control, among other things, water and sanitation (Ferraro, 2012). Drinking water supply depended on rainfall and was brought in from the rivers during droughts (Ferraro, 2012).

Some of the earlier river diversions were reversed in the mid nineteenth century for environmental, shipping, and health reasons (Fletcher & Spencer, 2005). Between 1880 and 1920, protective dykes were constructed at the three entrances to the Lagoon (Zanda, 1989). They allowed for new, bigger boats to navigate into the port more easily but altered natural sand

transport around the lagoon and created new erosion effects (Zanda, 1989). By this time, Venice was part of Italy and therefore no longer in control of protecting the lagoon itself and the needs of the mainland prevailed over the needs of Venice (Ackroyd, 2009; Fletcher & Spencer, 2005).

Site Overview

The UNESCO World Heritage site description for Venice and its Lagoon is as follows:

Founded in the 5th century and spread over 118 small islands, Venice became a major maritime power in the 10th century. The whole city is an extraordinary architectural masterpiece in which even the smallest building contains works by some of the world's greatest artists such as Giorgione, Titian, Tintoretto, Veronese and others. (UNESCO World Heritage Centre, 1987)

The UNESCO World Heritage site comprises the city of Venice and the surrounding lagoon, inscribed on the World Heritage List because it is a unique artistic achievement and has one of the highest concentrations of artistic masterpieces in the world (UNESCO World Heritage Centre, 1987). The artists that lived and worked there had considerable influence on the development of art and architecture across Europe (UNESCO World Heritage Centre, 1987). Venice is still an inhabited city but also holds a unique position as an archeological monument to its own historical importance as the capital of a Republican trading empire and a link between East and West (UNESCO World Heritage Centre, 1987). Because the boundaries of the city are so clearly delineated by water, Venice has retained the integrity of its built heritage and has remained quite similar to the city of the Middle Ages and Renaissance, contributing to the authenticity of the heritage site (UNESCO World Heritage Centre, 1987).

UNESCO's report from May 2016 on world heritage and climate change describes Venice as "one of the World Heritage sites most at threat from sea-level rise" and continues, "the

city's extraordinary assemblage of Byzantine, gothic, renaissance and baroque architecture is under immediate threat from rising sea levels" (United Nations Environment Program et al., 2016, p. 85). Venice sits at a singular site as a "city on water", and existing at the edge of land and sea leads to unique urban problems (Plant, 2002).

Challenges and Threats

High water levels and tourism have been identified as major challenges for the city of Venice (Fletcher & Spencer, 2005; Plant, 2002). For centuries, citizens have struggled to live with water, high tides, and storms, and to maintain the lagoon (United Nations Environment Program et al., 2016). The sea was once the key to Venice's identity and independence, providing a buffer against invading forces and shaping the unique urban landscape and is now a source of danger and vulnerability (Ferraro, 2012; Keahey, 2002; Madden, 2012). The delicate balance of life on water that allowed Venice to flourish is at risk today because of development and population growth in the area as well as natural processes that can no longer self regulate (Zanda, 1989).

Archeological research shows that the sea level has been gradually rising in Venice since its earliest buildings were constructed and that the sea level in the Adriatic was approximately sixteen feet lower at that time than it is today (Fletcher & Spencer, 2005; Keahey, 2002). Over time buildings in the city have been constructed at gradually increasing elevations (Fletcher & Spencer, 2005). Between the fifth and eleventh centuries Venetians raised the ground level by six feet (Keahey, 2002).

Sea level in Venice has risen by approximately thirty centimeters (almost twelve inches) since the end of the nineteenth century (Fletcher & Spencer, 2005; Keahey, 2002; United Nations Environment Program et al., 2016; Zanda, 1989). St. Mark's square is the lowest part of the city

(Fletcher & Spencer, 2005), at the beginning of the twentieth century the square flooded fewer than ten times each year, by the end of the same century it was flooding an average of forty to sixty times per year (Ackroyd, 2009; Fletcher & Spencer, 2005; Keahey, 2002; Ward, 2010; Zanda, 1989).

Acqua alta, the local name for exceptionally high tides (Fletcher & Spencer, 2005), are part of a natural cycle of winds and tides (Ackroyd, 2009) and generally occur due to winter storms between October and January (Keahey, 2002). These tides and the flood events that generally accompany them have been increasing in size and frequency (Ackroyd, 2009; Fletcher & Spencer, 2005; Keahey, 2002; Madden, 2012; Pacione, 1974; Zanda, 1989) because of rising sea levels and stronger and more frequent winter storms (Keahey, 2002). High tides and flood waters are also remaining within the city for longer periods (Pacione, 1974). Venice's location at the northern end of the Adriatic makes it vulnerable to unique weather patterns (Fletcher & Spencer, 2005; Keahey, 2002) and an unusually large range between high and low tides (three feet in the Adriatic while only one foot in the rest of the Mediterranean) (Keahey, 2002).

Higher sea levels in Venice are caused in part by global sea level rise due to climate change (Ackroyd, 2009; Keahey, 2002; Zanda, 1989) and compounded by natural and human-caused land subsidence, or sinking, in the area (Ackroyd, 2009; Ferraro, 2012; Fletcher & Spencer, 2005; Keahey, 2002; Pacione, 1974; Zanda, 1989). The Adriatic tectonic plate is sinking (Fletcher & Spencer, 2005) and this natural process was accelerated by pumping of groundwater between 1930 and 1970 (Ackroyd, 2009; Fletcher & Spencer, 2005; Keahey, 2002; Pacione, 1974; United Nations Environment Program et al., 2016). Groundwater pumping was stopped to slow the sinking process (United Nations Environment Program et al., 2016), though the land continues to sink because of the weight of the city (Ferraro, 2012; Keahey, 2002;

Pacione, 1974; Ward, 2010). Venice is also naturally sinking at a faster rate than other Adriatic coastal areas because it sits on river sediments and the creation of new channels for shipping within the lagoon has exacerbated subsidence (Keahey, 2002).

Venice also faces a variety of other challenges including motor boat and cruise ship traffic (Ferraro, 2012; Fletcher & Spencer, 2005), lack of canal maintenance because dredging would have removed toxic waste that could not be properly disposed of (Fletcher & Spencer, 2005; Keahey, 2002; Madden, 2012; Plant, 2002), and pollution and degraded water quality in the lagoon (Madden, 2012; Pacione, 1974; Plant, 2002; Zanda, 1989). These problems are caused by both human inaction, as sea defenses and infrastructure were neglected and allowed to deteriorate, and human action, in the form of industrial development near the older parts of the city (Keahey, 2002; Pacione, 1974; Plant, 2002).

Because of these complex challenges and the global interest in Venice and its artistic and architectural treasures (Keahey, 2002), the city has been the subject of recent research and scholarship. This research includes predictions and modeling of future climate change and flooding in the area (Carbognin, Teatini, Tomasin, & Tosi, 2010; Piero Lionello, 2012; P. Lionello, Galati, & Elvini, 2012; Riccardo Mel & Lionello, 2014; R. Mel, Sterl, & Lionello, 2013; Raicich, 2015; Scarascia & Lionello, 2013; Troccoli, Zambon, Hodges, & Marani, 2012; Zanchettin, Traverso, & Tomasino, 2007). Studies have also been done to explore specific challenges and aspects of vulnerability and make suggestions about institutional changes that authors see as necessary to the future safety of the city (Munaretto, Vellinga, & Tobi, 2012; Sipio & Zezza, 2011; Torresan, Critto, Rizzi, & Marcomini, 2012). The nature of the government structure in Italy and the views of residents of Venice, many of whom are opposed to change, make implementation of these potential solutions difficult (Keahey, 2002). *Earth Magazine*

published an article entitled “Climate Change Brings Hopeful News for Venice” (“Climate change brings hopeful news for Venice,” 2011). According to the article, climate change “may save the...city of Venice despite rising sea levels” because research indicates that storm surges are likely to decrease in the Adriatic Sea over the next century (“Climate change brings hopeful news for Venice,” 2011).

1966 Flood

The challenges facing Venice became recognized internationally in 1966 after a historic flood (Ferraro, 2012; Zanda, 1989). In November 1966, a massive storm system hit Italy and caused the worst flood in recent history, damaging art and cultural heritage in Venice as well as other Italian cities such as Florence (United Nations Environment Program et al., 2016). The storm surge flooded parts of Venice up to 2 meters above sea level for twenty hours (Fletcher & Spencer, 2005; Keahey, 2002; Madden, 2012; Plant, 2002; Zanda, 1989).

The flood was a wake-up call for Venice and the world because it exposed the city’s fragile position and the extent to which the city’s infrastructure and artistic heritage had fallen into disrepair and decay (Ferraro, 2012; Keahey, 2002; Madden, 2012; Plant, 2002). Within a few days of the flood, expressions of concern and calls for protection from future flooding had come from within Venice and Italy as well as from the international community (Keahey, 2002). This led to a gathering of scientists in 1969 to discuss the issues facing the city (Fletcher & Spencer, 2005). Funding and actual public works projects took much longer (Keahey, 2002).

Floods of this magnitude are estimated to have occurred only about five times in the entire history of Venice, meaning that many generations can live in the city without experiencing the damage of extremely high water (Keahey, 2002). Another large flood occurred in 1979

(Plant, 2002), with water levels reaching 5.4 feet (1.66 meters), just 11 inches (28 centimeters) lower than the 1966 flood (Keahey, 2002)

MOSE System

One of the proposed solutions to protect Venice from flooding is the Modulo Sperimentale Elettromeccanico (Experimental Electromechanical Module in English) or MOSE project, a series of 79 flood gates across the three entrances connecting the Venetian Lagoon to the Adriatic Sea that will rise when a tidal flood of at least 110 cm is predicted and will hold back flood waters until they recede (Ackroyd, 2009; Madden, 2012; Rinaldo et al., 2008; United Nations Environment Program et al., 2016; Ward, 2010). The MOSE system won a 1971 contest for designs to protect the city during flood events (Fletcher & Spencer, 2005). A prototype was tested between 1988 and 1992 (Fletcher & Spencer, 2005; Keahey, 2002). The project was delayed in the 1990s because of environmental concerns, other projects to clean up the lagoon and repair canal infrastructure began during this time (Keahey, 2002). The plans were officially approved in the early 2000s (Fletcher & Spencer, 2005; Keahey, 2002) and the project was originally due to be completed in 2011 (Ward, 2010). Construction is still underway and currently set to be completed in 2017 (United Nations Environment Program et al., 2016).

The decades-long delays in testing and approval of the project demonstrate the intense scientific, social, and political debates about to best protect Venice and its lagoon (Fletcher & Spencer, 2005). The gates are likely not a long term solution, they will help to control flooding until sea levels eventually rise above them (Keahey, 2002; United Nations Environment Program et al., 2016; Ward, 2010) and they will not prevent continued subsidence and rising of waters in the lagoon (United Nations Environment Program et al., 2016). This project indicates a shift in thinking about flood causes in Venice, the 1966 flood was caused by high water in several rivers

but these barriers are designed to protect Venice from the sea, which is now recognized as the bigger threat (Ward, 2010).

Throughout the planning and design process, many arguments have been made against constructing the barriers. The project is expensive, as of summer 2016 Venice had spent more than \$6 billion on it (United Nations Environment Program et al., 2016), and many Venetians oppose prioritizing the gates over other projects in the city, such as remedying neglected infrastructure management, that also need funding (Ackroyd, 2009; Keahey, 2002). Leaving the barriers closed for extend periods of time will cause water quality issues within the lagoon by preventing natural tidal flushing (Ackroyd, 2009; Fletcher & Spencer, 2005; Keahey, 2002; Madden, 2012; United Nations Environment Program et al., 2016). The barriers could also make certain flood events worse by trapping runoff and excess river water in the lagoon rather than allowing it to flow out to sea (Keahey, 2002; Rinaldo et al., 2008). Another criticism is that the gates only deal with flooding from rising seas, just one of several issues facing the city (Keahey, 2002).

London, another city that sits at low elevation and deals with periodic tidal flooding, built a similar barrier system on the Thames River in the 1980s (Keahey, 2002). Advocates for the Thames barrier argue that it is much more cost effective than repairing damage from a major flood (Keahey, 2002). London and Venice do differ in their layouts and flooding poses a much greater threat to human life in London than in Venice (Keahey, 2002).

Tourism

Another major concern in Venice is tourism (United Nations Environment Program et al., 2016). Venice is a cultural center and one of the world's most iconic and most popular tourist destinations (Madden, 2012; United Nations Environment Program et al., 2016). Rising

affluence across the globe is increasing the amount of tourism worldwide and the number of tourists visiting Venice is growing (Madden, 2012). In 2013, the city hosted nearly ten million overnight visitors and more than twenty million day visitors (United Nations Environment Program et al., 2016). The annual Carnival celebration, now highly commercialized to pay for the extra services required (including police, garbage collection, and street maintenance), draws hundreds of thousands of tourists each year (Madden, 2012; Plant, 2002).

Tourism brings money to the city and its businesses and creates jobs (United Nations Environment Program et al., 2016), however the number of visitors entering the city, frequently more than the population on any given day (Madden, 2012; Plant, 2002), is dangerous for the infrastructure and must be addressed (Plant, 2002; United Nations Environment Program et al., 2016). Measures have been put in place in popular areas to control the volume of visitors (Plant, 2002). The rising waters in Venice have not deterred tourists, the water covering the Piazza San Marco caused by the *acqua alta* is now another draw for visitors (Madden, 2012). The city's economy relies on tourism, which is also one of the forces slowly destroying the city (Madden, 2012; Plant, 2002; Ward, 2010).

The large numbers of tourists, combined with the high cost of housing and more available jobs outside the tourism sector on the mainland, has driven a migration out of the city center (Ackroyd, 2009; Madden, 2012; Plant, 2002; United Nations Environment Program et al., 2016; Ward, 2010). This is changing the nature of Venice from a living city to a museum of historical heritage (Madden, 2012; Plant, 2002; Ward, 2010), which shifts discussions about preservation and protection. The areas outside of the main tourism areas appear neglected and buildings are deteriorating because of water and subsidence (Ackroyd, 2009; Zanda, 1989). Some scholars believe that it is too late to restore Venice to a living city (Ackroyd, 2009) and others go so far as

to say that it may need to be abandoned completely (Ward, 2010). Rising sea levels are exacerbating problems and bringing the city closer to uninhabitable (Keahey, 2002; Madden, 2012). Venice is struggling to maintain the character of its city (United Nations Environment Program et al., 2016).

UNESCO Involvement

In addition to altering the Italian and international perception of Venice and its challenges, the 1966 flood led to greater involvement in Italy on the part of UNESCO (Keahey, 2002). The Italian government requested help from the organization immediately following the flood, though the initial concern for art was in Florence (Keahey, 2002). UNESCO established an office in Venice in 1973 and has worked to raise international awareness of the problems facing the city (Keahey, 2002; Madden, 2012; Ward, 2010). This has allowed individual restoration projects for artworks and buildings to take place while bigger urban plans are caught up in the local and regional governments (Keahey, 2002; Madden, 2012). Venice and Its Lagoon was inscribed on the UNESCO World Heritage List in 1987 (UNESCO World Heritage Centre, 1987).

In 2014, Venice was given a warning by UNESCO and a list of problems to act on before 2016, which included cruise ships and motorized vessels sailing in the city, infrastructure issues, creation of a sustainable tourism strategy, and the need for a coordinated approach to protection of the outstanding universal value (OUV) of the site (Cocks, 2016). In October 2015, UNESCO participated in carrying out a joint monitoring mission to review the state of conservation of all components of the site and found that both the authenticity and integrity of the site, criteria to remain on the World Heritage List, are threatened (World Heritage Committee, 2016). This report raised concerns about the volume of boat traffic, which causes wave action, air pollution,

and the risk for accidents like grounding and fuel spills (World Heritage Committee, 2016).

Venice is threatened by both inaction (lack of preservation, abandon) and excessive or poorly planned action (excessive wear, wave motion) (Plant, 2002; World Heritage Committee, 2016).

One big issue is a lack of consensus on a vision for the future among the many stakeholders at the local, regional, and national levels (World Heritage Committee, 2016). Non-governmental and civil society organizations are often excluded from decision-making processes (World Heritage Committee, 2016). The 2016 report stresses the need for collaboration between the many stakeholder groups (World Heritage Committee, 2016). In addition, it states that the decline in population in the historic city center is concerning and repeats calls for several actions such as regular maintenance for historic buildings, a sustainable tourism strategy, enforcements of speed limits, and exclusion of large ships and tankers from the lagoon (World Heritage Committee, 2016).

The organizations suggest that the MOSE project gates, which were under construction at the time of the report and expected to be operational within a year, be viewed as an experiment that will be adapted with expanding knowledge and that additional solutions will be needed and should be sought (World Heritage Committee, 2016). There is concern that proposed development projects in the area may damage the heritage site (World Heritage Committee, 2016). The report recommends specific immediate, short- and long-term measures to protect the property in the areas of concern as well as further examination by the World Heritage Committee to determine if the site should be placed on the List of World Heritage in Danger (World Heritage Committee, 2016). Addition to the list, which currently contains 55 sites primarily threatened by conflict and proximity to war zones, would lead to close monitoring by UNESCO officials that is likely unwelcome by the city (Cocks, 2016). UNESCO's World Heritage Site

Committee voted in July 2016 to postpone the decision about whether to add Venice to this list until 2017 (Cocks, 2016).

Other Action

In response to the 1966 flood, international organizations, such as British Venice in Peril and American Save Venice, were set up to raise funds for research and individual restoration projects (Ackroyd, 2009; Ferraro, 2012; Keahey, 2002; Madden, 2012; Pacione, 1974; Ward, 2010). Twenty-nine organizations in eleven countries were organized into an NGO called the Association of Private Committees for the Safeguarding of Venice, which works closely with UNESCO (Madden, 2012). Venice in Peril has held workshops and conferences resulting in reports on the challenges facing Venice (Fletcher & Spencer, 2005). Save Venice raises about a million dollars per year through masked balls, exclusive lectures, and high-end tours of Venice for wealthy Americans and has funded individual restoration projects on its own (Madden, 2012).

The lack of government action in Venice could become problematic for foreign donors (Keahey, 2002). The Venice in Peril chairperson has stated concerns about continuing to fund restoration on individual buildings if the whole city remains under threat from flooding (Fletcher & Spencer, 2005). Individual restoration projects can only go so far and may not matter if the city becomes uninhabitable (Pacione, 1974). Following restoration, heritage needs monitoring and maintenance so that it does not fall into disrepair again (Keahey, 2002). The stance of organizations like Save Venice and Venice in Peril is generally that they must do what they can, restore and protect heritage, and hope that the government does what it can to protect the city from future flooding (Keahey, 2002).

Some restorations, such as the recent work on the Ducal Palace, have been funded through corporate sponsorship (Madden, 2012). Many people protested the billboards that were added to the exterior of scaffolding, but the mayor defended the decision as an efficient way to pay for much-needed restoration of the city's architectural treasures (Madden, 2012). Citizens have also protested projects that change the appearance of the city, generally because worn materials are replaced or cleaned (Keahey, 2002).

Within Venice, a variety of actions have been taken or are currently underway to address smaller-scale issues. Businesses at ground level have worked to protect themselves from intruding water, including raising floor levels, creating temporary barriers across doorways, and the use of pumps to remove water from floods (Fletcher & Spencer, 2005). Projects have been completed or are currently underway to raise public surfaces such as roads, walkways, and bridges; create flood barriers; repair canals; and waterproof walls (Fletcher & Spencer, 2005; Keahey, 2002). The inner-city work will likely protect against smaller floods and high tides, but cannot protect against large flood events like the 1966 flood (Keahey, 2002).

Damage to Cultural Heritage

Much of the cultural heritage in Venice today is a result of large amounts of artistic work during the Renaissance (Madden, 2012). Cultural heritage in the city is fragile, vulnerable to deterioration and damage, and must be maintained in order for the city to maintain its historical meaning (Plant, 2002; Zanda, 1989). Buildings deteriorate over time due to environmental factors and age, these processes have accelerated over the past several decades (Zanda, 1989).

Many of Venice's buildings were constructed on the lagoon by driving wooden posts deep into the mud, building stone foundations on top of the pilings, and then constructing buildings on top of the foundations with brick, plaster, and marble (United Nations Environment

Program et al., 2016). The brick was kept dry because it was elevated above the impermeable stone foundations, however high tides now frequently reach higher than these protective stones and the rising sea is eating away at the fragile brick walls above (Fletcher & Spencer, 2005; Keahey, 2002; United Nations Environment Program et al., 2016; Zanda, 1989).

Water is drawn up through building materials by capillary action and causes surface erosion, structural damage, and damage to art in the buildings (Fletcher & Spencer, 2005; Keahey, 2002; Pacione, 1974; United Nations Environment Program et al., 2016). Affected art includes thousand-year-old mosaics on the walls of St. Mark's Basilica and eighteenth-century marble statues by the Venetian sculptor Antonio Canova (United Nations Environment Program et al., 2016). Dredging of deep water channels for shipping has let more sea water into the lagoon, increasing the salinity and therefore increasing the damage to buildings done by the salt (United Nations Environment Program et al., 2016).

In some cases, art may help to understand sea level rise, researchers have compared landscape paintings and historical photographs of Venice to present-day images to assess how high the average high tide has moved up the buildings (Fletcher & Spencer, 2005). Landscapes and cityscapes of Venice done in the eighteenth and nineteenth centuries could be used in future research to understand the extent to which water levels in Venice have changed over the past two or three hundred years.

Governance

Since falling to Napoleon, Venice has lacked the autonomy to act independently and protect itself, first under foreign rule and now as a part of Italy (Keahey, 2002; Plant, 2002). Venice's separation from the mainland allowed its success for centuries and now means that the city's challenges are not a priority for the government (Ackroyd, 2009; Keahey, 2002). Venice is

constantly affected by regional, national and international interests (Plant, 2002). The local government controls both the historic city center and the industrial zones on the coast of the mainland and the needs of the two areas are often at odds (Keahey, 2002).

The political situation in Italy is complicated and prohibits continuity (Keahey, 2002). After World War II, the Allies restructured the governments in Germany and Japan but Italy was technically an allied country, having surrendered in 1943. Instead of complete restructuring, the Allies maintained most of the existing government structure but added a third tier between national and local government (Keahey, 2002). Italy was also divided into twenty regions to distribute power to prevent the rise of another dictator like Mussolini (Keahey, 2002). The result of the success of this structure is frequent government turnover that makes continuity in things like public works projects difficult (Keahey, 2002). This inherent instability of the Italian government impedes initiatives in Venice, prevents state funding from reaching the city, and leads critics to believe that it is incapable of protecting Venice (Keahey, 2002; Plant, 2002).

The responsibility for restoration and intervention is divided between the levels of government (Keahey, 2002; Plant, 2002). The Italians have had issues with international intervention, including taxing foreign funding and criticizing UNESCO for getting involved with local issues (Keahey, 2002). Suggestions have been made to make Venice an independent state, modeled on the Vatican, and bring it under the charge of the European community (Plant, 2002). Others believe that Venice minimally needs special status within Italy (Plant, 2002) and that the legal and financial responsibility for longer-term protection solutions will need to be taken on by the government (Pacione, 1974).

Special laws. Between 1937 and 1966, the Italian Parliament had passed a series of special laws intended to provide Venice with funding for restoration, protection, and

development, but little was accomplished (Keahey, 2002). Two special laws have been passed since the 1966 flood, intended to address the challenges facing the city, along with a series of non-special laws passed in the 1990s and directed at more specific issues in Venice (Keahey, 2002).

Special Law 171 was passed in April 1973 (Keahey, 2002; Madden, 2012; Pacione, 1974; Ward, 2010). The law declared that problems of Venice and its lagoon were of “essential national interest” (Keahey, 2002; Ward, 2010) and asked for “unified effort” from Italy to protect the city (Keahey, 2002). It guaranteed funding for preservation of cultural heritage and to protect Venice and the lagoon (Madden, 2012).

This law defined the responsibilities of the different levels of government (Keahey, 2002). The state would fund projects to protect against flooding from canals and the sea, the restoration of buildings, and the reinforcement of infrastructure such as bridges, canals, and foundations; the regional government would be responsible for controlling water pollution; and the local Venetian government would be responsible for some restoration projects (Keahey, 2002). This division of responsibility is mostly still intact today (Keahey, 2002). This law also included an eighteen-month ban on activities that might worsen the situation, such as development and work on the lagoon (Pacione, 1974). The intention of the law was to carry out restoration of private homes and monuments, offset the sinking of the city and control pollution, provide new supplies of water to decrease extraction of well water and the resulting subsidence, and to reduce the dangers of high water (Pacione, 1974).

Over the decade following passing of Special Law 171, the Consorzio Venezia Nuova was created out of the need to coordinate projects (Keahey, 2002). The organization, still in place today, is made up of private and public Italian civil engineering and construction firms and is

tasked with designing and implementing projects to maintain the lagoon, prevent degradation, and put in place measures to keep sea levels in check and protect inhabited areas from *acqua alte* (Keahey, 2002; Plant, 2002).

The money promised by Special Law 171 was held up by debates over whether it should be used for public works projects or to develop the industrial zone on the mainland (Keahey, 2002). Guidelines for implementing the law were released in the spring of 1975 and contained vague promises about maintaining and expanding industrial zones, though in ways that were the least invasive to the lagoon (Keahey, 2002). This document also ordered an international competition to design solutions to protect the lagoon from *acqua alta*, which resulted in the MOSE project (Keahey, 2002).

The Italian government passed another Special Law (number 798) for Venice in November 1984, which allowed for a more flexible and experimental approach to solutions to the city's problems instead of the rigid timetable that had been set by Special Law 171 (Keahey, 2002). This law reconfirmed the division of responsibility between the levels of government (Plant, 2002). The mobile gate plan had been proposed by this time but was not specifically included in this law because of the law's push for flexibility and experimentation (Keahey, 2002). This law allowed for smaller scale infrastructure improvements to occur (Keahey, 2002).

Case Study: Amsterdam

Origins

Amsterdam is located in the county of North Holland in the western part of the Netherlands on the Amstel and IJ Rivers (Kaijser, 2002). It started as a small harbor town and developed into the world's most important city as a center of international trade (Miazzo & Kee,

2014). Amsterdam is young compared to other European cities, when urban centers like Paris and Venice were thriving, what would become Amsterdam was an uninhabitable area of small lakes and marshland (Cotterell, 1972; Mak, 2000). It developed too late to be a great medieval town (Cotterell, 1972). The area was once a part of the Roman Empire, there was a Roman fort nearby (Cotterell, 1972) and Roman artifacts have been found in Amsterdam, however there is no evidence of human habitation in the immediate area from that time (Mak, 2000).

As with Venice, there are myths about the origins of the city (Mak, 2000). The historical record shows that the first buildings in what is now Amsterdam were built at the end of the twelfth century (Cotterell, 1972; Mak, 2000). At the time, Holland was primarily marshland with lakes that increased in size with each storm and only a few areas were habitable (Mak, 2000). Around 1000 CE, settlers began to move into the marshland, clear away the vegetation, and dig trenches to let the water drain away so that the land was suitable for agriculture (Mak, 2000). Early diking at the mouth of the Amstel river began around this time as well (Cotterell, 1972; Mak, 2000). Several villages sprung up and the residents began to face the cycle of draining and sinking that would characterize life in the area, as the land is drained, the earth compresses and sinks and more draining becomes necessary (Mak, 2000).

The original settlement that became Amsterdam was narrow, but early settlers soon began filling in the Amstel river and building houses on the reclaimed land (Mak, 2000). In the middle of the thirteenth century the dam for which the city is named was built across the Amstel river, creating two harbors, a sea harbor and a river harbor, and the settlement spread from the east side of the river to the other bank (Cotterell, 1972; Grossi et al., 2007). The dam became the natural center of the city (Cotterell, 1972). Until the late Middle Ages, houses in Amsterdam were simple wood huts with reed or straw roofs and clay walls and floors (Mak, 2000). Most of

the inhabitants were fishermen and farmers, although there were likely also a few specialized craftsmen (Mak, 2000).

During the twelfth and thirteenth centuries, the area of Amestelle, around what is now Amsterdam, was governed by a noble family that had risen to power by exploiting hostility between the Counts of Holland and the Bishops who were responsible for administration in the area (Mak, 2000). Amsterdam first appears in official archival sources in October 1275 when the citizens of the settlement were granted freedom from taxation by the Count of Holland, allowing them to cross bridges and locks to trade across the county without paying tolls (Cotterell, 1972; Mak, 2000). Amsterdam was important enough at this time to be given favorable treatment but there is no mention in this thirteenth century document of a fully established city on the site (Mak, 2000).

A city charter, which dates from around 1300, removes Amsterdam from the authority of the Bishop, the Count, and the former ruling noble family and allows the citizens to govern themselves through councils, aldermen, and a sheriff (Mak, 2000). This charter allowed the city, protected by its walls, to develop undisturbed by the nobles and the uncertainties of the countryside (Mak, 2000). The Count gave the town a new charter in 1342 that gave Amsterdam more independence and clearly defined its boundaries (Cotterell, 1972).

During the fourteenth century, many European cities were isolated from the surrounding countryside, which was characterized by oppression and superstition that contrasted strongly with the trade and progressive ideas within the cities (Mak, 2000). This was not true in Amsterdam because it remained a small city for much of the fourteenth century and had a fair amount of contact with the surrounding countryside (Mak, 2000). For the first several centuries of Amsterdam's history, most of the inhabitants only lived in the city part time and were still

farmers (Mak, 2000). Amsterdam began to grow more rapidly after trade increased in the late fourteenth century (Cotterell, 1972).

Amsterdam grew into a successful trading city somewhat by chance, especially given the unstable land it was built on and its late development compared to other cities in the Netherlands (Mak, 2000). The invention of the cog, a large wooden ship that could carry large quantities of goods and sail on open seas, led to increased trade by sea instead of by river, which allowed Amsterdam to take a more active role in European trade networks (Mak, 2000). The cog led to an increase in trade with southern Europe, including France, Venice, and Genoa, and with England and Flanders (present day Belgium) (Mak, 2000). The Counts of Holland took measures to stimulate trade and make sea routes more advantageous than the old routes through the Netherlands, including giving merchants more freedom than was typical at the time (Mak, 2000).

The first stone houses were built around 1400, but throughout the fifteenth century much of the city was still wood and subject to multiple large and destructive fires (Cotterell, 1972; Mak, 2000). The first map of Amsterdam, dated 1544, shows that at least half of the houses were still wood, though bricks were also being used for construction by this time (Cotterell, 1972), and there were areas of the city that were entirely wooden into the seventeenth century (Mak, 2000).

Commercial Hub

The city's rise was primarily due to trade and the taxes collected on goods imported to Holland via Amsterdam (Mak, 2000). In the fourteenth century, Dutch sailors returning to foreign ports to pick up goods for import began to take Dutch products such as cheese, butter, and fish with them, transitioning towards being merchants (Mak, 2000). Remnants of a wharf have been found, which must have been in operation building ships around the end of the fourteenth century (Mak, 2000). The quality of the Amsterdammers ships and navigators allowed

them to successfully sail sea routes (Mak, 2000). Throughout the fifteenth century, Dutch merchants found great success (Mak, 2000). The original harbors had become too small and the city canals were increasingly being used to load and unload goods (Mak, 2000). Most large vessels were anchored in the IJ in front of the city (Mak, 2000).

Amsterdam was never truly a medieval European city, there was never a royal court there and the Church did not play a large role, therefore the social and political structures did not align with the typical European feudal system of ruling classes and serfs (Mak, 2000). From the beginning, Amsterdam was a modern city with independent citizens (Mak, 2000). The dam over the Amstel river and the square that had developed nearby was the center of the city and the center of government, which for centuries consisted of four mayors (called burgomasters), a sheriff, seven and later nine magistrates, and a council (Mak, 2000). The city council was made up of 36 citizens, typically wealthy merchants, who represented the inhabitants (Mak, 2000). The council elected the burgomasters and had to be consulted on important decisions (Mak, 2000).

By the end of the fifteenth century, Amsterdam had risen to such prominence that Emperor Maximilian of Austria had granted the city the right to incorporate the imperial crown in its coat of arms and, as one chronicler noted, was so famous that people in lands far away believed that it was a country not a city (Mak, 2000). The first map depicting a complete view of Amsterdam was commissioned by Emperor Charles V and is dated 1534, the artist also made a woodcut of the print in 1544 and sold copies (Mak, 2000). Based on modern excavations that have uncovered the buildings he depicted, the map is remarkably accurate and meticulously records measurements of buildings (Mak, 2000). In the sixteenth century, Amsterdam was not only bigger but also wealthier and busier (Mak, 2000). Amsterdam first demonstrated its

religious tolerance as primarily a commercial city in the early sixteenth century when Europe was full of religious conflict due to the Protestant Reformation (Cotterell, 1972).

In the late fifteenth century, the Netherlands had come under the control of the Hapsburg family, then ruling large sections of Western Europe (Cotterell, 1972). In 1555, the Hapsburg Emperor Charles V gave control of the Netherlands and Belgium, one country referred to as the Low Countries at the time, to his son Philip II, who was soon to become the king of Spain (Mak, 2000). Philip tried to impose the same feudal system on the Low Countries as was used in other Spanish territories and colonies at the time, but these countries were wealthy and powerful and their inhabitants were used to independence (Mak, 2000). Huge tax increases followed, as well as religious persecution against anyone who was not Catholic, and both ordinary citizens and the Dutch nobility turned against the Spanish (Mak, 2000). This was followed by a period of uprisings and conflict, which ended in 1581 with the formation of the Dutch Republic with Amsterdam as its capital (Mak, 2000). Calvinism became the new official religion but the unofficial religion remained freedom of trade, thinking, and writing (Mak, 2000). Catholics had to give up their churches and offices but were allowed to remain in the city and keep their trade (Mak, 2000).

When trade collapsed in Antwerp, Amsterdam's biggest competitor, in the late sixteenth century because of Spanish occupation, Amsterdam was still a bustling commercial hub (Mak, 2000; Rietbergen, 1998). Following Antwerp's fall, thousands of people migrated to Amsterdam bringing new industries, trade goods, and artistic techniques (Cotterell, 1972; Mak, 2000). Another wave of immigration occurred as Portuguese Jews fled from the Inquisition (Cotterell, 1972; Mak, 2000). By the end of the sixteenth century, Amsterdam had become very crowded,

its population had quadrupled but the city had not been expanded, so the government began the process of reclaiming land from the sea to provide more space for building homes (Mak, 2000).

Investment on the part of these wealthy merchants led to the large scale reclaiming of land in North Holland and expeditions to Asia and the Americas (Mak, 2000). In the mid seventeenth century, Amsterdam was a tolerant, modern city that had emerged from the Middle Ages (Mak, 2000). Amsterdam at this time was bustling, both life and business moved quickly and the city was at the forefront of the urbanization taking place across Europe during the seventeenth century (Mak, 2000). Its dominance of the emerging world economy was due to its industrialization and technical innovation, rather than military power (Mak, 2000).

In 1595 the Dutch had set out from Amsterdam to find their own route to India, independent of the Spanish and Portuguese (Mak, 2000). By this time, trade had shifted from the Mediterranean to new economic centers on the Atlantic coast, including Seville, Lisbon, Antwerp, Amsterdam, London, and French ports on the Atlantic coast (Rietbergen, 1998). The cultural exchange that had developed along the sea and land routes through the Middle East and central Asia now primarily took place on sea routes around the Cape of Good Hope (Rietbergen, 1998). The Dutch East India Company (Verenighde Oostindische Compagnie or VOC) was formed in 1602 and controlled Dutch trade and shipping in Asia through the seventeenth and eighteenth centuries (Mak, 2000). It had its headquarters in Amsterdam (Mak, 2000). The Dutch East India company eventually took control of much of the East Indies and the Spice Islands provided huge profits for the Dutch, but at the cost of much bloodshed (Ghosh, 2016). The Westindische Compagnie (WIC) was established in 1621 to oversee Dutch activity in the Atlantic, and under this company a trading post was established in 1647 on the mouth of the Hudson river that would become New Amsterdam and later New York City (Mak, 2000). The

WIC traded in sugar, tobacco, pearls, furs, tropical woods, ivory, and the Atlantic slave trade (Mak, 2000).

The Dutch were attacked by the French in 1665 and again in 1672, fueled in part by economic rivalries and the monarchy's dislike of Dutch tolerance and freedom of speech (Mak, 2000). By this time, things had begun to change for Amsterdam (Mak, 2000). Other European cities also had the characteristics that had once made Amsterdam unique and the sense of city unity had passed (Mak, 2000). Using the French as an inspiration, the city's elite became more aristocratic and opposition between the elite merchants and religious leaders grew (Mak, 2000).

Sixteenth- and Seventeenth-Century Art and Architecture

As a commercial hub that had emerged too late to be a major medieval city, Amsterdam lacked the imposing churches and palaces of other European cities (Mak, 2000). Its cityscape was dominated instead by ship masts and windmills (Cotterell, 1972; Mak, 2000). The Westerkerk, a Renaissance-style church and one of the first major building projects in the city, was built in the 1630s (Ching et al., 2011). A gothic style town hall was built in the mid seventeenth century with a large assembly hall on the first floor (Mak, 2000). The town hall, designed by Jacob van Campen, was intended to promote Amsterdam as a global city (Rietbergen, 1998). It was completed in 1662 and the architecture was influenced by the classical style popular in Italy at the time and modeled on civic buildings in Venice (Mak, 2000). The building was imposing in scale and the Citizen's Hall and surrounding galleries, courts, offices, and official apartments of the interior were opulently decorated (Mak, 2000). Frescos and reliefs depicted classical and biblical stories (Mak, 2000). The great hall contains a gigantic figure of Atlas with the globe on his shoulders and two enormous maps (terrestrial and celestial) made of

multi-colored marble (Rietbergen, 1998). These features reminded visitors of the Dutch colonial empire that spanned the world (Rietbergen, 1998).

With increased trade came the emergence of a wealthy merchant class and with that a class divide that was most evident in the physical segregation of the city, between the area near the Jordaan canal and the wealthy canal ring (Mak, 2000). When the city was expanded in the first decades of the seventeenth century, the city center was planned to be occupied by the prosperous upper classes (Miazzo & Kee, 2014). Canal houses were commissioned by leading mercantile families (Ching et al., 2011) and remain an important visual component of Amsterdam's heritage today (Kinder, 2015).

Because this new Amsterdam had emerged from the peaceful revolution in 1578, it changed the European perception of a successful city in a way that other free trading cities of the same time such as Genoa, Venice, and Antwerp were never able to (Mak, 2000). Amsterdam was a city based on wealth and freedom and attracted writers, philosophers, scientists, and artists (Mak, 2000). Because there was no nobility in the city and the Church rarely commissioned works of art, painters turned to the middle classes as patrons and began mass producing portraits, landscapes, and biblical scenes to be sold on the newly emerging art market (Cotterell, 1972; Mak, 2000). The wealth in Amsterdam during the seventeenth century led to a massive volume of artistic output during this time (Cotterell, 1972). Talented painters that lived and worked in Amsterdam during this period include Pieter and Paulus Potter, Pieter Lastman, Corenlis van de Voort, and the most famous of the set, Rembrandt Harmens van Rijn (Cotterell, 1972; Mak, 2000). Rembrandt ran a factory-like workshop under the art dealer Hendrick Uylenburg in which works were copied or produced at a fast pace, and had many patrons in the area in which he lived and worked (Mak, 2000). Some of Rembrandt's most well-known works

are individual or group portraits of the elite families who held power in Amsterdam because of their control of trade and shipping (Mak, 2000).

By the mid seventeenth century Amsterdam contained rows of townhouses facing relatively straight streets and canals (Ching et al., 2011). Most houses in Amsterdam consisted of a timber framework that held up a stone façade, the ground was soft and not ideal for building so houses had to be flexible and adaptable (Mak, 2000). It was common practice, especially in the seventeenth and eighteenth centuries to put a modern façade on a medieval house, so some wooden houses survive today hidden within newer construction (Mak, 2000). Medieval wooden houses were constructed so that each story jutted out further towards the street, resulting in the streets feeling even more cramped than they were and blocking out much of the daylight (Mak, 2000). The stone houses were built with inclining facades so that they did not look out of place among the wooden houses, and this tradition survives today (Mak, 2000). There were usually gardens behind the houses, often large and elaborately designed (Mak, 2000). Through the mid seventeenth centuries the interior decorations and furnishings were typically Dutch and sparse (Mak, 2000). After 1672, French fashion made its way into interiors in Amsterdam (Mak, 2000).

Decline and French Rule

By the end of the seventeenth century, the Dutch Republic was too divided and chaotic to be effectively governed (Mak, 2000). Amsterdam was no longer a bustling international trade center and its administrative system was out of balance, a small number of people held most of the power and continuously gave other government positions to family and friends (Mak, 2000). Other countries had adopted Dutch sailing technology and by the eighteenth century English shipyards were more advanced than those in Holland (Mak, 2000). London and Hamburg, with more easily accessible harbors and land bases on which to produce finished goods, took over the

role of prominent European port cities (Mak, 2000). Many countries stopped importing foreign produce, damaging the Dutch fishing market and further damaging trade in Amsterdam (Mak, 2000). As European tastes changed, trade with the east eventually collapsed in the late eighteenth century (Ghosh, 2016). The Dutch economy went into a recession and poverty was a big problem in eighteenth century Amsterdam (Mak, 2000).

Trading profits plummeted in the last years of the eighteenth century, when the Dutch Republic was caught up in conflict that began with the British declaring war and blockading the coast of the Netherlands (Mak, 2000). French troops invaded the Netherlands and were supported by Dutch patriots (Lintsen, 2002; Mak, 2000). In 1808 the Town Hall became the palace for Napoleon's brother Louis Bonaparte (Mak, 2000) who had been crowned King of Holland (Cotterell, 1972; Mak, 2000). In 1810, Holland was incorporated into the French Empire (Cotterell, 1972; Mak, 2000).

Following unrest under French control, the Prince of Orange took control of Holland in late 1813 (Cotterell, 1972; Mak, 2000). In the mid nineteenth century, Amsterdam was quieter and dark at night, which led to issues with people accidentally falling into canals, the whole city stank, cholera epidemics were problematic, and poverty was common (Mak, 2000). Death rates were high, life moved slowly (Mak, 2000). No major changes had been made to the city in the first half of the century and buildings had fallen into decay (Mak, 2000).

Revitalization and Industrialization

In 1825, a steamer company was established in Amsterdam that offered regular service to London, Hamburg, and other Dutch ports (Mak, 2000). Steam-driven machinery also came to some of the businesses in the city (Mak, 2000), though industrialization came to Amsterdam later than other European cities (Mak, 2000). Unlike other European cities in the nineteenth century,

Amsterdam did not undertake redevelopment projects to demolish and transform old parts of the city (Mak, 2000). This was related to the lack of absolute royal rule and the mentality of the middle classes, who preferred not to show off wealth (Mak, 2000).

Samuel Sarphati, a Jewish doctor, chemist, bread manufacturer, and philanthropist and provided the city with its largest building project of the nineteenth century, the Palace of People's Industry (Mak, 2000). He established, among other things, a bread factory, a rubbish collection, a society for land reclamation, a school, and a mortgage bank (Mak, 2000). Some of the buildings he built, such as the Amstel Hotel, still stand today (Mak, 2000). Vincent van Gogh, a great late nineteenth century artist, lived and worked in Amsterdam after 1877 (Cotterell, 1972).

The city had been revitalized in the second half of the nineteenth century and by the 1870s Amsterdam was bustling again (Cotterell, 1972; Mak, 2000). The economic upturn was due in part to proximity to Germany, which was becoming an industrial power by then, and in part to increased productivity in Dutch colonies (Mak, 2000). The revenue generated in the colonies was used to finance infrastructural projects including canals and railway lines and canals, which brought increased mobility for people, goods, and ideas (Mak, 2000). The population rose again and new neighborhoods were developed (Mak, 2000; Miazzo & Kee, 2014). Major buildings such as the Manege (1881), the Concertgebouw (1888), and the Rijksmuseum (1885), were all built in the 1880s (Mak, 2000). The second half of the nineteenth century was also a period of social change (Mak, 2000). By the end of the century, Amsterdam was bustling and prospering again (Mak, 2000), and in the late nineteenth century Amsterdam was one of the first cities to benefit from new methods of urban planning (Ching et al., 2011; Mak, 2000).

Twentieth Century

The Netherlands remained neutral during World War I, the only effects of the war felt in Amsterdam were a collapse in trade, hunger among the working class, and refugees from Belgium (Mak, 2000). In the 1920s, the city was extended for the first time since the seventeenth century, incorporating surrounding burrows and opening up inexpensive land for building (Mak, 2000). In the 1930s, urban development was organized along radial streets and waterways and green spaces behind the canal ring were left open (Miazzo & Kee, 2014). In the 1930s Amsterdam was still a bustling industrial harbor city (Mak, 2000).

The worldwide economic depression of the 1930s did hit Amsterdam, as did the spirit of social and political rebellions of the time (Mak, 2000). The Netherlands had managed to stay almost entirely removed from European wars for generations, and the Dutch were aware of the rise of the Nazi party in Germany in the 1930s but intended to remain neutral once again (Mak, 2000). Dutch Jews had lived in peace in the religiously tolerant country and most saw no reason to leave (Mak, 2000). Germany invaded the Netherlands in May 1940 (Cotterell, 1972; Mak, 2000). Amsterdam remained under Nazi control until May 1945, the Dutch royal family and government moved to England during the war (Cotterell, 1972). Many of the Dutch in local government positions collaborated with the Germans, particularly in deportations, and were still in their posts after the war though remained there because a well-functioning government was necessary to the reconstruction of the city (Mak, 2000).

The years after the war were focused on reconstruction, the city became one large building site using, in part, a building plan developed during the 1930s (Mak, 2000). There was a shortage of living space, which led to the development of new housing during the 50s and 60s (Mak, 2000). The Netherlands experienced similar post-war population growth and

suburbanization as other countries (notably the US) and the associated problems with rising poverty levels in cities (Miazzo & Kee, 2014).

Historical Water Management

The immense amount of work that has gone into keeping their country above water has given the Dutch a natural sense of ownership of the land (Bijker, 2002; Mak, 2000). There are three ways that the Netherlands has historically been threatened by water: (1) sinking landmass and rising sea levels make it difficult to drain away surface water and development and mechanical drainage systems were necessary for coastal land to remain habitable, (2) as storms reshaped the coast and created inlets and inland seas, the coastline grew from about 800 kilometers (500 miles) in the ninth century to about 3400 kilometers (2100 miles) at the beginning of the twentieth century, and (3) river flooding and poor quality of riverbeds and river estuaries (Lintsen, 2002).

Until the early middle ages, only a small area of the region, primarily the highest stream banks and the edges of coastal marshes and dunes, could be permanently settled (TeBrake, 2002). Beginning in the early ninth century, Dutch peasant farmers drained peat bogs to create fertile farmland (Kaijser, 2002; TeBrake, 2002). They dug drainage ditches to collect water from the upper layers of peat and created long, narrow plots of farmland (TeBrake, 2002). As this continued, canals were dug to carry the water into existing streams (TeBrake, 2002). These drainage canals doubled as a transportation network that aided urbanization and the development of commerce and laid the groundwork for the Dutch golden age during the seventeenth century when Amsterdam was a major European commercial and cultural center (Kaijser, 2002). The creation of new areas that could be used for agriculture was typical across Europe in the ninth and tenth centuries (TeBrake, 2002).

This wave of drainage and settlement continued to around the beginning of the fourteenth century, the new space accommodated and fueled the economic growth that occurred during the Middle Ages (TeBrake, 2002). This lowland area of the Netherlands also provided a site for urbanization and became densely populated (TeBrake, 2002). Subsidence occurred after this first round of drainage because draining of the water lowered the water table, which caused the peat to decrease in volume and compact, causing the land to sink (Kaijser, 2002; TeBrake, 2002). Trampling by humans and animals compacted the land surface further (TeBrake, 2002). This combination caused the surfaces of new lands to lower substantially, by up to two centimeters per year in some areas (TeBrake, 2002). Subsidence made drainage more difficult and made the lowlands much more vulnerable to flooding, particularly from strong storms, a series of which occurred between the middle of the twelfth and thirteenth centuries (TeBrake, 2002). In some areas, the land sunk so much that drainage was no longer possible and the land had to be abandoned (TeBrake, 2002).

Before the period of devastating floods that began around the middle of the twelfth century, drainage was the main method of water management (Reuss, 2002; TeBrake, 2002). By the twelfth century, some knowledge of hydraulics and engineering were necessary to find the shortest and most efficient drainage routes (TeBrake, 2002). Flood control measures such as dikes, dams, sluices, and drainage canals had become necessary to keep the land inhabitable (Pilkey et al., 2016; TeBrake, 2002). These measures succeeded in both drainage and preventing floods, but also led to further subsidence as the land compacted due to the lowered water table (Jelgersma, 1989; TeBrake, 2002). Dikes and dams were used to protect against flooding from external water (TeBrake, 2002) and to reclaim land from the sea (Jelgersma, 1989). Ditches and canals were also still used to drain off internal water (TeBrake, 2002). The iconic Dutch

windmills were constructed to power pumps to keep water out of low-lying land that was subject to sinking (Jelgersma, 1989; Pilkey et al., 2016; Reuss, 2002; TeBrake, 2002). The switch to the windmill system made it possible to drain lakes during the seventeenth century (Jelgersma, 1989). Bigger lakes were reclaimed in the nineteenth and twentieth centuries following the development of technologies powered by steam and electricity (Jelgersma, 1989).

Many of the medieval dikes and flood control structures lie under larger and newer structures that are still in use today (TeBrake, 2002). These early dikes were built using local materials, such as clay, wood, and seaweed, often in layers (TeBrake, 2002). The shapes of the dikes were adapted depending on their location and the body of water they encircled (TeBrake, 2002). The inhabitants of the lowland zones of the Netherlands in the Middle Ages understood that water management was a continuous project and that their complex systems required maintenance and relied on cooperation between many people and institutions (Kaijser, 2002; TeBrake, 2002).

Water Institutions and Governance. The earliest forms of democracy in the Netherlands arose around water management, local water boards were formed in the twelfth century (Bijker, 2002; Kaijser, 2002; Pilkey et al., 2016). Dutch water institutions have evolved over time (Kaijser, 2002). The Dutch were successful in the battle against water primarily due to good organization at the local level and cooperation (Lintsen, 2002; Mak, 2000). The public works system developed based on careful local management and high levels of involvement by local inhabitants with a strong knowledge of the local situation (Lintsen, 2002).

The early water boards were appointed and supervised by elected councils and were responsible for local water control structures (Bijker, 2002). Water boards were created in order to use technology more effectively and resolve conflicts over water management (Reuss, 2002).

This form of democracy was decentralized and formed the foundation of the Dutch political system (Bijker, 2002; Mak, 2000). The duties of the boards include communal tasks such as drainage, dike maintenance, and sluice management, they also could levy taxes and had some additional governing powers (Bijker, 2002).

At the end of the eighteenth century, more than a thousand diverse groups and organizations had some level of involvement in Dutch public works (Lintsen, 2002). These groups were well equipped to deal with local issues but problems arose when public works issues extended outside local borders (Lintsen, 2002). Because the public works system was fragmented among so many groups, cooperation was difficult (Lintsen, 2002). This issue contributed, along with political changes at the end of the eighteenth century, to the establishment of the Rijkswaterstaat, the first national agency to oversee water management, in 1798 (Bijker, 2002; Lintsen, 2002).

Between 1795 and 1813, power shifted rapidly in The Netherlands due to events in France (Lintsen, 2002). In 1815 the country became the Kingdom of the Netherlands (Lintsen, 2002). Under this political system, the Netherlands was a centralized state under a monarch who delegated most of the responsibility for public works to the provinces (Lintsen, 2002). The provinces controlled the water boards, local public works, and the main river dikes and sea defenses and were also responsible for national public works projects such as canals and coastal defenses (Lintsen, 2002). The Rijkswaterstaat was a state agency that was employed by either the nation or the provinces to work on projects at both the national and provincial levels (Lintsen, 2002). During this period the monarch, Willem I (1813-1840) promoted trade and industry and was responsible for digging new canals, improving other shipping routes, and various reclamation projects (Lintsen, 2002).

The work of the Rijkswaterstaat was informed by knowledge that had been tested in practice and passed down between generations (Lintsen, 2002). During the first half of the nineteenth century, the agency consolidated existing local and regional knowledge and improved their own organizational capacity in order to establish credibility, raise money from taxation, conduct complex projects, and mobilize labor (Lintsen, 2002).

In the mid nineteenth century, the monarchy's influence ended and water management was reorganized by parliament (Lintsen, 2002). Provincial public works departments were established and the Rijkswaterstaat only oversaw public works and projects of national importance (Lintsen, 2002). A government supervised project in the second half of the century worked to redirect and deepen river channels to prevent flooding (Lintsen, 2002). New estuaries were dug in some places and the rivers were systematically reshaped and given standardized riverbeds (width and depth) (Lintsen, 2002). The landscape was changed as features were leveled or changed, old structures were cleared to prevent blockages of ice and water, and new structures were built to control river flow (Lintsen, 2002). The Rijkswaterstaat was also involved in railway projects and the excavation of the North Sea canal (Lintsen, 2002). The new development of steam technology contributed to the success of the agency (Lintsen, 2002).

During the 1920s and 30s canals were dredged to increase navigability where previously the priority had been flood control (Lintsen, 2002). In the early 1930s, the Rijkswaterstaat was reorganized to increase functionality following years of criticism, failed projects, and difficulty keeping up with technological advances (Lintsen, 2002). During the depression, the Rijkswaterstaat was one of the few government agencies that did not have its budget cut and was able to invest in infrastructure projects and be the country's largest public employer (Lintsen,

2002). It also introduced new techniques and benefitted from scientific advancement (Lintsen, 2002).

In Amsterdam. Amsterdam gets its name from dam built over the river Amstel, one of several dams and locks built to keep out seawater (Mak, 2000). Archeological evidence shows that subsidence was in issue in Amsterdam from the time of the earliest settlements, land had to be raised every few years as it sunk into the marshland (Mak, 2000). After 1380, Amsterdam grew quickly and massive projects were undertaken to dig new canals and raise areas of land (Mak, 2000). In the mid fifteenth century the city had to be enlarged and a new canal was dug on the east side of the city, a few decades later a similar new canal was built around the west side of the city (Mak, 2000). The dam where the Amstel was built over and closed off with locks was the center of the city by this time, houses were built over the supporting arches and a square developed nearby (Mak, 2000).

Life in Amsterdam revolved around water. There was an annual “miracle procession” held in part to bless the ships and guarantee their safe passage (Mak, 2000). Saint Nicholas, the water saint, was popular and protected the sailors and those who lived on reclaimed land from the dangers of the sea (Mak, 2000). Storms and floods were a constant threat both to sailors and fishermen and to the inhabitants of Amsterdam who all lived just behind the dykes that kept out the sea (Mak, 2000). At the end of the seventeenth century, Amsterdam also had problems with its harbor silting up and it had to be dredged to maintain the depth needed for large ocean-faring vessels (Mak, 2000). Artificial islands were constructed in the harbor around this time for buildings for the Dutch East India Company and the Navy (Mak, 2000).

Canals. The first canals in Amsterdam were built in the early fourteenth century (Cotterell, 1972). By the end of the sixteenth century, the population of Amsterdam had

exploded and an urban expansion was necessary (Cotterell, 1972). This expansion in the first decades of the seventeenth century included the beginning of Amsterdam's canal ring (Cotterell, 1972; Mak, 2000). The three concentric half circles of canals were completed throughout the century (Miazzo & Kee, 2014). The construction of the canal built was a massive undertaking and provided work for thousands of people digging canals, building roads, transporting materials, draining water, and constructing bridges (Mak, 2000). The canal ring and canal houses along it were constructed for the newly emerging wealthy merchant class (Mak, 2000). The canal ring became Amsterdam's version of an urban monument or iconic feature (Mak, 2000). Sixteen canals were filled in between 1857 and 1895, this practice slowed when the historical societies and the city's elite lobbied to prioritize the canals as part of the beauty of the city (Kinder, 2015; Mak, 2000).

Site Overview

Both Amsterdam's Canal Ring and the Defense Line, consisting of a system of canals and locks to control water, are inscribed on the UNESCO World Heritage List. The site description for the canals within the city, officially inscribed as Seventeenth-Century Canal Ring Area of Amsterdam inside the Singelgracht, is as follows:

The historic urban ensemble of the canal district of Amsterdam was a project for a new 'port city' built at the end of the 16th and beginning of the 17th centuries. It comprises a network of canals to the west and south of the historic old town and the medieval port that encircled the old town and was accompanied by the repositioning inland of the city's fortified boundaries, the Singelgracht. This was a long-term programme that involved extending the city by draining the swampland, using a system of canals in concentric arcs and filling in the intermediate spaces. These spaces allowed the development of a

homogenous urban ensemble including gabled houses and numerous monuments. This urban extension was the largest and most homogenous of its time. It was a model of large-scale town planning, and served as a reference throughout the world until the 19th century. (UNESCO World Heritage Centre, 2010)

The canal ring indicates expertise in hydraulics and engineering as well as urban planning. The integrity and authenticity at the site are intact, the concentric canal arcs and radial streets and waterways survive in their entirety and many of the houses erected in the seventeenth and eighteenth century still stand. Visually, the area has been altered somewhat through the widening of streets and the replacement of buildings or facades (UNESCO World Heritage Centre, 2010).

Current Challenges

A quarter of the Netherlands is below sea level and is protected by a complex water management system, this area includes the urban centers of Amsterdam, Rotterdam, and The Hague, and much of the country's population (Bijker, 2002; Jelgersma, 1989; Kolbert, 2015; Pilkey et al., 2016; Stive, Fresco, Kabat, Parmet, & Veerman, 2011; Ward, 2010). More than half of the country is made up of waters and wetlands from the combined deltas of three major rivers, the Scheldt, Meuse, and Rhine (Jelgersma, 1989; Kaijser, 2002; Pilkey et al., 2016) and the country is bordered to the north and west by the North Sea (Kaijser, 2002; Wahl, Haigh, Dangendorf, & Jensen, 2013). Due to the country's position on the edge of the North Sea basin, the land is subsiding at a rate of a few centimeters per year (Jelgersma, 1989). This combination of circumstances puts the Netherlands at great risk from rising seas (Pilkey et al., 2016). The Dutch are concerned with flooding from rivers and storms and have the double challenge of

getting rivers to flow to the sea without flooding the low lying landscape while also keeping the sea out (Ward, 2010).

The area that lies below sea level is the country's economic center (Jelgersma, 1989; Stive et al., 2011) and contains vital parts of its international transport system, including major harbors and airports (Stive et al., 2011). Flooding would cause economic damage predicted at hundreds of billions in Euros (Stive et al., 2011). The economy in the Netherlands still depends on water today, the harbor in Rotterdam is one of the largest in the world and major sectors of the Dutch economy, including commerce, transportation, and agriculture, all depend on carefully controlled water (Kaijser, 2002). Devastating floods are major events in the country's history, Amsterdam residents believe that flooding events in the middle ages killed more people than the plague (Kinder, 2015), and remain a threat today (Kaijser, 2002). Water management was and continues to be key to economic development throughout the Netherlands and flooding is viewed as perhaps the greatest risk to life, ranked higher than terrorism by government officials (Kinder, 2015).

The Dutch response to this potential threat has been to construct an amazing and very expensive system of flood controls (Ward, 2010), meaning that the relationship between people and water is mediated by science and technology (Bijker, 2002). The Dutch landscape is now dominated by structural works such as locks, bridges, tunnels, and storm surge barriers (Kaijser, 2002; Lintsen, 2002) and thousands of people are employed to operate and maintain them (Kaijser, 2002). When predicted sea level rise and subsidence are combined, between 6 and 12 feet of sea level rise are projected by 2100 (Pilkey et al., 2016). Milder winters and drier summers will lead to greater river flow in the winters and less in the summers and saltwater threatens to introduce on freshwater sources (Jelgersma, 1989; Pilkey et al., 2016).

The Dutch prove that low-elevation living is possible (Kolbert, 2015). Some scholarship goes as far as to identify the Netherlands as the world's best prepared country for sea-level rise (Pilkey et al., 2016), the country not only recognizes sea-level rise as a threat (Ward, 2010) but a response has been carefully planned and is already being carried out (Pilkey et al., 2016). The Dutch think in longer terms than countries like the United States, designing for up to 10,000 year storms and flood events (Pilkey et al., 2016). Unlike in other countries where water management adaptations are not prioritized because large parts of the country are not coastal areas, flooding threatens the majority of the Netherlands and the population is united in backing solutions to the problem (Pilkey et al., 2016).

1953 Flood

At the end of January 1953 the North Sea flooded when a storm coincided with a high tide (Bijker, 2002; Pilkey et al., 2016; Ward, 2010). The storm surge is estimated to have reached a height of eighteen feet (Pilkey et al., 2016; Ward, 2010) and the flooding caused death and damage in the UK and Belgium (Pilkey et al., 2016). The Netherlands was hit especially hard when the flood breached dikes in numerous places (Bijker, 2002; Pilkey et al., 2016; Ward, 2010). Nearly two thousand people died as a result and damage was widespread (Bijker, 2002; Pilkey et al., 2016; Ward, 2010). Damage from the flood had to be repaired quickly so that the dike breaches did not become worse or irreparable (Bijker, 2002). Sandbags were used as immediate measures to manage the flood and machinery like dredges, ships, and crane would eventually be called in to repair breached dikes (Bijker, 2002).

Delta Plan

The 1953 flood figured into national discussions of water management (Bijker, 2002) and prompted the creation of the Delta Commission, a committee who worked to create a national

flood defense called the Delta Plan to combat flooding from both storm surges and river floods (Lintsen, 2002; Pilkey et al., 2016; Reuss, 2002). A month after the flood, a version of the Delta Plan was put forward that called for the closing of all but two tidal outlets to the North Sea (Bijker, 2002). Work on the Delta Plan unofficially began in 1955 and parliament officially adopted the plan in May 1958 (Bijker, 2002). Some of the planned closures required the development of new technology and skills (Bijker, 2002). The integration of scientific research and technological design that characterizes Dutch hydrological practice today came about during this project and new technologies developed alongside advances in scientific research (Bijker, 2002).

During the nineteenth and early twentieth centuries, the system for building and maintaining water control structures involved both government agencies and private construction companies (Bijker, 2002). Typically, the Rijkswaterstaat designed the project and monitored private companies, or groups of private companies, that were contracted to complete the construction (Bijker, 2002). This system shifted when private companies were given the contract to co-design the barrier for the Oosterschelde project, the last and most difficult closure of the Delta project and all that remained to be finished by the early 1970s (Bijker, 2002).

By the early 1970s, support for the Delta Plan had begun to wear thin in part due to the growing environmental movement (Bijker, 2002; Lintsen, 2002). The tidal ecology of the Oosterschelde became more valued than before and other estuaries that had been closed off were becoming polluted (Bijker, 2002). Food production was not as pressing as it had been immediately after World War II, so providing freshwater for agriculture was less important (Bijker, 2002). Alternative plans were proposed, one that called for leaving the Oosterschelde

open and another that suggested a porous flood barrier to keep out the tides but allow some seawater to pass through (Bijker, 2002).

In 1974, parliament accepted a compromise, a plan to partially close the Oosterschelde with a dam that would normally remain partly open but could be closed completely in advance of approaching storms (Bijker, 2002). A single project team consisting of engineers from four building companies, a hydraulics laboratory, and the Rijkswaterstaat was established (Bijker, 2002). Throughout its construction, the project faced further political and budget issues (Bijker, 2002). It was officially opened in October 1986 and is still used today to counter storm surges about once each year (Bijker, 2002).

Water in Amsterdam

Water has always been prominent in Amsterdam, more than a quarter of the surface area of the city is water and it plays a big part of culture in the city (Kinder, 2015). Amsterdam contains a variety of types of waterscapes, including canals, lakes, and floodplains (Kinder, 2015). With deindustrialization in the mid twentieth century, which included increased use of air and highway shipping, Amsterdam's smaller harbors and inland canals lost some of their economic value (Kinder, 2015). Amsterdam's canals were reconfigured to continue to make profits, this time from real estate and the service economy (Kinder, 2015). In the 1960s and 1970s, squatters, dubbed "houseboat hippies" by one author, lived in abandoned barges on the canals (Kinder, 2015). This began the shift towards perceiving water as a space for people to live on and around and showed the versatility of water (Kinder, 2015). Houseboat living has now taken on a role in life in the city (Kinder, 2015).

In the 1990s, canals became a central location for cultural events, including festivals and parades, similar to the way in which waterfronts in the United States are used for events like

fireworks (Kinder, 2015). These social practices brought life and meaning to Amsterdam's urban water (Kinder, 2015, p. 35). Three large annual festivals arose in the mid-1990s and became prominent by the late 2000s (Kinder, 2015). These include the Gay Pride Parade, Queen's Day, associated with leisure boating in Amsterdam, and the Canal Festival, a multi-day event with musical and cultural events centered on Amsterdam's water (Kinder, 2015). The Canal Festival is tourist oriented and caters to local participants but is mostly put on to attract international audiences (Kinder, 2015). It reinforces the international image of the canals as central to Amsterdam's beauty and historic importance (Kinder, 2015).

By the twenty-first century, water was seen as a public space and no longer as an unused space (Kinder, 2015). The variety of uses of water, from houseboats to public festivals, caused debate over how to regulate water use and designate water spaces, and what the future of Amsterdam's water should be (Kinder, 2015). Advocates including heritage advocates, preservationists, city planners, and members of the city council pushed for measures to protect and reconstruct the canals, arguing that they were integral to Amsterdam's urban identity (Kinder, 2015). Cultural heritage advocates pushed for redevelopment that focused on preservation and new designs that matched the historic buildings in order to maintain a meaningful and pleasant cityscape (Kinder, 2015). This heritage movement also pushed for clearing water spaces so that the reflections of the canal homes would be visible, which has been met with resistance from boaters and houseboat advocates, and for international recognition for Amsterdam's distinct urban features, particularly from UNESCO (Kinder, 2015).

The original application to UNESCO in the early 2000s was submitted for the medieval city center (Kinder, 2015). This application was not accepted because of the number of other medieval city centers already on the UNESCO World Heritage List (Kinder, 2015). An amended

application that focused on the seventeenth century canal belt waterways was approved in 2010 (Kinder, 2015). Historic preservation advocates compare Amsterdam's connection to water with Venice, citing the two cities as unique examples in which water is important to urban identity (Kinder, 2015).

Development in Amsterdam

New development and building has also been water centered (Kinder, 2015). Urban expansion in the 1990s and 2000s focused on industrial-scale waterways and larger shorelines (Kinder, 2015). These areas, outside the traditional city center and without the cultural importance of the historic canals, offered more space for development and many had been abandoned by industry in the second half of the twentieth century (Kinder, 2015). The expansion into what was recognized as an ecologically important area caused perceptions of water within the city to begin to include ecological concerns and increased public understanding and recognition of water's ecological attributes (Kinder, 2015). Water became a way to connect the city to nature and new types of waterways expanded the identity of Amsterdam's water beyond the canals (Kinder, 2015).

Technological advancements in the 2000s led to increased use of floating architecture across the Netherlands (Kinder, 2015). Currently construction has just occurred on a smaller scale, with floating apartment buildings, offices, and parks, but discussions have begun about building entire floating cities (Kinder, 2015). Environmental regulations may be a barrier to building floating cities though with some floating neighborhoods in Amsterdam architects have included underwater infrastructure that restores natural habitat functions (Kinder, 2015).

Modern Water Governance

Since 1798, the Rijkswaterstaat, the national government agency responsible for public works in the Netherlands, has been working on water management projects that include altering river landscapes, reducing the country's coastline and reclaiming land (Lintsen, 2002). The agency has also been involved in infrastructure development, including railway lines, navigable waterways, bicycle paths, and roads (Lintsen, 2002). The operation of the Rijkswaterstaat is complex: various administrative bodies, such as states, provinces, municipalities, and local water boards, are also responsible for public works and infrastructure; private companies can carry out many of the associated tasks; and the agency's work is intertwined with numerous political parties and diverse interest groups (Kaijser, 2002; Lintsen, 2002).

The Dutch political system has several characteristics that can be traced to early water politics, including a trust in technical solutions and close links between individuals involved in policy and scientists (Bijker, 2002). The political system compensates for the sense of vulnerability from the centuries old threat of inundation with the capacity to react quickly to disasters (Bijker, 2002). Dutch politics often find flexible solutions and the political culture in the Netherlands is focused on cooperation and compromise, which is encouraged by the threat of flooding (Bijker, 2002).

The Dutch water management strategy in the twentieth century focused on solidifying the divide between water and land and eliminating flood risks once and for all, which included the large scale and expensive Delta Works initiative (Kinder, 2015). There was also a recognition during this time that human intervention had caused the land to sink and therefore become more vulnerable to flooding (Kinder, 2015). By the mid-1990s, less than a decade after the completion of the Delta Works project, residential areas in river valleys were once again flooded (Kinder,

2015). As the idea that flood risk could be eliminated faded, new campaigns emerged emphasizing the need to live in partnership with, rather than fight, water (Kinder, 2015; Pilkey et al., 2016; Stive et al., 2011). There has also been increased recognition of the value of taking preventative action before the next flood event rather than waiting for it to occur and cleaning up the damage after the fact (Kinder, 2015; Stive et al., 2011).

A second Delta Commission was formed in 2007 and in 2008 released a report titled “Working Together with Water”, recommending strategies to create sustainable flood protection (Pilkey et al., 2016; Stive et al., 2011). This report included “Room for the River”, a project to conserve and expand wetlands and restore natural floodplains (Kinder, 2015; Reuss, 2002; Stive et al., 2011; Ward, 2010). 1.3 billion Euro (\$1.4 billion) has been allocated to this initiative, which includes publicity measures to change the perception of water from something that needs subduing to something to be integrated into life on land (Kinder, 2015). The goal of projects like this is to accommodate floodwater to reduce the risk of disaster instead of eliminating flooding (Kinder, 2015). Other recommendations from the report include increased flood protection, restoration of natural floodplains, restrictions on construction and development in at-risk areas, and replenishing beach sand and protecting coastal areas (Pilkey et al., 2016; Stive et al., 2011).

Once low-lying areas are allowed to flood, the new lakes provide prime areas for building floating architecture (Kinder, 2015). Floating architecture allowed for replacing land reclamation with flooding and de-reclamation, reversed historical urban expansion practices, and provided a revenue source for funding climate change adaptation (Kinder, 2015). Several government ministries provided financial, legal, and technical support for undertakings that combined de-reclamation and development (Kinder, 2015). Government support was key to helping floating architecture garner support (Kinder, 2015). Ministry spin-offs, such as the Living with Water

Foundation, are funded by the government and provide research and development assistance for projects (Kinder, 2015). This model of urban expansion on water via floating architecture prioritizes one type of climate action plan over others (Kinder, 2015). It brings focus to increased flood risk but does not work on other things, such as reducing emissions, and sidelines other ecological concerns (Kinder, 2015).

The Dutch anticipate spending between 1.2 and 1.6 billion euros (between 1.3 and 1.7 billion US dollars) annually until 2050 and slightly less through 2100 on management solutions (Pilkey et al., 2016; Stive et al., 2011). This does not include the annual cost of maintenance and management related to protection of the freshwater supply or supplemental funding if some projects are expanded (Stive et al., 2011). This translates to about 0.5% of the Dutch annual gross national product, and is therefore economically feasible (Pilkey et al., 2016; Stive et al., 2011). The Dutch also have the technological knowledge required (Stive et al., 2011).

The Dutch approach to water management shows that interventions to protect against sea level rise are possible but require a long-term view so that adaptation can begin before it is necessary along with funding and appropriate government structures for implementation (Stive et al., 2011). Part of the advantage in the Netherlands is that the country's coastline is relatively short and there is little area to retreat to, in larger countries like the United States, it is more cost effective to move away from the coasts than to attempt to strengthen the coastline (Pilkey et al., 2016). The cooperationist system of governance would be difficult to replicate in a country like the United States (Reuss, 2002) and the Dutch government allows for flexibility and experimentation (Buuren, Keessen, Leeuwen, Eshuis, & Ellen, 2015).

Conclusion

The histories of Amsterdam and Venice are remarkably similar, especially considering that they were both such anomalies in Europe at their respective heights. Both grew in locations that should have been impossible, emerging from the water where there was virtually no land to build on. From the very beginning, the inhabitants had to collaborate and work constantly against the water to survive. Both cities became, in some ways by luck, successful commercial hubs, taking advantage of increased and shifting travel and trade. The demands of managing water and the merchant mentality of the inhabitants were conducive to republican systems of government that were vastly different from the empires and monarchies that ruled the majority of the European continent for centuries. Both cities were relatively religiously tolerant and open to outsiders, which brought new ideas and the flourishing of the arts at times when wealth was abundant. Policies of neutrality allowed both to avoid the frequent conflict in Europe, though failed when Napoleon began his campaigns. Even their modern layouts are similar, both cities are subdivided into many small islands with canals in between and connected by bridges.

Under foreign rule in the early nineteenth century, both great cities continued in a decline that had begun as global trade slowed. Then, in the nineteenth century when industrialization swept through Western Europe, their paths diverge. Amsterdam became an industrial city and was revitalized while Venice became a tourist destination as industrial ports were developed on the nearby mainland. This highlighted other differences that had once been small. At their height, both Venice and Amsterdam were the capitals of great republics, but Venice lost its autonomy and importance when it became part of Italy. Amsterdam was able to retain its position and prominence as a powerful Dutch city. In the Netherlands, water management is a national priority while in Italy the needs of the mainland are often prioritized over the needs of Venice.

Modern Venice and Amsterdam are difficult to compare because the two cities face very different challenges around heritage and water. Amsterdam's biggest challenge in this area is that new construction might change the historical appearance of the canals and the homes lining them. The Dutch have the funding and the technological capabilities to keep excess water out of the city. The canals in Amsterdam are also a preservation priority for the public and for the government. In contrast, Venice faces the immediate threat of regular floods, which are increasing in size and frequency. The Italians are not currently capable of keeping water out of the city and keeping heritage dry. There are also opposing opinions about what projects should be prioritized and who is responsible for the protection of cultural heritage in Venice. Some heritage advocates argue that the heritage in the historic city center is of international significance and should be preserved through funding and work from the international community. Others see the protection of the city, its heritage, and its infrastructure as the responsibility of the city and the Italian government.

The primary difference between the two cities is that the national and local governments have taken responsibility for the protection of Amsterdam's cultural heritage, have set priorities, and has public support for projects. Amsterdam still has what Venice had for so long, the funding and institutional support to keep the city dry. For a thousand years, the Venetians lived in their lagoon simply by raising ground levels when necessary and constantly monitoring and maintaining infrastructure. Water management in the Venetian Republic was very similar to the system the Dutch still have today. Venice has been allowed to fall into decline and lacks the funding, government institutions, and population to keep up with the work necessary to sustain a city in the lagoon.

The subjects of current scientific scholarship indicate this difference between Venice and Amsterdam. Recent scholarship on Venice focuses primarily on the wide variety of challenges that the city faces and recommendations for potential, often short-term, solutions. Scholarship on Amsterdam highlights the urban planning and water management that the Dutch have so successfully completed and the current, and very expensive, initiatives that are being implemented. A 2002 issue of the journal *Technology and Culture*, published by Johns Hopkins University, was titled “Water Technology in the Netherlands” and focused entirely on the subject of how the Dutch have managed to keep water out of their low-lying country. This successful management has to come from, or at least be supported by, local institutions, the government, and the citizens.

Examining the issues of sea level rise in relation to heritage in Venice and Amsterdam provides context for understanding the broader debate about response to rising sea levels. For centuries, Venetians have adapted to life on water by raising floor levels and reclaiming land. The Dutch tended towards mitigation, building increasingly more elaborate flood control structures and systems to keep out the sea. In the Netherlands today, water management is moving towards adaptation and creative solutions that allow people to live with water instead of constantly fighting against it. Some scholars believe that it is too late for Venice to be saved, and that ultimately the city and its centuries of heritage will have to be abandoned.

The stories of Amsterdam and Venice will continue to evolve and be shaped by new knowledge as both heritage and challenges are inherited by future generations. What lies ahead for their urban identities, relationships to water, and respective cultural heritages is uncertain. The present circumstances of these two water cities are as different as their pasts are similar, and their futures may diverge even further.

References

- Abel, D. (2017). The biggest threat to Trump's Mar-a-Lago? Climate change. *The Boston Globe*.
- Ackroyd, P. (2009). *Venice: Pure city*. New York, New York: Doubleday.
- Bijker, W. E. (2002). The Oosterschelde storm surge barrier: A test case for Dutch water technology, management, and politics. *Technology and Culture*, 43(3), 569-584.
- Brown, P. L. (2015). Receding waters in California expose artifacts to plundering. *The New York Times*.
- Buuren, A. v., Keessen, A. M., Leeuwen, C. v., Eshuis, J., & Ellen, G. J. (2015). Implementation arrangements for climate adaptation in the Netherlands: Characteristics and underlying mechanisms of adaptive governance. *Ecology and Society*, 20(4).
- Carbognin, L., Teatini, P., Tomasin, A., & Tosi, L. (2010). Global change and relative sea level rise at Venice: What impact in term of flooding. *Climate Dynamics*, 35, 1055-1063.
- Cassar, M. (2005). *Climate change and the historic environment*. London: UCL Centre for Sustainable Heritage.
- Ching, F. D. K., Jarzombek, M. M., & Prakash, V. (2011). *A global history of architecture* (2 ed.). Hoboken: Wiley.
- . Climate change brings hopeful news for Venice. (2011). *Earth Magazine*, 56.
- Cocks, A. S. (2016). How Italy stopped Venice being put on UNESCO's Heritage in Danger list. *The Art Newspaper*. Retrieved from <http://theartnewspaper.com/news/conservation/how-italy-stopped-venice-being-put-on-unesco-s-heritage-in-danger-list/>
- Colette, A. (2007). Case studies on climate change and world heritage. Retrieved from <http://whc.unesco.org/en/activities/473/>
- Cotterell, G. (1972). *Amsterdam: The life of a city*. Boston, MA: Little, Brown and Company.
- Daire, M. Y., Lopez-Romero, E., Proust, J. N., Regnaud, H., Pian, S., & Shi, B. H. (2012). Coastal changes and cultural heritage: Assessment of the vulnerability of the coastal heritage in western France. *Journal of Island & Coastal Archaeology*, 7(2), 168-182. doi:10.1080/15564894.2011.652340
- Davidson, A. (2016). How climate change will destroy our global heritage. *The New Yorker*. Retrieved from <http://www.newyorker.com/news/amy-davidson/how-climate-change-will-destroy-our-global-heritage>
- de la Fuente, D., Vega, J. M., Viejo, F., Diaz, I., & Morcillo, M. (2011). City scale assessment model for air pollution effects on the cultural heritage. *Atmospheric Environment*, 45(6), 1242-1250. doi:10.1016/j.atmosenv.2010.12.011
- de la Fuente, D., Vega, J. M., Viejo, F., Diaz, I., & Morcillo, M. (2013). Mapping air pollution effects on atmospheric degradation of cultural heritage. *Journal of Cultural Heritage*, 14(2), 138-145. doi:10.1016/j.culher.2012.05.002
- Erlandson, J. M. (2008). Racing a rising tide: Global warming, rising seas, and the erosion of human history. *Journal of Island & Coastal Archaeology*, 3, 167-169.
- Ferraro, J. M. (2012). *Venice: History of the floating city*. New York, NY: Cambridge University Press.
- Fletcher, C. A., & Spencer, T. (Eds.). (2005). *Flooding and environmental challenges for Venice and its lagoon: State of knowledge*. New York: Cambridge University Press.
- Gamboni, D. (2005). Preservation and destruction, oblivion and memory. *Negating the image: case studies in iconoclasm*, 163-177.

- Gazquez, F., Rull, F., Medina, J., Sanz-Arranz, A., & Sanz, C. (2015). Linking groundwater pollution to the decay of 15th-century sculptures in Burgos Cathedral (northern Spain). *Environmental Science and Pollution Research*, 22(20), 15677-15689. doi:10.1007/s11356-015-4754-6
- Ghosh, A. (2016). What nutmeg can tell us About Nafta. *The New York Times*.
- Gillis, J. (2016). Flooding caused by global warming has already begun. *New York Times*.
- Grossi, C. M., Brimblecombe, P., & Harris, I. (2007). Predicting long term freeze-thaw risks on Europe built heritage and archaeological sites in a changing climate. *Science of the Total Environment*, 377(2-3), 273-281. doi:10.1016/j.scitotenv.2007.02.014
- Guarino, B. (2016). World Heritage Sites, including Statue of Liberty and Stonehenge, threatened by climate change, UNESCO says. *The Washington Post*.
- Harvey, D. C., & Perry, J. (Eds.). (2015). *The future of heritage as climates change: Loss, adaptation and creativity*. New York, NY: Routledge.
- Harvey, F. (2016). Statue of Liberty and Venice among sites at risk from climate change, says UN. *The Guardian*. Retrieved from <https://www.theguardian.com/environment/2016/may/26/statue-of-liberty-venice-climate-change-threat-un-report>
- Hinkel, J., Lincke, D., Vafeidiz, A. T., Perrette, M., Nicholls, R. J., Tol, R. S. J., . . . Levermann, A. (2014). Coastal flood damage and adaptation costs under 21st century sea-level rise. *Proceedings of the National Academy of Sciences of the United States of America*, 111(9), 3292-3297.
- Howard, A. J. (2013). Managing global heritage in the face of future climate change: The importance of understanding geological and geomorphological processes and hazards. *International Journal of Heritage Studies*, 19(7), 632-658. doi:10.1080/13527258.2012.681680
- Howard, A. J., Challis, K., Holden, J., Kinsey, M., & Passmore, D. (2008). The impact of climate change on archaeological resources in Britain: A catchment scale assessment. *Climatic Change*, 91(3-4), 405-422. doi:10.1007/s10584-008-9426-9
- Huijbregts, Z., Kramer, R. P., Martens, M. H. J., van Schijndel, A. W. M., & Schellen, H. L. (2012). A proposed method to assess the damage risk of future climate change to museum objects in historic buildings. *Building and Environment*, 55, 43-56. doi:10.1016/j.buildenv.2012.01.008
- Jelgersma, S. (1989). Vulnerability of the coastal lowlands of the Netherlands to a future sea level rise of 1metre. In R. Frassetto (Ed.), *Impact of sea level rise on cities and regions: Proceedings of the first international meeting 'Cities on Water'* (pp. 60-63). Venice: Marsilio Editori.
- Kaijser, A. (2002). System building from below: Institutional change in Dutch water control systems. *Technology and Culture*, 43(3), 521-548.
- Keahey, J. (2002). *Venice against the sea: A city besieged*. New York, NY: St Martin's Press.
- Kinder, K. (2015). *The politics of urban water: Changing waterscapes in Amsterdam*. Athens, GA: University of Georgia Press.
- Kolbert, E. (2015). The siege of Miami. *The New Yorker*. Retrieved from <http://www.newyorker.com/magazine/2015/12/21/the-siege-of-miami>
- Latour, B. (2002). What is iconoclasm? Or is there a world beyond the image wars? *Iconoclasm, beyond the image-wars in science, religion and art* (pp. 14-37): ZKM and MIT Press.

- Lintsen, H. (2002). Two centuries of central water management in the Netherlands. *Technology and Culture*, 43(3), 549-568.
- Lionello, P. (2012). The climate of the Venetian and North Adriatic region: Variability, trends, and future change. *Physics and Chemistry of the Earth*, 40-41, 1-8.
- Lionello, P., Galati, M. B., & Elvini, E. (2012). Extreme storm surge and wind wave climate scenario simulations at the Venetian littoral. *Physics and Chemistry of the Earth*, 40-41, 86-92.
- Madden, T. F. (2012). *Venice: A new history*. New York, New York: Viking.
- Mak, G. (2000). *Amsterdam* (P. Blom, Trans.). Cambridge, MA: Harvard University Press.
- Marzeion, B., & Levermann, A. (2014). Loss of cultural world heritage and currently inhabited places to sea-level rise. *Environmental Research Letters*, 9(3), 7. doi:10.1088/1748-9326/9/3/034001
- Mel, R., & Lionello, P. (2014). Storm surge ensemble prediction for the city of Venice. *Weather and Forecasting*, 29, 1044-1057.
- Mel, R., Sterl, A., & Lionello, P. (2013). High resolution climate projection of storm surge at the Venetian coast. *Natural Hazards and Earth System Sciences*, 13, 1135-1142.
- Miazzo, F., & Kee, T. (Eds.). (2014). *We own the city: Enabling community practice in architecture and urban planning*: trancityxvaliz.
- Munaretto, S., Vellinga, P., & Tobi, H. (2012). Flood protection in Venice under conditions of sea-level rise: An analysis of institutional and technical measures. *Coastal Management*, 40, 355-380.
- Nettley, A., DeSilvey, C., Anderson, K., Wetherelt, A., & Caseldine, C. (2014). Visualising sea-level rise at a coastal heritage site: Participatory process and creative communication. *Landscape Research*, 39(6), 647-667. doi:10.1080/01426397.2013.773965
- Norwich, J. J. (1982). *A history of Venice*. New York, NY: Alfred A. Knopf.
- O'Brien, G., O'Keefe, P., Jayawickrama, J., & Jigyasu, R. (2015). Developing a model for building resilience to climate risks for cultural heritage. *Journal of Cultural Heritage Management and Sustainable Development*, 5(2), 99-114. doi:10.1108/jchmsd-06-2013-0021
- Pacione, M. (1974). The Venetian problem: An overview. *Geography*, 59(4), 339-343.
- Phillips, H. (2015). The capacity to adapt to climate change at heritage sites-The development of a conceptual framework. *Environmental Science & Policy*, 47, 118-125. doi:10.1016/j.envsci.2014.11.003
- Pilkey, O. H., Pilkey-Jarvis, L., & Pilkey, K. C. (2016). *Retreat from a rising sea: Hard decisions in an age of climate change*. New York, New York: Columbia University Press.
- Plant, M. (2002). *Venice: Fragile city, 1797-1997*. New Haven: Yale University Press.
- Raicich, F. (2015). Long-term variability of storm surge frequency in the Venice Lagoon: An update thanks to 18th century sea level observations. *Natural Hazards and Earth System Sciences*, 15, 527-535.
- Reeder-Myers, L. A. (2015). Cultural heritage at risk in the twenty-first century: A vulnerability assessment of coastal archaeological sites in the United States. *Journal of Island & Coastal Archaeology*, 10(3), 436-445. doi:10.1080/15564894.2015.1008074
- Reuss, M. (2002). Learning from the Dutch: Technology, management, and water resources development. *Technology and Culture*, 43(3), 465-472.

- Rice, A. (2016). When will New York City sink? *New York Magazine*. Retrieved from <http://nymag.com/daily/intelligencer/2016/09/new-york-future-flooding-climate-change.html>
- Rietbergen, P. (1998). A new society: Europe and the wider world since the fifteenth century *Europe: A cultural history*. New York, NY: Routledge.
- Rinaldo, A., Nicoótina, L., Celegon, E. A., Beraldin, F., Botter, G., Carniello, L., . . . Marani, M. (2008). Sea level rise, hydrologic runoff, and the flooding of Venice. *Water Resources Research*, 44.
- Scarascia, L., & Lionello, P. (2013). Global and regional factors contributing to the past and future sea level rise in the Northern Adriatic Sea. *Global and Planetary Change*, 106, 51-63.
- Sipio, E. D., & Zezza, F. (2011). Present and future challenges of urban systems affected by seawater and its intrusion: The case of Venice, Italy. *Hydrogeology Journal*, 19, 1387-1401.
- Smith, G. S., Messenger, P. M., & Soderland, H. A. (Eds.). (2010). *Heritage values in contemporary society*. Walnut Creek, CA: Left Coast Press.
- Stapley-Brown, V. (2016). Louvre and Orsay shut down due to flood threat. *The Art Newspaper*.
- Stive, M. J. F., Fresco, L. O., Kabat, P., Parnet, B. W. A. H., & Veerman, C. P. (2011). How the Dutch plan to stay dry over the next century. *ICE-Civil Engineering*, 164, 114-212.
- Strathern, P. (2013). *The Venetians*. New York, NY: Pegasus Books.
- TeBrake, W. H. (2002). Taming the waterwolf: Hydraulic engineering and water management in the Netherlands during the Middle Ages. *Technology and Culture*, 43(3), 475-499.
- Torresan, S., Critto, A., Rizzi, J., & Marcomini, A. (2012). Assessment of coastal vulnerability to climate change hazards at the regional scale: The case study of the North Adriatic Sea. *Natural Hazards and Earth System Sciences*, 12, 2347-2368.
- Troccoli, A., Zambon, F., Hodges, K. I., & Marani, M. (2012). Storm surge frequency reduction in Venice under climate change. *Climatic Change*, 113, 1065-1079.
- UNESCO. (2008). *Convention concerning the protection of the world cultural and natural heritage*. Retrieved from <http://whc.unesco.org/archive/opguide08-en.pdf>
- UNESCO Office in Cairo. (2016). Tangible cultural heritage. Retrieved from <http://www.unesco.org/new/en/cairo/culture/tangible-cultural-heritage/>
- UNESCO World Heritage Centre. (1987). Venice and its Lagoon. Retrieved from <http://whc.unesco.org/en/list/394>
- UNESCO World Heritage Centre. (2007). *Climate change and World Heritage: Report on predicting and managing the impacts of climate change on World Heritage and Strategy to assist the States Parties to implement appropriate management responses*. Retrieved from <http://whc.unesco.org/en/series/22/>
- UNESCO World Heritage Centre. (2008). *Policy document on the impacts of climate change on world heritage properties*. Retrieved from <http://whc.unesco.org/en/CC-policy-document/>
- UNESCO World Heritage Centre. (2010). Seventeenth-Century Canal Ring Area of Amsterdam inside the Singelgracht. Retrieved from <http://whc.unesco.org/en/list/1349>
- United Nations Environment Program, UNESCO, & Union of Concerned Scientists. (2016). *World heritage and tourism in a changing climate*. Retrieved from <http://whc.unesco.org/en/activities/883/>

- Wahl, T., Haigh, I. D., Dangendorf, S., & Jensen, J. (2013). Inter-annual and long-term mean sea level changes along the North Sea coastline. *Journal of Coastal Research*, 65, 1987-1992.
- Ward, P. D. (2010). *The flooded earth: Our future in a world without ice caps*. New York: Basic Books.
- Westley, K., Bell, T., Renouf, M. A. P., & Tarasov, L. (2011). Impact assessment of current and future sea-level change on coastal archaeological resources-Illustrated examples from northern Newfoundland. *Journal of Island & Coastal Archaeology*, 6(3), 351-374. doi:10.1080/15564894.2010.520076
- World Heritage Committee. (2016). *Report of the joint UNESCO/ICOMOS/RAMSAR reactive monitoring mission to Venice and its Lagoon, Italy*. Paper presented at the United Nations Educational, Scientific and Cultural Organization Convention Concerning the Protection of the World Cultural and Natural Heritage, Istanbul, Turkey. <http://whc.unesco.org/en/documents/142101>
- Yahaya, A. (2006). The scope and definitions of heritage: From tangible to intangible. *International Journal of Heritage Studies*, 12(3), 292-300.
- Zanchettin, D., Traverso, P., & Tomasino, M. (2007). Observations on future sea level changes in the Venice lagoon. *Hydrobiologia*, 577, 41-53.
- Zanda, L. (1989). The case of Venice. In R. Frassetto (Ed.), *Impact of sea level rise on cities and regions: Proceedings of the first international meeting 'Cities on Water'* (pp. 51-59). Venice: Marsilio Editori.