Beyond Barriers: Exploring the Futures of Climate Infrastructure on the Venetian Lagoon

Vanessa Toro Barragan[1], Collyn Chan[2], Elizabeth Haney[3], Azka Mohyuddin[4], Mary Anne Ocampo[5], Ari Ofsevit[6], Bella Purdy[7],Mary Hannah Smith[8], Angela Wong[9]

[1] *Massachusetts Institute of Technology, vtb@mit.edu*
[2] *Massachusetts Institute of Technology, collync@mit.edu*
[3] *Massachusetts Institute of Technology, ehaney@mit.edu*
[4] *Massachusetts Institute of Technology, azkamo@mit.edu*
[5] *Massachusetts Institute of Technology, maocampo@mit.edu*
[6] *Massachusetts Institute of Technology, ofsevit@mit.edu*
[7] *Massachusetts Institute of Technology, bpurdy@mit.edu*
[8] *Massachusetts Institute of Technology, smithmh@mit.edu*
[9] *Massachusetts Institute of Technology, awong5@mit.edu*

Abstract: For the last fifteen years the Italian government has been building the Experimental Electromechanical Module floodgates (MOSE) in the inlets from the Adriatic Sea to the Venetian Lagoon, to protect the historic city of Venice from flooding events. At the same time MOSE represents just one technological solution for the climate resiliency of Venice and its surrounding islands--in the face of additional varied and complex socio-environmental threats. Broader threats include subsidence, infrastructure degradation, the pressures of mass tourism, and a decline in the resident population on the islands of the lagoon. MOSE's construction site, a 180,000 square meter concrete platform, at the Malamocco inlet represents a uniquely massive space to respond to these forces. A team of Massachusetts Institute of Technology students use site and environmental systems planning approaches to suggest three hypothetical visions for this site that serve the residents of Pellestrina and the larger socio-economic development for the lagoon islands, while ensuring that these options bolster residents' ability to respond to urban disaster risk. The design concepts explore a range of demolition and reuse possibilities for the site in their three explorations: deconstruction and sustainable fishing, contextual tourism that can shift to disaster resilience, and a potential reuse of the most elevated area on Pellestrina to form a new village in the face of sea level rise.

Keywords: Climate Change, Resiliency, Infrastructure, Venice

Introduction

The most devastating flooding of Venice, when nearly two meters of water inundated the city, occurred in November, 1966. Since then, the Italian State has been focusing on planning initiatives to protect urban areas from high waters, safeguard the coastal islands from storm events, restore lagoon ecosystems, and plan for socio-economic development on the islands within the 550 km^2 area that makes up the lagoon area. Pellestrina, an island of fishing and agricultural villages spread along the 11 km coastline, has always acted as part of the

larger infrastructure protecting Venice and the Lagoon, but administrative attention has rarely focused on a comprehensive approach to sustaining the economy, culture and social cohesion of Pellestrina itself. As the construction of Venice's Experimental Electromechanical Module floodgates (MOSE) nears completion, the project leaves behind a gargantuan construction site on the northern shores of Pellestrina Island--larger than Piazza San Marco (Figure 1).

Figure 1: Size Comparison Piazza San Marco vs. Site

In the spring of 2019, on behalf of their client the Consortio Venezia Nuova (CVN) students in the Massachusetts Institute of Technology (MIT)'s Department of Urban Studies and Planning (DUSP) site planning course explored potential futures for the former construction site that increase the vitality of Pellestrina itself. Students analyzed the site, Pellestrina and the larger Veneto context using a multifaceted approach, integrating a study of topography, hydrology, sea level projections, mobility and infrastructure networks, land use, and settlement patterns; as well as spatial and temporal relationships between individual site factors and local and regional contexts. The MIT team combined the traditional site planning approach along with interdisciplinary learnings from oceanography, engineering and urban design to formulate strategies for the site. These strategies for coastal resilience included awareness of physical and cultural infrastructures, housing and economic development, and flood responsive landscapes. The strategies respond to an uncertain projections of sea level rise and climate adaptation, and aim to achieve long-term economic and social sustainability by more flexibly responding to the diverse demands of Pellestrina, as well as the Venice municipality as a whole. Students formulated three hypothetical site plans for the land remaining at the north end of Pellestrina Island following the upcoming completion of the MOSE project, after exploring two central questions:

> *As the MOSE project nears 90% completion, the Venice Water Authority and Consorzio Venezia Nuova is investigating how this land can best serve the residents of Pellestrina and the larger socio-economic development for the lagoon islands. How can this land reclamation and infrastructure be reimagined?*

Ultimately the students developed three hypothetical design options:

1. *The Future of Fishing:* REPURPOSE MOSE's infrastructure for a modern-day local economy based on new and traditional fishing technologies. Utilizes the uncertainty in sea level rise as an opportunity for adaptive aquaculture management.
2. *Resilience in Reuse:* BUILD new form of coastal defense that builds on the site's historic assets, bringing life to the MOSE platform and preparing Pellestrina for a new era.
3. *Murazzi 2.0:* TRANSOFORM divisive infrastructure into a connection. This project proposes design elements that connect the villages of Pellestrina to their history, to the Adriatic and to a site of new opportunity.

Course Context

Since its first offering in 1935 MIT's site planning course has been taught by only a handful of instructors including Kevin Lynch, Donald Appleyard, Tunney Lee and Gary Hack. In 1956 Kevin Lynch took what was seen as a mainstream course in site engineering and turned it into a whole-system approach to planning the built and natural environments. Under the direction of Eran Ben-Joseph, the class began incorporating hands-on, client-based projects dealing with a variety of sites. Today, Mary Anne Ocampo brings her experience as a practicing urban designer to continue the whole-systems approach pioneered by Lynch and in this course was able to build upon longstanding relations between MIT, CVN and IUAV (Università Iuav di Venezia). MIT researchers have been involved in the evaluation of multiple steps of MOSE engineering and construction since as early as 1997 (Merali, 2002; Munaretto et al., 2012).

Study Area and Site Context

Figure 2: Site Context

Pellestrina and her northern neighbor, Lido, are two crucial barrier islands that separate the Venetian Lagoon from the Adriatic Sea. Pellestrina stretches for nearly 12 kilometers, but is often less than 500 meters wide and in some places as narrow as 50 meters. The island's population of approximately 4,000 people living in 4

villages has declined in recent years due to the lack of affordable housing and employment on the island. With rising environmental hazards, the closing of a major shipyard, and fishing regulations, the island has suffered economically and environmentally for the last decade. An additional impediment is the island's remoteness: the island is removed from the historical city center of Venice and administratively from the adjacent city of Chioggia. Access to Venice and larger employers in Mestre are only possible with arduous travel. Travel to Venice requires transferring from bus to vaporetto (water taxi) on a trip that takes over an hour and up to 2 hours depending on your location

For over one thousand years the site and the island of Pellestrina have served as a vital barrier between the historical city of Venice and the Adriatic Sea. Since its first description in the historical record, Pellestrina has been a place formed by the struggle between the destructive forces of the ocean and human resistance, where storm surge has ripped away earthen dikes, beaches and landfill and the people of the Venetian lagoon have rebuilt even stronger defenses (Goy, 1985).

The worst flooding in Venice's history struck the lagoon in 1966, with some of the greatest devastation occurring on Pellestrina. A combination of sirocco winds, swollen rivers and a low pressure storm brought a devastating high tide, "acqua grande" to Venice on November 4. The storm ripped away the boulders of the murazzi and water levels in the lagoon reached record highs, with a peak at 194 centimeters above the tidal gauge at Punta della Salute. The tides would stay at over 100cm for nearly 24 hours, inundating homes, churches and storefronts. On Pellestrina 4000 people—nearly the entire population of the island—evacuated, as the storm flooded homes, salinized the soil and caused an estimated of 40 billion lira in damage across the lagoon (Gugliuzzo, 2018).

In response the flood of 1966, the Italian government established special legislation for the safeguarding of the city of Venice and the Venetian Lagoon in 1973, which recognized the idea of mobile barriers. A second law in 1984 created a national committee, the Comitatone and entrusted design and implementation of to the Consorzio Venezia Nuova (CVN), a concession of the national Ministry of Infrastructure. Multiple designs for the MOSE were considered, but a system of mobile floodgates was finally selected because of their buoyancy, and requirements that the floodgates be invisible when not in use.(Munaretto et al., 2012)

Figure 3: Site

The construction of the MOSE system required a new site near the inlets which occurred in 2005 Initial construction focused on a sheetpile outline of the future platform, which was filled with dredged material, which was then covered with cement and reinforced by jet grouting to stabilize the soil 20 meters below sea level. Here the four-story tall 4200 ton casons rose at a busy worksite, next to a worker's camp constructed for the large number workers needed for the project. Eventually a "syncrolyft" was constructed on the end of the island that had been a semi-public beach and woodland area, with part that some locals used as a dumping ground. Upon the completion of the construction of the casons, the MOSE platform has also been used as a storage and staging area for the MOSE floodgates. With the final floodgate installed, this massive piece of infrastructure holds remnants of all of the phases of construction that happened there—anchors, heavy equipment, shade tents and hundreds of concrete piles.

2019 marks the completion of the MOSE floodgate installation and the end of use for the MOSE platform. The current post-construction plan for the site, referred to informally as the "Europe Plan" calls for the deconstruction of the platform in order to restore and reconstitute protected habitats affected by the construction. The plan requires that "For each of the community habitats and species affected by construction activities, one or more compensatory measures have been developed, with a precautionary approach, aimed at the reconstitution or redevelopment of areas that are increasingly larger than those temporarily and permanently occupied by the work." (*Piano delle misure*, 2016)

This plan includes a number of measures for environmental restoration, including seagrass transplantation, rebuilding the the barene and reconstructing dunes. At the MOSE site itself the platform is to be removed and replaced with a beach at an estimated cost of € 3,520,000. The worker camp and adjacent area is to be reforested and historical structures renovated as part of a nature park, at an estimated cost of €5,500,000. The MOSE site is situated in a unique position, where both historic military and hydrological defenses sit side by side. These protective structures are located at the entrances to the Venetian Lagoon, and have acted as the first line of defense against man-made and natural threats. (*Piano delle misure*, 2016)

Site Analysis

Environmental and Military Protections

The Venetian Lagoon, which houses Pellestrina Island, is a man-made ecosystem in constant need of protection against natural forces. What began as a shallow estuary formed by natural processes transformed into a haven for communities fleeing from the aftermath of the collapse of the Roman Empire, where the preservation of the lagoon environment became an essential part of the security of the Venetian republic and naval power. The Serenissima would ultimately divert major rivers over the course of centuries to prevent the sedimentation of the lagoon.(Bondesan and Furlanetto, 2012; Tosi et al., 2009)

Throughout the history of the Serenissima, Venetian authorities sought to enhance the defense capabilities of the historical city by fortifying the edges of the protective lagoon. In places like Pellestrina, fortification sometimes included military facilities along lagoon entrances. Hydrological structures--dams, dykes and seawalls--often served a similar military purpose--to maintain the protective characteristics of the shallow Venetian Lagoon. The need to fortify the edges of the lagoon from the encroachment of the sea was a reoccuring theme over the history of Venice. Ultimately flooding led Venetian authorities to embark on a 40 year construction project beginning in 1741 to build 20km long seawall of Istrian stone across Chioggia, Pellestrina and Lido. (Charlier et al., 2005; Goy, 1985)

The Flood of 1966 spurred two special laws for Venice, which resulted in the selection and construction of mobile flood barriers, MOSE, as a protective measure at the entrances to the Venetian Lagoon. Beyond the floodgates, CVN has engaged in restoration and climate adaptation projects within the lagoon itself, including protecting and reconstructing the environment of the lagoon--replanting seagrass, rebuilding the partially submerged islands called *barene* and restoring Adriatic dune structures.

Ranging between 2.5 and 3 meters above sea level, the MOSE platform is one of the highest elevated sites on Pellestrina island, where much of the land is only between 1 and 2 meters above sea level, though is protected by the 5.2m high murazzi wall. A wide range of ecological habitats can be found throughout Pellestrina Island. In general, there are four types of environments: woodlands, littorals, meadows, and areas with sparse amounts of flora. The northern and southernmost edges of the island contain mature woodland and shrub ecosystems. The interior of the island is primarily comprised of agricultural and urban managed landscapes. Meanwhile, the Adriatic Sea-facing edge of Pellestrina is populated by growing dunes, and vegetation to support dune formation. (“Altimetria, Carta Tecnica Regionale del Veneto,” n.d.; “Microrilievo della pianura del Veneto,” 2015)

Demographics, Culture, and Economy

An analysis of the demographics reveals similar trends across the lagoon: an older generation and declining population due to age and emigration. Since 2014, the city has lost approximately 6% of its residents. Pellestrina’s population is also declining, despite regular births and new immigrants to the island. The lives of the residents of Pellestrina are closely tied to other islands in the lagoon and the mainland. Pellestrina residents are dependent on the lagoon for jobs and daily services. Venice’s population is declining (“Popolazione,” 2017; “Stradario e Popolazione,” 2010).

The culture and history in the Venice city center is the most popular tourist attraction within the lagoon. Most tourists come to see Venice’s unique art and architecture. Tourists also frequent the historic villages on Murano, Burano, Torcello, and Chioggia which offer crafts, shops, and restaurants. Lido and Sottomarina feature popular beaches that attract tourists. Pellestrina does not maximize the potential economic benefits from tourism, and

there lacks a strong tourism anchor to promote on the island. The nature reserve Ca'Roman is the main attraction on Pellestrina, along with the free beaches and vision of a "real" lagoon community. Pellestrina's economic history is rooted in agriculture and fishing. However, the sector is decling and local residents are dependent on other areas within the lagoon for jobs and daily services. Most of the surveyed permanent residents of Pellestrina responded that they: were in favor of developing Pellestrina for tourism, believe the island could benefit from tourism, are concerned about changes to daily life, damages to buildings and environment, and trash ("Pellestrina Summer School Survey of Island Residents," 2018)

Venice is a part of a larger regional economy, the Greater Veneto Region, which it is connected to by road and rail. The region's public transportation company, Azienda del Consorzio Trasporti Veneziano (ACTV), provides an extensive transportation network by land (buses and trams) and sea (frequent small passenger ferries known as vaporetti). Additionally, international airports connect the Greater Veneto Region to international travelers. ACTV's transportation system allows access to the barrier islands of Pellestrina, Chioggia, and Lido. Vaporetti flow from Venice to outlying islands and south, via a bus connection, to Chioggia. Flows of water traffic within the lagoon also include pcean-going passenger ships use the Lido inlet, ommercial traffic destined for Porto Marghera through the Malamocco inlet as well as local traffic is comprised of smaller personal boats and fishing craft. The city of Chioggia has a fishing fleet of 221 fishing vessels which use the Chioggia inlet to travel between the lagoon and the Adriatic.

Climate Change Risk leading to 2100

This study used dramatic sea level rise scenarios of 110cm and 160cm for 2100 to guide site designs. The study sought to look further than 2050 given that infrastructure has a long useful life beyond 30 years from today. Global sea level rise projections, which have a wide range of uncertainty, cannot be applied directly to the Mediterranean Sea for several reasons (Centro Euro-Mediterraneo sui Cambiamenti Climatici, 2017; Galassi and Spada, 2014; Hoegh-Guldberg et al., n.d.; Marcos and Tsimplis, 2008): A) Global models do not accurately take into account the Mediterranean Sea. The models' grid scales are too large to capture the Strait of Gibraltar, the narrow waterway through which the Mediterranean is connected to the Atlantic Ocean. The vertical resolutions of the models also do not capture the shallow Adriatic Sea. B) Globally, thermal expansion of water from increases in temperature is the major contributor to rising seas. However, in the relatively contained Mediterranean, salinity is another key driver to changes in sea levels . Greater evaporation from warmer temperatures and decreases in precipitation lead to increases in salinity of the water body. Greater salinity results in more dense water, which may decrease water levels. The density of the water in the Mediterreanean also impacts the outflow and inflow from the Atlantic through the Strait of Gibraltar.

Sea level rise projections are relative to mean sea level. However, note that the datum reference points from which sea level is measured differ for bathymetry and altimetry: Bathymetry tidal heights refer to the tide gauge at Punta della Salute as the 0 reference point. Punta della Salute is currently 23.5cm above the altimetric datum due to subsidence and other factors. Currently, the actual mean sea level is 30cm higher relative to this reference point. Meanwhile, altimetry refers to the IGM 1942 datum, the official datum of the Italian national altimetric network (Città di Venezia, n.d.).Topographers use this datum as the 0 reference point and refer to it as "mean sea level." It is 23.5 cm above the Punta della Salute reference point. Currently, the actual mean sea level is 6.5 cm higher relative to this reference point.

Given uncertainty in projections, the MIT team sought to plan for a range of possible future scenarios and developed designs to be adaptable. Good planning and design needs to incorporate a myriad of future conditions rather than be limited by a single future scenario amidst uncertainty in projections or assume that the future will be the same as the past given a changing climate.

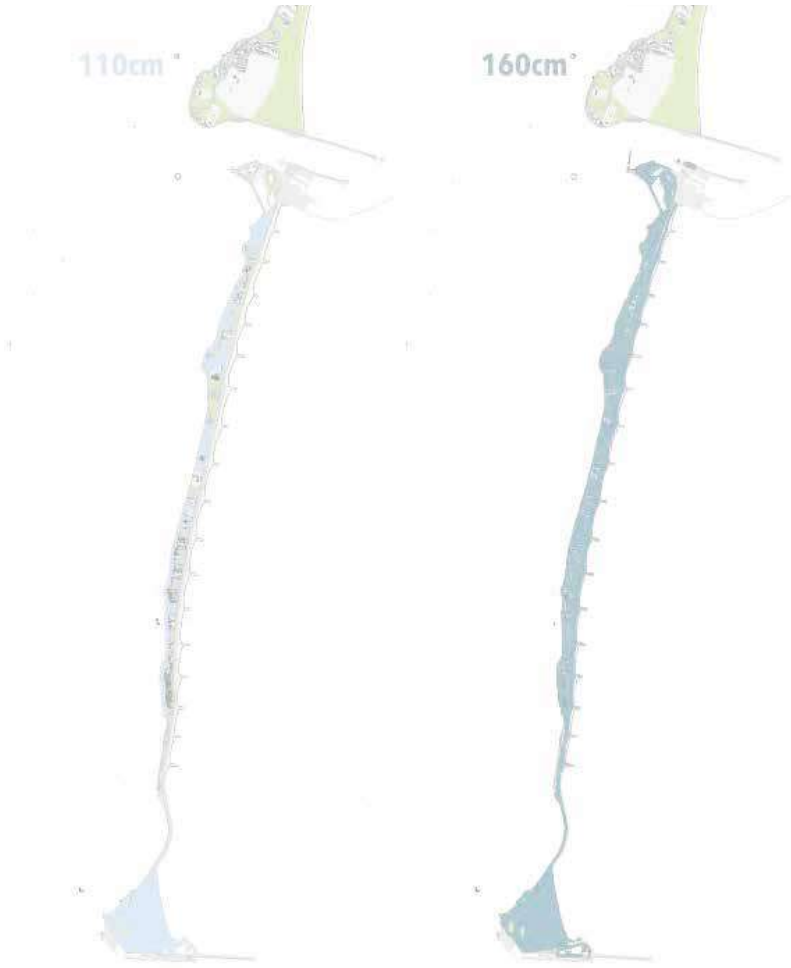

Figure 4: Sea Level Rise Under 110 & 160cm Scenario

Figure 5: Tidal Ranges under 110cm and 160cm Scenarios

Significant portions of Pellestrina will be permanently inundated from the lagoon side under the 110cm scenario. Most of Pellestrina will be permanently inundated under the 160cm scenario. Flooding will be exacerbated with acqua alta events as study flood maps do not take into account storm surge associated with acqua alta events. A team of international experts verified that MOSE gates would be able to protect against sea level of only 50cm (Munaretto et al., 2012).Because of this Pellestrina and the rest of the lagoon may need to undertake adaptation measures to ensure resilience under these future sea level rise scenarios, such as increasing the height of the mini-walls on the lagoon side. It is critical to note that these flooding maps are preliminary and the methodology needs to be refined. The methodology (from MIT Summer Workshop 2017) is based on land elevation points scattered throughout the island rather than sea level and flood modeling. The methodology does not account for a 20 cm mini-wall adaptation measure on the lagoon side of the island, which may mean fewer areas may be permanently inundated under the 110cm scenario. The mini-walls are between +1.30 and +1.40 m high with respect to the IGM zero of 1942 .(Franco and Tomasicchio, 1992)Lastly, the analysis was not conducted at a granular scale, which would be particularly useful for site planning purposes. Recent climate conditions serve as a baseline for understanding future projections. In the Veneto region, summers have been hot and mostly dry, and winters have been cold and wet. Over the past 50 years in the Veneto region, temperatures have increased significantly during every season, especially summer and winter maximums and summer minimums. Winter rainfall has decreased over the past 50 years. According to the Italy 2017 National

Plan for Adaptation to Climate Change, in the Venice climate region: temperatures are projected to continue to increase, the wet winter season will become wetter, and the dry summer season will become drier (Centro Euro-Mediterraneo sui Cambiamenti Climatici, 2017). Intensification of winter rains may cause riverine flooding in the drainage basin and exacerbate water levels and acqua alta. Climate projections between 2021-2050 for the Venice climate region under the greenhouse gas emissions scenarios RCP4.5 vary (moderately low emissions scenario) and RCP8.5 (business as usual) but overall trends are projected to continue into 2100.

Design Options

Taking each of these portions of analysis into account, the authors of this study each formed design teams, which formulated three hypothetical design options for the site.

The Future of Fishing: Repurposes MOSE's infrastructure for a modern-day local economy based on new and traditional fishing technologies.

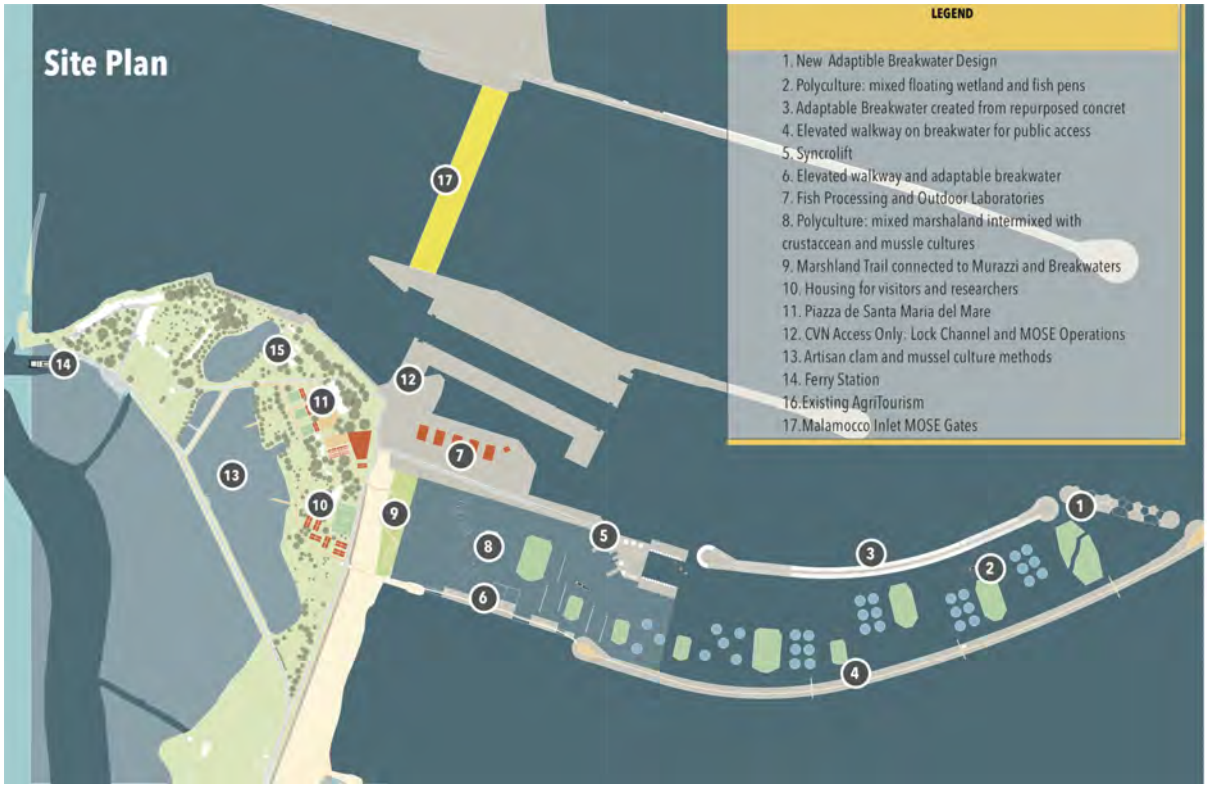

Figure 6: Future of Fishing Site Plan

The Future of Fishing design option re-envisions the MOSE construction platform as a hub for a revitalized fishing economy where Pellestrina can be the 21st century leader of sustainable acquaculture, researching how to integrate floating vegetation with fish pens to provide water purification while at the same time producing low-impact food for the region. Furthermore, this site and environment can function as a nursery for species that have been declining within the lagoon and can help to revitalize and repopulate species that have been threatened as a result of the overexploitation and pollution to date. Our design idea centralizes Pellestrina as the focus for this type of environmental research and local economic hub that supports the residents of this island and allows for a reasonable amount of public access to tourists and visitors that can see and be inspired by the leadership of Pellestrina's sustainable food production and lagoon management.

The design recognizes the history of fishing guilds on Pellestrina, which from the 1500s exercised considerable political influence in the region although the work itself was difficult. In the 1880s a cooperative movement arose to unite resources amongst fishermen and protect against the potential economic downfalls associated with the fishing industry. At this time, Pellestrina Island was home to two fishing villages and cooperatives. Until the 1960s fishing was strong, when manufacturing and industry began producing harmful ecological and economic effects. Subsidence, chemical waste, and dredging for commercial shopping damaged many of the habitats of the lagoon that had sustained rich fishing resources. Fishermen either moved away from lagoon resources to the resources of the Adriatic open sea fishing or switched to the manufacturing economy. Today, the continuation of fishing traditions is uncertain, as young Pellestrinans seek job opportunities outside of the islands' bleak economic prospects by moving to the mainland centers of Mestre, Padua, and Treviso. Lack of lucrative job opportunities in fishing, agriculture, and/or tourism puts the island's socio-cultural future at risk and exacerbates the pressures of the tourism industry, shifting the Venice lagoon archipelago from a city structure to a 'park', utilized primarily by outsiders rather than its own inhabitants (Cipriani, 2017).

Lagoons are ecologically important habitats: they provide marshlands for migratory bird species, they filter nutrients in water through vegetative uptake, and they provide marine species nurseries to grow their young. They are also economically rich places, offering their inhabitants a local economy. In 1994, the Venetian lagoon business contributed to $80 million in economic benefits, directly and indirectly.At that time and into 2000s, the Venetian lagoon contributed 33% of Mediterranean fishery production. In 2011, after years of slow decline of the fishing industry and increase in the acquaculture industry, acquaculture businesses surpassed those of fishing in the lagoon (Rosetto, 2000; Zaccariotto, 2014)

This design team considered the wide range of possible "natures" to be preserved on the site, as between two spectrums, from platform permanence to complete platform removal, and high use and management to low use and management. If the platform is kept, high use could involve a heavily landscaped waterside destination park. An intermediary among these extremes involves partial removal of the platform and moderate management – an ideal opportunity to incorporate Pellestrina's economic history in order to have the site serve as a learning environment for adaptive aquaculture.

This partial platform deconstruction reuses that platforms' concrete, while retaining much of the platform's originally constructed border of filled sheetpile. Deconstruction could retain most of the border, break up the concrete material to repurpose for a new breakwater, and remove the dredge material for appropriate depths for acquaculture. The new breakwater is designed a few meters north of the existing breakwater in order to protect the aquaculture area from currents around the Malamocco inlet. The remaining concrete from the platform could be reused to reinforce the murrazi along the rest of Pellestrina.

Pneumatic and hydraulic breakers could facilitate paltform demolition and are often used in concrete demolition projects involving foundations and pavement, including underwater. Demolition could also involve cutting concrete for reuse, as well as pressure bursting, which involves pressure in boreholes to split the concrete. Lastly, wrecking balls and explosives are used for large volumes of concrete but may create a lot of noise, dust, and vibration which may cause damage to the surrounding structure. Pneumatic and hydraulic breakers may be the most suitable for deconstruction of this platform site and would require consultation with civil engineers.

Resilience in Reuse: A new form of coastal defense that builds on the site's historic assets, bringing life to the MOSE platform and preparing Pellestrina for a new era.

Figure 7: Resilience in Reuse Site Plan

The MOSE platform presents a unique opportunity for the Island of Pellestrina. Rather than destroy the platform, the national, regional and local governments could work together to explore possibilities for productively reusing the site. The site's elevation means that it is relatively secure from flooding and the threat of sea level rise and its size means that it can accommodate a variety of different uses. The location on the north end of the island, on the outskirts of the closest village but near public transportation and a beach, make it an ideal spot to develop tourism on the island without disrupting life for current residents. Resilience in Reuse is structured around the notion that different activities can share space, and that existing forms can be repurposed for new uses as the need arises.

In the short term, the site can be used for tourism and events. Though the impacts on the lagoon are still uncertain, climate change will impact Pellestrina and likely lead to increased risk of flooding. In the long term, the site can easily transition to a base for flood disaster response and recovery operations. The short-term uses provide new economic opportunity to the island, while long-term maintenance of the platform ensures islander resiliency in the face of an uncertain future. In addition to the concrete platform, existing assets like MOSE gates and CVN activity could be incorporated into future uses. This design idea provides a venue to celebrate Venice's history of coastal defense and defiance of flooding. surge and sea level rise in the near future. This design concept considers how to protect the island's residents.

While the island is relatively secure from flooding at present, Pellestrina will be at risk of flooding from storm from future disasters like the catastrophic flood of 1966. Space for disaster evacuation and response activities are included in the buildings on the site. It also envisions on-site activities to increase community resiliency, like retrofit construction demonstrations, and a public learning center focused on climate change.

The MOSE platform is higher than most of the rest of island, making it an asset for the island, and a perfect site for recovery and evacuation in the case of disaster. In the future, should parts of the island become permanently flooded, housing built on the platform will be available for resident resettlement.

The Protezione Civile is the government body that manages disaster planning in the Venetian Lagoon. It has an office in Pellestrina and a disaster management plan in place for the island. However, this plan is focused on present risks and does not take the effects of climate change on water levels into account. In the future, the organization may want to change its plan and locate its evacuation, relief, and recovery efforts on the site, because of its proximity to the ferry, space for large crowds, and relative security from flooding.

A small survey of Pellestrina residents completed during MIT's 2018 Pellestrina Summer School found that residents were generally in favor of developing tourism on the island. This design idea would bring a hotel, campsite, and bungalows to the North side of the island. Visitors would enjoy amenities on site, but would have easy access to the ferry or to the villages to the South. Major events could also be hosted on the platform for short periods of time, as an alternative location to sites in the already crowded historic Venice. This level of tourist activity could enliven the economy, but would not overwhelm Pellestrina residents because the site is detached from the nearest village.

Murazzi 2.0: Transforming divisive infrastructure into a connection. This project proposes design elements that connect the villages of Pellestrina to their history, to the Adriatic and to a site of new opportunity.

Figure 8: Murazzi 2.0 Site Plan

Squarely facing the risks of climate change this proposal sites a new village on the highest point in Pellestrina, the MOSE platform, returning the lagoon side to a more natural state that allows for agrotourism. The north side of the platform is now a pier and market and the south side is the commercial and retail pier. The structures of

the blocks are based off of the size and the location of caissons during the manufacturing process for MOSE. This size allows the incorporation of housing and open space, mitigating the amount of concrete expose on the platform. This typology also connects physical structures to the history of resilience and adaptation on the island.

Pellestrina's long history as a barrier island and protector of the region as created infrastructures that have divided island life, both north-south and east-west. The site is located at the north end of the murazzi, at an elevation that is secure from most flooding predictions. It is close by to public transportation, the beach and a natural marshland that makes it an ideal spot for both tourism and a more recreational lifestyle that is well-connected to the region. Easy access to the Adriatic and agricultural space supports the existing fishing and gardening industries on the island. Murazzi 2.0 begins with a transformation of the murazzi from a seawall into a pleasant and active pathway that leads the villages of Pellestrina directly to the MOSE platform site. A development at this site, with the appropriate programming, can provide a destination the brings the villages on Pellestrina together, highlights the island's histories of coastal protection and economic development, and provides a physical and intentional opportunity to open the island to the Adriatic and its uses.

The Murazzi wall separates the beach from the rest of the Island with few points of access. At it's widest, the beach and Murazzi make up to 1/3 of the Island's width and at its narrowest, it is almost 1/2 the width of the Island. The seawall creates a spine, driving development orthogonally with the majority of buildings facing the lagoon side. The sea wall becomes the back and with it, the Adriatic. Sea side is more barren and less utilized. In Murazzi 2.0, the seawall is redeveloped into a multi-modal pathway that connects the villages and ends at the MOSE site. This identity will be celebrated in Murazzi 2.0, by reclaming the connection with the Adriatic, hosting a MOSE museum that features the history of protection on Pellestrina, and tourism that highlights the design of the site based on past structures. Developing commercial and retail space on the site focused on creating local jobs as well as developing housing and transportation for ease of access to the region is key to the project. In 2016, the cultural association was evicted from their long-time office and they needed to find a new space for the lacemaking school and lace collection. The new development will bring a community space for lace making and other artist spaces for both living and working in. As a destination for these activities, Pellestrina's local economy and tourism may benefit from connecting to the larger region known for its crafts.

Conclusion

The MOSE platform is young infrastructure. The site provides an opportunity to reenvision a controversial, enormous purpose built parcel with knowledge of the value of it's solid base, a foundation on which to build or repurpose. The site is unique, but it has many parallels as other piers and other oceanside developments in the developed world have seen their uses diminished and many have been abandoned or rebuilt for a different use.

Given the size of the parcel approximately 170,000 square meters, or the size of two dozen soccer fields, and its rectilinear shape, the site is well-positioned for a redevelopment which can dovetail with the needs and desires of the surrounding community. At the same time the current Europe plan recognizes the value of adjacent sensitive habitats, and seeks to restore the site's former life as a beach. This course belives the cost and scope of this project may be underestimated at € 3,520,000 for platform removal and beach restoration and €5.500.000 for naturalization of the work camps into nature park preserves (*Piano delle misure*, 2016). As such, the range of options in this study offer paths other than costly destruction, providing options that mirrors the range of development across Pellestrina itself, where villages range in development from densely built Pellestrina to remote Ca'Roman.

The student researchers also kept in mind the reason for the structure itself: the MOSE flood protection system. While Alta Acqua is most visibly present in Venice itself, this student team was keenly aware of how higher

water will affect the MOSE platform site and the surrounding area in Pellestrina. With this in mind, constructing resilient infrastructure, building structures which can accommodate changes in climate in both the long and short terms, and building infrastructure is crucial to sustain Pellestrina's history, culture and economy.

The future of the MOSE platform in Pellestrina is in flux: whether and how long it will stay in place. For the MIT student team, these questions prompted an exploration of the potential futures outside of the Europe Plan.

Students began with the "Future of Fishing": a partial removal, where the resulting structure will form a miniature lagoon adjacent to the MOSE project, and one which will become a new, Adriatic-side, fishing village, complete with supporting structures but without significant permanent population (Figure 9).

Figure 9: Future of Fishing Perspective

The next more intensive use, "Resilience in Reuse," will keep some of the MOSE uses on the site, but retain some new structures for various temporary uses, from large events to emergency evacuation shelter, as well as building some permanent structures on the platform itself, while still retaining significant open space with less programming to promote creativity and happiness (Figure 10).

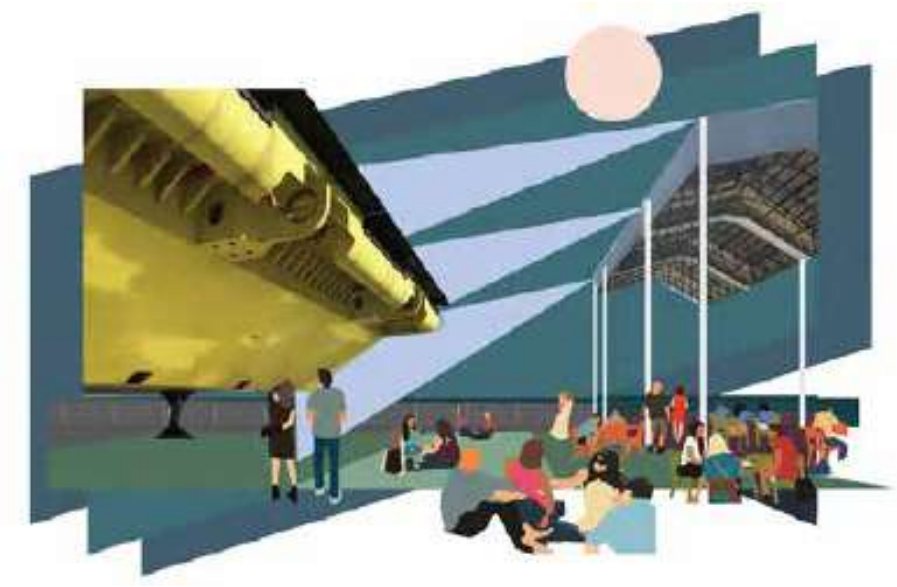

Figure 10: Resilience in Reuse Perspective

Finally, the "Murazzi 2.0" will reimagine the platform as a dense village, building a relationship between the Adriatic and the island and developing the local economy and using the Murazzi to connect the Adriatic side of the island to the Lagoon rather than to separate it (Figure 11).

Figure 11: Murazzi 2.0 Main Road Perspective

Given forward movement on the Europe Plan, the site may not even exist in a matter of years, so the student team sought to uncover a number of alternative possibilities to provoke questions about the tradeoffs and synergies between construction and destruction, naturalization and reuse. The course recognized the legal background for the Europe Plan, as well as a changing European Union environment, where such the future of such a large undertaking may rise and fall based on local, regional, national and even Eurozone politics, finances and policy. Utlimately, the class found a reevaluation of the site's future compelling given the

uncertainty around projected environmental changes due to global warming and the even more uncertain projections about localized environmental changes in the Venetian Lagoon and the Adriatic Sea.

The future of the study site remains to be determined. If current plans proceed, the site must be dismantled and deconstruction of hundreds of thousands of square meters of fill and concrete must removed sustainably to develop a new beach will form along the lock and breakwater. If the site is kept, a longer range vision for sustainable futures on the littoral islands could be created. Seemingly just as likely, if the site is kept in a state of limbo, the site could serve useful purposes even if retained temporarily. Each of this study's plans begin to address these options, and the authors' hope that the plans, or at least elements thereof, can help planners and policymakers in the Veneto region widen the possibilities planned for the future of this site. This site is at a crossroads, and provides the potential to link sea and lagoon, beach and murazzi, and past, present and future.

While the MOSE platform on Pellestrina is not old, it faces, like much of the infrastructure from other eras, an uncertain future. Yet in many cases, this infrastructure has been creatively reused, creating iconic places out of infrastructure once considered an eyesore. In any number of cities, old, disused piers have been converted in to parkland or even used for housing. Imagine if New York had torn down old West Side Line railroad instead of redeveloping it into the High Line. Disused infrastructure can be an opportunity, and our study of this site seeks to bring the principles of urban design to the site.

Acknowledgements

Special thanks to our instructor for the course where we developed this paper, Mary Anne Ocampo. Elena Zambardi our client at Consortio Venezia Nuova, as well as Matteo Basso, Frederico Sbetti and Laura Fregolent from IUAV, Paola Malanotte Rizzoli and Andrew Whittle from the Massachusetts Institute of Technology.

References

Altimetria, Carta Tecnica Regionale del Veneto, n.d.

Bondesan, A., Furlanetto, P., 2012. Artificial fluvial diversions in the mainland of the Lagoon of Venice during the 16th and 17th centuries inferred by historical cartography analysis. Géomorphologie: relief, processus, environnement 18, 175–200. https://doi.org/10.4000/geomorphologie.9815

Centro Euro-Mediterraneo sui Cambiamenti Climatici, 2017. Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC).

Charlier, R.H., Chaineux, M.C.P., Morcos, S., 2005. Panorama of the History of Coastal Protection. Journal of Coastal Research 211, 79–111. https://doi.org/10.2112/03561.1

Cipriani, L., 2017. Isole di Possibilita: Venezia e la citta laguna. Aracne editrice, Universita Iuav di Venezia.

Città di Venezia, n.d. Riferimenti altimetrici [WWW Document]. URL https://www.comune.venezia.it/it/content/riferimenti-altimetrici

Franco, L., Tomasicchio, G., 1992. Hydraulic and Mathematical Modelling of Historical and Modern Seawalls for the Defence of Venice Lagoon. Presented at the 23rd International Conference on Coastal Engineering, American Society of Civil Engineers, Venice, Italy.

Galassi, G., Spada, G., 2014. Sea–level rise in the Mediterranean Sea to 2050: Roles of terrestrial ice melt, steric effects and glacial isostatic adjustment (No. Global and Planetary Change).

Goy, R.J., 1985. Chioggia and the villages of the Venetian lagoon: studies in urban history. Cambridge University Press, Cambridge [Cambridgeshire] ; New York.

Gugliuzzo, E., 2018. The “Serenissima” at hazard: the Historical Phenomenon of Acqua Alta in Venice. https://doi.org/10.6092/2240-7715/2017.2.33-45

Hoegh-Guldberg, O., et al., n.d. Impacts of 1.5°C of Global Warming on Natural and Human Systems 138.

Marcos, M., Tsimplis, M., 2008. Comparison of results of AOGCMs in the Mediterranean Sea during the 21st century. Journal of Geophysical Research Oceans 113(C12).

Merali, Z., 2002. Saving Venice [WWW Document]. Scientific American. URL https://www.scientificamerican.com/article/saving-venice/ (accessed 5.30.19).

Microrilievo della pianura del Veneto, 2015.

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. https://doi.org/10.1080/08920753.2012.692311

Pellestrina Summer School Survey of Island Residents, 2018.

Piano delle misure di compensazione, conservazione e riqualificazione ambientale dei SIC-ZPS IT3250003 e IT3250023; dei SIC IT3250030 e IT3250031 e della ZPS IT3250046 – QUADRO AGGIORNATO, 2016.

Popolazione: dati e studi [WWW Document], 2017. . Comune di Venezia. URL https://www.comune.venezia.it/it/content/statistica-statistiche-popolazione-0 (accessed 1.30.19).

Rosetto, L., 2000. The Management of Fishery in the Lagoon of Venice. IIFET 2000 Proceedings.

Stradario e Popolazione, 2010.

Tosi, L., Rizzotti, Frederica, Zecchin, M., Giulano Brancolini, Luca Baradello, 2009. Morphostratigraphic framework of the Venice Lagoon (Italy) by very shallow water VHRS surveys: Evidence of radical changes triggered by human-induced river diversions.

Zaccariotto, F., 2014. Piano per la Gestione delle Risorse Alieutiche delle Lagune della Provincia di Venezia, 2015-2019.