ABSTRACT

Title of Thesis:	SUSPENDED CULTURE: AGRITECTURE FOR A CONTEMPORARY CLIMATE
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This thesis explores how the relationship between wetland restoration and farming on Maryland's Eastern Shore create resilient coastal infrastructure. Coastal communities were designed for a climate that no longer exists and are ill equipped to face the rapidly changing landscape due to climate change. The Chesapeake Bay is already facing saltwater intrusion, rising sea levels, warmer temperature, and more frequent extreme weather events that threaten the productivity and livelihood of people, plants, and animals of Maryland's Eastern Shore. Farms whose practice is threatened by the new climate can actually utilize wetlands intentionally for protection from flooding, poor water and soil quality, and pollution. Therefore, this thesis is aimed at designing a resilient farm and wetland park in an area whose history is closely woven with that of the land and agriculture. In the interest of longevity, the three design criteria are (1) closeness with and respect for the landscape, (2) adaptability, and (3) carbon neutrality. Overall, the coastal farm and wetland park seeks for design solutions to resilient and sustainable infrastructure in the intersections between the built and natural environment.

GROW THE SWAMP: WETLAND FARMING ON MARYLAND'S EASTERN SHORE

by

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Chapter 1: Synopsis

Section 1: Introduction

This will explore the historically volatile relationship between human activity and wetlands by designing a responsible and resilient carbon neutral farm on a site with redeveloped wetlands on a coastal site in Maryland's Eastern Shore. Agriculture has been an integral part of life and business on Maryland's Eastern Shore since European settlement because of its ideal climate and fertile soil. However, much of the farming industry in Maryland's Eastern Shore is at risk due climate related sea level rise and saltwater inundation. Wetland restoration and preservation is one tool to help protect the land required for farming. Contextually, the main purpose of wetland preservation is to reinforce resilient and sustainable building, but side effects include biodiversity, pollution mitigation, and recreation. Therefore, finding a balance between building practices and wetland restoration not only ensures the future of agriculture in delicate landscapes, but also supports overall wellbeing of both people and the planet.

Fertile soil is produced, at least partially by wetlands that in 1780, was estimated to account for roughly 20% of Maryland's surface area.[1] There is some variation in Maryland's current wetland inventory ranging from 6.5%[1] to 9.4%[2] of total surface area. Nonetheless, the USDA has estimated that by 1987, 110 million acres of United States wetlands have been drained for agriculture.[1] The data supports the link between certain favorable products of

[1] Thomas Dahl, *Wetland Losses in the United States 1780's-1980's* (Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service, 1990), 12.
[2] Denise Clearwater et al., *An Overview of Wetlands and Water Resources of Maryland* (Maryland Wetland Conservation Plan Work Group, 2000), 8–10.

wetlands, such as fertile soil, and agriculture, but ultimately that wetlands were drained so that that cash crops could be produced on dryer land.

However, since accelerated climate change raises sea level and threatens coastal communities, including Maryland's Eastern Shore, many farms that were established near coastal wetlands are at risk. Farms must withstand current environmental conditions and inevitably of the changing landscape to preserve critical agricultural practices and meet current and future needs of the population. Coincidentally, one tool that can be used to protect coastal buildings against flooding and pollution of climate change are wetlands. Methods that sustainable agricultural architecture can use to achieve resiliency explored in this thesis are (1) minimized stress on wetland ecosystems that offer protection against climate driven catastrophes and (2) carbon neutral design practices.

Section 2: Research Questions

Research questions that guide this analysis are:

1. Can the built environment change society's attitudes towards the natural landscape?
2. How can a necessary agricultural industrial complex be a community asset?
3. How do buildings address an ever changing and delicate ecosystem and climate?

Section 3: Scope & Objectives

The aim of this thesis is to explore the intersections between environmentalism and architecture. If architecture is a built response to a problem, then using design as a tool to mitigate ecosystem loss and climate change is within reach. Essentially, the design of a carbon neutral farmstead is a matter of sustainable infrastructure.

Specifically located in Easton, Maryland, this project could be relevant towards other sites whose economy emphasizes agriculture and whose land is at significant risk of sea level rise and flooding. The campus serves three major stakeholders, in no specific order, (1) wetland supported biophilia, (2) private farm population including employees, crops, and livestock, and (3) the larger Easton community including produce consumers and site visitors.

As useful tools in climate change mitigation, sea level rise, and biodiversity, wetlands are critical landscapes that deserve the attention of designers. Although existence of buildings and people is not inherently good for the land, this project seeks to find an acceptable building location and methodology that reduces wetland harm while its program will produce goods, food, and recreation for people. Architecture needs to address the expedited transformative property of the coast due to climate change. The climate and landscape are actively changing, which impacts wetlands, agriculture, and human activity. It is imperative to analyze and reimagine current infrastructure to address the immediate inevitability of the site and its impact on both the built and natural environment. Therefore, the scope of this project includes a master plan that considers the legacy of the land as it is transformed over time by (1) re-constructing a coastal wetland and buffer zone and (2) locating and designing an environmentally conscious agricultural complex.

Both the site and building are functional. The main purpose of the wetland and buffer zone is to protect and sustain the farm over time. Agrarian buildings and land produce goods and food for consumption. Farm buildings and the natural site act in conjunction to act as a recreational destination for the community where people can traverse the site, by bike, foot, or small boat craft. In enjoying the wetland ecosystem and farm setting, visitors can passively gain a heightened appreciation for and connection to nature and food production.

Chapter 2: Wetlands

Section 1: Classification

Overview

In order to be able to use wetlands as a mitigation tool to protect coastal farms against climate change, we must first understand how to classify and locate a wetland, which has not always been a simple endeavor. Understanding wetland classification is critical in defining how the building and site can be designed to ensure the prosperity of certain elements critical for that particular wetland environment. For example, it would be remiss to propose planting rice along an estuary as it cannot grow in salt water. The differences between each type of wetland also determines how the land can be manipulated to maintain a productive wetland and how useful of tools they may be in the design. Being that this thesis is focused on measurable restoration and preservation practices of wetlands along Maryland's Eastern Shore, the research discussed is location specific.

History & Definition

There is a wide range of definitions for a wetland, many of which contradict each other. A discrepancy in terminology is due in part by the varying characteristics of a wetland according to size, location, water quality, and human intervention. Colloquially referred to swamps, marshes, bogs, fens, mires, or mores throughout the 19th century, defining a wetland was inconsequential as they were often drained for agriculture. The word "wetland" was first cited in the 1956 article, Wetlands of the United States, but was not commonly used until the mid-twentieth century.[1] The need for a precise definition of a wetland and its boundaries, or delineation, arose from regulation and preservation efforts first recognized in the late 1970s.[1]

The Environmental Protection Agency provides that a wetland is an area, **"**where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.**"**[3] Three main characteristics of wetlands are, (1) constant or recurrent presence of water at the surface or substrate, (2) unique soil conditions, or hydric soils, and (3) support of hydrophates, aquatic vegetation, but an absence of flood-intolerant biota.[4]

Form & Typology

Wetland boundaries are defined by the vegetation and its response to environmental gradients.[11] Typically, wetlands are bound by a broad transition zone to uplands.[5] The shape and location of a wetland is typically determined by topography. The riparian zone is land that is in direct discourse with a body of water whose ecosystems are maintained by high water tables and periodic flooding.[6] Conversely, agricultural wetlands are always anthropomorphic in that wetlands are landscaped and managed to produce or support food and fiber production.[10]

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[3] Unisted States Environmental Protection Agency, "What Is a Wetland?," United States Environmental Protection Agency, *Wetlands*, last modified May 12, 2022, https://www.epa.gov/wetlands/what-wetland.

[4] National Research Council, Division on Earth and Life Studies, Commission on Geosciences, and Committee on Characterization of Wetlands, "Executive Summary: Definitions, Factors, Criteria, and Indicators," in *Wetlands: Characteristics and Boundaries* (Washington, D.C.: National Academy Press, 1995), 3–5.

[5] National Research Council, Division on Earth and Life Studies, Commission on Geosciences, and Committee on Characterization of Wetlands, "Wetland Functions," in *Wetlands: Characteristics and Boundaries* (Washington, D.C.: National Academy Press, 1995), 40–42.

[6] National Research Council, Division on Earth and Life Studies, Commission on Geosciences, and Committee on Characterization of Wetlands, "Especially Controversial Wetlands," in *Wetlands: Characteristics and Boundaries* (Washington, D.C.: National Academy Press, 1995), 152–160.

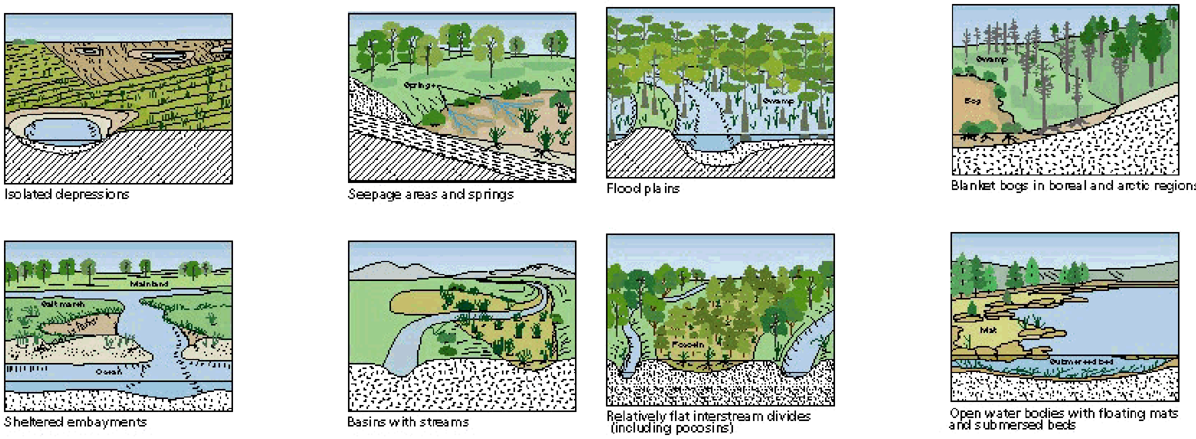

Figure 2.0 Typical Wetland Positions Relative to Topography (Source: United States Geological Survey)

Cowardin wetland classification system utilized by the U.S. Fish and Wildlife Service for the National Wetlands categorizes wetlands based on “landscape position, vegetation cover, and hydraulic regime.”[3] Major typologies under this system include (1) marine, (2) tidal, or estuarine, (3) lacustrine, (4) palustrine, and (5) riverine wetlands.[3] Three most populous typologies of Maryland’s Eastern Shore are, (1) estuarine, (2) palustrine, (3) riverine.[7]

The Chesapeake Bay is the largest United States estuary.[8] Maryland’s estuaries are ecosystems where freshwater drains from land and meets the salty water from the Atlantic Ocean, meaning that the water’s salinity increases from north to south.[9] Estuaries are biologically productive areas as they are a source of food, migratory rest, and breeding.[9] A number of plant and animal species have adapted to living in brackish water.[9] The subsystems of

[7] “Maryland Coastal Atlas,” n.d., https://gisapps.dnr.state.md.us/coastalatlas/WAB2/.
[8] Chesapeake Bay Program, “The Estuary,” *Chesapeake Bay Program*, https://www.chesapeakebay.net/discover/ecosystem/the-estuary.
[9] National Oceanic and Atmospheric Administration, “What Is an Estuary?,” *National Ocean Service*, https://oceanservice.noaa.gov/facts/estuary.html.

an estuarine wetland are (1) subtidal, consistently submerged areas, and (2) intertidal, areas with both flooded and open air periods.[10]

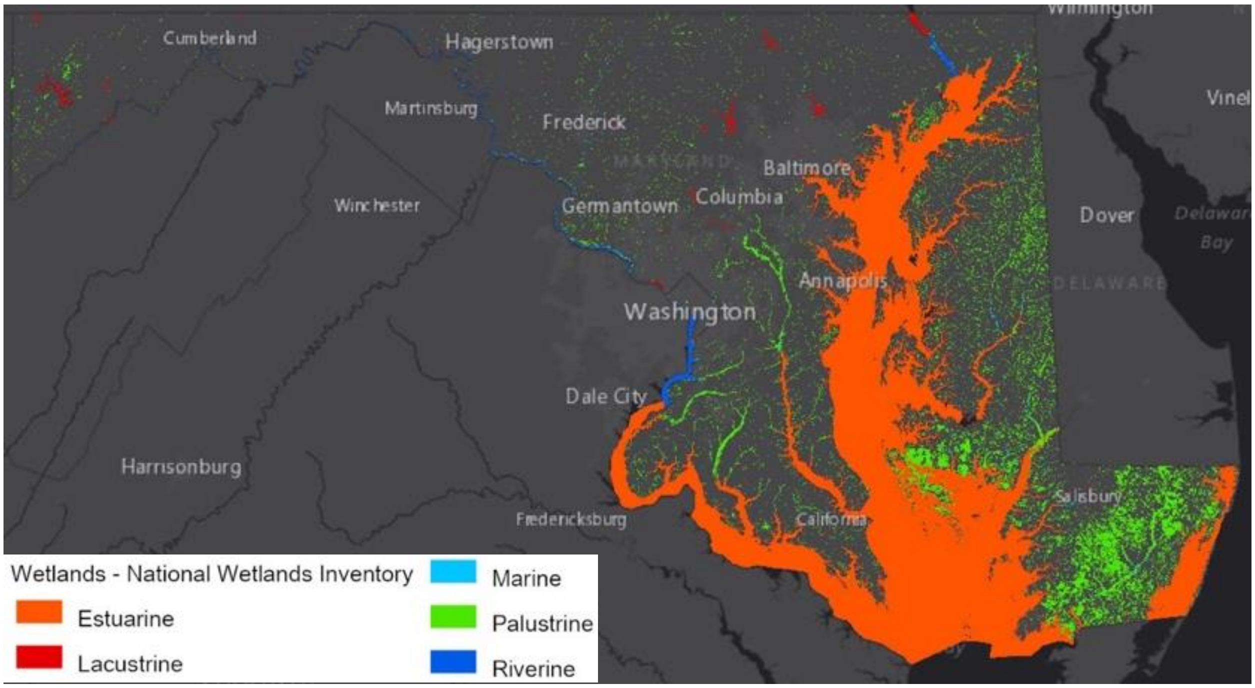

Figure 2.1: Maryland Wetland Map (Source: Maryland Coastal Atlas)

Conversely, palustrine wetlands are fresh water situated on the boarders of rivers, lakes, streams, ponds, isolated depressions, and broad flat areas.[11] Riverine systems are habitats contained in a channel bound by uplands. Downstream, the fresh moving water drains into a lacustrine or estuarine wetland, and then a stationary body of water.[10] The four riverine subsystems used to characterize the lotic system, swiftly moving water, are (1) tidal, where water level fluctuates for at least part of a growing season, (2) lower perennial, permanently flowing

[10] Ralph Tiner and David Burke, *Wetland of Maryland*, National Wetlands Inventory (Hadley, MA and Annapolis, MD: U.S. Fish and Wildlife Service, Ecological Services, Region 5 and Maryland Department of Natural Resources, June 1995), 10–12, https://www.fws.gov/wetlands/Documents%5CWetlands-Of-Maryland.pdf.
[11] Chesapeake Bay Program, *Chesapeake Bay Wetlands: The Vital Ink Between the Watershed and the Bay* (Annapolis, MD: U.S. Environmental Protection Agency, 1997), 4–5.

water with a well-developed flood plain, (3) upper perennial, permanently flowing water with little to no flood plain, and (4) intermittent, channels containing non-flowing waters for part of the year.[8]

Riverine wetlands are bound by riparian zones, sharing many functions such as water storage, sediment retention, pollution removal, and habitat maintenance.[10]

Section 2: Value

Overview

Coastal agriculture is widely accepted as an important industry as it has been a part of the culture in Maryland's Eastern Shore for centuries, provides employment, and nourishment for people. Wetlands are equally as important as they are comparable to rainforests and coral reefs in terms of global productivity.[12] Yet, coastal agriculture has grown at the expense of wetlands because their benefits are much easier to perceive. This thesis uses the built environment to amplify wetland value demonstrating how prosperous wetlands can protect and add value to coastal agriculture and buildings. If value wetland value is better understood, if people understand how a wetland might benefit them, they are empowered to protect and respectfully utilize them.

Interest in wetland preservation has increased as their value has become more fully understood.[13] To further ecosystem mitigation, the perceived value of wetlands must demonstrate

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[12] Unisted States Environmental Protection Agency, "How Do Wetlands Function and Why Are They Valuable?," United States Environmental Protection Agency, *Wetlands*, last modified June 15, 2022, https://www.epa.gov/wetlands/how-do-wetlands-function-and-why-are-they-valuable.
[13] Thomas Dahl and Gregory Allord, "Technical Aspects of Wetlands History of Wetlands in the Conterminous United States," 2425 (Presented at the National Water Summary on Wetlands Resources, U.S. Geological Survery, 1997), https://water.usgs.gov/nwsum/WSP2425/history.html.

how their inherent functions can be interpreted in terms of human benefit.[14] Three facets of wetland services, (1) provisional, (2) regulatory, and (3) cultural, support four constituents of well-being, security, basic material for good life, health, and good social relations, that ultimately amount to freedom of choice.[14]

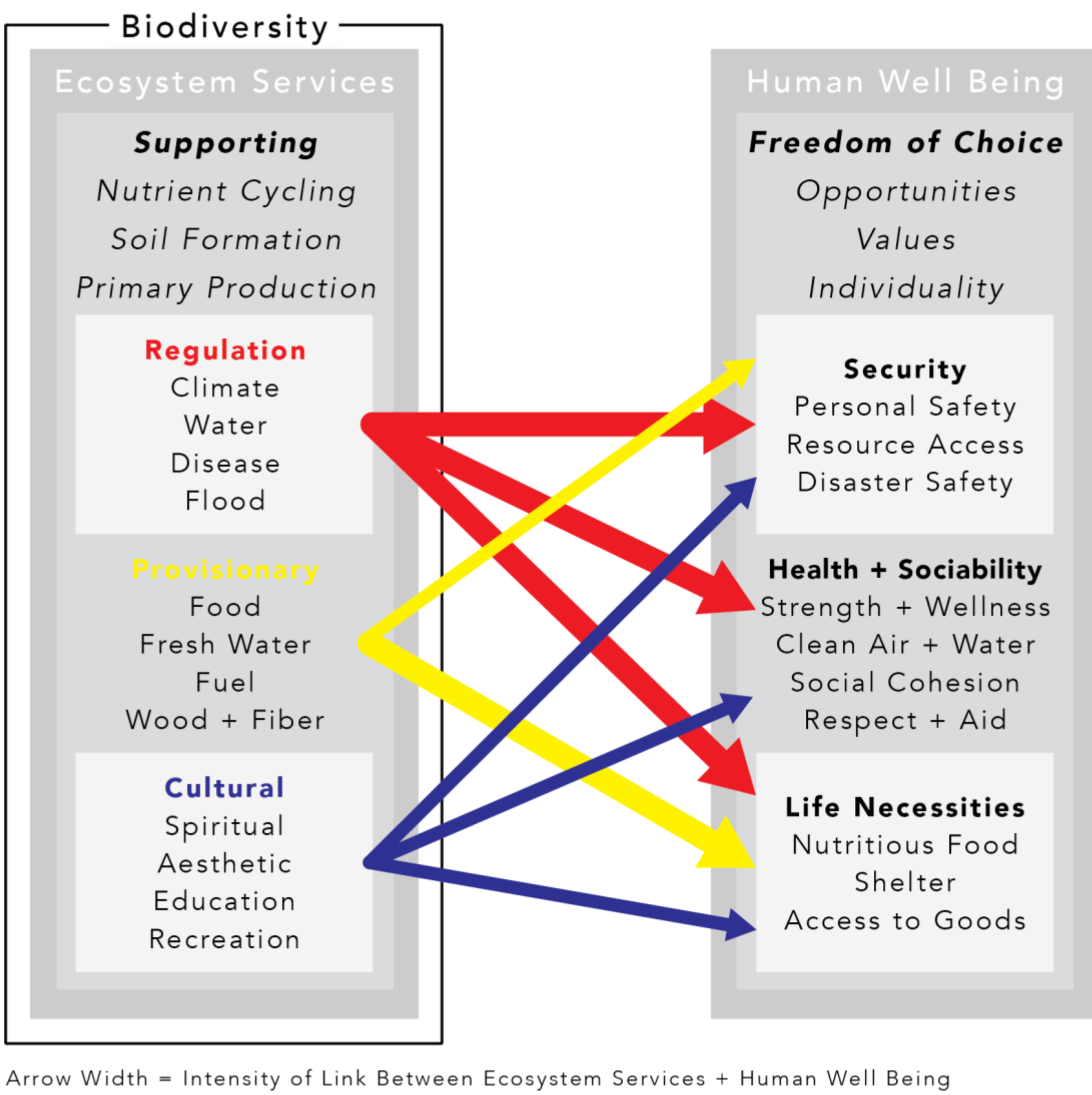

Figure 2.2 Paradigm of Ecosystem Services (Source: Author)

[14] William Mitsch and James Gosselink, "Ecosystem Services," in *Wetlands*, 5th ed. (Hoboken, NJ: John Wiley & Sons, Incorporated, 2015), 527–560.

Provisional

A wetland's biodiversity supports a diverse range of provisions, or physical products such as food, fiber, water, game, and medicine.[14] Whether a wetland serves as a bird's primary habitat or migratory resting place, they support large populations of waterfowl, which intern supports the hunting industry. A wetland bird, whether it be mallard, osprey, oriole, heron, etc. is often drawn to a wetland because it's food and shellfish population act as a rich source of food.[15] Over 95% of fish and shellfish produced in the U.S. are wetland dependent for at least part of their life. This intern supports a recreational fishing community, who are less efficient than commercial fishers, meaning that they are valuable assets to local economies.[14]

Certain wetland animals and vegetation, such as the horseshoe crab, are invaluable medicinal research tools. Other wetland plant species have proven themselves as valuable commercial products. Although it can be difficult for certain conventional agricultural crops to grow on a wetland, cattails, rice, cranberries, papyrus, and salt marsh cordgrass are all examples of productive agricultural goods.[14] The aforementioned horseshoe crab is one example of an endangered or threatened species that wetlands support. The mitigation of migratory tidal marsh habitats and regulating hunting laws saw that the whooping crane flock increased from 15 to 600 over the span of 52 years.[14]

Regulatory

Regulating ecosystem services such as flood mitigation, storm abatement and coastal protection, and climate regulation support human health, security, and basic needs.[14] As anthropogenic climate change increases the intensity and rate of extreme weather conditions, so

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[15] Ineta Kacergyte et al., "Quantifying Effects of Wetland Restorations on Bird Communities in Agricultural Landscapes," *Biological Conservation* 273 (August 16, 2022): 11.

does the need for flood and stormwater management. Wetlands, especially riverine, are important buffers and useful tools as they intercept flooding and subsequently slow and distribute run off peaks over a more manageable time frame to reduce flood damage.[14] A hydraulic simulation conducted by Ogawa and Male proved an inverse relationship between upland wetland removable and downstream flooding.[14] Similarly, natural coastal marshes are more resilient against storm forces than buildings and other structures.[14] Maintaining a coastal wetland buffer to protect settlements against storms is a much cheaper option than rebuilding or constructing complex infrastructures.

Wetlands can also cycle nitrogen, carbon, and sulfur to help regulate atmospheric pollutants and climate change.[14] Wetlands can process excess nitrogen, created largely by ammonia for fertilization, through denitrification. Essentially, temperate wetlands are a source of organic carbon and act as buffers for agricultural runoff, creating the perfect environment for denitrification to balance the global nitrogen allowance.[14] If a wetland and its water table are in acceptable conditions, the soil can pack in and store carbon indefinitely and sequester greenhouse gases and atmospheric carbon emissions.[14]

Wetlands also offer positive effects on aquifers and water sources. There is some evidence that small inland wetlands can recharge regional groundwater banks.[14] Whether naturally sources or artificially applied, a wetland’s biochemistry has multiple attributes that improve water quality and can even act as wastewater treatment.[14]

Cultural

Finally, the aesthetics and subsidence of a wetland offer cultural benefits, and thus have some effect on the social, mental, and physical wellness of a human. This phenomenon is perhaps best demonstrated visually by American artist, John Singer Sargent, who worked to capture the essence and cultural appeal of a wetland.[14] The ecological diversity provides a beautiful landscape for research sites and leisure. Wetlands are popular destinations for certain recreational activities because of the landscape's splendor. Beyond recreation, wetland dependent resources have sustained global societies throughout time.

Figure 2.3 Two Girls Fishing, 1912 (Source: John Singer Sargent)

Figure 2.4 An Outdoor Study Painting (Source: John Singer Sargent)

Section 3: Threats

Overview

Since European settlement in the United States, America has lost over half of its wetlands. From 1780 to 1980, Maryland has lost 73% of its wetlands.[16] The country saw the greatest rate of national wetland loss between 1950-1970 and has since slowed.[17] Historically, the most common wetland alterations have been, (1) draining, dredging, and filling, (2) modification of hydraulics, (3) highway construction, (4) mining and mineral extraction, and (5) water pollution.[18] Although all anthropogenic to some extent, this thesis categorizes wetland threats into, (1) indirect, including matters of vegetation and climate triggered by people and (2) direct human causes.

Direct

Direct threats include, hydraulic alterations, land conversion, and pollution.[17] Hydraulic alterations cause changes in the water table that keep it from saturating or inundating the soil in a wetland. Common hydraulic alteration practices are deposition of fill material for development, draining for development, farming, and mosquito control, dredging and stream channelization for navigation, development, and flood control, diking and damming, diversion of flow to or from wetlands, and increased water and pollution runoff from the addition of impervious surfaces in the watershed.[17]

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[16] William Mitsch and James Gosselink, "Appendix A," in *Wetlands*, 5th ed. (Hoboken, NJ: John Wiley & Sons, Incorporated, 2015), 701–702.
[17] Unisted States Environmental Protection Agency, *Threats to Wetlands* (United States Environmental Protection Agency, September 2001), https://www.epa.gov/sites/default/files/2016-02/documents/threatstowetlands.pdf.
[18] William Mitsch and James Gosselink, "Traditional Wetland Management," in *Wetlands*, 5th ed. (Hoboken, NJ: John Wiley & Sons, Incorporated, 2015), 481.

Although wetlands are natural filters, too many sediments, nutrients, pesticides, and heavy metals degrade wetlands and water quality. Pollutants are widespread, but mainly come from urban, agricultural, mining, and tree cultivation run off, air pollution from machinery and factories, old and leaky landfills and dumps, and marinas where boats increase turbidity and release pollutants.

Indirect

Indirect causes include vegetative damage and climate change.[17] Invasive plant and animal species can out compete and destroy wetlands. For example, a flock of invasive Canada Geese released by people on Maryland's largest freshwater tidal wetland, Jug Bay, on the Patuxent River, have grazed through nearly all of the natural wild rice on the bay. Wild rice is an important food source for many other waterfowl who stop along Jug Bay during their migration south.[19] Climate change and sea level rise have also affected Jug Bay by increasing water salinity and prolonged flooding that certain types of vegetation cannot survive, changing the landscape and ecosystem.[19] In fact, frequent storms harbor run off nutrients to a wetland, that when combined with warming waters, induces algae growth and conditions that are harmful for aquatic life.[20]

[19] Chesapeake Bay Program, "Wetlands," *Chesapeake Bay Program*, https://www.chesapeakebay.net/issues/whats-at-risk/wetlands.
[20] Chesapeake Bay Program, "Nutrient Runoff," *Chesapeake Bay Program*, https://www.chesapeakebay.net/issues/threats-to-the-bay/nutrient-runoff.

Chapter 3: Sustainable Design

Section 1: Carbon Neutral Design Principals

Overview

Construction, building operation, and agriculture contribute considerably to climate change via emissions, pollution, and land use. To ensure the future of agricultural buildings and the productivity of the landscape, they must limit their contribution to climate change. Zero impact buildings require that resource and energy use first be limited and then be supplied by renewables.[21] The "concept of O" in terms of building provides that, (1) buildings manage energy needs within their system boarders, (2) made of renewable materials and sources, (3) minimize water use and capitalize on eco-sanitation concepts, (4) place the least demand on the land, and (5) limit air pollution.[21]

Livestock, storage, and small housing program lends itself well to passive design strategies. Farmstead architecture lends itself well to reduced building carbon and energy loads because many of the spaces are either outdoors or require little temperature control like storage or utility spaces. The lower required energy load gives room for more creative and resilient active energy systems in the building. Passive sustainable site strategies are based on how the resiliency against sea level rise, excessive heat, saltwater intrusion, and unplanned marsh migration.

Carbon neutral construction also takes building materials into account. The way a material is sourced, processed, and transported impacts its carbon footprint. There are tools such

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[21] Ronald Rovers, Jacques Kimman, and Christoph Ravesloot, "The Concept of O," in *Towards 0-Impact Buildings and Built Environments* (Amsterdam: Techne Press, 2010), 22.

as EC3 that helps measure a building's embodied carbon by analyzing the materials. Therefore, EC3 provides concrete information that can be applied to material sourcing and performance. Being able to calculate the carbon accrued by building materials is important in understanding a building total carbon footprint. A true carbon neutral building is designed with sustainable local materials in conjunction with passive and efficient active building systems.

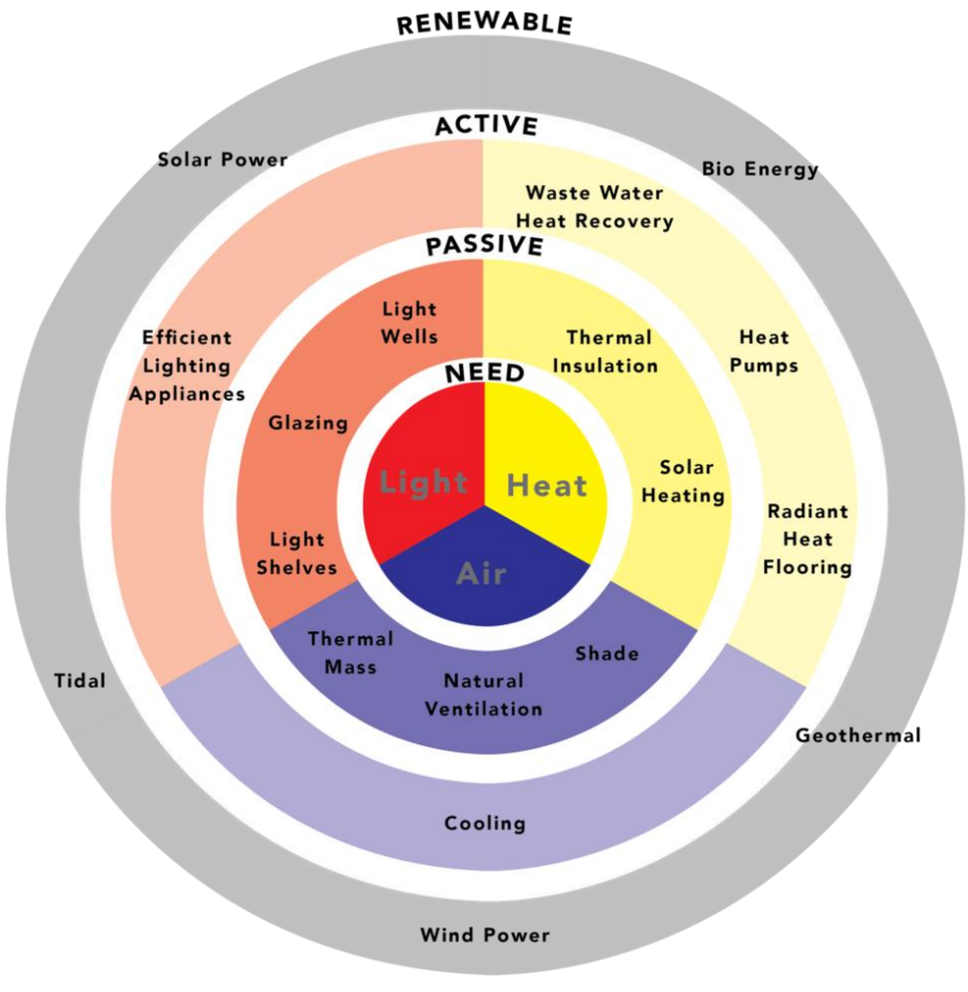

Figure 3.0 Net Zero Building Approach (Source: Author)

Passive Strategies

Passive design strategies are closely related to specific climates and the site. Easton, Maryland is in a mixed – humid climate zone. The psychometric chart is a tool used to help decide which design strategies are best suited towards building design. The most effective bioclimatic strategies for this area are solar shading, passive solar heating, natural ventilation, and wind protection of outdoor spaces. Ideal active systems include dehumidification, heating, and cooling.

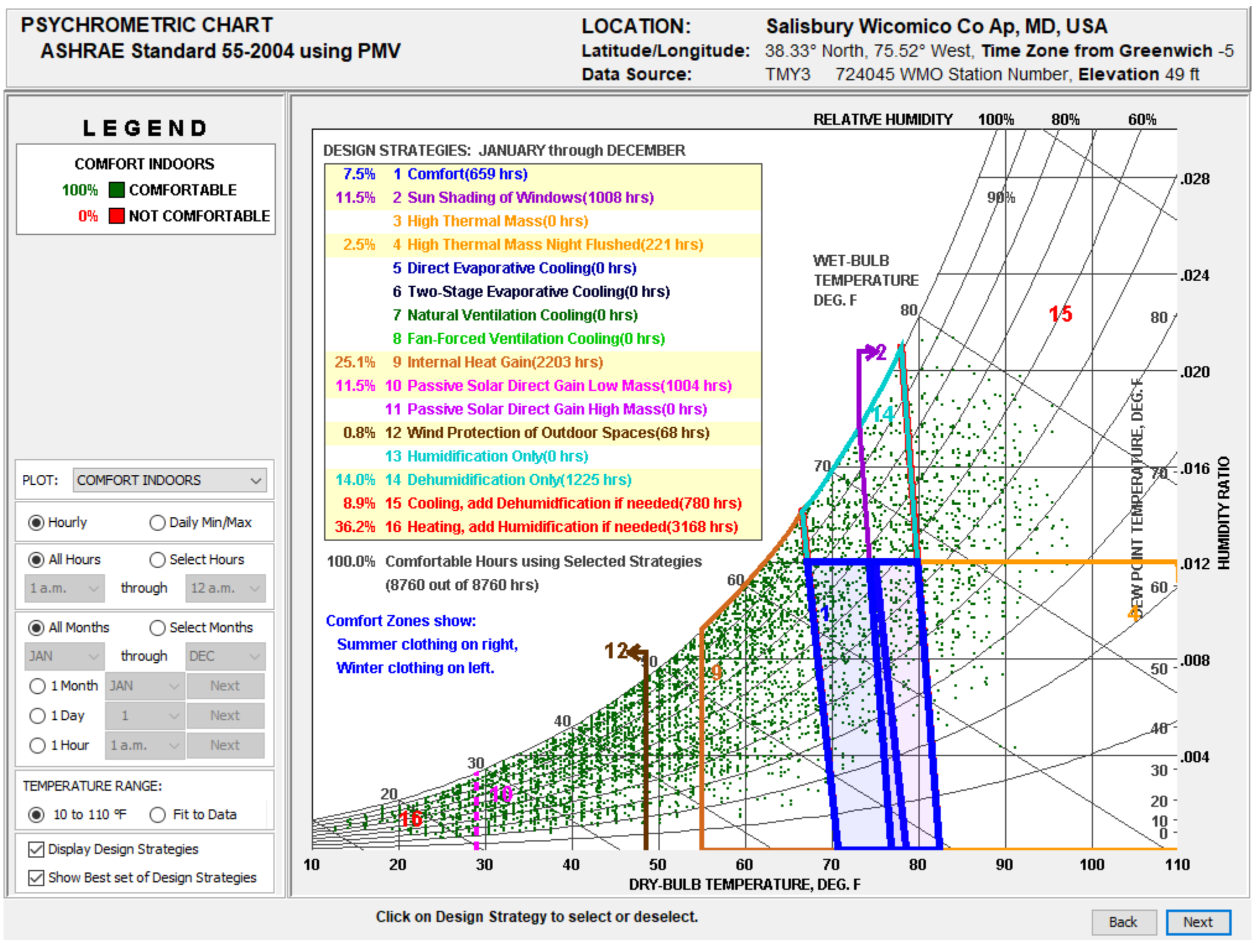

Figure 3.1 Psychometric Chart for Salisbury, MD (Source: Climate Consultant)

Although Easton, Maryland, the thesis site, is about fifty miles away, passive energy design strategies are made based off of information collected by Climate Consultant in Salisbury, Maryland. The distance can account for variance in the specific microclimate of the thesis site but is generally close enough to be able to make well educated design decisions. General passive strategies for cold climates include, (1) avoiding large north or windward facing glazing, (2) building massing that shields winter winds, (3) utilize natural plantings and topography to shelter from wind, and (4) avoiding sites exposed to concentrated winds.[22] The building mass and glazing should be configured to take advantage of passive heating by the winter sun.[22] Glazing and building materials should have a high heat capacity and thermal performance characteristics. Heat loss in the building enclosure should be minimized by (1) keeping the building mass compact, (2) arranging utility spaces as buffers towards colder north facing or windward sides, and (3) have a well detailed building envelope.[22] Therefore, generally speaking, the most suitable passive heating strategy is solar heating and both cross and stack ventilation are useful passive cooling techniques. The R-value of the building enclosure is important in ensuring a thermally efficient building mass.

A wind rose of the area demonstrates that westwardly winds are slightly predominant, but that the fastest winds come from the south. However, the wind rose does not account for coastal winds generated by the water. The building massing should be oriented on the site to guard crops and other exterior program from exuberant winds. Furthermore, the building location should be determined by any preexisting topography or trees that may dampen dramatic winds. After

[22] Edward Allen and Joseph Iano, "Passive Heating and Cooling Systems," in *The Architect's Studio Companion* (Hoboken, New Jersey: Wiley, 2017), 222.

passive design strategies are decided on, the focus should be on selecting the most efficient active strategies.

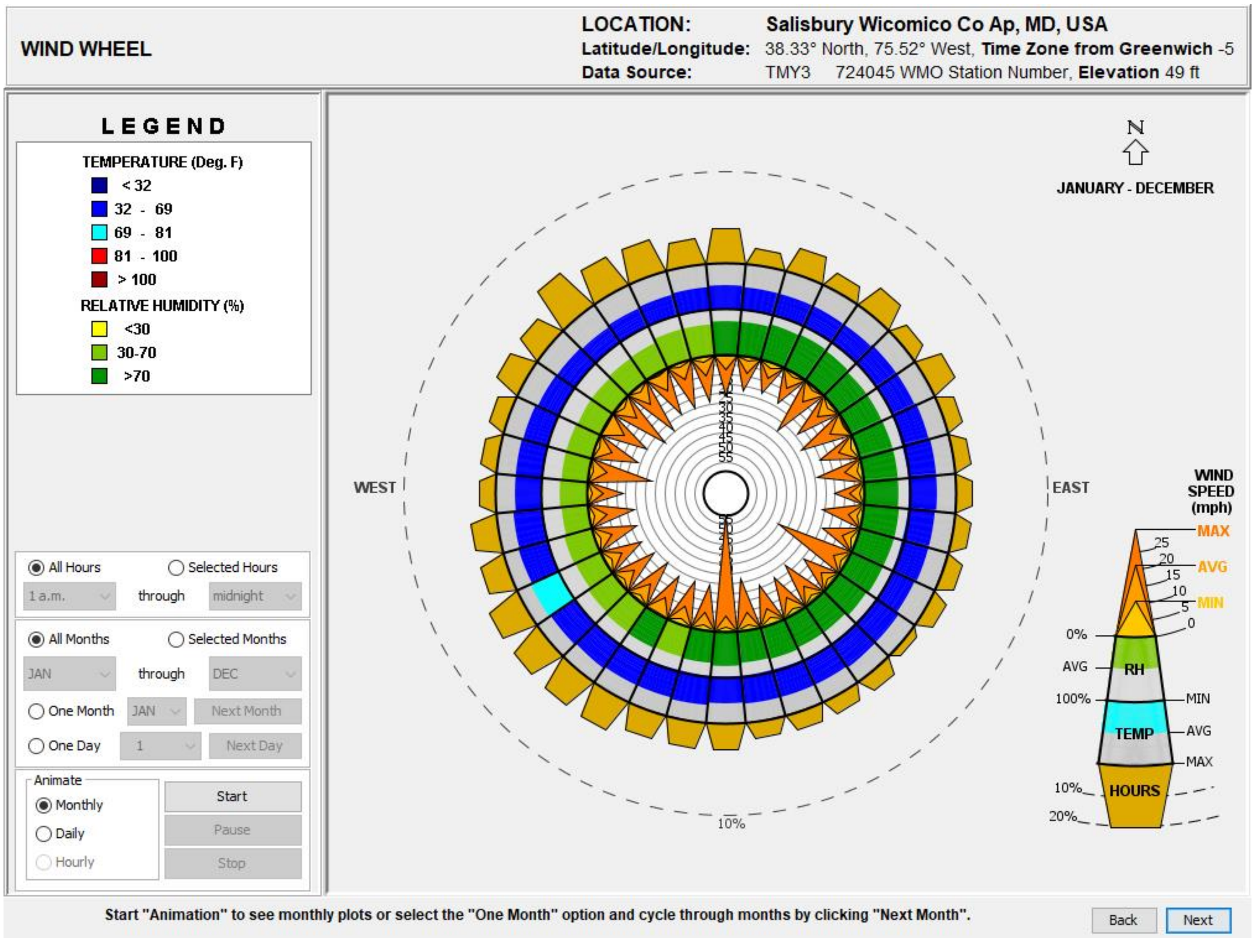

Figure 3.2 Wind Rose for Salisbury, MD (Source: Climate Consultant)

Active Strategies

Active building systems assist passive systems in creating a comfortable building climate. Right sizing active systems is key in keeping energy loads down. Once passive daylight is maximized, the lighting system should include the most efficient LED light accessories that provide just enough light for the function of each individual space. Exterior lighting is necessary for agriculture and park infrastructure, but should be designed to limit light pollution, especially in an area so close to an ecosystem that may be affected by excess light. Automatic timed, or motion sensor lights are a tool in which to keep electricity waste down.

Active heating and cooling systems will be chosen in the design stage of the thesis as they are highly dependent upon specific building requirements. Per the psychometric chart, active heating and cooling will account for 45.1% of the building's thermal comfort. To minimize heating and cooling loads, conditioned spaces should be minimized. An energy analysis of the building through software such as Sefira will be done to select an appropriately scaled temperature control system.

Site water collection and reuse systems, although can work in conjunction with natural elements and topography to determine flow direction and rates, are ultimately active systems because they include pumps. Active cisterns can collect grey water for reuse in bathrooms. Sophisticated greywater systems can filter the water of bacteria and viruses so that it can be used in drip irrigation tubing for crops.[23]

Section 2: Adaptability

Overview

Farms are historically adaptable structures. Fluctuating size, economy, and crop yield materialized in the building over time. Inherently simple structures, early farms were simple to add to and modify. Contemporary adaptable architecture accommodates for a changing culture, commerce, and climate. This thesis examines adaptable design and deconstruction as a methodology to plan for resilient coastal agriculture.

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[23] "Irrigating Plans with Greywater," *Greywater Action for a Sustainable WAter Culture*, https://greywateraction.org/greywater-choosing-plants-and-irrigating/.

Design

Many principles for adaptable design are actually common practice and lend themselves well to agricultural buildings. Clear spans and generous floor to floor heights maximize flexibility without significant structural alterations.[24] Similarly, the structural grid should be regularized and avoid load baring interior walls.[24] Floors should be flat to allow for easy renovation. Durable materials and minimal finishes that are mechanically fastened are key for utilitarian agricultural use, have longer lifespans, and can be easily repurpsed.[24] Assemblies of mechanical fasteners make deconstruction and reassembly easier to execute than building comments constructed with adhesives.[24] Overall, buildings are more sustainable and have higher financial value as the aforementioned design considerations allow for renovation based on occupant desire or inevitable climate change.

Deconstruction

Designing for deconstruction keeps building materials out of landfills and lowers demand for new material sourcing and thus raising availability for low impact materials. Along with lower VOC emissions, volatile organic compounds, that are hazardous to health, adaptable buildings necessitate a more careful construction process that allows for more control of hazardous biproduct and dust.[24]

Adaptable buildings and assembly should be planned so that deconstruction is simple and safe.[24] They should be made of durable, low-toxicity materials to increase salvage yield.[24] Mechanical, electrical, IT, and plumbing services should be planned so that they are accessible so that they can be updated or maintained without damage to other services or building

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[24] Paula Melton, *Buildings That Last: Design for Adaptability, Deconstruction, and Reuse* (The American Institute of Architects, n.d.), 7–12.

components. Simple building systems, standard sized beams and columns made of one material, helps with disassembly and marketability.[24] Wood and steel exposed connections express structural intent.[24] Permanently adhering materials such as spray-foam insulation and concrete should be avoided.[24] Finally, high quality mechanical fasteners in lieu of adhesives allow for building deconstruction. Adaptable building design emphasizes durable and homogonous materials, modular building components and fasteners, and simple structural and service systems that carry economic, environmental, and health benefits. A good, sustainable building can be characterized as one that can outlive its intended use. Therefore, adaptable building techniques should be employed in coastal areas where flexible building functions and even locations can help ensure a dignified response to a rapidly changing climate.

Chapter 4: Time

Section 1: Overview

This chapter weaves all three elements of this thesis, climate, wetlands, and agriculture together with time. No element of this thesis is static. Resilient coastal agriculture is cognizant of many constantly moving parts. Plants take time to grow, the sea gradually rises, tides cyclically wipe away the shoreline. The land, what it can support, and the people who live there will change as well. Buildings have a longer lifespan, so for them to responsibly sit on the planet for decades, they must be designed with consideration of the transformative nature of the land it sits on and people who use it.

Section 2: Climate & Agriculture

Historic Cycles

The purpose of this thesis is not to prove climate change, but act on the immediacy of its effects. The Earth undergoes millennial climate change cycles initiated by its orbit around the sun on roughly 100,000 year periods, otherwise known as Milankovitch cycles.[25] Temperature changes in the range of 5-15 degrees Fahrenheit spark feedback loops including (1) sea ice and snow retreat that reduces the amount of sunlight the Earth reflects, (2) heat caused increases in atmospheric water vapor, a greenhouse gas, (3) greater levels of methane and carbon dioxide in

[25] United States Department of Agriculture, "Natural Climate Cycles," *Climate Change Resource Center*, https://www.fs.usda.gov/ccrc/education/climate-primer/natural-climate-cycles

the atmosphere caused by melted permafrost, and (4) carbon dioxide once sequestered by the ocean is released and heats the planet even more so.[26]

Signs of stress on life are apparent with prolonged exposure to temperatures above 77 degrees Fahrenheit with high humidity.[27] Even short exposure to 95 degrees Fahrenheit with high humidity or 104 degrees Fahrenheit with low humidity is lethal to humans, livestock, poultry, and plants.[27] Following a unsustainable period of heating, the Earth's orbit eventually changes so that summer sunlight in the Northern Hemisphere is limited, sparking a feedback loop of cooling.[26]

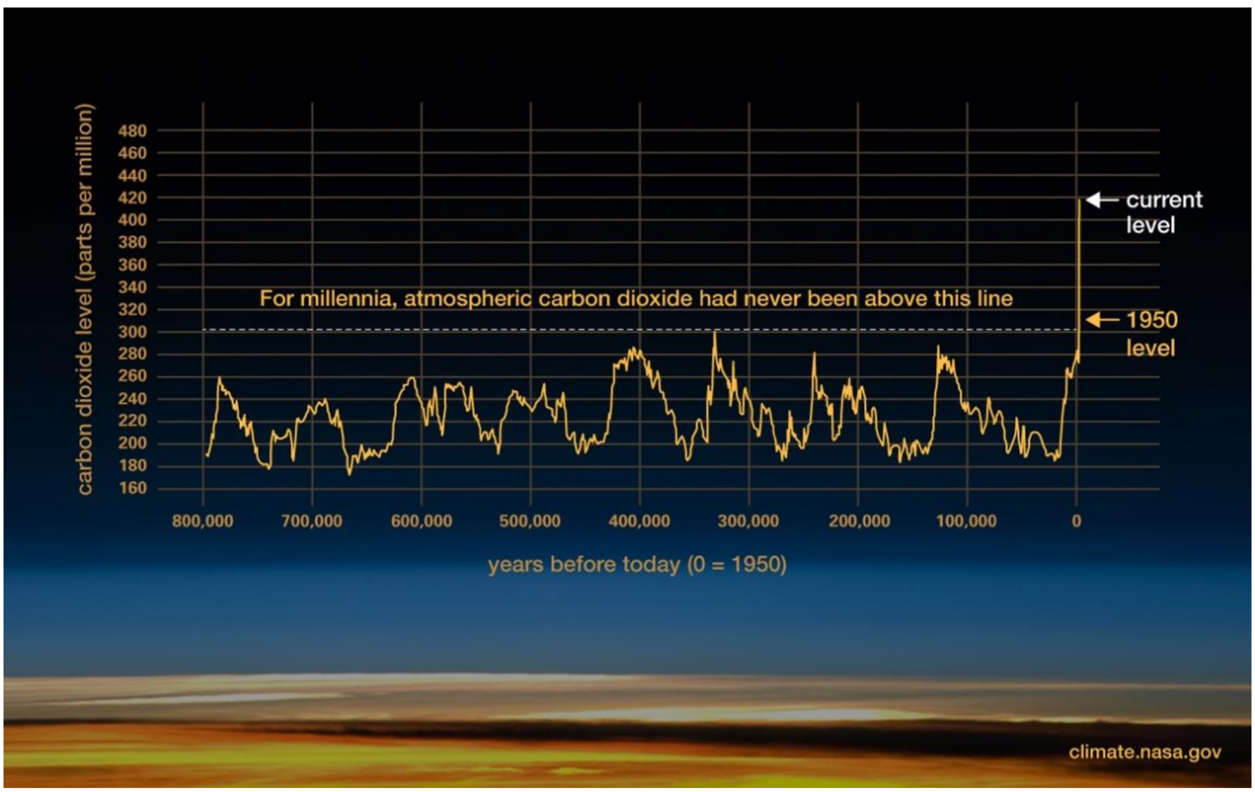

Figure 4.0 Carbon Dioxide Levels Over Time (Source: NASA)

[26] David Herring and Rebecca Lindsey, "Hasn't Earth Warmed and Cooled Naturally throughout History?," *Climate.Gov*, last modified October 29, 2020, https://www.climate.gov/news-features/climate-qa/hasnt-earth-warmed-and-cooled-naturally-throughout-history

[27] Senthold Asseng et al., "The Upper Thresholds of Life," *Lancet Planet Health* 5 (2021): 378–385.

Present

Climate change is not contingent upon belief. Regardless of whether or not people are ready to accept it, the climate has experienced historic change since the industrial revolution. Evidence gathered from ice cores, rocks, and tree rings by satellites and other instruments prove that the Earth is amidst its ninth climate cycle.[28] Similar to the delicate balance of wetland health, greenhouse effect is essential to life on earth, but human intervention has added so many greenhouse gases to the atmosphere, that the greenhouse effect's ability to slowly release heat into space has been altered.[29] The five greenhouse gases are (1) $CO_{2,}$ (2) methane, (3) nitrous oxide, (4) chlorofluorocarbons, and (5) water vapor.[29] Since the industrial revolution, the Earth's current warming has been so exaggerated, that the sun alone cannot be cause.[29]

To animate the structure of modern climate history, imagine three separate clocks, (1) climate science, (2) public opinion, and (3) business, that all tick at their own individual rate.[30] To truly mobilize resilient design and climate mitigation the rate of all climate clocks must align.[30] However, this has never been the case. As markets begin to capitalize on the shifting public opinion regarding climate science, society is close to synchronizing the proverbial climate clocks and making real progress towards climate preparedness. Architects must capitalize on the moment where the business markets and public opinion finally catch up with climate science. design buildings with a special attention to reduce carbon.

The Earth is already experiencing the earlier effects of climate change. Since 1980, extreme weather disasters have cost Maryland \$10-\$20 billion.[31] Frequency of these events has

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[28] Earth Science Communications Team at NASA's Jet Propulsion Laboratory, "How Do We Know Climate Change Is Real," *Global Climate Change*, last modified December 8, 2022, https://climate.nasa.gov/evidence/.
[29] Earth Science Communications Team at NASA's Jet Propulsion Laboratory, "The Causes of Climate Change," *Global Climate Change*, last modified December 8, 2022, https://climate.nasa.gov/evidence/
[30] Eugene Linden, *Fire and Flood: A People's History of Climate Change, from 1979 to the Present* (Penguin Random House LLC, 2022).

increased steadily from 0.7 events between 1980-1989, 2.7 events from 2010-2019, and 5.0 events in 2021 alone.[27] Given the now inescapable nature of severe weather events, the state needs to plan and build resilient structures to save lives and exasperated cost of responding to and rebuilding what was lost.

Inevitable Future

The built environment accounts for nearly 50% of greenhouse gas emissions. Agriculture accounts for 11% of greenhouse gas emissions. Sustainable architecture can be a useful tool in helping the agriculture industry, along with technological advancements, supply food for a higher population with more efficient practices.

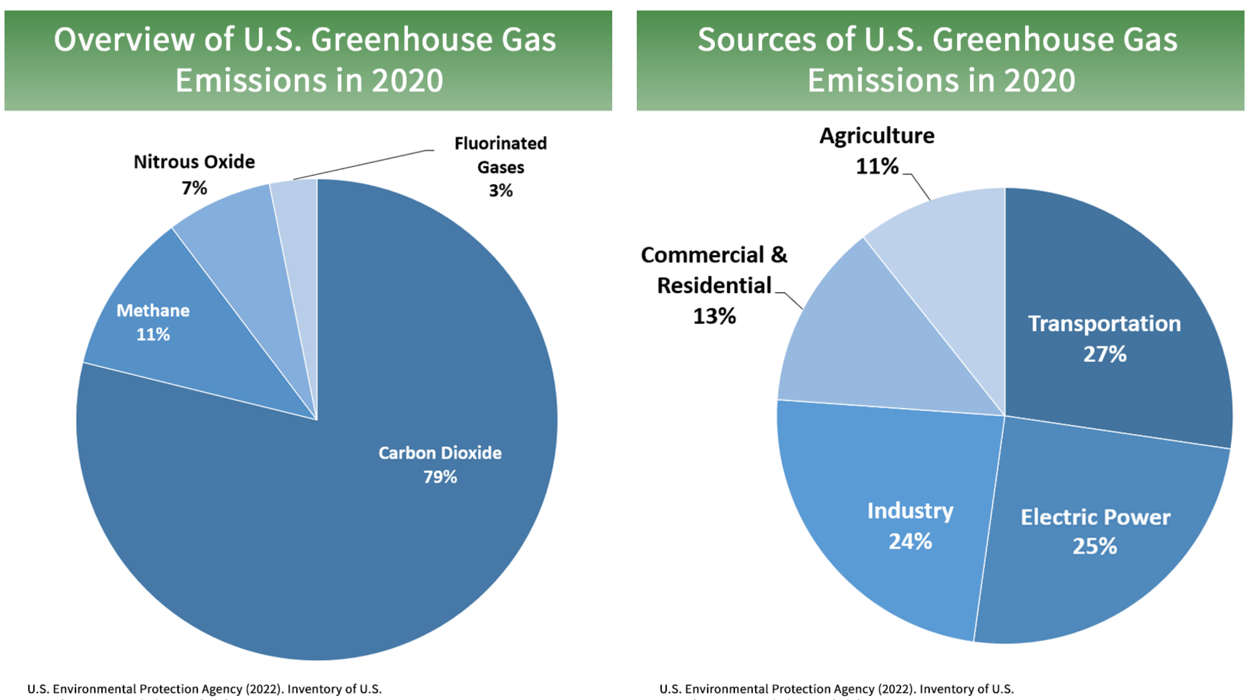


Figure 4.1 U.S. Greenhouse Gas Emissions Summary (Source: Environmental Protection Agency)

Even if the building and agriculture sectors were able to cut greenhouse gas emissions today, some effects of climate change, like sea level rise are now inevitable. The most society can hope for now is to slow the process enough to properly prepare for the effects of sea level rise and its resultant effects such as flooding and extreme weather. Building practices need to change to have less of an effect on the planet, and design thinking can be used to help plan for agriculture resilient against extreme heat, significant sea level rise, and saltwater intrusion.

In 2030, the average daily temperature in Talbot County, Maryland is expected increase about 3 degrees from 1961-1990 observed temperatures at 70 degrees Fahrenheit on average. Whether or not life is comfortable in the future is up to how effective we are at decreasing greenhouse gas emissions. High temperatures cause strain on humans, plants, and livestock. Heat stress results in lower yields and reproductivity in farm animals.[27] Under a continually warming climate, food security becomes more unlikely. Strategies to mitigate heat stress require more resources but include (1) increased shading, (2) passive thermal building design, and (3) increased airflow.[27] However, little can be done for the livestock raised outside in uncontrolled conditions.

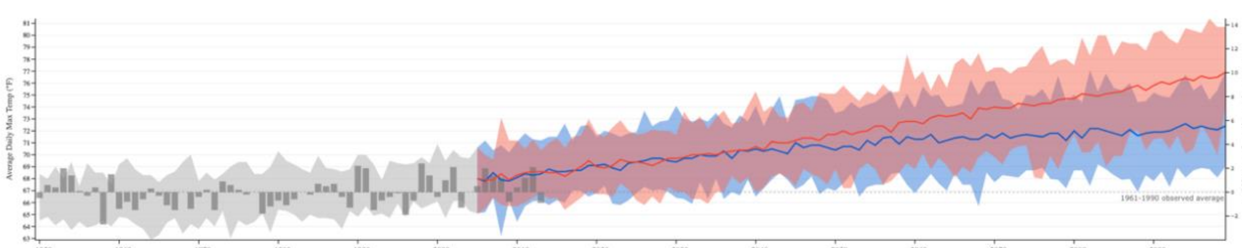
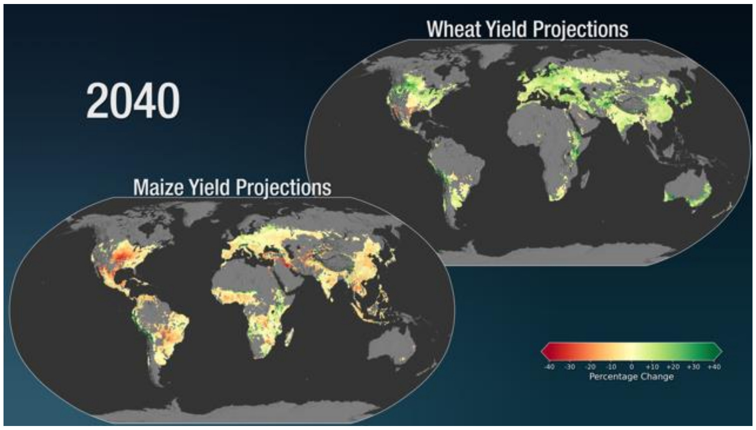
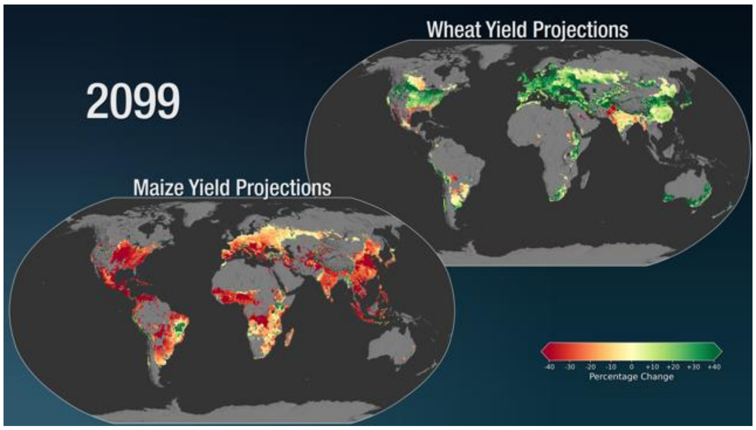


Figure 4.2 Average Climate Projection (Source: National Center for Environmental Information): Grey represents modeled history. Blue represents average temperature projections if humans stop increasing global emissions of greenhouse gasses. Red represents the average temperature if greenhouse gas emissions continue to rise through 2100. The red range shows that average temperatures will reach 77 degrees Fahrenheit, the upper threshold of life where organisms are strained significantly, by 2100.

Maize, or corn, and wheat, two major crops, show changes in yields due to climate change as early as 2030.[31] Corn yields are negatively affected by a warmer climate. Wheat yields on the other hand will increase production as more of the country begins to experience conditions ideal for wheat growth.[31] Yield changes will occur for crops other than maize and wheat as well, effecting the global economy and human nutrition.





Figures 4.3 (Top) & 4.4 (Bottom) Global maize (corn) & Wheat Yield Projections (Source: NASA): Aggregate of information from multiple computer models show that by 2040 U.S. maize yields start a decrease in production that eventually results in an average 35% yield decrease by 2099. Global wheat projections on the other hand, could be increased by 17% and level off by 2050.

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[31] Earth Science Communications Team at NASA’s Jet Propulsion Laboratory, “Global Climate Change Impact on Crops Expected Within 10 Years, NASA Study Finds,” *Global Climate Change*, last modified December 8, 2022, https://climate.nasa.gov/news/3124/global-climate-change-impact-on-crops-expected-within-10-years-nasa-study-finds/.

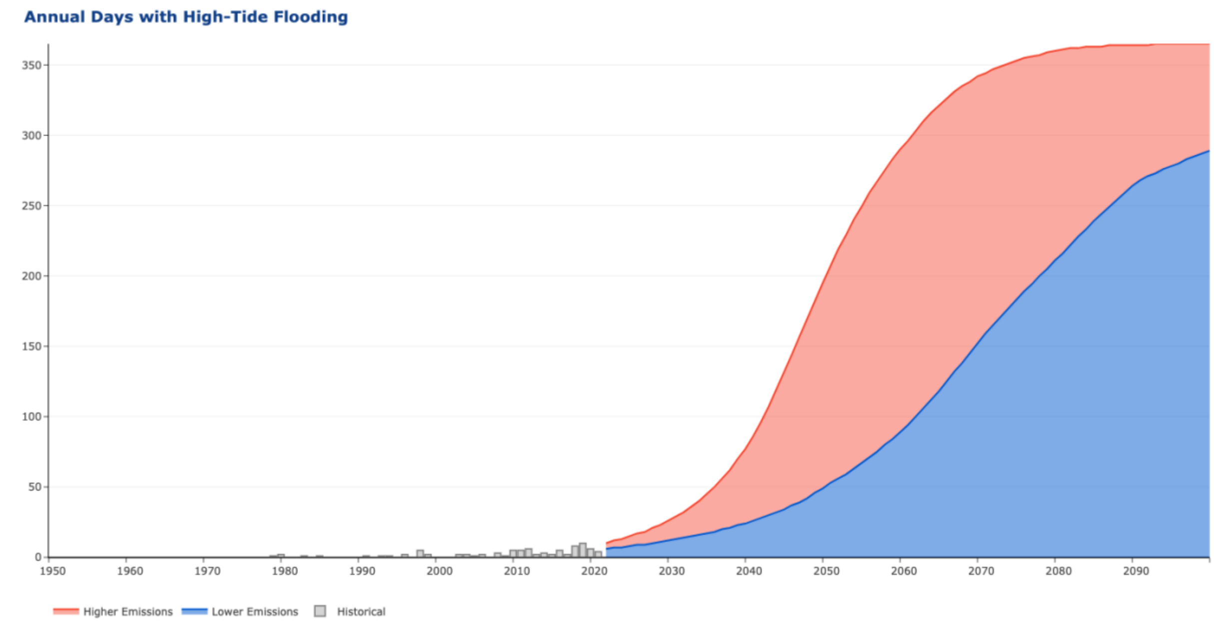

Figure 4.5 High Tide Flooding (Source: National Center for Environmental Information): Grey represents modeled history. Blue represents average tidal flooding projections if humans stop increasing global emissions of greenhouse gasses. Red represents the average tidal flooding projections if greenhouse gas emissions continue to rise through 2100.

Land on the Chesapeake Bay is continually and gradually disappearing due mainly to aquifer withdrawal, or extraction of groundwater, and the natural settling of land. Meanwhile, sea level rise is double the national average in this area, and tidal flooding is becoming more frequent.[29] The Chesapeake Bay is an estuary, it is the tidal mouth of a river, where the tide meets the stream. Water salinity of the Chesapeake Bay decreases as it moves farther from the ocean up north. However, the combination of sea level rise, sinking land, and tidal flooding is changing the water and soil chemistry all along the Chesapeake Bay, increasing salinity. This has a further negative affect on Eastern Shore farms as saltwater intolerant crops such as wheat, soy, and maize yield falls and saltwater resistant plants flourish in the area. Formally known as saltwater intrusion, landward movement of seawater, dehydrates traditional coastal crops and makes water undrinkable.[32] Salt concentrates increase as vegetation dies and creates soil where nothing can grow.[32] With saltwater intrusion and increased water levels, natural forces are creating a condition where wetlands are re-claiming coastal lands on Maryland's Eastern Shore. As a result, farms that have been on the land since European settlement are being forced to either leave, or re-structure their land, buildings, crops, and operations to thrive under new conditions.

Section 3: Wetlands & Agriculture

Pre – 17th Century: Native Americans

It is believed that the earliest settlers of what is now recognized as Easton, Maryland, are the Nanticoke Tribes people.[33] These people enjoyed life on the edge of the land, and looked to wetlands as a source of food, medicine, water, and materials. With said provisions came a spiritual tie to wetlands.[33] Any degree of human intervention changes a wetland. Trails formed in tall grasses as Native Americans tread through the land to hunt and harvest cattails, fish, wild rice, or oysters. However, their limited population and migratory patterns, the earliest people to see the value in wetlands caused little more disruption than the animals who frequented wetlands for water and food.[34] When Native Americans began to clear land for agriculture, the same land was productive for generations because (1) wetlands prevented land erosion, (2) the land was fertilized with fish and seaweed, and (3) crop rotation system.[34]

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[32] Carrie Anderson, "Saltwater Intrusion," *College of Agriculture & Natural Resources*, https://agnr.umd.edu/saltwater-intrusion.
[33] "Native Americans," *Maryland Manual On-Line: A Guide to Maryland & Its Government*, https://msa.maryland.gov/msa/mdmanual/01glance/native/html/01native.html.
[34] John Teal and Mildred Teal, *Life and Death of the Salt Marsh* (New York: Ballantine Books, 1969).

The Nanticoke, Choptank, and Algonquin tribes were Tidewater people who called the modern-day Eastern Shore home.[35] As recorded by Captain John Smith in 1608, the Nanticoke Tribe made offerings of friendship, traded with, and acted as guides to the first Europeans who came ashore to what is now known as the Nanticoke River. As European settlements grew, conflict became inevitable. Resources diminished and threatened Native American hunting and farming practices. When tribes migrated for the winter, they would often return to find settlements on their land. As a result, Algonquins left the area by the 18th century, the reservation granted to the Choptanks by Maryland was sold to developers by the government in 1822, and most of the Nanticokes left Maryland by the mid-18th century.[36]

17th – 18th Century: European Settlement

It was on the banks of marsh creeks where Native Americans and Europeans, fisherman and fur traders, first interacted.[34] From the time Europeans began to then settle wetlands, the sanctity of the wetland was at risk. Left un-supervised, cattle grazed on and destroyed wetland grasses. Farmers harvested the same grasses for animal fodder and building materials. As the rumor of prosperity spread, European populations grew, and villages cropped up around the water banks. Agricultural settlements stripped the land of its resources year-round as permanent roads, bridges, piers, and buildings infringed upon the natural landscape.[34] Mosquitos and greenheads plagued settlers and livestock with disease. Settlers found plants such as the rose mallow, or marshmallow, that could be boiled down and used to cure coughs and dysentery. The

[35] "Native Americans of Maryland," *History of American Women*, https://www.womenhistoryblog.com/2008/06/native-americans-of-maryland.html.
[36] "Native American Tribes in Maryland," *Wikipedia*, June 17, 2022, https://en.wikipedia.org/wiki/Native_American_tribes_in_Maryland.

marsh was a popular source of food for settlers as well; salty greens for salads, berries, fish, deer, and waterfowl meat were once in abundance.

With time and more population growth, wetland ecosystems saw significant change as pioneers saw no limit to the natural resources, they would harvest from a wetland.[13] More cattle required more wetland grasses for fodder, decreasing the food source for animals like deer, birds were over-hunted to near extinction early on. Technological advancements such as horse drawn mowers further expedited wetland terraforming as horses had difficulty moving throw soft, muddy land.[34] Enter the scene, drainage. Drainage ditches were dug with spades and epical duo-bladed saws that dug narrow channels through peat, redirecting flow of water, and drying the land.[34]

19th – 20th Century: Westward Expansion & Changing Technology

Some of the country's first wetland maps stem from the American Civil War, 1861-1865, as traversing swamps and marshes presented a logistical issue for armies.[13] Routes around, though, or over wetlands were built.[13]

After the American Civil War, wetland forest materials were used to build railroads that often time cut through these ecosystems, in order to make the west more accessible.[25] As land and resources on the west coast rapidly depleted, westward expansion promised an influx of new materials and land to claim. Furthermore, the railroads made more wetlands, ripe for development, accessible to Americans.[25]

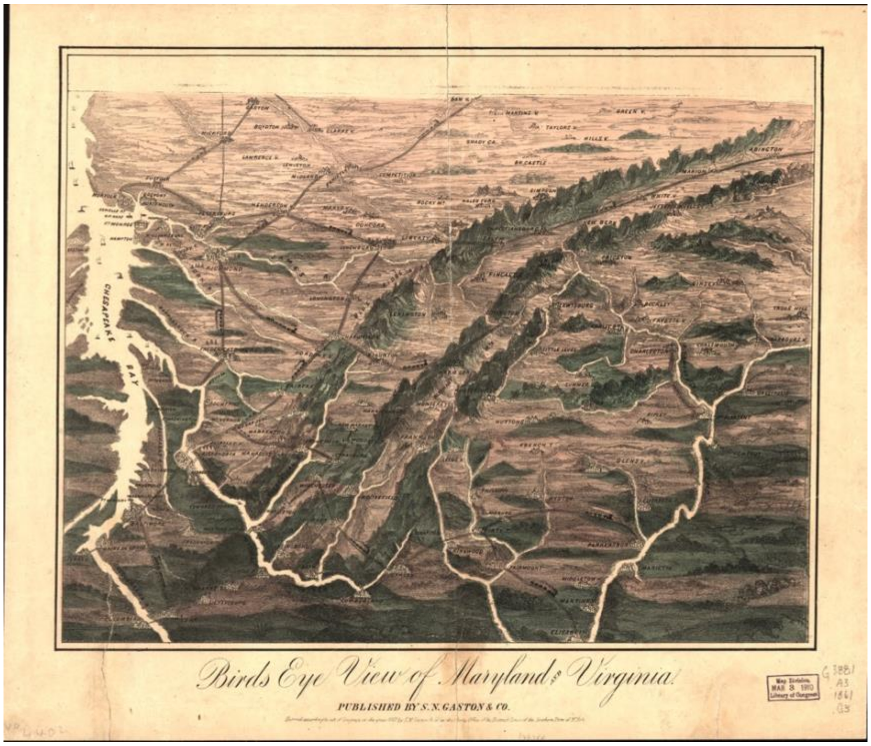

Figure 4.6 Bird's Eye View of Maryland & Virginia (Source: Library of Congress) Not to scale. Prepared in 1861 for use in the American Civil War. Panoramic map showing topography, waterways, railroads, and places.


Figure 4.7 (Left) & 4.8 (Right) View in the Chickahominy Swamp & The Chickahominy - Alexander's Bridge (Source: Library of Congress) 1862, Virginia. Watercolors by William McIlvaine.

By the first half of the 20th century, two world wars, booming population, industrial growth, and desire for the U.S. to establish themselves as a "world leader" further facilitated industry and agriculture.[13] Urban and agricultural expansion drained all types and sizes of wetlands.[25] In the 1930's, the United States Government essentially helped farmers drain wetlands for free. Uniquely, perhaps linked to the state's long wetland history, the Maryland General Assembly recognized that wetland alteration may result in flooding, erosion, and habitat loss in 1933.[37] The Waterway Construction Statute thus attempted to regulate waterways and their 100-year floodplains.[29] Regardless, the U.S. Department of Agriculture's Agricultural Conservation Program sponsored the draining of 23 million hectares of wetlands for farming between 1940 and 1970.[18]

Wetland alteration or destruction is, in a sense, an extreme degree of wetland management.[37] The earliest examples of wetland litigation was implemented to protect food sources when bird populations were hunted to near extinction soon after European settlement. Up until the mid 1970's, the United States' wetland policy was to drain them.[37] Federal laws, regulations, and public policy became clearer and more decisive as scientists were able to quantify and qualify, by defining ecosystem services, wetland losses.[37] The Federal Water Pollution Control Act of 1956 was clarified, renamed the Clean Water Act and amended in 1968 and 1972.[37] Under the Clean Water Act, waterways and wetland pollution became a misdemeanor and made it dredging or filling much more difficult.[37] By the 1970's scientific research proved the fragility and agency associated with wetland conservation enough to spark state wide and federal policy and regulatory trends that was successful in halting further destruction and gave wetlands a chance to heal. Our generation must advance conservation in an

[37] Mitsch and Gosselink, "Traditional Wetland Management," 504.

attempt to replenish wetland stock. This thesis examines how the human focused fields of architecture, and the built environment can further promote ecosystem services and wetland remediation, thus protect against extreme weather, climate change, and food insecurity.

Present

As of October 7, 2022, wetland classification fueled debates regarding the power of the Environmental Protection Agency and the Clean Water Act are currently being discussed in the Supreme Court.[38] The vague nature of wetland classification has caused confusion about what is considered wetland "adjacent" and what areas are subject to protection under the Clean Water Act.[38] The case of Sackett v. Environmental Protection Agency was brought to the Supreme Court by an Idaho couple who were directed by the E.P.A to halt construction of their home on a wetland area near Priest Lake.[38] Backed by the power of the Clean Water Act, the E.P.A threatened the couple with substantive fines.[38] In a classic debate about the extents of federal power in the United States of America, the Supreme Court threatens to limit the power of the E.P.A and a significant amount of protected wetlands because some believe the definition of a wetland is too broad. The decision puts over fifty years of progress made regarding wetland restoration and health, especially since polluted or destroyed wetlands put further stress on remaining acreage. This thesis looks into the role of the built environment in helping bridge the gap between wetland science and public perception by demonstrating how buildings could be built responsibly in the landscape.

On a slightly more optimistic note, Federal Farm Service Agency provides that it is committed to altering the wetland agriculture relationship by (1) avoid, to the extent possible,

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[38] Adam Liptak, "On New Term's First Day, Justices Hear Case on E.P.A. Power Over Wetlands," *The New York Times* (October 3, 2022), https://www.nytimes.com/2022/10/03/us/supreme-court-epa-sackett-wetlands.html.

negative wetland disturbances, (2) protect the nations long term ability to produce food and fiber, (3) reduce sedimentation, (4) improve water quality, and (5) help preserve the nation's wetland stock.[39] There are various voluntary programs available to farms that incentivize wetland preservation through tax benefits and easement purchasing. In addition to the monetary and social programs still offered by the government, the design and construction of necessary buildings on a wetland should be revisited to minimize its footprint on the land and adapt to the changing landscape and climate in hopes of preserving food security for the future.

Section 4: Agriculture, Culture & Technology

Historic Rural Heritage & Character

The history of tradition, family, diligence, and spirituality fostered by the American farm does not exist avoid from the sexism, racism, and genocide that underwent to build and operate farmsteads. As mentioned in the "Pre-17th Century: Native Americans" sub-section of Section 3: Wetlands & Agriculture in this thesis, Native Americans sustained themselves by foraging and hunting before farming with a rotating crop system fertilized with local materials. Their migration patterns allowed soil chemistry to naturally balance out and so their arable land was resilient and productive. However, European settlers took advantage of these migration patterns to sometimes steal and build farmsteads on Native American land. European settlers eventually and effectively bullied Native Americans off of their land by means of murder, war, enslavement, and land theft.

Enslaved people effectively built the America we know today. The economic success of America is due to the African and Native American people forced into building and managing

[39] USDA, "Wetlands," *Farm Agency U.S. Department of Agriculture*, https://www.fsa.usda.gov/programs-and-services/environmental-cultural-resource/water-resources/wetlands/index.

farmland. Where poor indentured servants helped sow the land in Europe, European settlers in America used their racist ideals to legitimize forced labor, torture, and rape of African and Native American people. Without slavery, European settlers would have not been able to gather resources, build, farm, care for their families, or sell their good at the same level of production needed for firm establishment and growth. The widespread economic success of American Agriculture is undoubtedly built on a dark history of human atrocities, manipulation, dejection, and violence. Unfortunately, but realistically the effects of slavery are deep rooted and still visible in contemporary American social and economic structures.

That is not to say however, more positive cultural practices in American agriculture do not simultaneously exist. Food is a pillar of life. Therefore, the buildings used to produce it are just as spiritual in expression as they are practical. The earliest representation of a barn is a Roman mosaic from the 2nd century Liberii farm villa in Tunisia depicting a procession of workers, hunters, and cattle down an axial path to centrally located tall portal of a basilica style barn.[40] The basilica barn form is comprised supported by columnar structural system with tall central circulatory aisle and compressed side aisles.[40] There are clear links between the basilica barn typology and temple and religious structures.

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[40] Dewey Thorbeck, "Rural Architectural Heritage," in *Architecture and Agriculture: A Rural Design Guide* (New York: Routledge, 2017), 18–26.

Figure 4.9 The Great Coxwell Tithe Barn in Oxfordshire (Source: Anguskirk via Flickr)

Figure 4.10 Great Coxwell Barn West Porch Interior (Source: Montacilla via Wikimedia)

Practical by design, the program and form of the barn is mutable. Sited to maximize working efficiency, buildings of a farmstead were made of local materials.[40] Therefore, farmstead typology varies according to specific function, and region. Initially, the family, animals, and equipment all resided in one utilitarian building, the house. The house barn blended work with the hearth, it was in essence, a family's livelihood. That is until, a family accumulated enough wealth to build a separate building from the barn to live in.[40] Separated farmstead program included, (1) a barn to house and support animals, (2) greenery for crop protection and storage, and (3) an equipment shed.

The English barn, more common of the Maryland area typically consisted of three bays.[41] The central threshing bay was the largest in both area and height.[41] Materials include brick, timber, and stone. Some examples of timber structural expression include (1) cruck framing, where curved timbers span from floor to roof and act as principal posts and rafters, (2) basilica style, and (3) aisled hall, where the central span posts and braces are separate from the side aisles.[41] It is also notable that the load and support timber structure was made to be easily expanded on when necessary.[41]

[41] Elric Endersby, Alexander Greenwood, and David Larkin, *Barn* (New York: Houghton Mifflin Company, 1992), 18–25.

Figure 4.11 (Left) An Enormous, and Quite Angular, Grain Elevator in Las Cruces, the Hub City of Southern New Mexico, 27 Miles From the Border with Far-Western Texas (Source: Library of Contress) 2021, Carol M. Highsmith & Figure 4.12 (Right) A Silo Feeding, Prince Georges County, Maryland (Source: Library of Congress) 1935 by Carl Mydens & United States Resettlement Administration

Figure 4.13 (Left) Vintage Grain Elevator in Malta, Illinois (Source: Library of Congress) 2020, Carol M. Highsmith & Figure 4.14 (Right) Metal Grain Elevator and Silos near Prescott, Washington (Source: Library of Congress) 2018, Carol M. Highsmith

European farmers who left settled in America brought their traditions of construction, barn typology, and farming practices, but needed to learn how to effectively farm foreign land.[40] Farming was a family affair. Children, women, and men of the family had to participate in work in order to stay afloat. Even when family roles shifted, women went from managing animals to more domestic tasks and housekeeping, each family member had a critical job in maintaining the farm up until the agricultural depression in the 1920's.[40] Then, larger farms squeezed many smaller family farms out business, a trend still apparent today.[40] The overhead required to start a farm is so high, that many of the Country's small family farms have been handed down from previous generations.[40] The small family farm, in all its traditional glory, history of heinous crimes against people, center of family life, utilitarian but still expressive in form made way for a homogenized large scale industrial farm that made up for its lack of spirit with profit.

Figure 4.15 Noon Hour on Berry Farm, Bottomley's near Baltimore, Md. The Dining Room. (Source: Library of Congress) 1909, Lewis Wickes Hine

Previous & Present Industrialization

Small American family farmers applied their large skillset to diversifying their farm. They grew a range of crops and provided for various types of livestock with adequate outdoor access and relatively good quality of life.[42] If grown for profit, the various crop species were grown in monocultures, where one crop was grown on a single field to maximize efficient use of soil and climate conditions.[43] Industrial farms further capitalized on efficiencies of a monoculture practice, but at a scale impossible for individuals or animals to maintain. Machinery and technology were needed to apply fertilizer, pesticides, and harvest crops. The scale at which livestock was produced also increased to meet demands of a large growing population. Their quality of life soon declined. Apparent even through the emergent capitalistic farm building form, there was little heart, or care in the industrial farm whose main purpose was to maximize efficiency and profit by any means possible.

Today, food in the United States comes from massive scale operations.[42] Although not an inherently insidious practice, genetic modification has been used to increase food and goods yields at the expense of both quality of life and product. The mechanization of farming practices and widespread pesticide and fertilizer use on a constantly productive plot of land increased production and greenhouse gas emissions.[43] Industrialized farming practices today are hardly sustainable under any lens. The industrialized farm tends to only implement a change if it will yield economic growth or is forced upon them by the government. For example, current popular industrial farming practices are to grow crops in long strips alternated in a crop rotation system. The strips prevent pesky soil erosion while the crop rotation helps support soil health and yield.

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[42] Johns Hopkins Canter for a Livable Future, "Indsutrialization of Agriculture," https://www.foodsystemprimer.org/food-production/industrialization-of-agriculture/.

[43] "Monoculture Farming in Agriculture Industry," *EOS Data Analytics*, last modified October 20, 2020, https://eos.com/blog/monoculture-farming/.

The current industrialized American agricultural landscape has been reinforced by generations of self-affirming technology and ideas. The industry has not been very critical on how their practices contribute to or withstand the effects of climate change.

Future Technology & Practices

The future of agriculture is about merging the heritage of the historic family farm with industrial efficiency and technology to create a new farm typology that is capable of producing food for an enormous population under the conditions presented by climate change. Many contemporary industrialized farms neglect building and architecture to focus on land exploitation and production. The architecture of a farm building can reduce its role in climate change and protect the farmstead against extreme weather and a sea level rise. The farm building can once again, represent the heart of the practice. The design can draw from environmental systems to balance technological function, reduce harm to the land, and reintegrate the life into the structure of the building.

One new farming practice being developed is pixel farming. Pixel farming derives its name from the pixelated organization of a crop field.[44] Various types of crops are planted in smaller plots can deliver more ecosystem services to the land and has the potential to increase crop yields[44] With utilizing the pixel cropping technique, a farmer can grow up to thirty different crops on a plot of land that can potentially have major benefits on biodiversity. The pixel crop system essentially draws upon ideals of Cartesian space, where land is planned in a strict grid without any sense of center or place. The Cartesian grid is applied to a much smaller plot of land and then overlapped with other plots of land that have different characteristics.[45]

[44] "Pixel Cropping," *Wageningen University & Research*, https://www.wur.nl/en/project/pixel-cropping.htm.
[45] Richard Armstrong and Conrad Therrien, *Countryside Report* (Amsterdam: Taschen, 2020).

The way people think about food has essentially come full circle. The growing popularity of organic food and organic food markets such as Mom's, Wholefoods, and Yes! Market show that people want locally grown food that has been treated with care and minimized harm to the planet. However, these practices are often more expensive to achieve. The changing land and climate dictates what can be locally produced. As a response, scientists are therefore developing strains of saltwater resistant wheat and discerning between existing crops that can be grown in the changing landscape.[32] Architecture can be used in conjunction with science and technology to design a farmstead where the buildings (1) are informed by the land, (2) are adaptable, (3) whose return on systems pay for themselves, (5) work with other buildings and site systems to create an integrated system, and (6) make a visual statement.[46]

[46] Dewey Thorbeck, "Rural Architecture and Rural Design," in *Architecture and Agriculture: A Rural Design Guide* (New York: Routledge, n.d.), 64–65.

Chapter 5: Precedent Analysis

Section 1: Mason Lane Farm Operations Facility

Site & Program

The Mason Lane Farm Operations Facility designed by De Leon & Primmer Architects Workshop in Goshen, Kentucky supports a 2,000-acre agricultural property with an equipment storage barn, workspace, produce storage barn, and a grain silo.[46] The property serves as farm support, recreation, and wildlife habitat conservation purposes and capitalizes on the intersections between site and building to create a complex where both entities work as a singular integrated system.[46 40]

Figure 5.0 Project Vicinity Map (Source: De Leon & Primmer Architects Workshop)

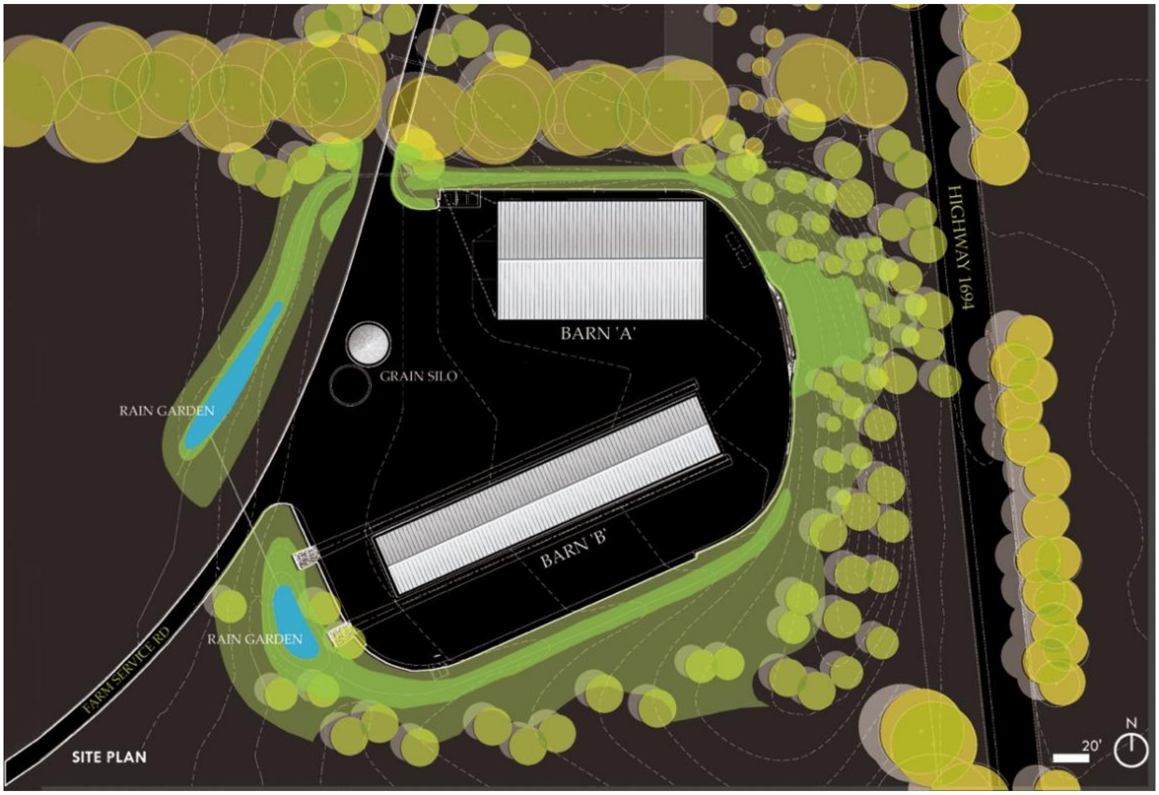
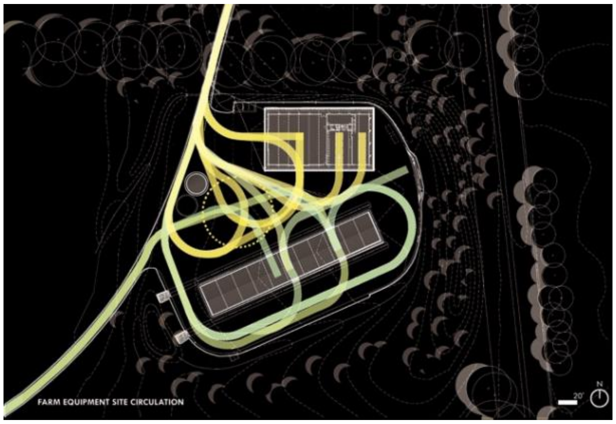


Figure 5.1 Site Plan (Source: De Leon & Primmer Architects Workshop)

The specific site location criteria were (1) centrality within the farm, (2) proximity to existing electrical and transportation infastructure, (3) adjacency to tree windbreak line where existing full grown trees slow dangerous windspeeds, (4) best views, (5) on a previously cleared plot, (6) and proximity to the onsite farm manager's residence.[46] The consolidation of all program pieces into two buildings was integral in minitimizing the building footprint on the land. Building orientation is also cognizent of foot and large machinery circulation.[46]

Minimizing use of water is a priority as site landscaping consists of only native and regionally adapted plants that do not require active irrigation. Using existing topography and semi pervious gravel, storm water is directed towards two rain gardens that slowly recharge the groundwater table. In the interest of limiting maintenace, ground gutters are used in lieu of traditional building gutters. A final consideration in site design is that the buildings were organized in a way that contains and limits outdoor lighting requirements. [46]



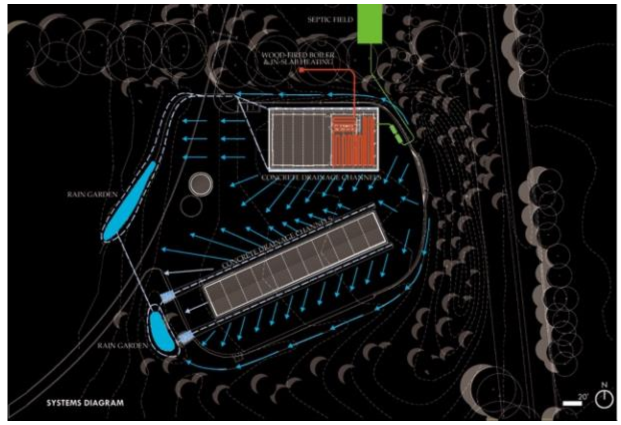


Figure 5.2 (Left) Farm Equipment Site Circulation (Source: De Leon & Primmer Architects Workshop) Figure 5.3 (Right) Systems Diagram (Source: De Leon & Primmer Architects Workshop)

Construction & Materials

Barn ‘A’ is constructed with a pre-engineered wood truss frame and encloses workshpaces and storage with a corrugated metal sheet façade. The interior is finished with concrete and laminated timber.[46]

Barn ‘B’ also utilizes a pre-engineered wood truss frame construction, but with a locally sources bamboo lattice exterior.[46] The building typical structural expression of barns with an emphasis on layered construction. Bamboo was chosen as the façade material because of the rapid rate at which it grows, durability, and flexible structural properties. Adaptable in nature, the bamboo façade sectioned off and assembled with metal ties that allow for ease of maintenance and localaized replacement.[46] Both barns have a concrete floor finish and the high solar reflectance of gravel and building roofs limits the heat island effect.[46]

Figure 5.4 Barn ‘A’ Façade Detail (Source: De Leon & Primmer Architects Workshop)

Figure 5.5 (Left) Barn ‘A’ Interior Storage (Source: De Leon & Primmer Architects Workshop) &
Figure 5.6 (Right) Barn ‘A’ Interior (Source: De Leon & Primmer Architects Workshop)

Figure 5.7 Barn ‘B’ Façade Detail (Source: De Leon & Primmer Architects Workshop)

Passive & Active Design

From the onset, the architects and client prioritized passive site, such as the stormwater management rain gardens, and building design strategies. Building openings and operable floor to ceiling glazing not only prioritizes passive natural ventilation, but natural lighting as well.[40] A consolidated program reduces the building energy loads while program grouping further economizes energy needs. For example, the workspaces are grouped in barn ‘B’ and include a radiantly heated floor that is powered by an external wood-fired broiler.[46] Storage facilities that do not need temperature control include porous façade systems that allow for maximize natural ventilation.

Passive design strategies are used to lower the energy needs of the building as much as possible, so that active lighting, cooling, and heating systems are used only when necessary. Both the physical and carbon footprint of the farm buildings are limited, proving that a contemporary agricultural building can be utilitarian and ecologically minded. Mason Lane Farm Operations Facility is a good steward of the land, both utilizing it for livelihood, but taking on the responsibility to safeguard wildlife habitats by allowing the site to organically inform the building response, using locally sources and resilient materials, and minimizing building energy requirements.

Figure 5.8 Barn ‘B’ Façade Detail (Source: De Leon & Primmer Architects Workshop)

<u>Section 2: Deepwater Woolshed</u>

Program & Site

The Deepwater Woolshed near Wagga Wagga, Australia by Peter Stutchbury considers how both people and animals might work more comfortably together to produce necessary goods in an extremely hot climate. To limit heat, the building is oriented on the site to capture the prevailing northeasterly winds. Woolshed design is reimagined prioritizing work conditions for shearers and the highest standard of care for the sheep. Building design priorities include, (1) intimate shearer's recreational area, (2) noise isolation, (3) separate building for chemicals and dust, (4) adaptable structure, (5) ease of human and sheep mobility, and (6) durability.

Figure 5.9 Deep Water Wool Shed (Source: OZ.E. TECTURE)

Construction & Materiality

The major building material, a typical industrial façade choice, is metal cladding. Paired with south facing metal mesh screens, the building material choice was made based on its conductive abilities in the harsh climate. The entire building assembly are screwed and fixed in place, making the building adaptable and easily maintained.[46]

Passive & Active Design

When hot, an irrigation system sprays water on the metal cladding, cooling the building. An active system also spills water down the south-westerly metal mesh screens for evaporative cooling, lowering the temperature of the air naturally ventilating through the building. Metal mesh screens also provide passive shade and protection from harsh winds. Strips of skylights allow for controlled natural lighting in the building.[46] Overall, smaller scale innovations act in conjunction with the building orientation on the site to create a comfortable climate for sheep and workers.

Figure 5.10 Louver & Assembly Detail, Deep Water Wool Shed (Source: OZ.E. TECTURE) & Figure 5.11 Overhang & Mesh Screen Detail, Deep Water Wool Shed (Source: OZ.E. TECTURE)

Chapter 6: Site Documentation & Representation

Section 1: Site Selection

There were three possible sites along Maryland's Eastern Shore, Elkton, Easton, and Salisbury for this thesis project. The three cities were initially chosen because of their agricultural history and population. Then, to quantify their appropriateness for this thesis were graded using the following criteria. Ultimately, the site in Easton was chosen for this thesis site.

LOCATION	Locust Point, Elkton	Tred Axon | Trippe Creek | Goldsborough Creek, Easton	Pemberton, Salisbury
Wetland Relationship	Estuarine I Major Buffer Zone + Medium Wetland Opp. 3	Estuarine I High Buffer Zone + High Wetland Opp. 5	Riverine I Low Buffer Zone + Med. - Low Wetland Opp. 3
Sea Level Rise & Flooding	Moderate 2	Considerable 5	Moderate 3
Agricultural Economy	$375 Mill. Net Cash Income I 533 Farms 73,793 Acres Farmland 3	$71 Mill. Net Cash Income I 317 Farms 93,622 Acres Farmland 4	$196 Mill. Net Cash Income I 494 Farms 88,559 Acres Farmland 5
Population Density	5,245 people I 124 ppl / mi² 3	4,254 people I 116 ppl / mi² 4	15,053 people I 800 ppl / mi² 4
Environmental Stress	Low 1	Extreme 5	Moderate 4
Water Stress	Medium - High 5	Medium - High 5	Low - Medium 2
Existing Site Use	Agr. + Mid Density Residential 3	Agr. + Forest 5	Agr. + Low Density Residential 5
Urban Density	Medium 3	Low 2	Medium - High 4
Goods Connection	Near Mainland + 10 min. from downtown I Near Del. + Penn. 5	Near MD 333 + 15 min. from downtown 4	Near Route 50 I 10 min. from downtown I Near Del. 5
Biodiversity	Forest Species + Horse Shoe Crab Adj. 4	Shellfish + Forest 4	Forest + Sensitive Species 5
Size	250 Acres 4	359 Acres 3	391 Acres 3
Blue Infastructure Rank	High 4	Medium - High 3	High 4
TOTAL Scale: 1 (Low) - 5 (High)	40 / 60	49 / 60	47 / 60

Figure 6.0 Site Selection Matrix (Source: Author)

Maryland's Eastern Shore has been inhabited and farmed since before European settlement. Its community has a responsibility to safeguard the quality of water, air, and biodiversity unique to the Chesapeake Bay. The mix of fresh and salt water in the Chesapeake Bay make it the largest estuary in North America.[47] Therefore, Maryland’s Eastern Shore is a natural location to explore the relationship between the built and natural environments.

Coastal farming practiced on Maryland’s Eastern Shore is at risk due to climate change. Therefore, the primary factors concerning site selection concern the landscape and environmental stressors. Primary environmental site considerations included, (1) wetland relationship and buffer opportunity as defined by the Maryland Department of Natural Resources, (2) biodiversity, (3) water and environmental stress also characterized by the Maryland Department of Natural Resources and, (4) sea level rise, and (5) blue infrastructure rating provided by the Maryland Department of Resources, the Chesapeake and Coastal Program, and the National Oceanic and Atmospheric Organization, that evaluates near shore tidal habitats and critical natural resources.

The next set of criteria in site evaluation are socioeconomic and agriculturally related. Logistically, the sites are all well connected by roads and highways so that there is a reliable connection to goods. Population and urban density are important factors so that the proposed farm to have a greater impact on producing local food. To further agency and locate the building in a site where it will be the most useful precedent to the community, the number of farms, farmland acreage, and larger percent of the economy accounted for by agriculture.

Section 2: Site Context & Inventory

Boundaries

The selected site in Easton, Maryland is a peninsula, sitting between the Trippe Creek, Tred Avon River, and Goldsborough Creek. On land, the site neighbors the Otwell Woodland

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[47] “Chesapeake Bay Facts,” *National Park Service*, https://www.nps.gov/chba/learn/nature/facts-and-formation.htm.

Preserve to the north and smaller rural communities to the north and east. It is approximately 360-acre site, enough land to support a mid-sized agricultural complex and landscape park both in its current state and in the most landscape alterations predicted in 100 years.

Figure 6.1 Site Boundaries (Source: Google Earth)

Existing Buildings

Within the site boundaries is at least one preexisting farm, the Otwell Family Farm. The site includes the original farm buildings to the south, and new ones to the north. The southern historic farm buildings have now been converted to full time living quarters.

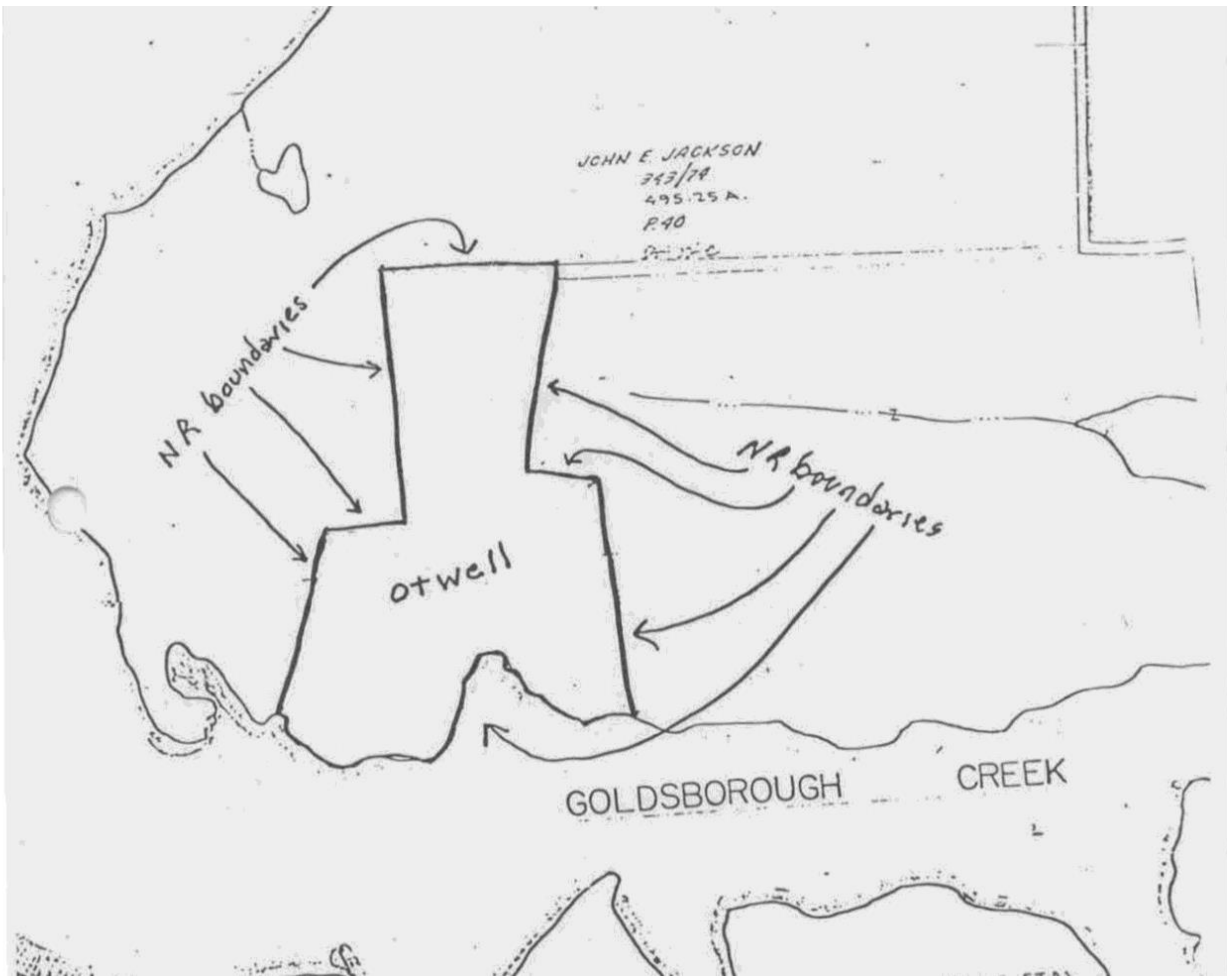

Figure 6.2 Otwell Site Boundaries (Source: Maryland Historical Trust Survey)

Figure 6.3 Otwell Family Farm (Source: Google Earth)

The original Otwell Farm Building was built around 1720-1730 with additions around 1800-1810, and renovations in the early 19th century.[48] In 1783, the family farm included a brick house “in bad repair”, frame kitchen, three tobacco houses, a fowl house, milk house, and three log cabins, all mostly in bad repair.[48] The original “T” shaped plan of the main family house remains.

[48] *Otwell*, National Register of Historic Places Inventory Nomination Form (Otwell: Maryland Historical Trust, April 5, 2004).

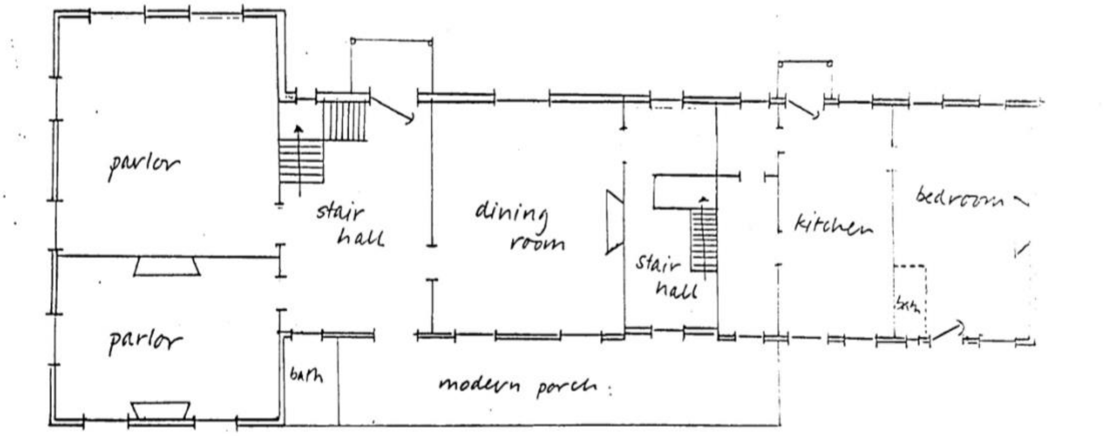

Figure 6.4 Otwell Farm First Floor Plan (Source: Maryland Historical Trust Survey)

Figure 6.5 Exterior Photo of Otwell Family Farmhouse (Source: Maryland Historical Trust Survey)

Native Species

The Otwell Woodland Preserve is an unusually old forest with a mix of hardwoods and loblolly pines as it has not been timbered since 1900.[49] The flora and fauna at the Otwell Woodland Preserve are relevant given its proximity to the site. Tree species include beech, various oaks, hickories, sweet gum, pines, and tulip-trees.[49] The shrub layer consists of American holly, Amelanchier, flowering dogwood, sassafras, pawpaw, and poison ivy.[49] Seasonally blooming may-apple, spring beauties, and wood sorrel populate the forest floor.[49] The shore line is a tidal marsh consisting of cattail and cordgrass.[49] Its sheltered position provides sanctuary for wintering waterfowl and birds such as canvasback, scaup, American widgeon, hooded pergansers, green herons, great blue herons, ospreys and king fishers.[49]

The waterways surrounding the peninsula are habitat to various aquatic life as well. Adult tidal finfish and juvenile herring populate the area.[7] The waterways are also where white perch spawn.[7] Historic oyster plantings are situated off the coast of the Tred Avon River and Trippe Creek.[7] The northwestern part of the site is a public shell fishery.[7] The entire waterway surrounding the site is a sensitive mussel habitat area.[7]

Water

The thesis site is mainly an estuary with some minor palustrine wetlands occupying the site.[7] The Maryland Department of Natural Resources identify the entire site as an opportunity for wetland restoration.[7] Furthermore, nearly the entire continuous coast line presents itself as a potential riparian buffer zone to help filter sediments from adjacent waterways.[7]

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[49] "Otwell Woodlands," *The Nature Conservatory*, https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/otwell-woodlands-1/.

Perhaps the most pertinent site factor is sea level rise. Due to emissions already in the atmosphere, the coast is going to suffer two feet inundation by 2100. Sea level rise occurs faster on the Chesapeake Bay, so we can assume that the coast of this site will be engulfed some time before 2100. If emissions continue, nearly the entire site will be drowned with five-to-ten-foot sea level rise.


Figure 6.6 (Left) Existing Site & Figure 6.7 (Right) 0-1' Sea Level Rise (Source: Maryland Coastal Atlas)

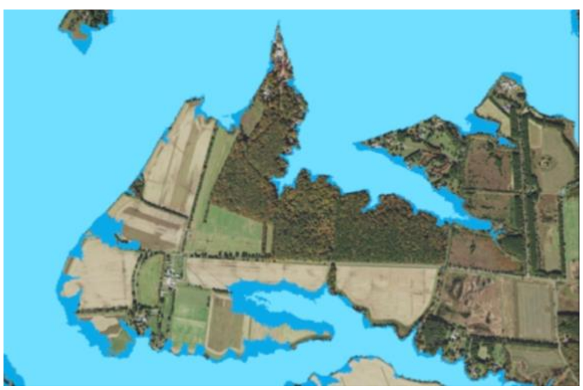



Figure 6.8 (Left) 2-5' Sea Level Rise & Figure 6.9 10' Sea Level Rise (Source: Maryland Coastal Atlas)

Chapter 7: Design Response

Section 1: Problem Identification

Contextual Overview

This thesis is about how architecture can shape the future of historic coastal agriculture. The site of this thesis sits along the banks of Maryland's Chesapeake Bay It shares the benefits of being located on one of the East Coast's most prominent watersheds. Although only 4,500 square miles, the Chesapeake Bay watershed supplies water to 1.5% of the entire US east coast's population. It is also home to countless plants and animals, including both oysters, and wild rice. However, the health of the bay is precarious, and it suffers sea level rise at twice the national rate.

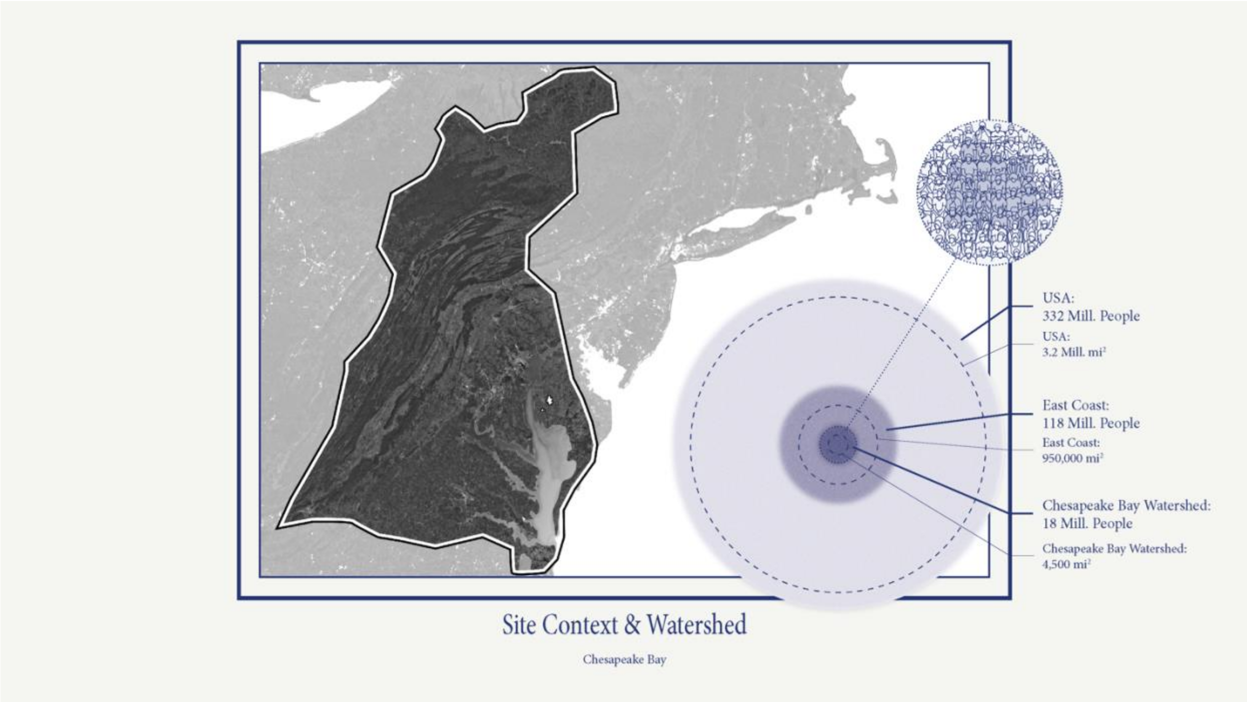


Figure 6.10 Site Context & Watershed (Source: Author)

Specifically, the site is located 8 miles south of Easton, Maryland, a town traditionally known for its long-standing history, calm, and natural beauty, but is rapidly gaining a reputation as one of Maryland's most prominent culinary hotbeds.

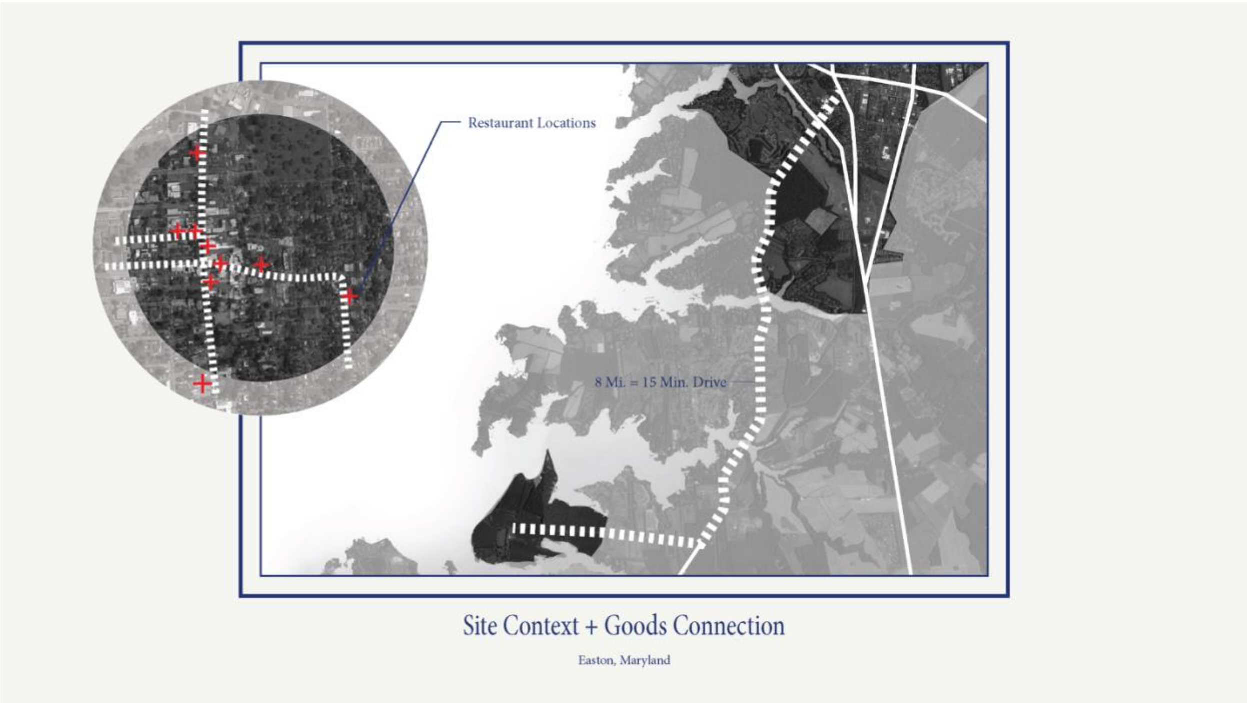


Figure 6.11 Site Context & Goods Connection (Source: Author)

Although shifting towards a more service-based industry, Easton's economy is still dependent on agriculture where farms make up 50-69% of its land area, 90% of which is still owned by families who are responsible for producing the top 7% of grain and poultry for the state.

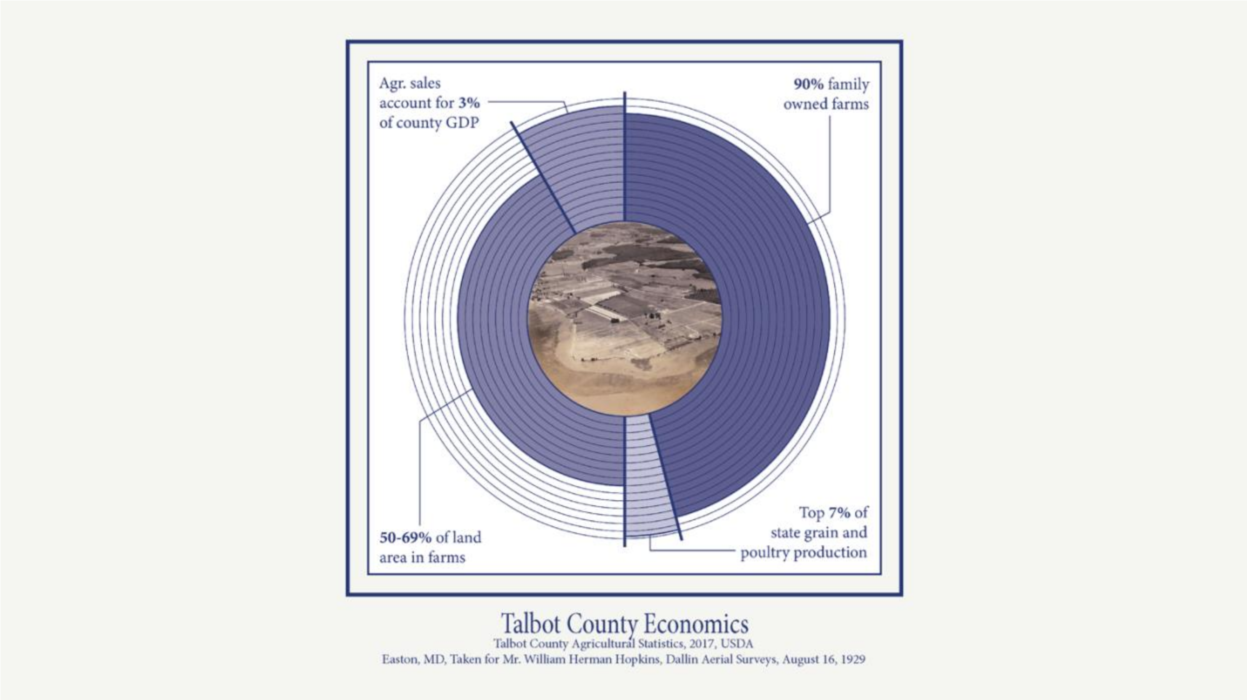


Figure 6.12 Talbot County Economic Data (Source: Author)

Historic Overview

As mentioned earlier, the site's agricultural ties are deeply rooted, where even before European settlement, the Nanticoke Tribe's people enjoyed life on the edge of the land and looked towards the landscape as a source of food, such as oysters and wild rice, medicine, and materials. There was a reverence for the land, and people maintained natural ecosystems, fertilized goods with local fish and seaweed, and rotated crops based on their migratory patterns that allowed the land to naturally recharge. Yet, most of the Nanticoke people were driven away from the land by the late 18th century by European settlers who saw no limit to the resources offered by the land.

Figure 6.13 17^{th}-18^{th} Century: European Settlement (Source: Author)

Almost immediately, settlers changed the landscape by either overharvesting what they found valuable or transforming it to permanently support their culture. By the 18th century, population was exponentially growing, and we begin to see permanent coastal settlements. More cattle required more wetland grasses for fodder, more people required more hardy agricultural land. Technological advancements made terraforming very productive, where more and more land was drained to support the population of people, at the expense of native animals and plants.

Wetland drainage and terraforming became even more prominent during the American Civil War and continued as the country expanded westward. By the 20th century, 2 world wars, booming population, and technological growth further facilitated industry and agriculture, again at the expense of natural resources and landscapes.

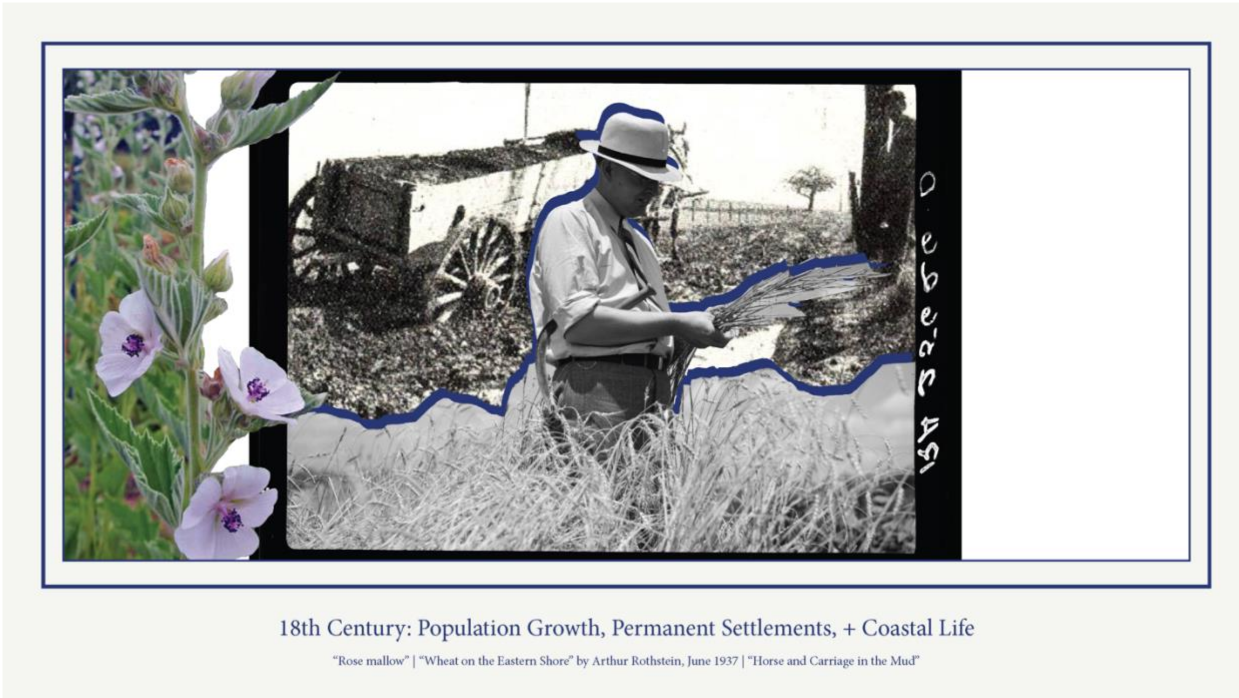


Figure 6.14 18th Century: Population Growth (Source: Author)

Figure 6.15 18th-20th Century: Wetland Drainage, Mapping, & Changing Technology (Source: Author)

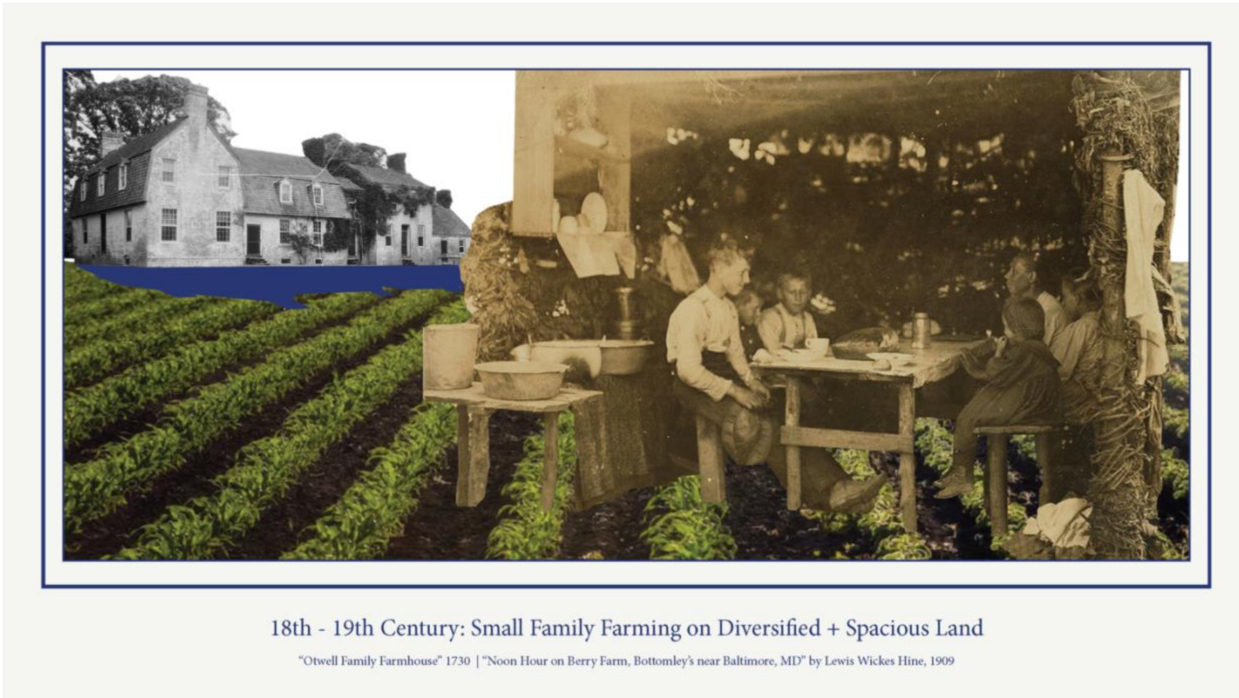


Figure 6.16 18th-19th Century: Small Family Farming on Diversified & Spacious Land (Source: Author)

Simultaneously, an American culture, rooted in the European traditions and closely tied to agriculture was formed. Traditions of a practical and even spiritual barn construction and farming practices required that all members of a family have a crucial role in working the farm. These farms maintained a vested interest in the health of the land they lived on.

But since the Great Depression, industrialized farming pushed the small family farm out of the picture. Efficiency at an immense scale overshadowed any expression, quality, or care in the practice of farming. This scale of agriculture only expedited its negative effects on the land and climate.

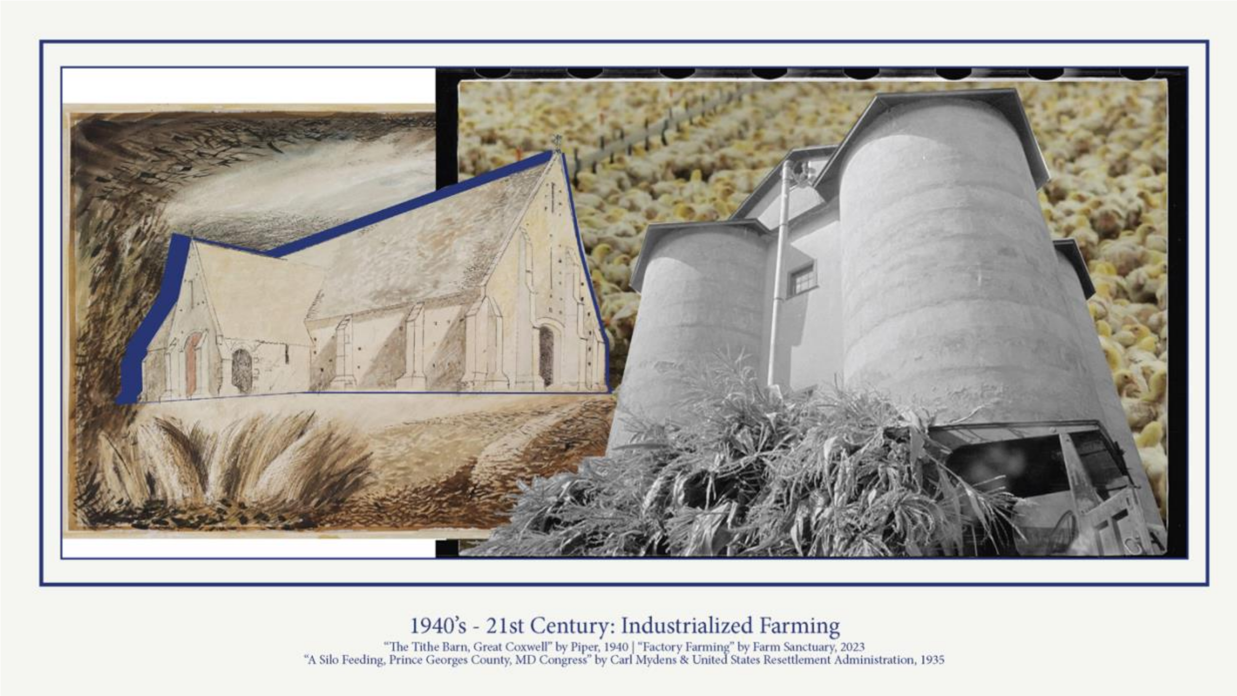


Figure 6.17 1940’s-21st Century: Industrialized Farming (Source: Author)

So much so that by the 1970’s environmental policies were finally adopted nationwide to preserve the integrity of the country’s natural resources. There was widespread acceptance that we needed to preserve the environment to protect and improve the quality of life of people, plants, and animals for current and future generations.

Yet, measures were perhaps not drastic enough, as the climate and landscape are changing beyond our control today. Coastal agricultural communities like Easton are suffering sea level rise, saltwater intrusion, and temperature spikes that are forcing us to modify our lifestyles and the way we produce food.

Figure 6.18 1970's-21st Century: Environmental Protection (Source: Author)

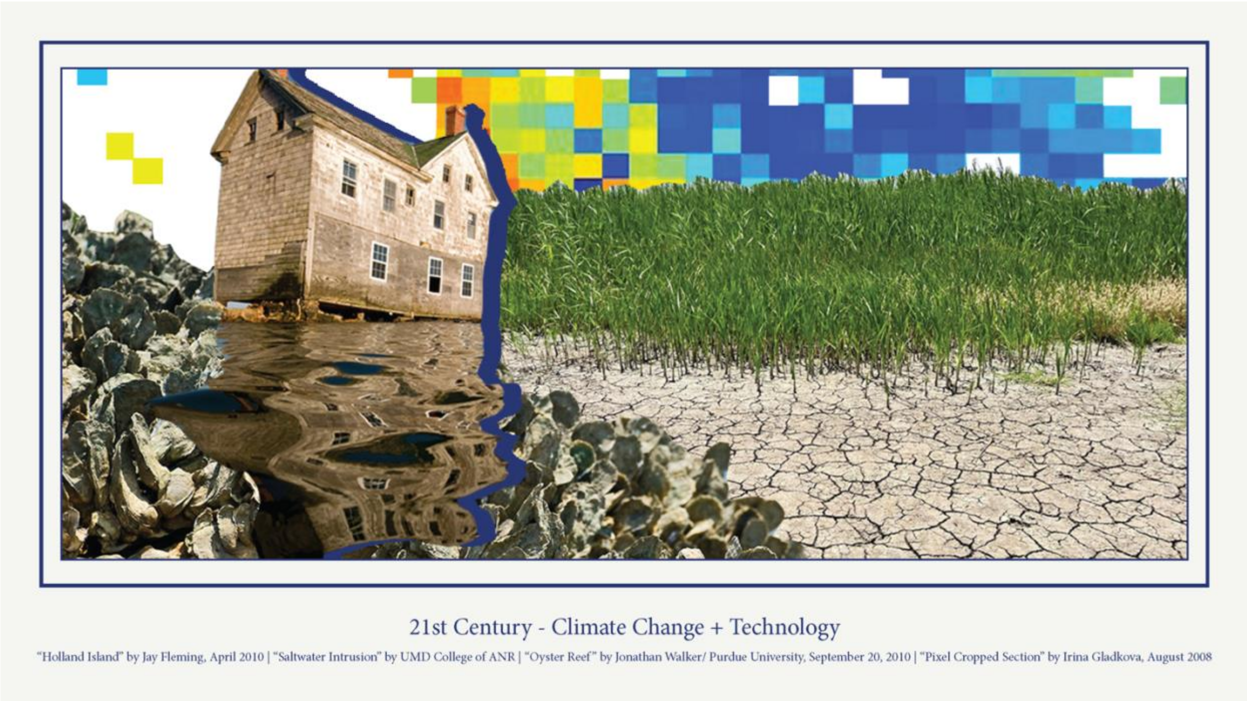


Figure 6.19 21st Century: Climate Change & Technology (Source: Author)

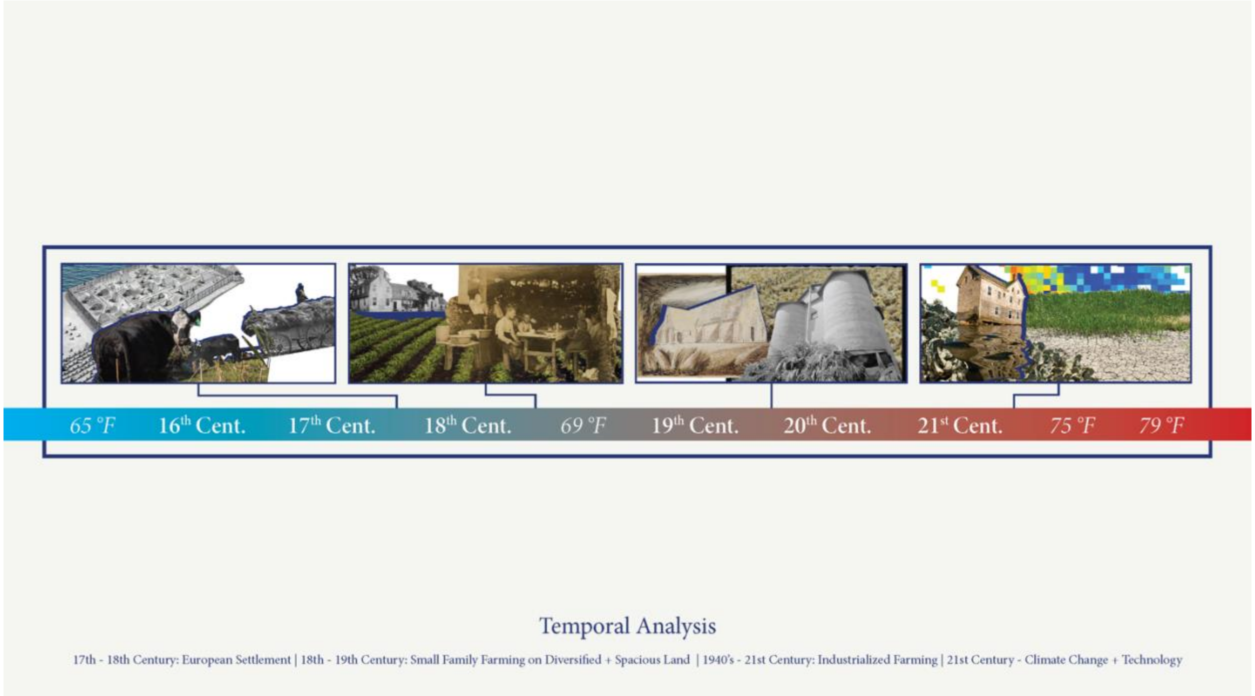


Figure 6.20 Temporal Analysis (Source: Author)

Looking at a historic overview, we can see a trend of different groups of life having been eradicated to make way for a new inhabitant. From Native Americans, plants, and animals to European settlers and family farmers who were pushed out by large scale industry. Today, the livelihood of those that remain on Maryland's Eastern is threatened by climate change.

Climate & Site

However, Easton's economy, people, infrastructure, and culture still rely heavily on agriculture. Thus, this thesis examines agricultural practices in these communities so that they can sustain themselves in the future.

Looking at Nasa's projections for high tide flooding and temperature change, the future of agriculture the way we have practiced it is bleak. The projected temperature by 2050 is about 71 degrees with 50-200 days of high tide flooding. By 2090, there will be at least 300 days of high tide flooding with an average temperature of 75 degrees. This tidal flooding and extreme weather severely lower or even eliminate agricultural productivity and alters ways of life as we understand it.

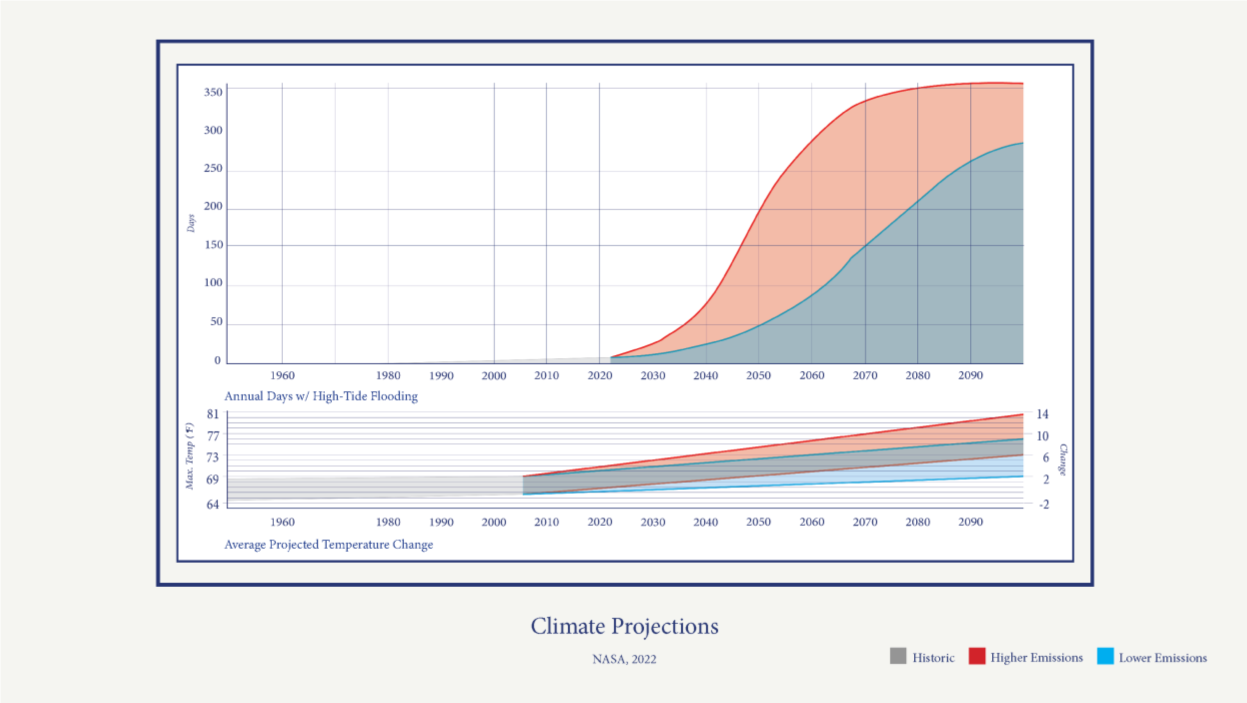


Figure 6.21 Climate Projections (Source: Author)

Considering that climate change is continuing to modify this landscape, we can look at the shape of the land over time, to better understand how it may need to look to ensure the viability of coastal agricultural practices now and in the future.

During the 17th century, the Otwell farmhouse was built on a peninsula 15 minutes south of present-day Easton. As the farm grew and the land was maintained by one family, the natural landscape and wetland were more or less intact. As population grew and communities were established on the peninsula, the area of the natural land mass began to rapidly decline. By the late 20th century, established communities and agriculture have depleted most natural resources, such as wetlands, on the site.

Figure 6.22 Historic Land Mass & Wetland (Source: Author)

Figure 6.23 Otwell Farm Settlement (Source: Author)

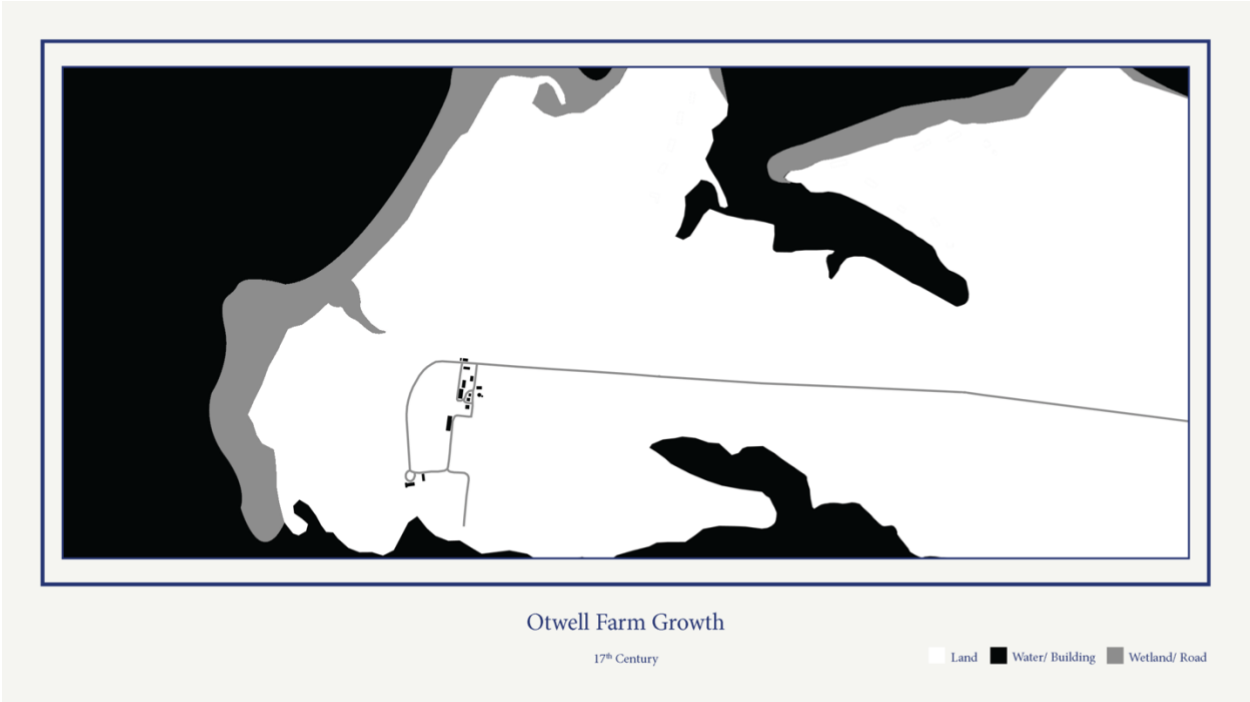


Figure 6.24 Otwell Farm Growth (Source: Author)

Figure 6.25 Population Growth (Source: Author)

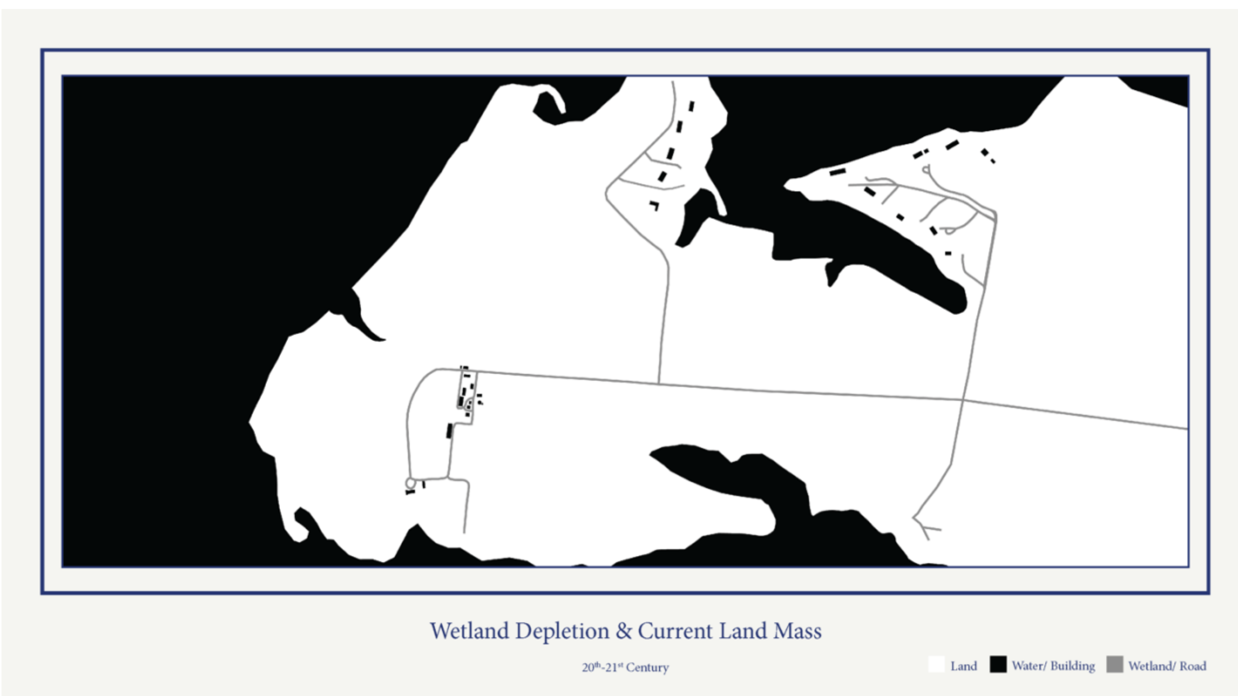


Figure 6.26 Wetland Depletion & Current Land Mass (Source: Author)

Using NASA's temperature change models and NOAA's sea level rise models, we can foresee what the land will look like given 2–10-degree temperature change, in as soon as 25 years. A 2–14-degree change, projected even by conservative measurements to occur within the century causes 6-foot sea level rise. If emissions and temperatures continue to rise, this is what the land will look like under 8-foot sea level rise. Finally, a temperature increase of at least 35 degrees will significantly change the shape of the land.

Hurricanes, whose intensity, and frequency are increasing, threaten to severely flood and damage the site.

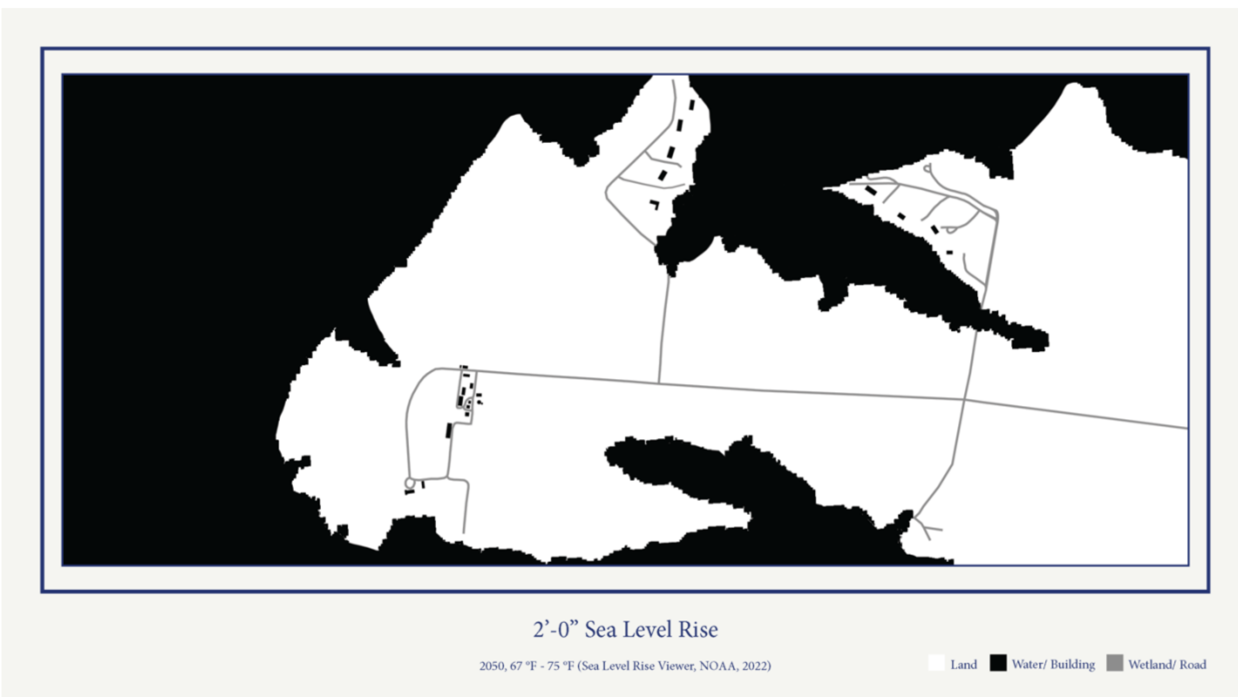


Figure 6.27 2’-0” Sea Level Rise (Source: Author)

Figure 6.28 6’-0” Sea Level Rise (Source: Author)

Figure 6.29 8’-0” Sea Level Rise (Source: Author)

Figure 6.30 10’-0” Sea Level Rise (Source: Author)

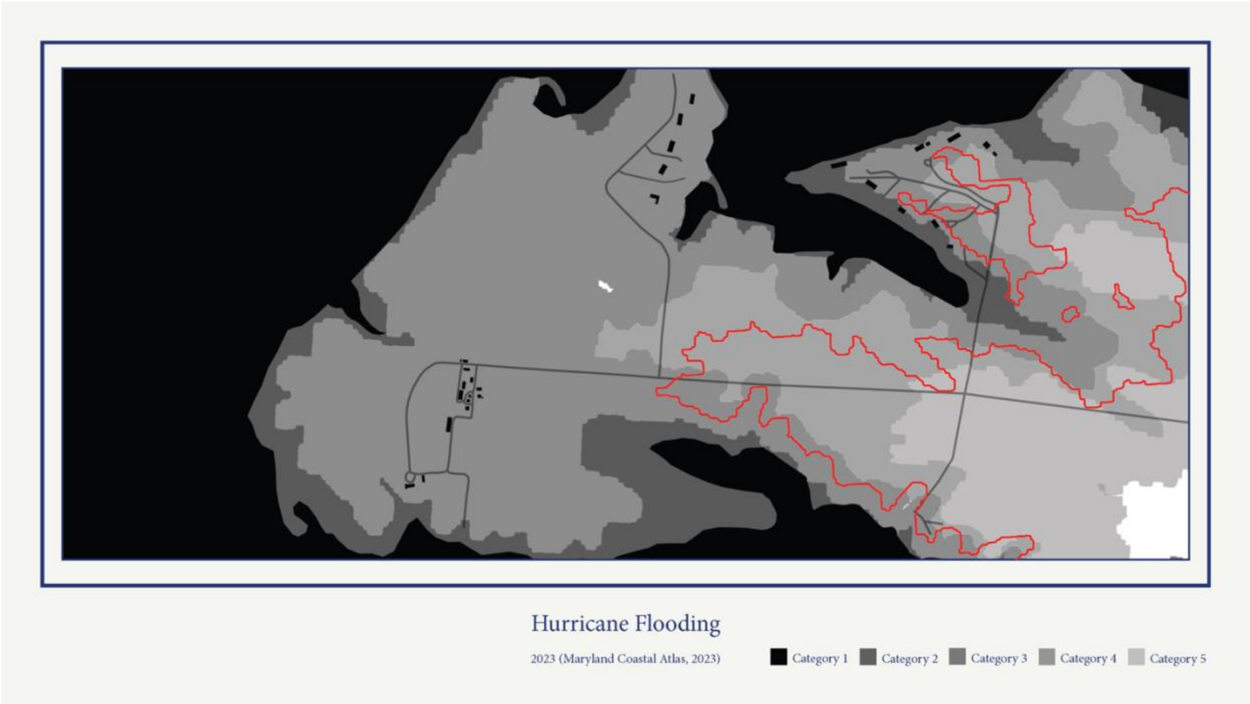


Figure 6.31 Hurricane Flooding (Source: Author)

Section 2: Site Strategy

Clearly, the land is at risk, and thus the agricultural practices tied to it. So, to envision how coastal agriculture can persist, we can examine how communities respond to environmental unrest. This matrix shows that in order to plan a slow, short distance, and permanent response to climate change, this thesis implements setbacks, relocated structures, and environmental migration.

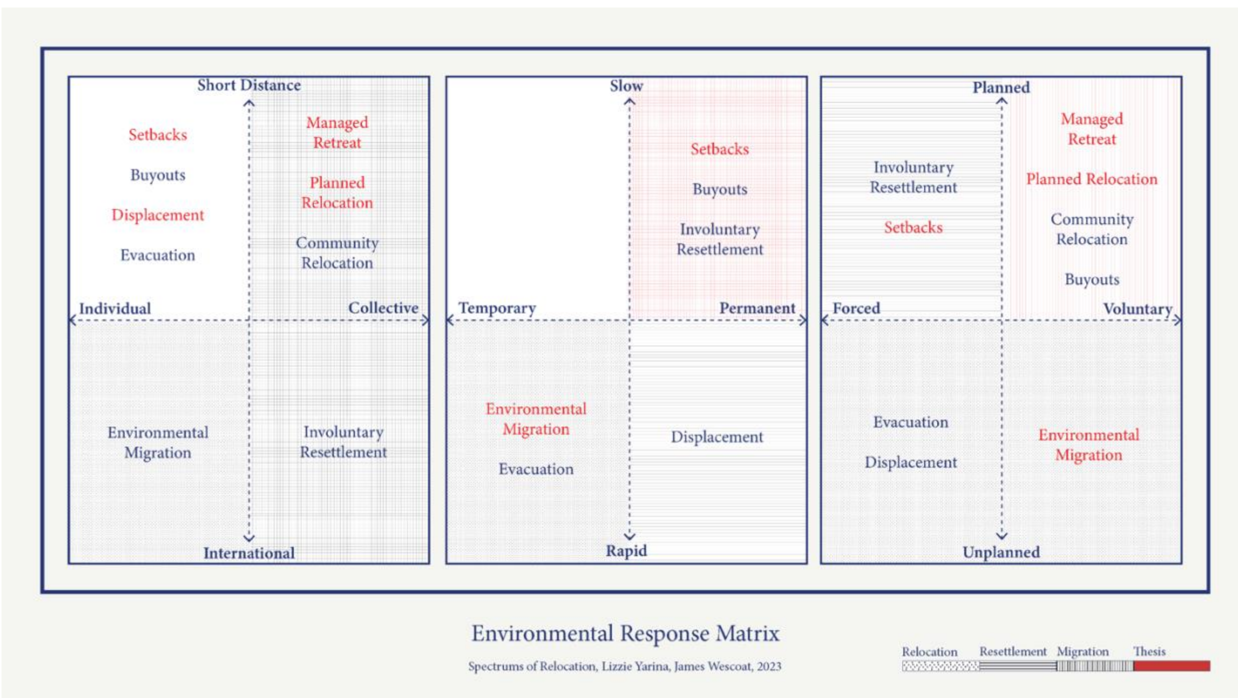


Figure 6.32 Environmental Response Matrix (Source: Author)

In returning to the sea level rise diagrams, we can see how the existing structures currently situated on the site will be affected by sea level rise. They will no longer exist. The first order of action in reimagining coastal agriculture, is to reshape the productive land. An examination of the land under more detail where a dashed line represents the old land mass. The land has been cut and filled so it has gone from being extremely flat, to including 10’ of elevation on site.

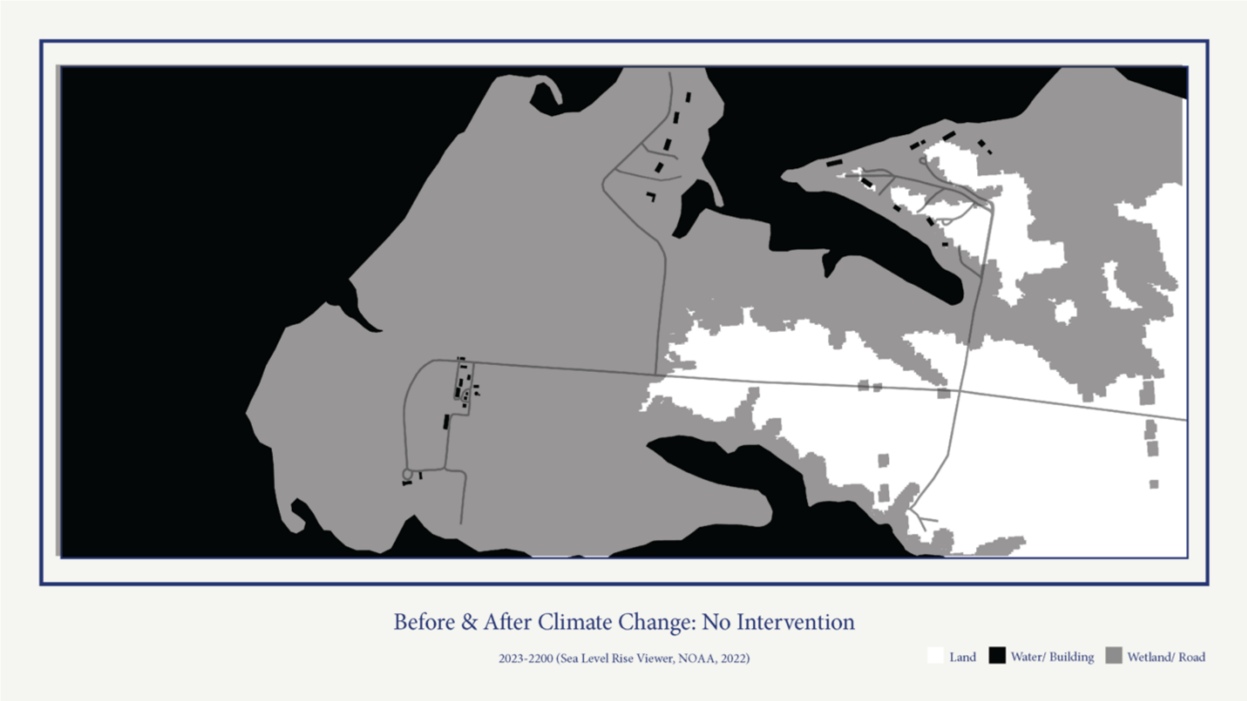


Figure 6.32 Before & After Climate Change: No Intervention (Source: Author)

Figure 6.33 Before & After Climate Change: Land Intervention (Source: Author)

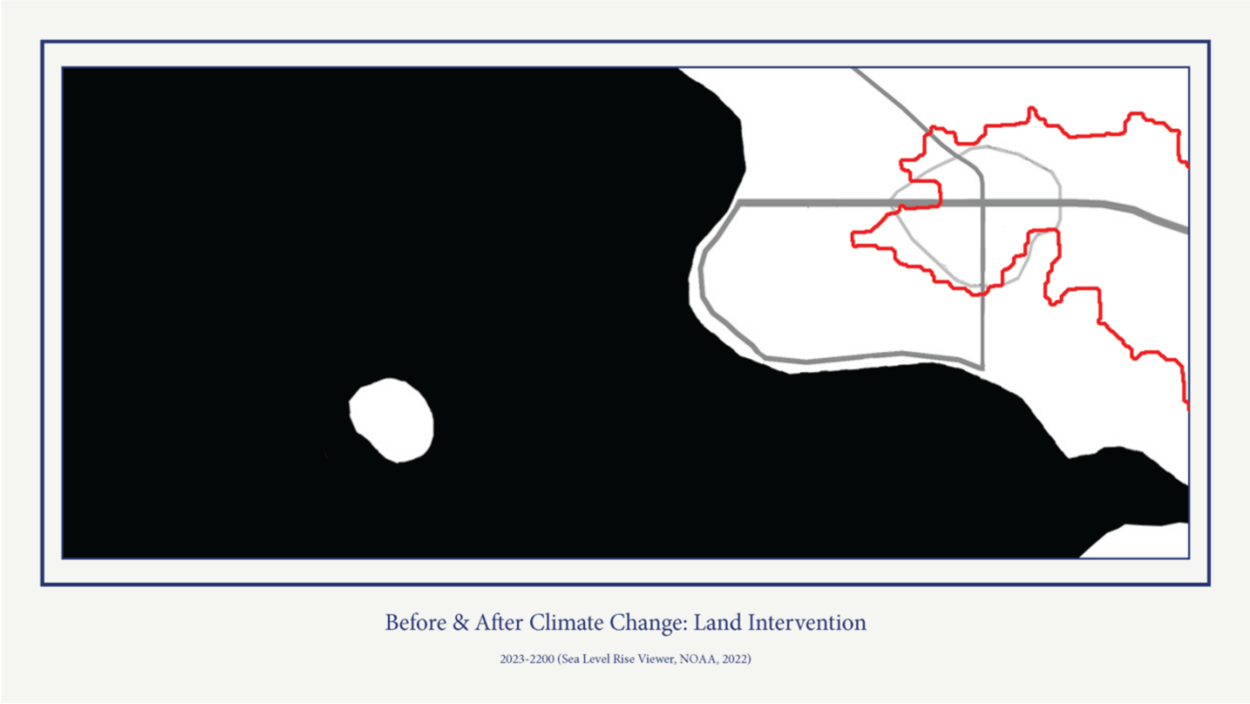


Figure 6.34 Before & After Climate Change: Land Intervention (Source: Author)

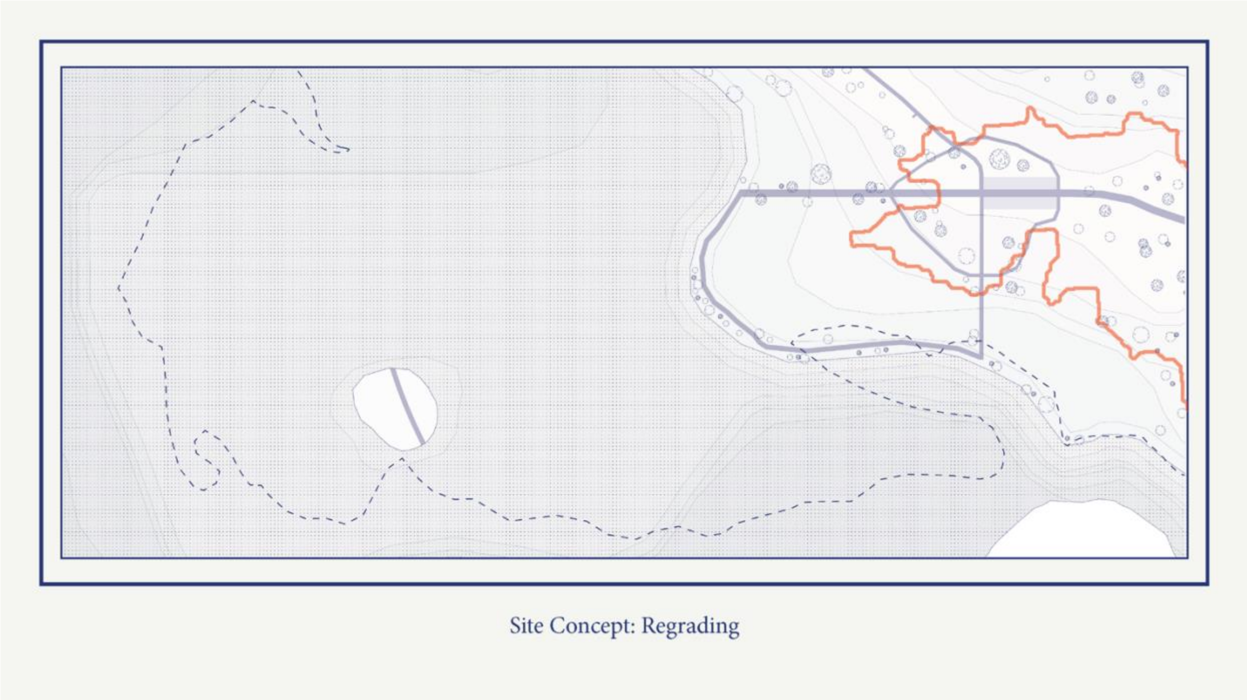


Figure 6.35 Site Concept: Regrading (Source: Author)

Regardless of the program, existing farm operational buildings are at risk. The next order of action is to reprogram and relocate them to the newly elevated land. Under these conditions, the land is best suited to produce wild rice and oysters, as it has since the 16th century. Although operational buildings are relocated, the circled historic Otwell Farm building remains on an island, as a relic of past lifestyles and practices. The historic Otwell farmhouse remains on existing topography, when the water rises, house will be affected. People will no longer be able to interact with the house and view it instead as a structure floating in water. the A boardwalk structure is built, with nodes at the existing coastline.

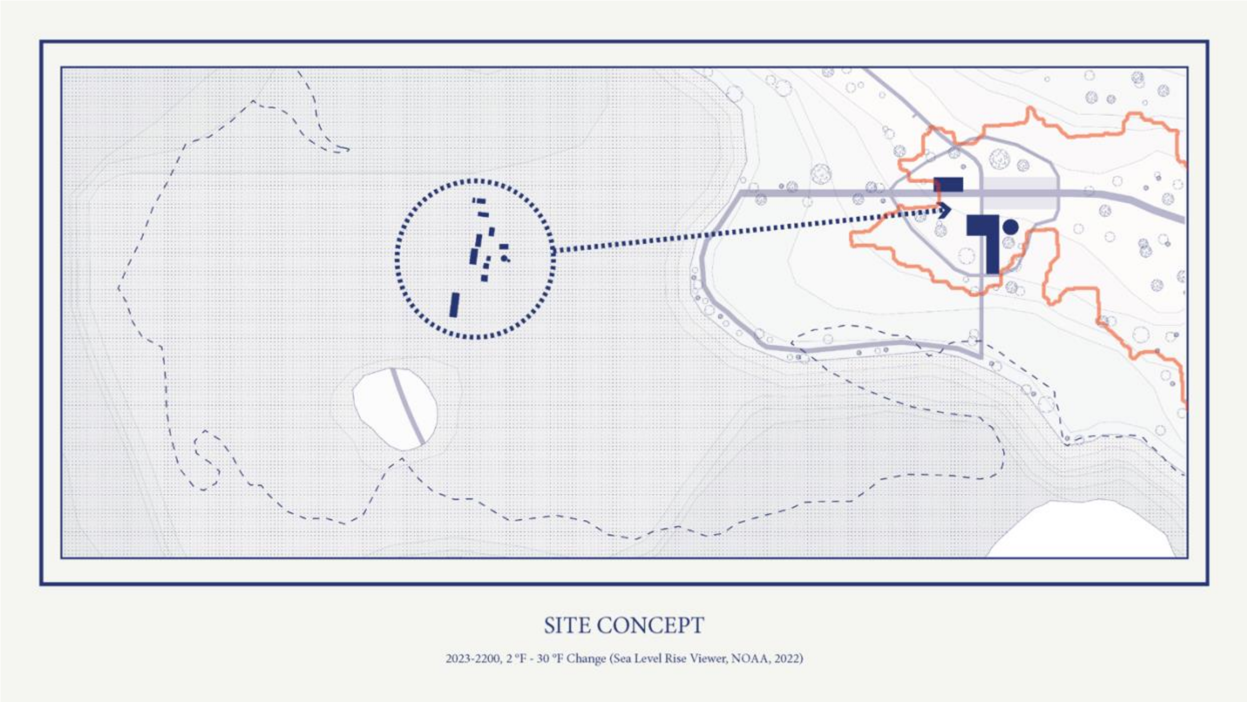


Figure 6.36 Site Concept: Relocation (Source: Author)

The boardwalk creates a pilgrimage for people to walk on and not only interact with the water and aquaculture practices, but to remind us of what was before climate change. There are circuits of multiple lengths suitable for various people, but the longest walk out from the land is 0.6 miles long. It also acts to shape and contain aquaculture practices on the farm, while wild rice fields are shaped by the newly terraced landscape.

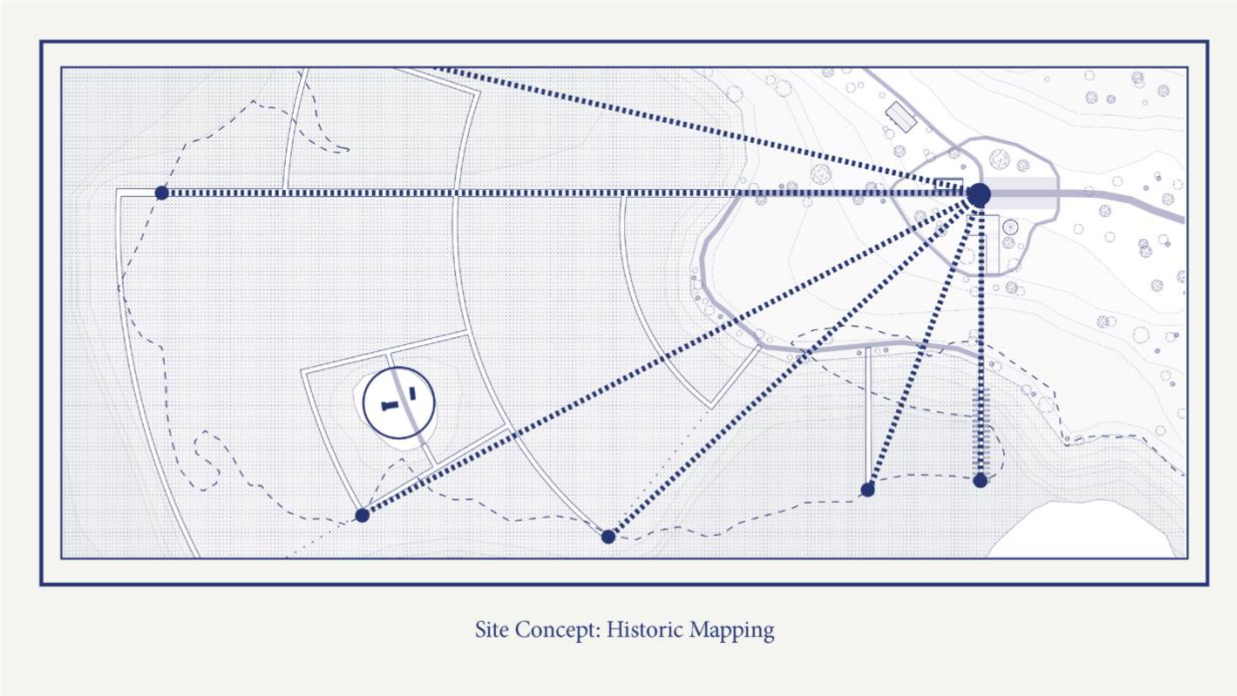


Figure 6.36 Site Concept: Historic Mapping (Source: Author)

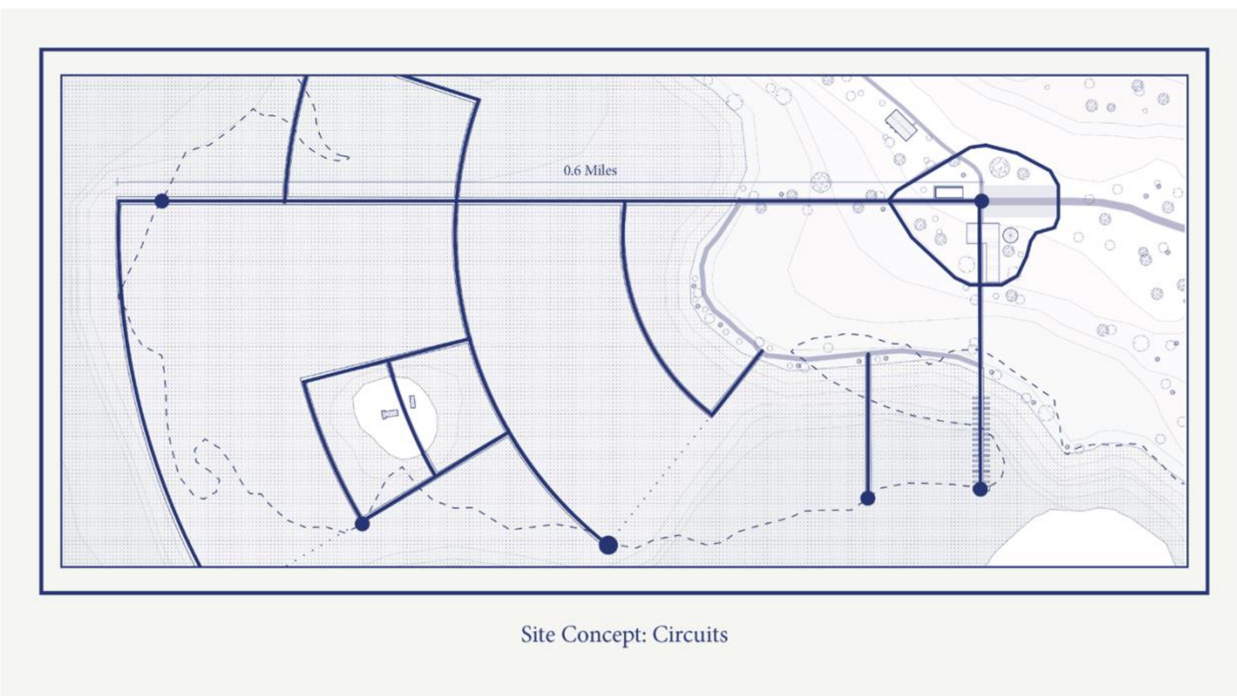


Figure 6.37 Site Concept: Circuits (Source: Author)

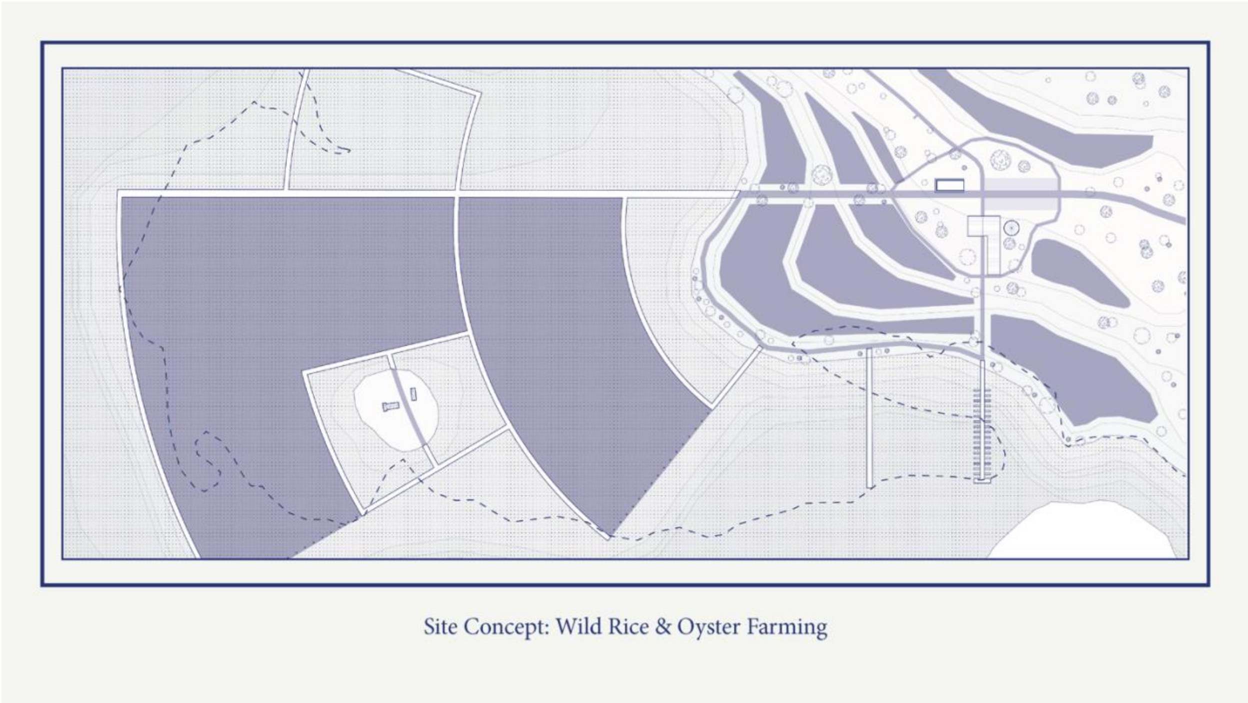


Figure 6.38 Site Concept: Wile Rice & Oyster Farming (Source: Author)

We can start to see a connection between land and water. I first tried separating these functions both in the design scheme, and representationally by color coding, etcetera. But these efforts became a bit convoluted, which wound up being a critical point in the design process. I realized that, really, this thesis is about how the functions of land and water are changing. People in these affected coastal areas need to face the reality that climate change is blurring the boundaries between land and water. This thesis works in conjunction with these forces so that small coastal farmers can react and reframe their practices with grace.

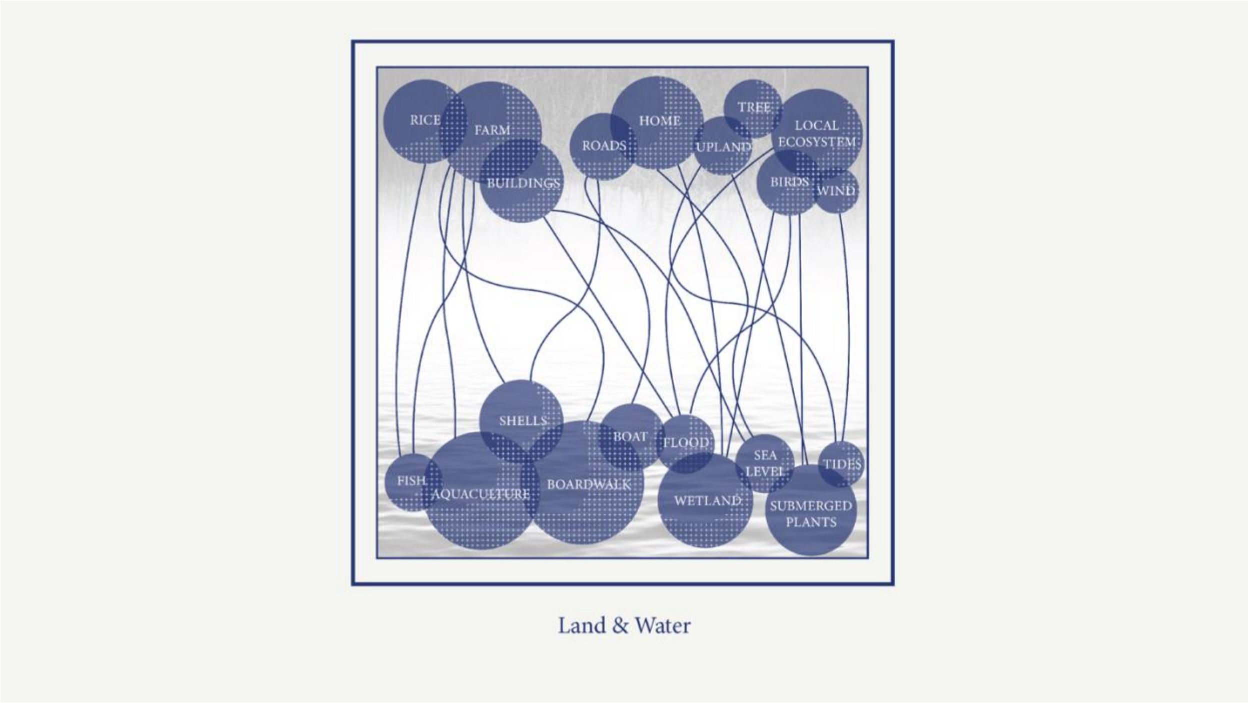


Figure 6.39 Land & Water (Source: Author)

Therefore, this thesis tackles this problem by acknowledging indefinite boundaries. We cannot keep operating in the same ways that got us here, so we must think ahead of the changing landscape, reimagine what the land and water can produce in terms of food, and build in a more sensitive and resilient manner. This diagram shows how different goods move throughout the site and eventually end up on the dining tables in local restaurants. Where the dark line represents

movement of oysters, and the lighter thinner line represents wild rice.

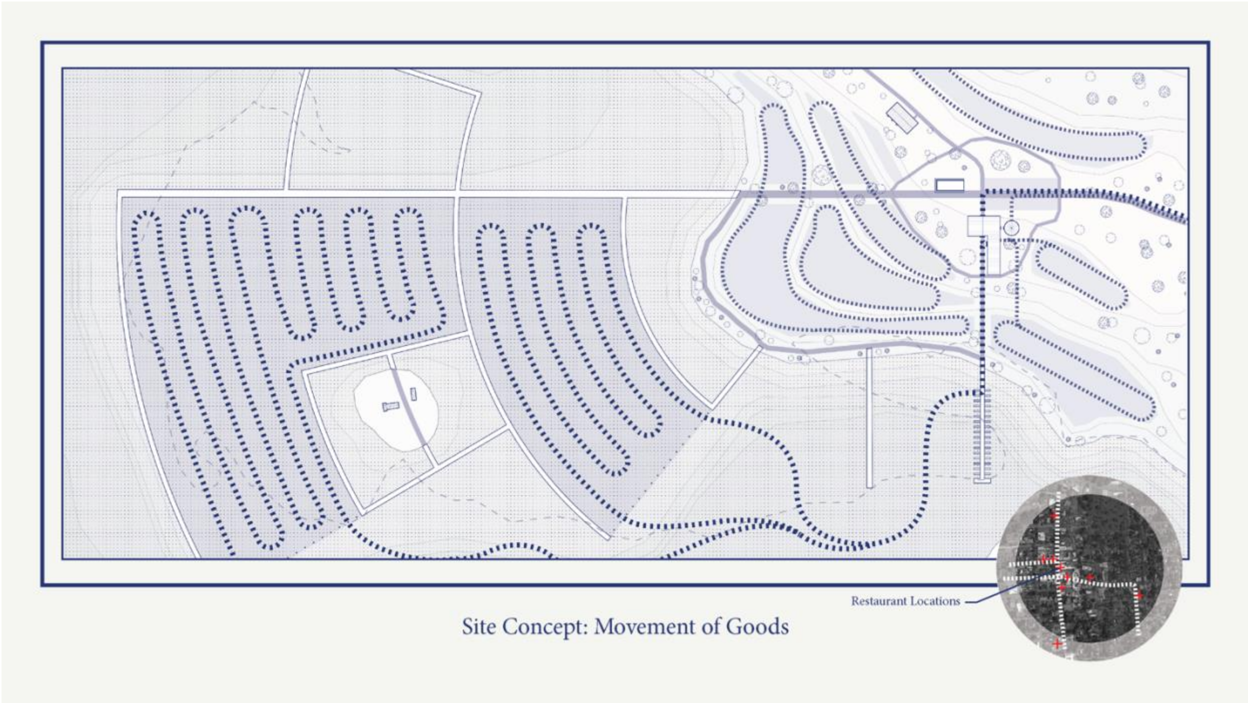


Figure 6.40 Site Concept: Movement of Goods (Source: Author)

Zooming in, the aquaculture practice from which this thesis earned its name is called, Suspended Culture. Oysters are grown in suspended bags with attached buoys that float and sink on the water. This system uses natural tides to rotate oysters while growing. Nearly 750,000 oysters can be grown in 1 acre, these oysters provide food, but also filter between 15-40 million gallons of water daily to help improve bay health. The wild rice produced is grown using a historic rice-fish method, a mutually beneficial relationship where fish naturally fertilize, weed, and reduce pests for the rice paddies they call home.

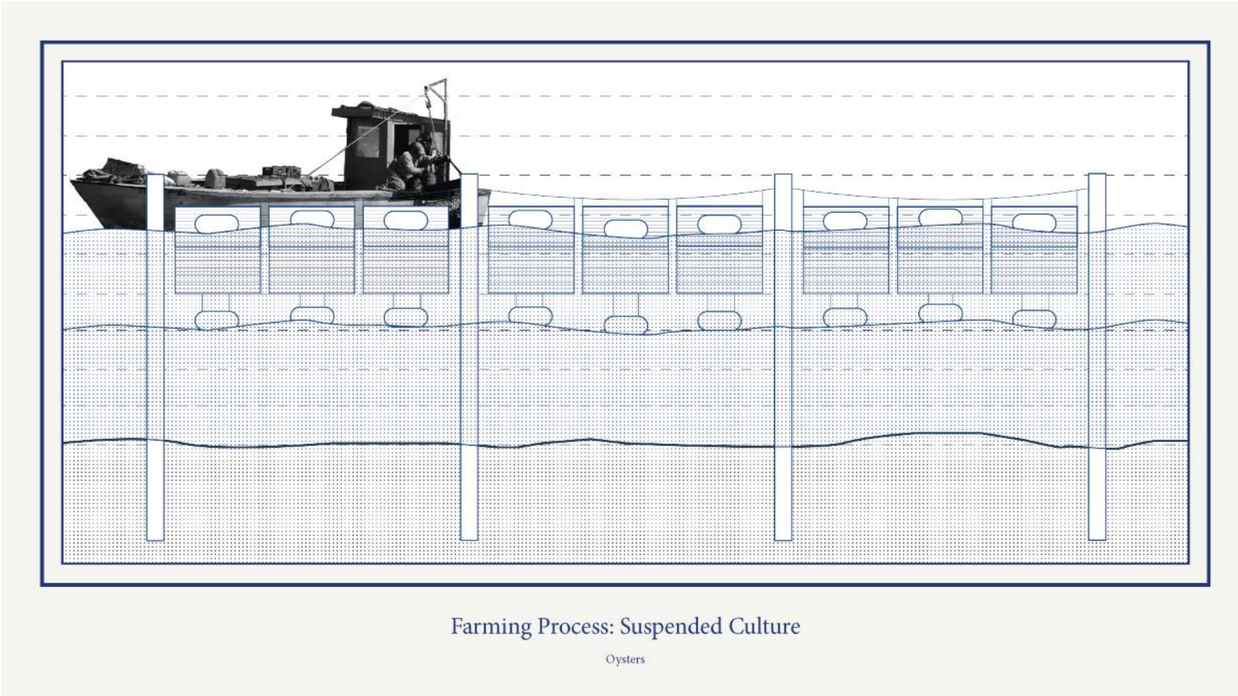


Figure 6.41 Farming Process: Suspended Culture (Source: Author)

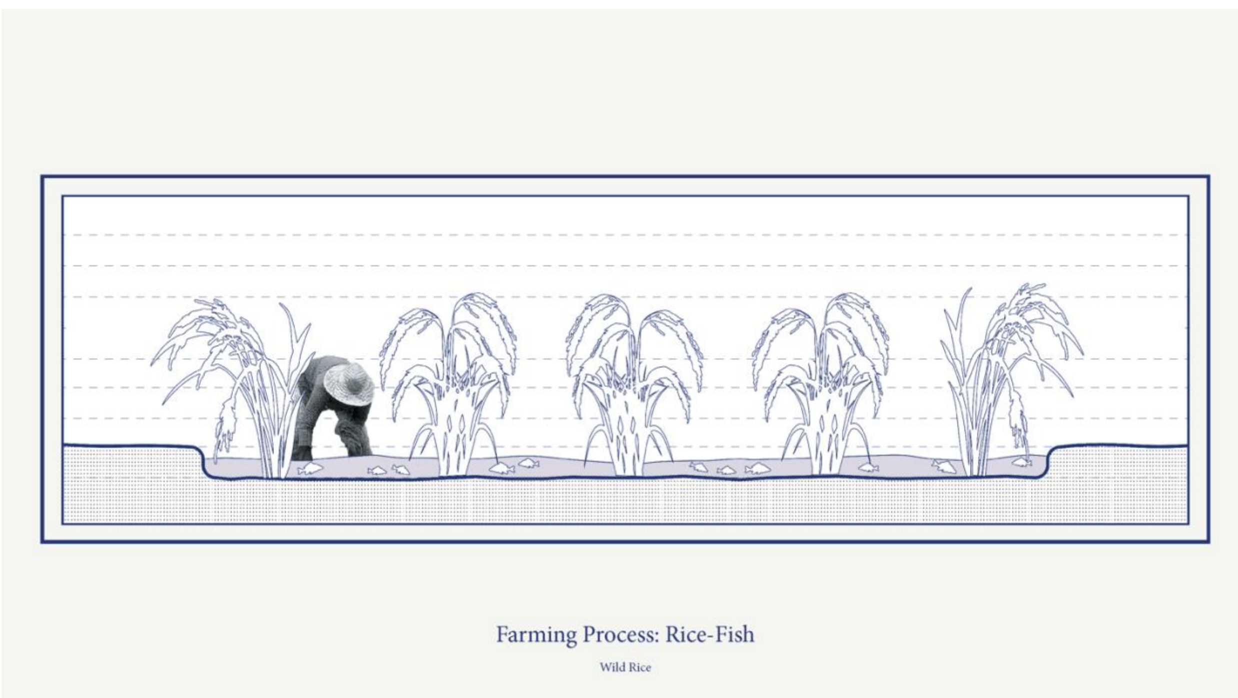


Figure 6.42 Farming Process: Rice-Fish (Source: Author)

The rice-fish farming is one sustainable aspect of the site. Where terraced rice paddies also reduce erosion and slow flow of stormwater. Wetlands will be re-instituted on the coast and intermittently between the boardwalk. The shells from the oysters will be used for paths. Relocated operations buildings are designed with efficient structures and include solar roof panels.

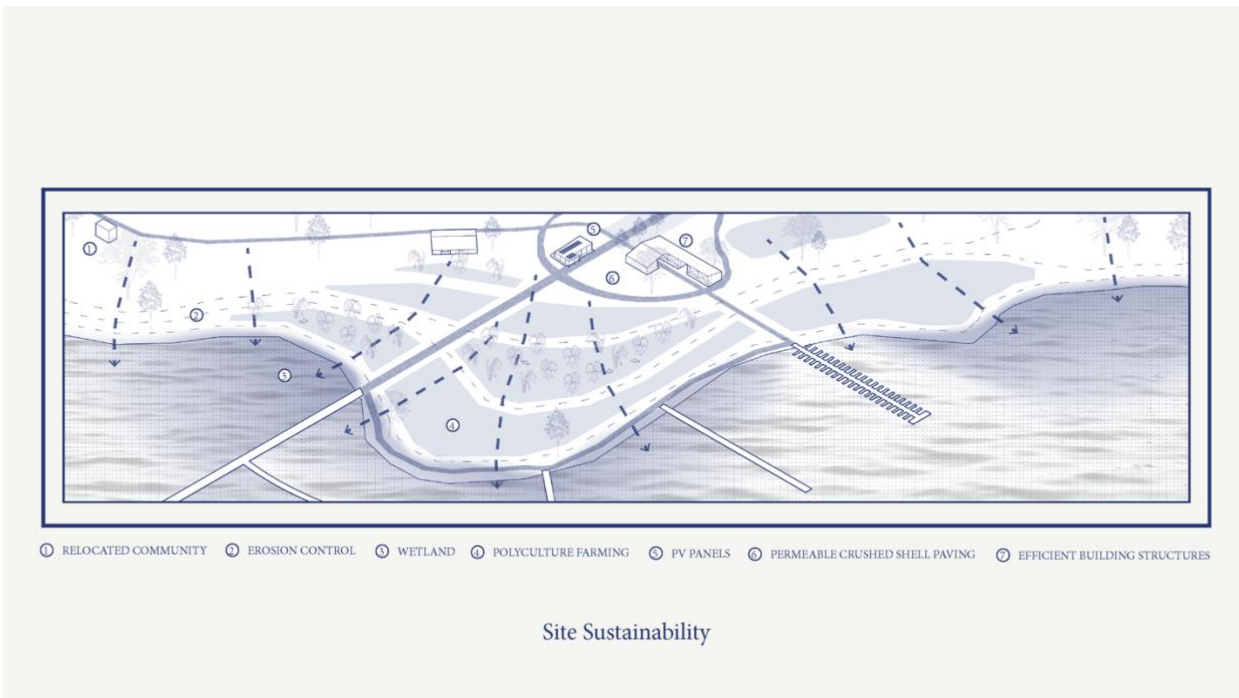


Figure 6.43 Sustainability (Source: Author)

Section 3: Design

Overview

A closer look shows how visitors and goods simultaneously circulate throughout the site. Where oysters grown in the nursery move water, how rice is grown, processed, how people move throughout the visitor center and site, and finally how farm owners get to and from their home. Shown is a view of the entire complex from the boardwalk.

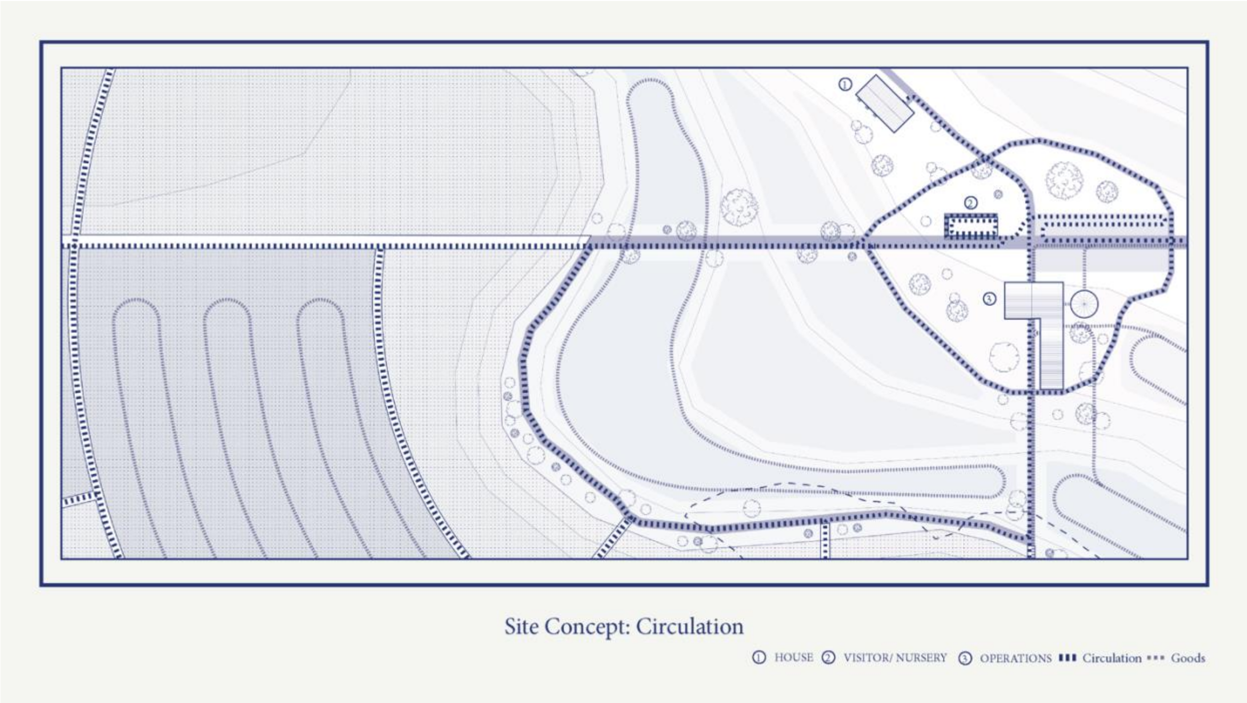


Figure 6.44 Site Concept: Circulation (Source: Author)

Figure 6.45 The Farm (Source: Author)

Operational Building

The form of the operations building takes root in precedent, where each facade is associated with the proportions and organization of two prominent barn typologies of the region, English barns and Crib barns. The building itself is not meant to provide views of the site, but becomes a spectacle, where people can peek and witness the process involved in producing their food. Finally, the building is constructed with gabion walls that allow natural ventilation.

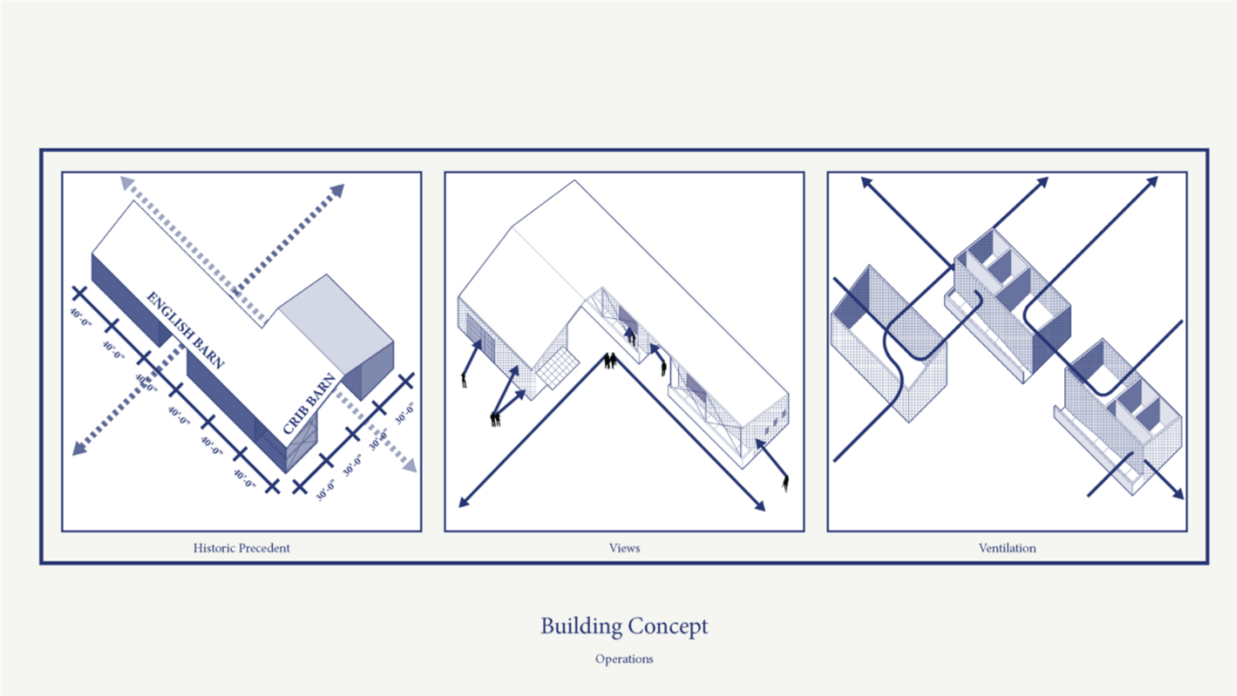


Figure 6.46 Building Concept (Source: Author)

The steel structural grid, whose gabion enclosure is connected without adhesives and can be easily adapted or repaired. The sturdy gabion wall units are stacked, and create a sense of permanence, durability, heaviness, and connect the primary farm building to the earth. The garage building with its manually operable garage doors, breezeways, and two processing massing that sit 5’ above the ground.

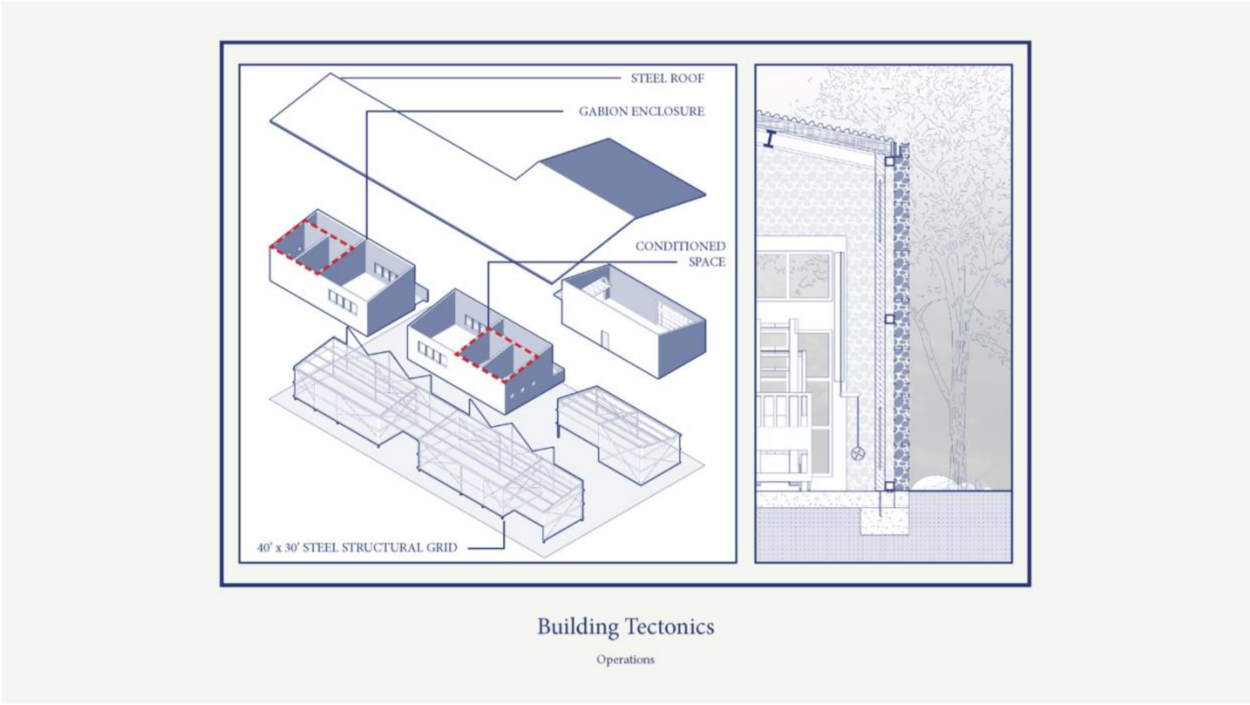


Figure 6.47 Building Tectonics (Source: Author)

Figure 6.48 Building Approach (Source: Author)

In section, we can see the rice storage and processing rooms that the breezeway separates from the oyster processing and storage rooms to the right. On the far right is an open patio for both works and visitors to gather and rest in the shade. Note how the space between the rocks in the gabion wall system create openings for light to peek into the building.

When cut through the garage, we can see where the large machinery for both farming functions are located in relation to the processing and storage half of the building. This side of the building features a classic gable roof and breezeway characteristic of crib barns. Although mainly in use by farmers, visitors can walk around and interact with the exterior of the building. Again, the gabion provides a sense of scale, texture, natural ventilation, and light.

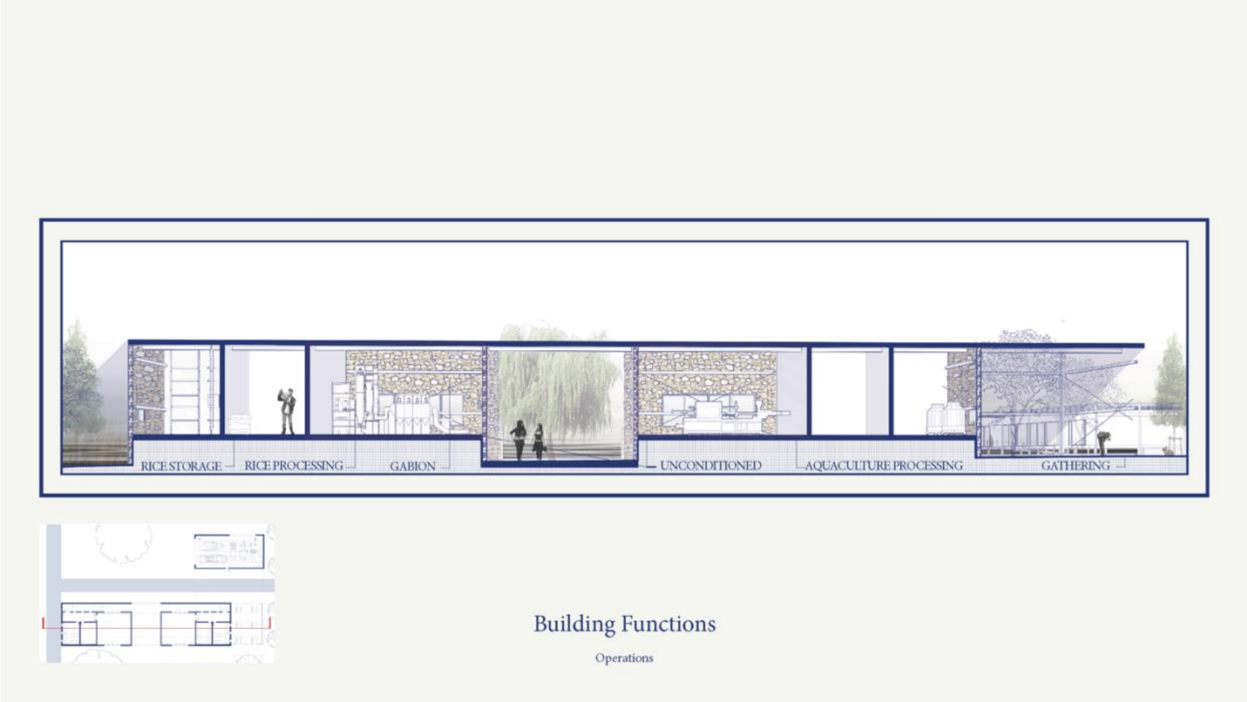


Figure 6.49 Building Functions (Source: Author)

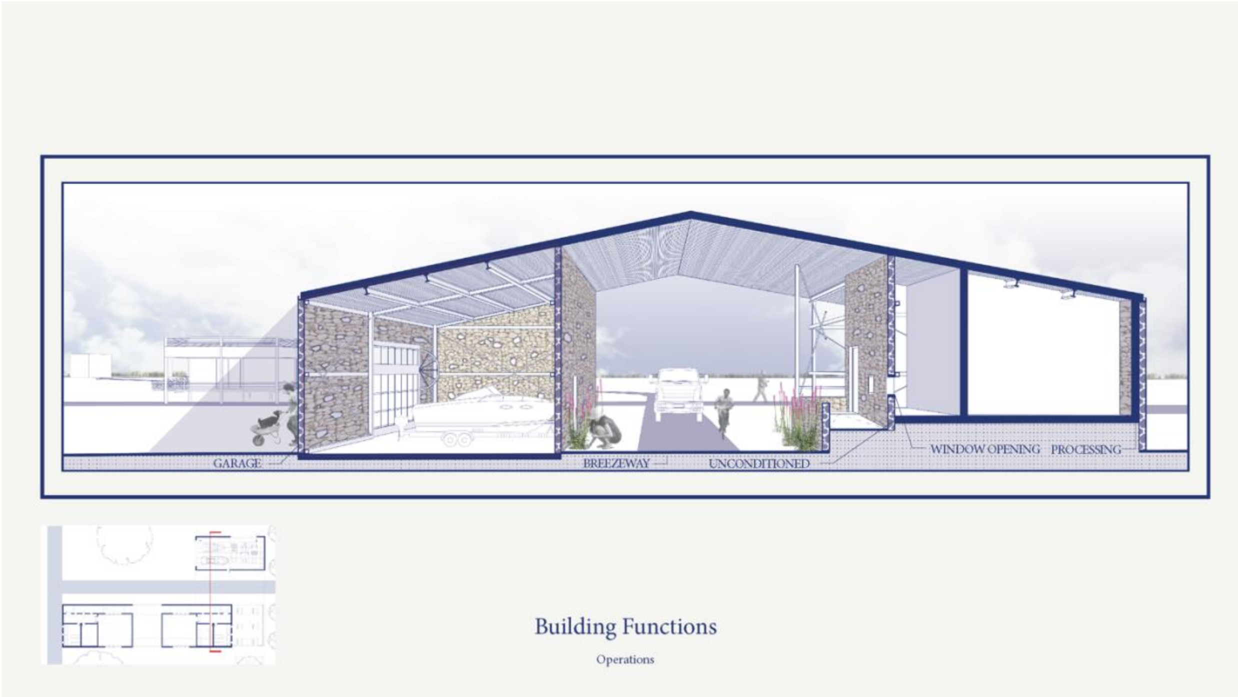


Figure 6.50 Building Functions (Source: Author)

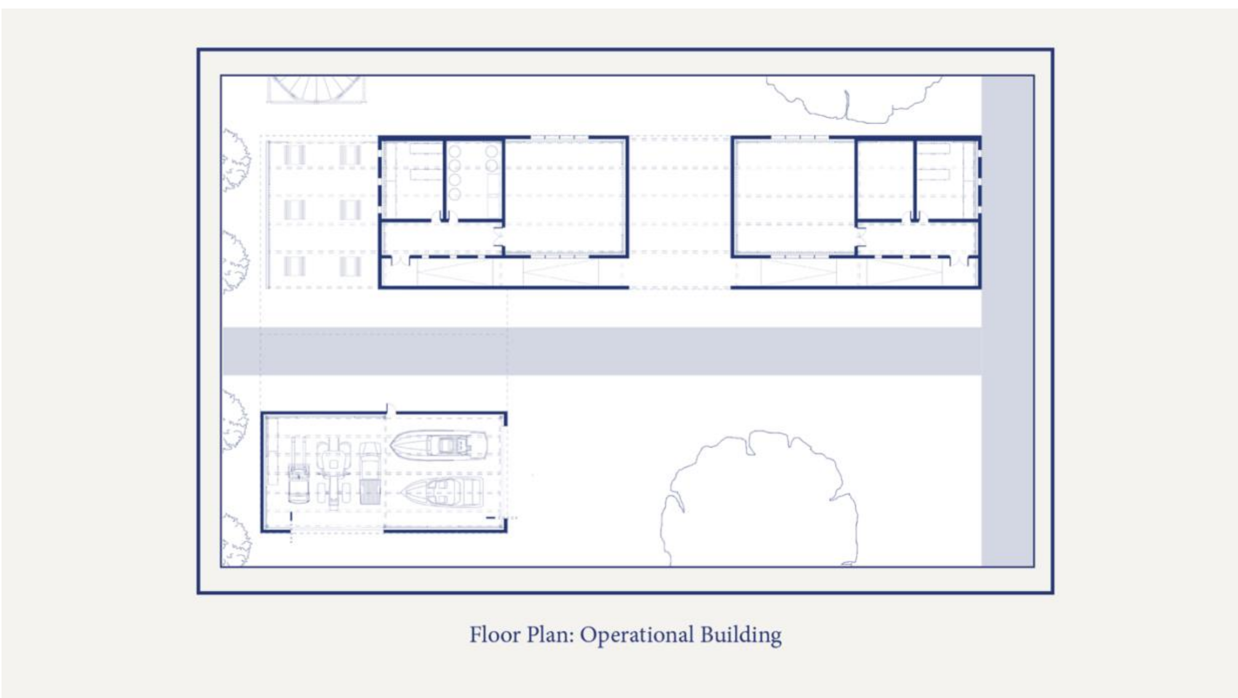


Figure 6.51 Floor Plan: Operational Building (Source: Author)

Visitor, Office, & Nursery

In contrast, the visitor building, and nursery is designed to sit lightly on the earth atop a hard wood structural system, but still maintains an adaptable assembly. A ramp provides access to the building but wraps around and connects visitors to the roof. The building is made of local cypress wood, and brings visitors and workers close together by blending a gallery and gathering space with administrative space and a nursery to grow oysters. The gallery and corridor are unconditioned and create a thermal barrier for the other building functions.

Unlike the operations building, the visitor building prioritizes views of the site at various levels. The timber columns, ramps, tall windows, and PV panels connect the building from the ground the sky. Meanwhile, the tall windows are practical and allow for natural ventilation. The lighter feeling natural elements such as the horizontal cypress wood siding and timber structure integrate the building with the landscape. It has a lighter, less permanent feel than the operations.

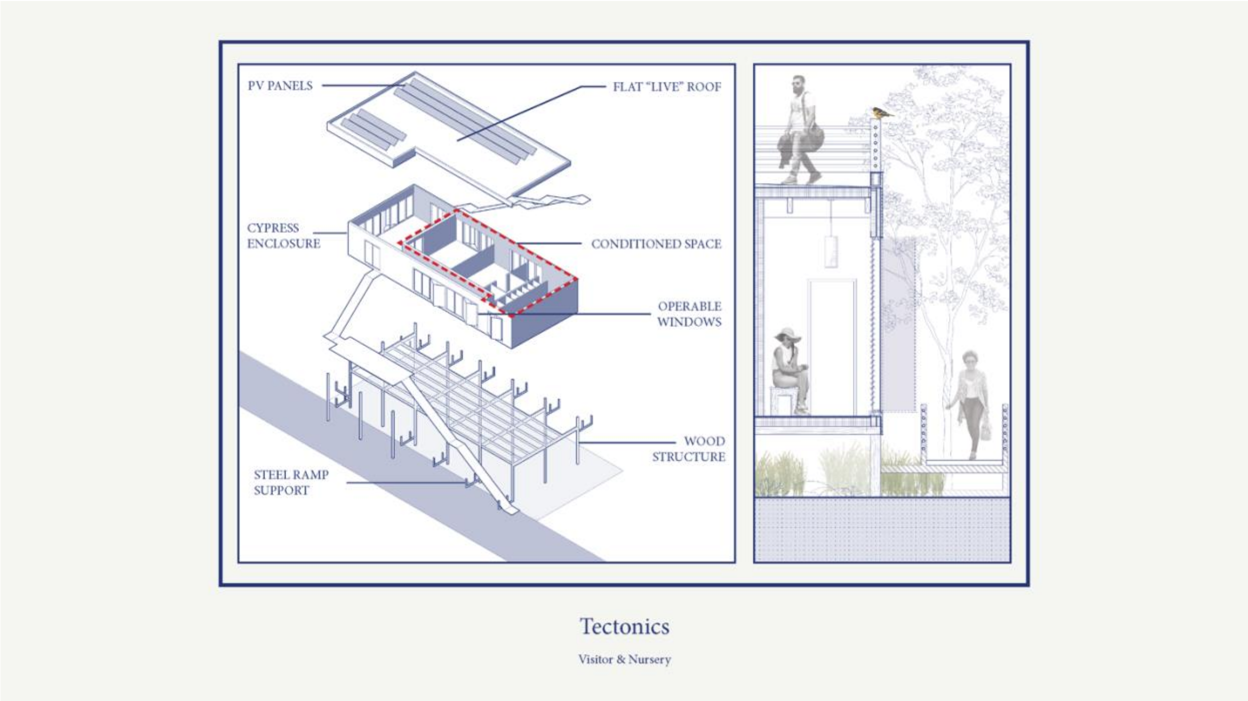


Figure 6.52: Tectonics (Source: Author)

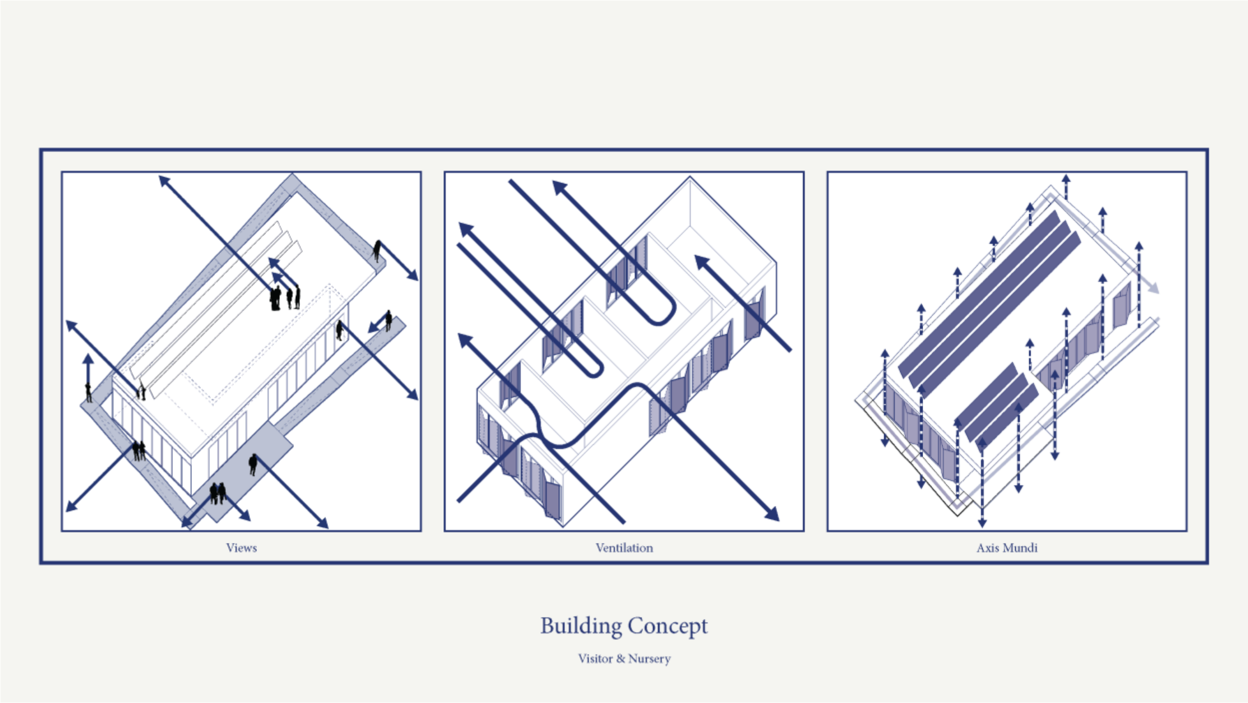


Figure 6.53 Building Concept (Source: Author)

Figure 6.54 Entry (Source: Author)

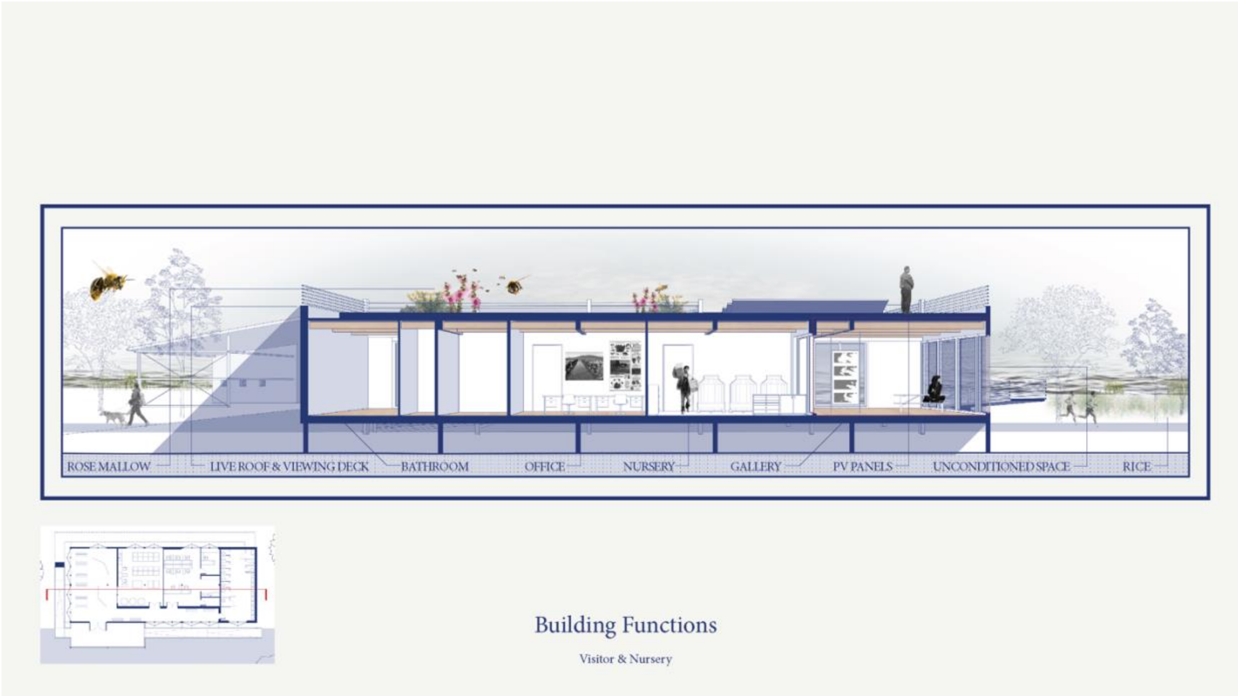


Figure 6.55 Building Functions (Source: Author)

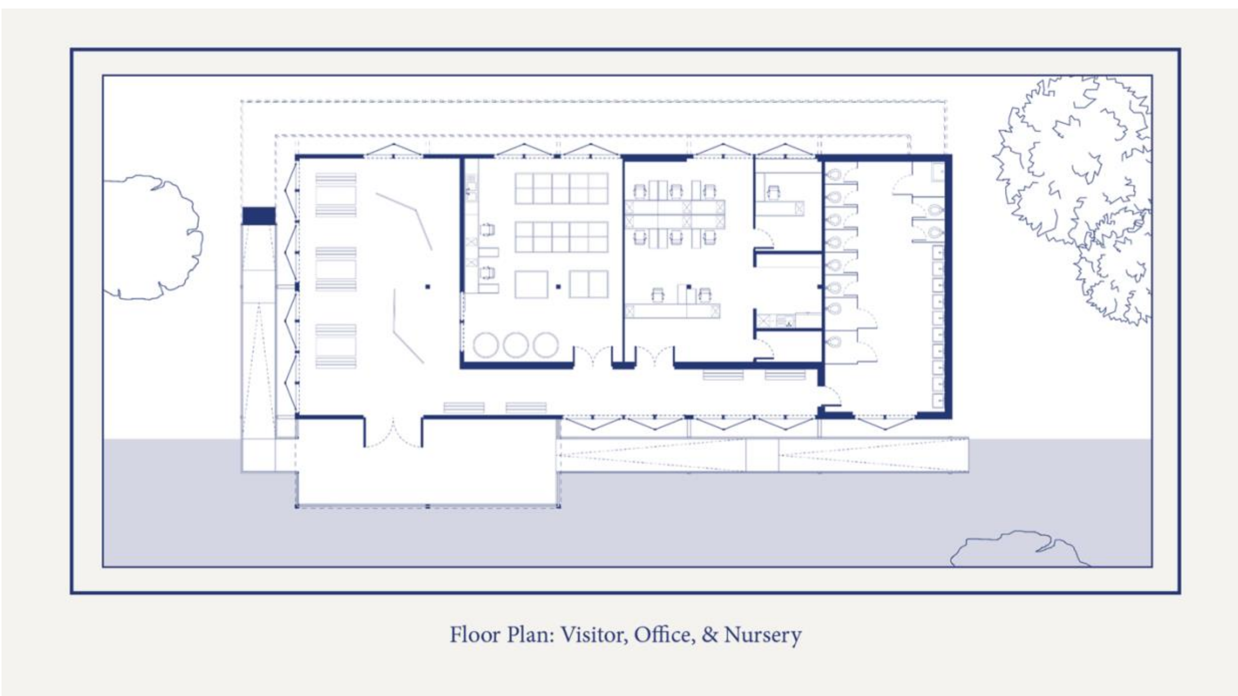
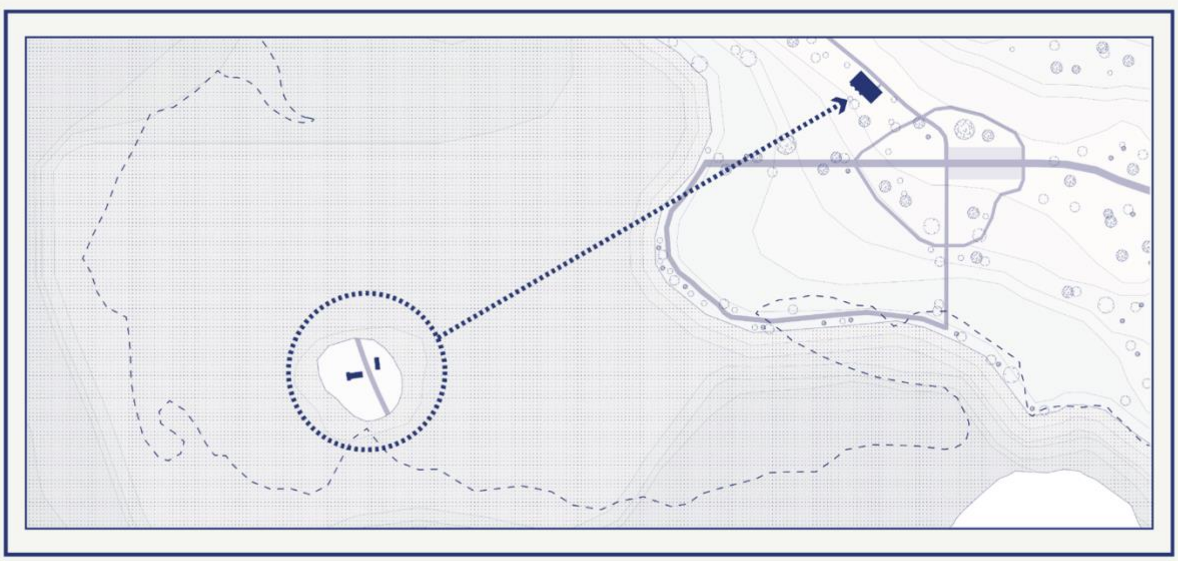


Figure 6.56 Floor Plan: Visitor, Office, & Nursery (Source: Author)

In section, the administrative office to the left, oyster nursery, and unconditioned gallery space for visitors to the right are all visible. The gallery space provides seating opportunities, information about the land and agriculture, and views out towards the water. The live rooftop is planted and includes PV panels for people to be able to examine, as well as extended views of the site and Chesapeake Bay.

House

Although the functional house is relocated, the historic Otwell house is preserved, and primarily functions as a relic and precedent for the new house that is better located and suited for the contemporary climate and family needs.



Site Concept: Housing Relocation

Figure 6.57 Site Concept: Housing Relocation (Source: Author)

Figure 6.58 Historic House(Source: Author)

The house was organized to support a multi-generational family that might live on the farm. There are separate entrances for someone who may have been working outside to enter through the southernmost garage, where they can clean up and store outdoors clothing. The bedrooms and kitchen in the larger building mass are separate from more formal house functions. The building masses are organized to prioritize rising and winding down with east-west light, as well as appropriate shading.

The house form was derived from an analysis of the historic T-shaped Otwell house. The more private functions, bedrooms, and kitchen, shape the more formal gathering spaces in the house. But the building is organized such that all spaces are connected visually to the outdoors.

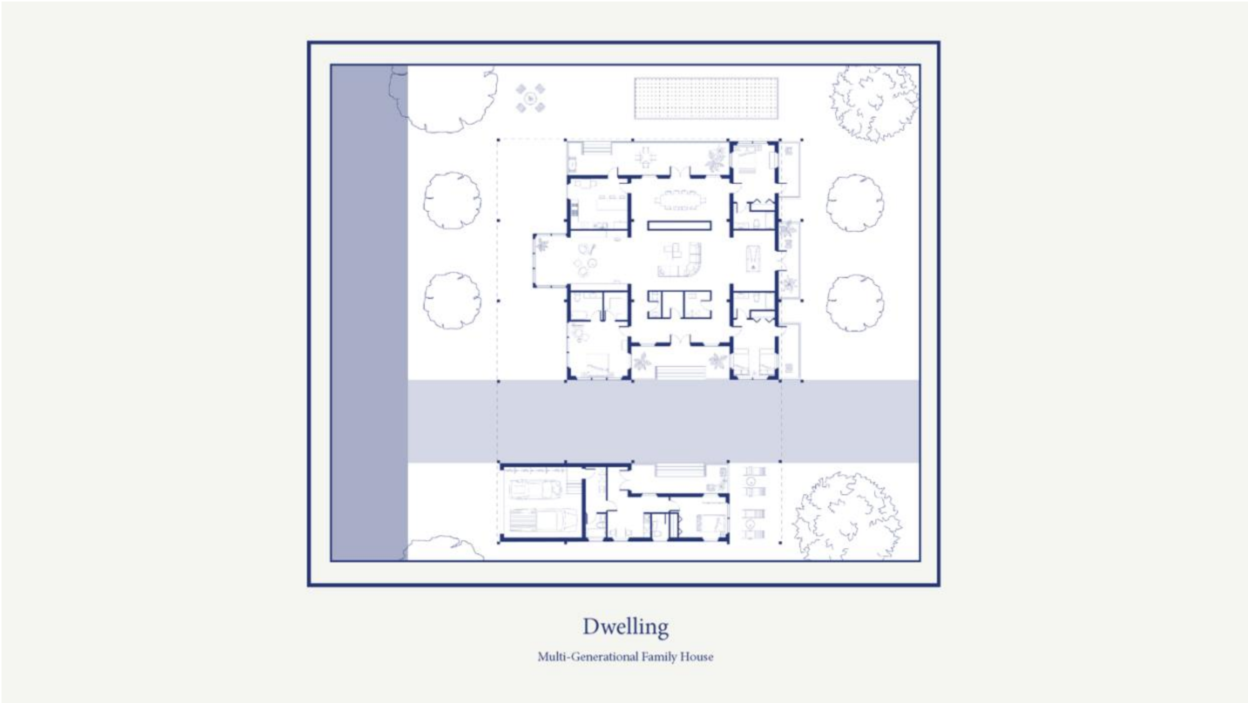


Figure 6.59 Dwelling (Source: Author)

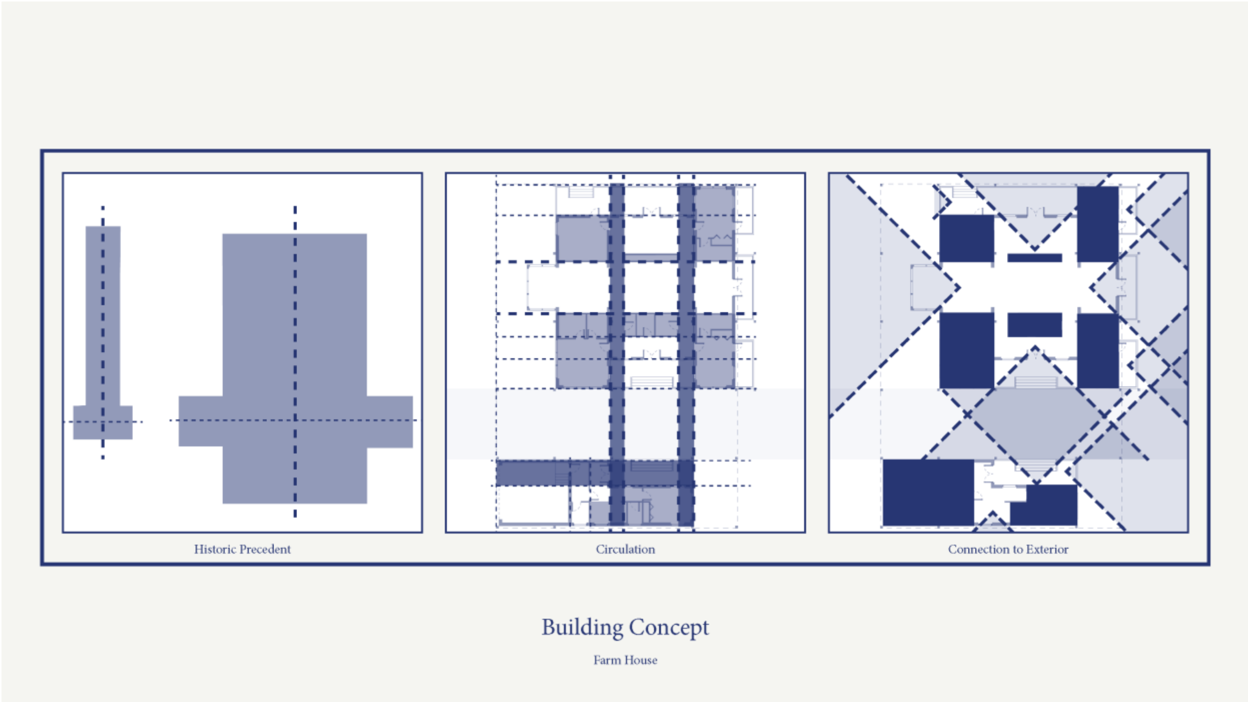


Figure 6.60 Building Concept (Source: Author)

Conclusion

In summary, Suspended Culture acknowledges the immediacy of climate change and how it threatens coastal agricultural practices as we know it. The thesis disrupts the cycle of displacement on the land by planning for the current and future realities of it by designating land to produce historic local food goods, invites people to interact with the landscape and agricultural practices, acts as a memorial to the history of the site and climate, and designs, specific, efficient, and durable buildings connected with the site.

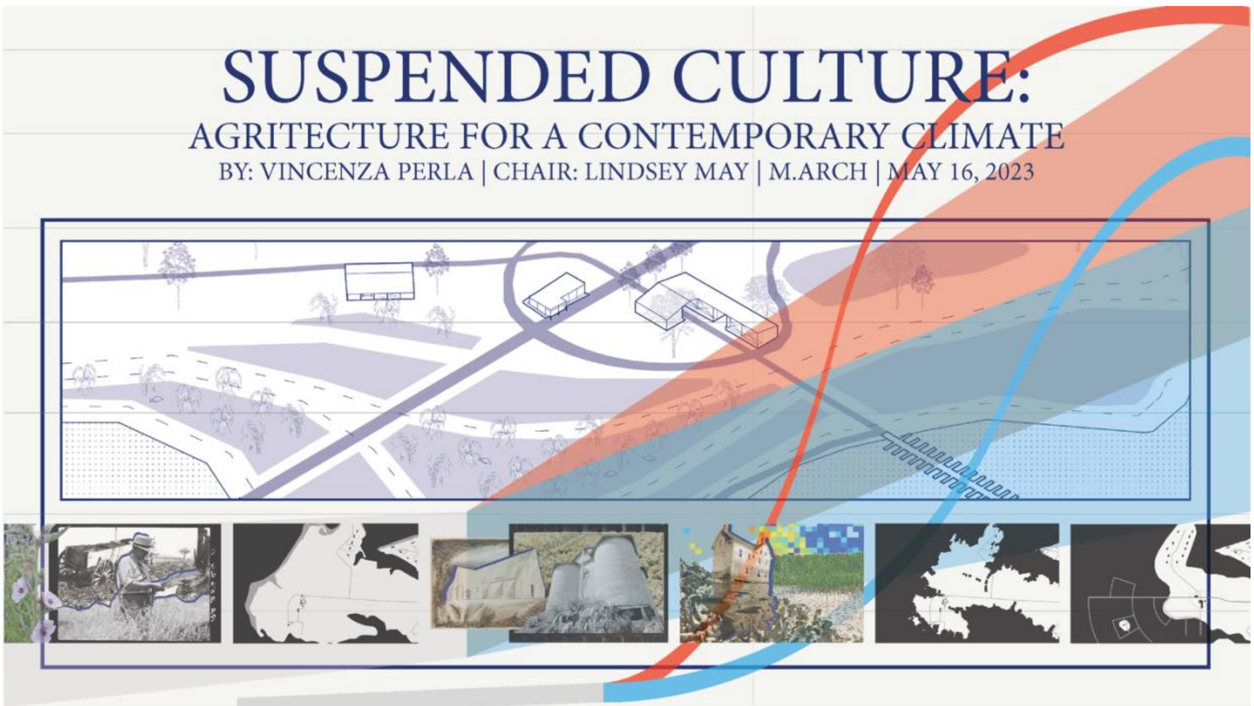


Figure 6.61 Conclusion (Source: Author)

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