Signs of Climate Change in the Hudson River Valley

**Extreme Precipitation**
- As the surface of the planet warms, more water evaporates into the atmosphere and turns into clouds.
- More water in the atmosphere means more frequent and intense rain storms.
- Our current infrastructure cannot handle the volume of rain water, leading to flooding in places that normally stay dry.

**Storm-Based Flooding**
- Projected extreme rainfall means that more and more areas that normally stay dry will begin to experience flooding during storms events.
- According to the National Climate Assessment, there was a 71% increase in very heavy precipitation from 1958-2011.

**Changing Temperature**
- Summers may be hotter and winters colder because climate change increases air temperature and shifts in air currents.
- Urban areas covered with pavement and concrete contribute to even higher temperatures in the urban environments.

**Sea Level Rise**
- Ocean tides push into the Hudson River all the way to Troy, so if the ocean level rises, so does the river level.
- There are two causes of sea level rise: first, as the water gets warmer it expands. Second, land-based ice is melting due to rising temperatures.
- So, a melting ice shelf in Greenland can change the water level in Piermont.

**Climate Change: A Global Phenomena**

**Causes**
- Recent rapid climate change is caused by human emissions that stay in the atmosphere.
- These emissions - greenhouse gases – come from burning fossil fuels for energy, transportation, industry, and other human activities.

**Effects**
- On a global scale, warming temperatures are melting ice shelves, raising sea level and adding more moisture into the air.
- Global changes in the air lead to more frequent and intense natural disasters on the ground, like hurricanes, heat waves and droughts.
- Effects can vary widely from place to place.

**Evidence**
- Our atmosphere is warming faster than it has in thousands of years.
- According to NOAA, ten of the warmest years on record have occurred since 1998.
- We know this from measuring ice core samples, tree rings, satellite images and more.

**Responses**
- Reducing greenhouse gas emissions can lessen the impact of climate change in the future.
- Adapting to changes happening now include taking action to reduce vulnerability to flooding, heat waves and other threats.
- Designing our waterfronts to recover from flooding is an important step we can take today.

**WHAT’S WITH THE WEATHER?**

Piermont copes with climate change

Experiencing climate-associated impacts in Piermont

- The major climate-associated impact experienced in Piermont is increased flooding from the Sparkill and the tidal Hudson.
- The Village’s waterfront neighborhoods, business district and emergency services are all vulnerable to flood risk.
- Piermont’s entire waterfront was seriously impacted by flooding during Tropical Storms Irene and Lee in 2011 and by a record-breaking storm surge during Hurricane Sandy.
- Beyond storm events, some waterfront areas are experiencing flooding during high tides, even during clear weather.

For more information, contact: Associate Professor Joshua F. Cerra, JFC299@cornell.edu. Website: http://tinyurl.com/CornellCAD
The Cornell Climate-adaptive Design (CaD) studio is a design research program that links Cornell students in landscape architecture with Hudson Valley communities to explore design alternatives that envision more climate resilient waterfront communities. By working with both the studio process and the design products it creates, we seek to inspire climate awareness and action within the communities with whom we work.

**WHAT IS CLIMATE-ADAPTIVE DESIGN?**

Envisioning vibrant waterfront communities

The design process begins with an initial analysis of the site including site visits to better understand the place that we are working in, and meeting with the community to understand their vision for a future waterfront. This analysis allows us to identify current and future challenges and opportunities.

During the design process we continually meet with stakeholders and community members to share our initial ideas and design concepts, including an onsite stakeholder workshop. We are committed to finding design strategies that work for many, and seek ongoing participation from the community.

On our campus in Ithaca, NY we refine the design concepts based on the information and feedback gathered during our community and stakeholder meetings.

At the end of the semester we present our final designs to the community to inspire further discussion about the value of vibrant and resilient waterfront communities.

**Partners**

Associate Professor Joshua F. Cerra directs the Climate-adaptive Design studio at the Cornell Department of Landscape Architecture. We work closely with our partners including Hudson River Estuary Program as part of the New York State Department of Environmental Conservation, Cornell Soil and Water Lab, Cornell Cooperative Extension, Scenic Hudson, and critically, our key community partners which have included Kingston, Piermont, Catskill and Hudson since 2015. The CaD Studio also wants to thank the many students and research assistants that have worked on this project over time.
CAD STUDIO IN PIERMONT
Building on strong foundations to inspire change

CaD Studio in Piermont

Piermont is located on the western shore of the Hudson River at the mouth of the Sparkill Creek near the northern edge of the Palisades, approximately 30 miles from NYC. The CaD studio took place in the Village of Piermont during the fall of 2017. A class of Cornell University undergraduate design teams, which included students from the Landscape Architecture, Biological & Environmental Engineering, and Urban & Regional Studies departments - proposed strategies to provide Piermont with innovative approaches to flood resiliency.

The Study Area

The CaD studio study area included a large section of the Piermont waterfront, extending from Piermont Marsh to the marina on North Piermont Avenue. The study area included Piermont Pier, the downtown business district and residential neighborhoods. The study area extended west to NYS Route 9W to include areas with potential to accommodate strategic relocation of key assets out of the flood zone.

The Stakeholders

Piermont stakeholders who participated in the CaD Studio process included elected officials and village staff; members of the Piermont Waterfront Resilience Commission, Local Waterfront Revitalization Committee and Planning Board; and representatives of community organizations, including the fire department, Sparkill Creek Watershed Alliance, Piermont Landing Condominium Association and the Piermont Civic Association.

The Issues

Stakeholders described a community that considers the natural world to be part of its identity. There is a strong interest in protecting the marsh, and in investigating methods for improving water quality in the Sparkill Creek. Strengthening connections to the waterfront, maximizing the recreational potential of Piermont Bay and capitalizing on the arts for economic development were identified as priorities. Flooding is the primary climate-related concern for stakeholders. There is a need to address vulnerable building and infrastructure, as well as traffic circulation and roadway flooding to assure safe evacuation routes. Some stakeholders expressed a vision of a future for Piermont as the “Venice on the Hudson”, while others want to explore innovative options for flood-prone neighborhoods, including amphibious housing and strategic relocation.
**DESIGN PRINCIPLES**

**Five Key Principles That Guide The Design Process**

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**DESIGN A WATERFRONT**

Maximize the value of what a waterfront can be

Designing a waterfront means:

- Taking advantage of and contributing to its waterfront location
- Emphasizing water-dependent and water-enhanced uses

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**Water-dependent Activities**

Activities that can only be conducted on, in, over, or adjacent to a body of water.

- Swimming
- Boat Launching
- Fishing
- Kayaking
- Sailing
- Water Trail

**Water-enhanced Activities**

Activities that do not require direct access to water, but whose waterfront location adds to the public’s use and enjoyment of the water’s edge.

- Hotel
- Restaurant
- Picnicking
- Wildlife Watching
- Scenic View
- Hiking
- Biking
- Walking

**Water-independent Activities**

Activities not requiring direct access to the water and whose waterfront location does not contribute to public use and enjoyment of the water’s edge.

- Parking
- Filling
- Grocery
- Field Sports
- Storage
- Auto Repair


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**CASE STUDY:**

**Scenic Hudson’s Long Dock Park, NY**

Located on the waterfront in Beacon, NY, this project showcases flood adapted structures and nature-based solutions for greater resilience. The site was once a transportation and industrial hub, and is now a destination for water-based activities. Long Dock Park features a floodable kayak pavilion, a beach for launching boats, a river overlook deck, a restored barn that is now a meeting and education center, a waterfront sculptural installation that highlights tidal changes, and trails that lead through rehabilitated wetlands and meadows.
DESIGN FOR FLOODING

Working with water may be better than working against it

Design for flooding means:

- Understanding strategies for reinforcement, adaptation, and strategic relocation
- Making choices that minimize flood risk
- Reinforcement
  Techniques that exclude or limit water from entering locations, like levees, sea walls, and hardened shorelines. While sometimes used to protect important infrastructure or development at risk of flooding, these solutions also carry “residual risks” if reinforced infrastructure fails, for example by over-topping by water.
- Adaptation
  Design techniques that incorporate uses and structures that can accommodate flooding, such as floodable landscapes and wet flood-proofed buildings.
- Strategic Relocation
  Design techniques that move important uses that cannot accommodate flooding out of the floodplain to places where they will not be impacted by water.

DESIGN FOR COMMUNITY

Waterfronts should be universally accessible and decidedly memorable

Designing for community means:

- Providing equitable access to waterfronts for the public benefit
- Creating a sense of place and destination
- Contributing to the prosperity and vision for the community
**Designing with nature means:**

- Building a healthy Hudson by creating and maintaining healthy terrestrial and aquatic ecosystems

**Interventions include:**
- Green Infrastructure
- Living Shorelines
- Assisted Marsh Migration
- Canopy Connectivity

**Benefits include:**
- Water Quality Enhancement
- Shoreline Stabilization
- Stormwater Management
- Recreation
- Shading and Temperature Regulation

**Designing for change means:**

- Creating adaptable places that consistently provide value with changing conditions

**Interventions include:**
- Phase 0: Assess the Issue
- Phase I: Provide the Framework
- Phase II: Attract Users
- Phase III: Fill in the Gaps

**Projects over time include:**
- 2020
- 2080
- 2100

**Benefits include:**
- Public Space
- Development
- Transportation
- Education

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This constructed wetland concept captures runoff from storms to improve water quality while contributing to the character and aesthetic of its park setting.
2080 Masterplan

Emphasizing connections between people, water and the environment, this design concept features a combination of resilience techniques. By 2080, the Pier is protected by reinforcement of the shoreline with a pedestrian walkway atop a floodwall. The marsh is allowed to migrate inland, facilitated through strategic relocation of southeastern neighborhoods. An elevated walkway provides access to the second story of storefronts on Piermont Avenue, preserving the Village's commercial core.

I. Green Connections

Piermont Avenue features a floodable green corridor that accommodates inland marsh migration while screening intertidal surfaces with vegetation.

II. Water Connections

Two park areas are designed to illustrate Piermont’s relationship with water. One park is linked to the Hudson to exhibit changing water levels as sea level rises; a second park is sited above an existing parking lot that periodically floods, allowing for parking when not flooded with new green space permanently above it.

III. People Connections

This design concept strives to keep people connected to the water under changing conditions. Permitting considerations for marsh boardwalks include minimizing impacts by constructing narrow walkways raised high on helical piles. Inland walkways that provide access to water-dependent uses are best.

What is this project about:
"Piermont is a community situated amongst a natural landscape, deeply connected to the Hudson River. Our project aims to enhance Piermont’s relationship with nature and the Hudson through strengthening all of the places and connections that give Piermont its unique identity. In this way, we see Piermont as "reappearing" because it emerges as an example of a climate adaptive community that can withstand flood waters as they come.”
- Blake Enos, Sage Magee, and Jacob Kuhn

CaD Studio Design Team:
Blake Enos (BSLA ’18)
Sage Magee (BSLA ’18)
Jacob Kuhn (BS Urban & Regional Studies ’18)
PIERMONT NEXUS

What is this project about:
"Piermont Nexus will transform the flood-prone village into a safe, vital, and attractive waterfront community, by improving its preparedness for sea-level rise and extreme storm events in the next six decades; strengthening its connectivity both within and without, for mankind as well as for wildlife; and enhancing its economic and cultural competitiveness."
- Woo Young Choi, Yiren Du, and Shaun Wu

I. Gathering at the Hub

2080 Masterplan

This bold design concept envisions elevating the entire downtown area on a ‘megaberm’ of fill above frequent flooding levels. The foundation upon which the downtown would be sited features an ecological “edge” composed of green spaces, room for marsh migration and wildlife habitat.

A New Urbanist “Hub” at Flywheel Park provides a mixed-use center with residences re-located from flooded neighborhoods, commercial outlets, and community gathering spaces to form a new town center, all elevated well above projected sea level rise and flooding from storm events.

II. Softening the Edge

Built on the Southeastern corner of the elevated intersection of Ferry Road and Piermont Avenue, the Terrace is envisioned as a series of artificial platforms planted with vegetation. Further design development would be necessary to understand if such an intervention could be permitted, and how it would withstand wave action and ice shear while tying into the rest of the shoreline.

III. Measuring Sea Level Rise

The elevated Pier will provide non-automotive access to the Hudson River while featuring a floodable fishing facility and demonstrations that educate visitors about sea level rise. A water feature at the end of the Pier would register river levels relative to projections for sea level rise over time.

CaSt Studio Design Team:
Woo Young Choi (BSLA ’18), Yiren Du (BSLA ’18), Shaun Wu (BS Urb & Regional Studies ’19)

The Climate-adaptive Design Studio is provided through a partnership between Cornell University Water Resources Institute and the New York State Department of Environmental Conservation's Hudson River Estuary Program.
The project seeks to balance strategic relocation of low elevation locations and uses with installation of levees to protect other neighborhoods. This approach is not without technical challenges and residual risks of flooding by overtopping or bank failure during a major flood. The Commercial Pier would provide business development opportunities while also serving as a barrier protecting Piermont from objects floating downstream during river flooding.

II. Protecting Piermont Landing

Flooding in Piermont Landing would be reduced by the installation of a berm with a pedestrian path on top and a bioengineered shoreline at the water’s edge.

III. Exploring Amphibious Housing

In this concept, new housing would be built on stilts, yet able to adjust by floating with changing tidal and sea level rise elevations. This approach would require further development to investigate design efficacy, site suitability and permitting requirements.
PIERMONT: THE NEW BEGINNING

CaD Studio Design Team: Abdulaziz Alrifaie (BSLA ’18), Lucas Bulger (BS Urban & Regional Studies ’19), Naixin Ren (BSLA ’19)

What is this project about:
"We envision a world-class resilience museum that expands beyond the scope of a building, becomes the center of Piermont’s community, educates residents and tourists on our design interventions, and solidifies Piermont as an international leader in climate adaptation.”
- Abdulaziz Alrifaie, Lucas Bulger, Naixin Ren

I. Attraction, Education, Preparation

The museum concept includes a flood-proofed building and incorporates demonstrations of best practices for flood resilience, as a sort of road map or "legend" for the Village itself as a showcase of adaptation strategies. Elevated walkways throughout the village and marsh offer a tour through different adaptation techniques, including flood-proofing, facilitated sediment accretion to encourage wetland creation, and green infrastructure.

II. Connect, Construct, Adapt, Expand

The proposed concept calls for a phasing of projects and policy that would allow implementation of the entire plan over time. Suggested techniques for facilitating strategic relocation included a gradual phase-in of zoning, transfer of development rights, rebuilding restrictions, tax-increment financing and buyouts. This design also included a breakwater north of the pier to create shallow water vegetated habitat that could also protect the north side of Piermont. From a practical standpoint, installation of a breakwater and/or levee would require review for feasibility and permitability should such interventions be actively pursued.

2080 Masterplan

This team acknowledged that Piermont has re-invented itself many times in its history, and recognized the community’s capacity to adapt to change. To this end, they proposed reconstructing a more resilient waterfront by providing limited flood protection while facilitating relocation of neighborhoods susceptible to projected sea level rise over time. A proposed levee would have an engineered weir to allow passage of creek flows and daily tidal fluctuation, while protecting against significant Hudson flood events. The levee would also serve as a bike path as part of a comprehensive bike plan. In response to stakeholder input, this team proposed a 'resilience museum' that would serve as both exhibition space and as a floodwall along the north end of the pier.

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