Resilient Connecticut Synthesis Report Appendix A

Support Activities

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Appendix A – Support Activities

Several support activities were completed to support the planning process throughout each phase of the Resilient Connecticut project including flood risk assessment and high-resolution model development, adaptation option evaluation, and capacity building research led by UConn affiliated faculty, researchers and staff. The following is a summary of support activities completed over the course of the project.

Flood Risk Assessment

The goal of the flood risk assessment under the Resilient Connecticut project is to establish a robust and scientifically validated strategy for evaluating and mitigating flood risks along the Connecticut coast. This involves leveraging high-resolution models and empirical data to create accurate flood risk maps, identify vulnerable areas, and guide infrastructure planning and resilience-building measures to protect communities from future flood events exacerbated by climate change.

The flood risk assessment aims to achieve the following specific objectives:

- Identify Vulnerable Areas: Determine the areas most susceptible to flooding due to storm surges, high tides, and sea-level rise.
- Quantify Flood Risks: Develop probabilistic models to estimate the likelihood and severity of flooding events for different return periods.
- Guide Infrastructure Planning: Provide data and insights to support designing and implementing resilient infrastructure and flood mitigation measures.
- Enhance Community Resilience: Equip local governments, planners, and stakeholders with the necessary tools and information to improve community preparedness and response strategies.
- Integrate Climate Change Projections: Incorporate future sea-level rise and climate change scenarios into flood risk assessments to ensure long-term resilience planning.

Implemented Actions

1. Model Development and Calibration:

The project utilized the Finite Volume Community Ocean Model (FVCOM) coupled with the Simulating WAves Nearshore (SWAN) model to simulate coupled coastal circulation and wave model of the 44 highest storm surge events in Long Island Sound from 1950 to 2018. Topographic data is combined from the LIDAR Digital Elevation Model (DEM) and the USGS Coastal National Elevation Database (CoNED). Data sources included tide gauges, buoys, and airports for water levels, wave heights, and wind speeds. Time series of surface water elevations were reconstructed using eight tidal constituents and adjusted based on observations from the Montauk, NY station. Wave boundary conditions were obtained from NOAA's WAVEWATCH III hindcast data, providing significant wave heights, wave directions, and peak periods. This model offered detailed water level and wave height data, which were essential for understanding historical storm impacts and predicting future risks.

2. Extremal Analysis and Probability Distributions:

Poisson-Generalized Pareto Distributions (GPD) were fitted to the modeled water levels and wave heights to estimate annual exceedance probabilities for different return periods (10%, 3%, 2%, and 1%

AEP). This statistical approach allowed for precise quantification of flood risks across various Connecticut coastal towns.

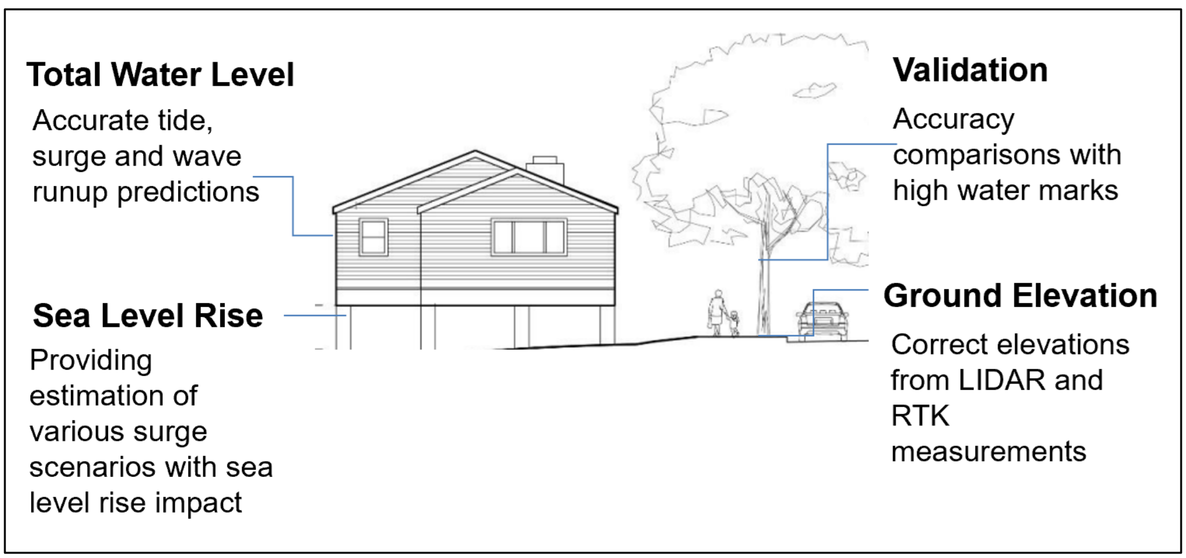
3. Integration of Sea-Level Rise Projections:

The models incorporated an upper-bound projection of 20 inches of sea-level rise by 2050. This integration assessed the impact of future sea-level changes on storm surge and flood probabilities. The analysis revealed a significant increase in the frequency of extreme flood events, with a 10-year storm event potentially becoming a 2-year event under future sea-level conditions.

4. Model Evaluation through Field Work:

Field observations and data from NOAA tide gauges at Kings Point, Bridgeport, New Haven, New London, and Montauk and buoys (NDBC buoys 44025 and 44097) validated the model results. Comparisons are made for significant historical storms, including Hurricanes Irene and Sandy. This step was crucial to ensure the accuracy and reliability of the flood risk assessments. The validation confirmed that the model predictions were within acceptable error margins compared to historical data and other studies, such as the North Atlantic Coast Comprehensive Study (NACCS) and FEMA flood maps. The model accurately predicted peak water levels and wave heights, with errors primarily occurring in areas with complex local bathymetry.

The model evaluation process also involved deploying water level sensors and current meters in strategic locations to collect field data. The data collected during fieldwork showed that the models provided reliable flooding extents and depth predictions. The fieldwork was performed in Guilford, New Haven, Norwalk, Stamford, and Branford to cover a range of morphological conditions across the study area.



Caption: Factors included in the development of high-resolution flood models for the Resilient Connecticut study area.

The high-resolution FUNWAVE-TVD model was calibrated using observed data from significant historical storms, such as Super Storm Sandy, and validated against 17 locations of observed high-water marks (HWM) in Branford, Norwalk, and New Haven and Acoustic Doppler Current Profilers (ADCP) measurements for minor storms in 2015 in New Haven harbor with absolute error ranging between

0.07-0.13 m. The validation process showed good agreement between modeled and observed data, with root mean squared errors (RMSE) of 0.25 meters and a Willmott score of 0.92, indicating high reliability.

5. Development of Flood Extent Maps:

Flood Extent Maps were created and used as inputs for the flood models. These maps project the estimated flood extent for the shoreline towns. The maps were also used to prepare an accessible online storm surge viewer which can be found at https://circa.uconn.edu/sea-level-rise-and-storm-surge-viewer/.

6. Coordination with Related Programs:

The project team coordinated with ongoing studies conducted by the US Army Corps of Engineers (USACE), NOAA, and other regional efforts. This coordination ensured consistency in flood risk modeling and the adoption of best practices. Collaborative efforts included reviewing and comparing results to enhance the overall resilience strategy for the Connecticut coast, which led to the need for high-resolution models in specific regions.

7. High-Resolution Model Development

Flood hazard planning requires accurate estimations of total water elevation due to predicted tide, surge, and wave runup to design flood protection structures and improve coastal risk planning for severe storms. The conventional approaches of flood modeling are limited due to either.

i. simple static estimates,
ii. the application of a coupled circulation and phase-averaged wave models in coarse resolution,
iii. failing to calibrate and validate with in-situ data,
iv. or not considering sea-level rise projections in mapping the flood extent.

In support of Phase III planning activities, the CIRCA team performed high-resolution nearshore modeling studies to assess and estimate flood risk in Branford, Norwalk, Fair Haven, and Fairfield under historical and future scenarios. Open boundary forcing includes wave and surge water levels from a Long Island Sound model described by Liu et al. (2020). The elevations of bridges or underpasses are not indicated in the DEM data and were surveyed onsite with RTK GPS. The modeled maximum water levels were compared with USGS high water mark (HWM) measurements taken during Superstorm Sandy. The nearshore model uses the boundary conditions from the Long Island Sound model. The study used a fully nonlinear Boussinesq wave model called FUNWAVE-TVD and ADCIRC-SWAN, which simulates how waves move and interact with the coastline. This model is particularly good at predicting wave behavior in shallow waters, where waves can break and run onto shore. A total of 6 scenarios of current floods (10-,50- and 100-year) and future floods (10-, 50- and 100-year +20 inches sea level rise) were considered. This study's advanced modeling approach provides a more accurate understanding of flood risks along Connecticut's coast. By predicting how extreme storms and future sea-level rise will impact the region, high-resolution models demonstrated superior accuracy in predicting total water levels, wave runup, and overtopping in shallow water regions, supporting better flood risk management and helping build more resilient coastal communities.

Additionally, CIRCA investigated water flow through a narrow inlet connecting a coastal basin to the ocean, specifically focusing on a site in Guilford, Connecticut. CIRCA employed four ocean circulation models (ADCIRC, FVCOM, ROMS, SCHISM) to simulate tidal exchanges and water levels. The research highlights that in such narrow inlets, the primary force balancing the water flow is the lateral shear created by the channel's banks rather than bottom friction, which is more influential in wider channels. This lateral shear causes a significant reduction in tidal amplitude and delays in the tidal phase on the basin side of the inlet. Observations and model results showed significant tidal attenuation and phase lag due to the inlet's strong lateral shear and horizontal eddy viscosity.

The study developed an analytic model to predict bayside water levels, which closely matched the complex numerical simulations and provided an efficient method for estimating water exchange in narrow inlets. This simplified model offers a faster and more efficient way to estimate water exchange in similar narrow inlets. The study's results underscore the importance of using high-resolution models to accurately simulate tidal dynamics in narrow coastal inlets, providing valuable guidance for coastal management and flood protection efforts. These findings help improve our understanding of how narrow inlets can significantly impact water flow and material exchange in coastal environments.

8. Mapping Product Evaluation

The evaluation of mapping products, including the Coastal Vulnerability Index (CVI, which was the pilot project of the Climate Change Vulnerability Index), was conducted in Milford and in other regions to develop, demonstrate, and assess the effectiveness of these tools through Resilient Connecticut collaborative engagement. The detailed analysis of various contributors and focus zones helps identify critical areas that need attention and adaptation measures. Participants provided feedback on the tools' usability, accuracy, and comprehensiveness. They also discussed their experiences with flooding and coastal hazards to validate the model predictions. The groups found the CVI and related mapping products effective in highlighting vulnerable areas and guiding adaptation planning. The tools were valuable for raising awareness and engaging the community in resilience planning. The collected feedback has been instrumental in refining the tools, ultimately enhancing their role in supporting informed decision-making and fostering community resilience against coastal flooding and sea-level rise and led to more complex climate change index mapping.

Key Findings of Long Island Sound Model (Liu et al., 2020)*:*

The Long Island Sound model from FVCOM-SWAVE focused on accurately estimating the annual exceedance probability of water levels and wave heights using a high-resolution coupled wave-circulation model in Long Island Sound. Key findings include:

- Higher water levels for given return periods along the western Connecticut coast than the eastern coast. This spatial variation highlights the need for region-specific flood mitigation strategies. For instance, the 1% annual exceedance probability, corresponding to a 100-year storm event, resulted in water levels of approximately 2.78 meters in Bridgeport, 2.55 meters in New Haven, and 2.03 meters in New London. These findings are crucial for identifying areas at higher risk of flooding and prioritizing them for resilience planning.
- An eastward increase in significant wave heights. For example, the 1% annual exceedance probability for wave heights showed values of 4.48 meters in Bridgeport, 3.98 meters in New Haven, and 4.91 meters in New London in open ocean. Understanding these patterns is crucial for coastal infrastructure design and
- Validation of model results with tide gauge and buoy observations, showing good agreement with the NACCS study. This validation confirmed the reliability of the model predictions.

- Comparisons with other studies, such as the North Atlantic Coast Comprehensive Study (NACCS) and FEMA flood maps, revealed that existing models often overestimate or underestimate flood risks due to their lower resolution and simpler approaches.
- The advanced FVCOM-SWAVE model provided more accurate and detailed predictions, highlighting the importance of using high-resolution models for flood risk assessments.
- The study demonstrated the significant impact of a projected upper bound of 20-inch sea-level rise by 2050, which would reduce the return periods for extreme events, thereby increasing the frequency and severity of flood events. This finding underscores the urgency for adaptive planning and infrastructure resilience.

Key Findings from High-Resolution Model Development (Liu et al., 2021)*:*

The high-resolution model development simulates wave and storm surge flooding scenarios for different return periods. Key actions included:

- The flood risk assessment utilized the FUNWAVE-TVD, a high-resolution, phase-resolving Boussinesq wave model, to accurately simulate the nearshore wave dynamics and wave runup processes. This model was applied to three Connecticut coastal towns: Branford, Norwalk, and New Haven, which were chosen for their complex topography and unique coastal features. Use a fully nonlinear Boussinesq wave model (FUNWAVE-TVD) with a high-resolution grid to determine total water elevation on shores.
- The model incorporated high-resolution bathymetry and topography data from the USGS Coastal National Elevation Database (CoNED), ensuring a detailed representation of the coastal landscape.
- Simulating four flooding scenarios: 10-year, 10-year plus 20 inches (sea-level rise), 100-year, and 100-year plus 20 inches.
- The resulting risk maps indicated little difference in flood extents between 1% and 10% AEP scenarios for 2050, emphasizing the need for adaptive planning and implementing resilient infrastructure to cope with more frequent flooding.
- The FUNWAVE-TVD model was evaluated against existing flood risk maps, including FEMA's Flood Insurance Rate Map (FIRM), the North Atlantic Coast Comprehensive Study (NACCS), and the FVCOM-SWAVE model. These comparisons highlighted the advantages of using high-resolution, phase-resolving models for accurate flood risk assessment. FEMA's methodology uses one-dimensional empirical wave runup equations applied perpendicularly to the shore using the RUNUP 2.0 model. This approach does not account for complex nearshore wave interactions such as diffraction and reflection, resulting in coarse spatial variations and often overestimating total water elevations, particularly in regions with intricate coastal topography.

  In contrast, NACCS employs a more sophisticated coupled ADCIRC-STWAVE model to simulate storm surges and wave impacts on a regional scale, including synthetic and historical storms. However, NACCS uses a coarser spatial resolution (200 meters) and lacks calibration for specific in-situ measurements in Long Island Sound. This leads to higher root-mean-square errors in predicted water levels and wave heights compared to FUNWAVE-TVD, especially in areas with complex shallow-water dynamics. FUNWAVE-TVD, with its phase-resolving capabilities and fine spatial resolution, provides more accurate predictions of wave processes, including wave runup and overtopping, making it more suitable for detailed coastal flood risk assessments in regions with complex coastal features.

Adaptation Option Evaluation

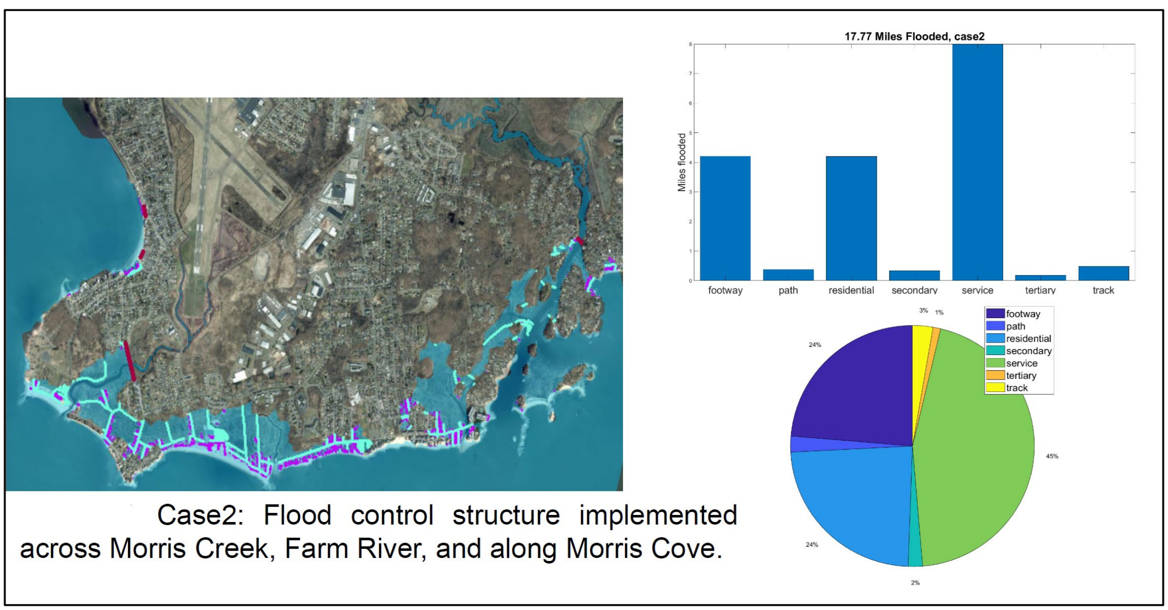
Risk Reduction Assessment through Flood Control Structure Evaluation: West Haven & East Haven

A pilot project was developed to employ simulation tools to evaluate the effectiveness of various adaptation strategies identified as a high priority in two vulnerable areas identified in the Phase II regional planning process, in West Haven and East Haven, CT. These strategies include building berms, raising roads, and modifying culverts to reduce vulnerability. The CIRCA team developed simulations to provide a quantitative assessment of the reduction in flood risk and other benefits offered by different adaptation designs.

The flood depth maps generated by ADCIRC simulations assess the impacts on streets, buildings, and lifelines using GIS tools. The analysis included estimating the amount of water on streets (including sidewalks and parking areas), buildings, and critical infrastructure in selected study areas.

The East Haven study showed significant reductions in flooded buildings and roads under different flood control scenarios:

- Case 0: No flood control structure.
- Case 1: Implementing a flood control structure across Morris Creek and Farm River.
- Case 2: Implementation of flood control structures across Morris Creek, Farm River, and along Morris Cove.



Caption: Evaluation of potential effects of different adaptation options in the Morris Creek and Farm River in East Haven, CT.

The results indicated that implementing flood control structures could lead to substantial decreases in flooded buildings. Case 1 reduced flooded buildings by 25.5% and flooded roads by 13.4%, and Case 2 (up to 76%) and roads (up to 20%).

The West Haven study simulated the impact of a 100-year storm event with a 20-inch sea-level rise and future sea-level rise under three road-raising scenarios

- Scenario 1: Elevate the road to 9 feet.
- Scenario 2: Implement city-proposed Phase 1 and 2 plans.
- Scenario 3: Elevate the road to 11 feet.

New Haven Harbor, zoom on West Haven, buildings flooded: 10 years + 20 inches vs 100 years + 20 inches.

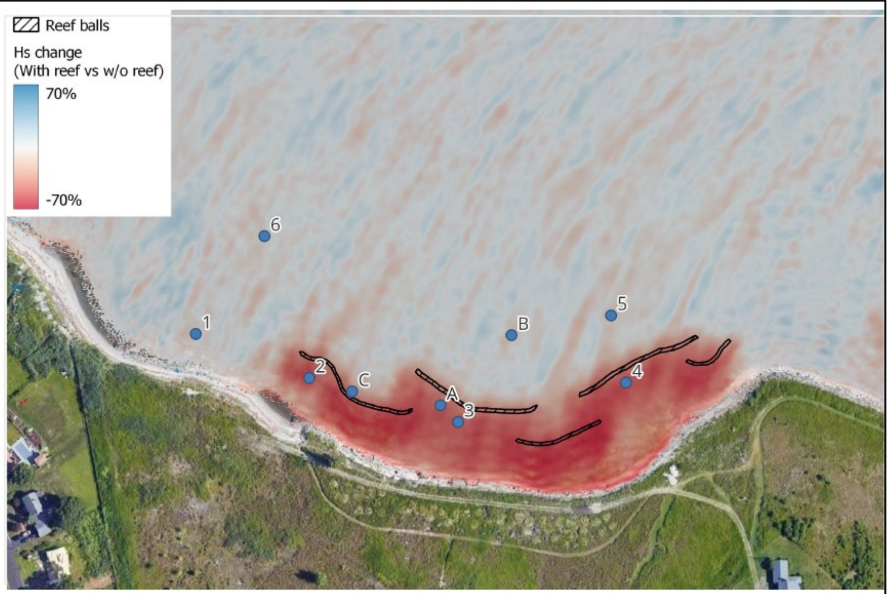
Caption: Evaluation of the extent of flooded structures and buildings under a scenario that includes elevation of Beach Street and First Avenue in West Haven, CT.

The results indicated extensive flooding while road-raising scenarios (Scenarios 2 and 3) significantly reduced flood extent. Scenario 3, with an 11-foot elevation, nearly eliminated flooding, demonstrating the effectiveness of this mitigation measure.

The research provided valuable insights into the most effective strategies for flood mitigation in urban areas by simulating different scenarios.

Risk Reduction Assessment through Artificial Reefs: Stratford & Great Island Marsh, Old Lyme

This study aimed to determine the best place for these reef balls to maximize their wave-reducing effects. The FUNWAVE-TVD v3.5 model was used to simulate this area, with the reef balls represented as zones of elevated bottom in the model's bathymetry. Observations and model results were compared to evaluate the wave transmission coefficient and the effectiveness of the reef balls.



Modeled significant wave height change caused by the reef balls in Stratford, CT. Red indicates decrease and blue indicates increase.

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Caption: Modeling assessment of the effectiveness of reef balls at Stratford Point, Stratford, CT.

The model showed that the reef balls in Stratford reduced wave heights by about 60%. Observations matched the model's predictions, confirming the accuracy of their simulations. The model predicted a potential wave height reduction of up to 70% for the Great Island Marsh with the new reef ball arrangement. This significant reduction could help protect the marsh from ongoing erosion.

The study confirms that reef balls can effectively reduce wave heights and protect coastal areas from erosion. Placing these structures at optimal depths can maximize their wave-dampening effects.

Products Created

1. Flood Risk Maps:

High-resolution flood risk maps were developed for Connecticut coastal towns. These maps depict floodwater elevations and significant wave heights for different annual exceedance probabilities (10%, 3%, 2%, and 1%). They serve as crucial tools for local planners, policymakers, and stakeholders, providing actionable insights for flood risk management

2. 2050 Risk Maps:

Future risk maps were prepared to account for a projected 20-inch sea-level rise by 2050. These maps illustrate how increased sea levels affect flood extents and frequencies, offering essential data for long-term coastal resilience planning and decision-making.

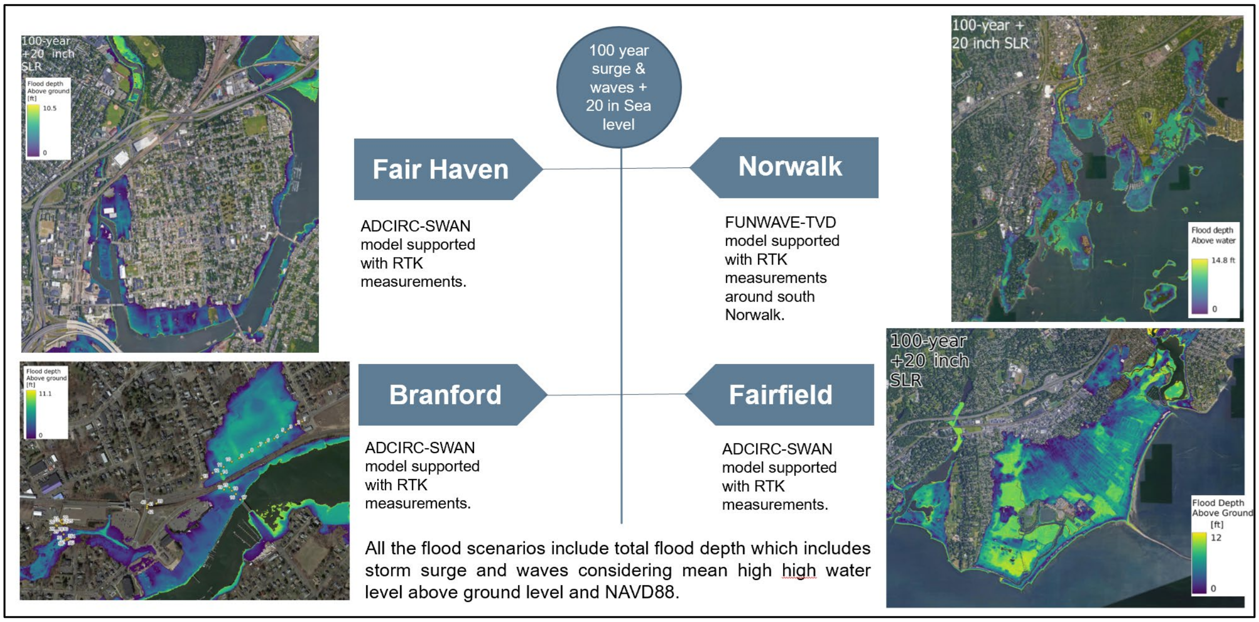
After validating the models, the project used high-resolution simulations to create flood risk maps for 2050, considering a projected sea-level rise of up to 20 inches. These maps provide critical insights into future flood risks, guide long-term planning and resilience-building efforts, and can be accessed through Sea Level Rise Viewer.

3. Data Sharing and Mapping Capability through Online Data Portal:

An online portal was created to share digital elevation models, flood risk maps, and critical infrastructure inventories with stakeholders. This portal facilitates access to the data needed for informed decision-making and community engagement.

4. Reports and Documentation:

Comprehensive reports detailing the flood risk assessment methodologies, results, and implications were produced. These documents provide a scientific foundation for understanding flood risks and formulating adaptive measures to enhance community resilience.



Caption: Risks maps were prepared to support planning in several communities selected for site plan development in Phase III of Resilient Connecticut including the Fair Haven section of New Haven; South Norwalk; Meadow Street, Branford; and the South End of Fairfield, CT.

Capacity-Building Activities

Several projects were initiated to build capacity for resilience planning, involving applied research led by faculty from the University of Connecticut or CIRCA in areas such as economic risk modeling, legal analysis, and the characterization of vulnerable populations. These activities aim to enhance local and regional planners' technical and analytical capabilities, ensuring they are well-equipped to implement resilience strategies. This includes developing research projects on the economic impacts of climate adaptation and the legal frameworks necessary to support resilience initiatives.

1. Neighborhood Scale Heat Index Variability

The CIRCA team deployed heat sensors across urban neighborhoods in several communities to measure and map heat index variability. This initiative aims to identify areas most vulnerable to heat and understand how environmental conditions related to human heat stress vary within urban settings.

CIRCA installed heat sensors in different locations in each town to assess temperature across different land-use typologies and environmental features. Cities selected for this research included New Haven during 2020-2021 and Danbury and Norwalk during the summer of 2022. These sensors were placed 8-10 feet above ground level on poles or trees to continuously record temperature, humidity, and dew point temperature every 10 minutes. The sensors provide real-time feedback on street-level climate conditions, including temperature, relative humidity, and dew point. The data is used to compute the heat index, representing the human-perceived equivalent temperature. The study classified local climate zones using a machine learning approach with tools like Google Earth Pro and SAGA GIS using the methodology developed by (Alfonso Fragomeni et al., 2021; Oke, 1982). Socio-economic characteristics were analyzed using the social vulnerability index and Census Data, while the Climate Change Vulnerability Index (CCVI) was used to identify the most vulnerable locations.

Caption: Yaprak Onat, CIRCA Associate Director of Research, installing a heat sensor in Norwalk, CT.

Key Findings:

Heat Index Variability: There is significant variation in temperature and humidity across different locations, with differences reaching 5-10°F. This variability highlights the importance of localized climate data in understanding urban heat stress.

Impact on Vulnerability: The study emphasizes that these temperature differences should be considered when developing adaptation solutions to extreme heat, as they directly affect human comfort and health.

2. Heat Vulnerability and Land-Use Influence

This research project, led by Dr. Mariana B. Alfonso Fragomeni, Ph.D. student Tracey Miller, and undergraduate assistant Katherine Day, aims to identify changes in heat vulnerability and the influence of land use over 20 years in Fairfield and New Haven Counties, Connecticut.

Methodology

The study utilized thermal remote sensing and localized sensor measurements to analyze land surface temperature (LST) and land-use and land-cover (LULC) changes. Data was sourced from the Landsat satellite collection and the National Land Cover Dataset (NLCD). The researchers applied the local climate zones (LCZ) classification to explore the relationship between LST changes and urbanization. Additionally, a network of heat sensors was deployed in New Haven to measure air temperature and relative humidity, which facilitated the calculation of the heat index and assessing heat vulnerability.

Findings

The results revealed that urban heat islands' occurrence and intensification are closely linked to vegetation loss due to urbanization. The most significant temperature increases were associated with the loss of forest cover. Developed areas exhibited higher surface temperatures than vegetated areas, with urban environments reaching maximum surface temperatures of 141.7 degrees Fahrenheit. The study highlighted the critical role of preserving tree canopy cover and forested ecosystems in mitigating heat vulnerability and enhancing public health.

Conclusion

The findings of this project are crucial for local decision-makers as they determine communities' thermal vulnerability. The study emphasizes the importance of land-use planning and urban design, prioritizing vegetation conservation. Addressing the impacts of urban heat islands is essential for improving human health and well-being.

More details on the study can be found of the project page here: https://resilientconnecticut.uconn.edu/heat-vulnerability/

3. Zones of Shared Risk Charette

The Zones of Shared Risk Charette, led by UConn's Community Research & Design Collaborative (CRDC) under the direction of Dr. Peter Miniutti and Dr. Mariana Fragomeni, focused on sustainable planning and design in coastal Connecticut areas vulnerable to climate change. The project aimed to identify lands of unique value and shared risk, creating a foundation for effective risk reduction strategies. This study was developed to build on the zones of shared risk concept and articulate an approach for the wider study area in Phase II of Resilient Connecticut.

Methodology

The CRDC team comprehensively analyzed natural and cultural land features to determine future land uses that balance conservation, preservation, and sensible development. The study included the creation of detailed maps that illustrate the effects of projected sea-level rise and flooding over time in coastal areas of New Haven and Fairfield Counties. These maps integrated data on topography, elevation, projected flooding, ecological systems, structures, roadways, and land uses with social characteristics. The analysis identified areas impacted by sea-level rise, infrastructure vulnerability, and socially vulnerable populations using the Social Vulnerability Index (CDC).

Findings

The analysis revealed that approximately 2,193.33 acres of watersheds are projected to be impacted by sea-level rise, with the South Central Shoreline and Quinnipiac River being the most affected subregions. The infrastructure analysis showed that 1,678 buildings and 116.68 acres of roadways are at risk of flooding. The social vulnerability analysis highlighted that 695.45 acres are socially vulnerable, while 570.48 acres are identified as Opportunity Zones.

Conclusion

The project underscores the importance of proactive and holistic planning efforts to mitigate the adverse effects of sea-level rise and improve residents' overall quality of life. The detailed maps and analysis serve as valuable tools for designers, decision-makers, and citizens to understand and address the shared risks associated with climate change.

More details on the study can be found of the project page here:
https://resilientconnecticut.uconn.edu/zones-of-shared-risk/

4. Transit-Oriented Development for a More Climate-Resilient Connecticut

This research was conducted by Dr. Norman Garrick, Dr. Carol Atkinson-Palombo, and Dr. Rosalie Singerman Ray. It analyzed the challenges and obstacles to implementing Transit-Oriented Development (TOD) along the Metro-North New Haven main line in Connecticut. The study focused on evaluating the vulnerability of the Metro-North mainline and its associated TOD areas to sea-level rise and provided recommendations for improving TOD implementation.

Methodology

A mixed-methods approach was employed, including content analysis of TOD plans, stakeholder interviews, and quantitative analyses of bus service, street networks, and sea-level rise impacts. The study utilized CIRCA's 1% annual exceedance probability (AEP) storm surge flood shapefile for 2050 to assess the vulnerability of TOD zones to sea-level rise.

Findings

The research identified several challenges to TOD implementation, including issues with coordination, political opposition, and inadequate transit infrastructure. Many of the Metro-North main line and associated TOD areas are vulnerable to sea-level rise, highlighting the need for proactive planning. Additionally, enhanced bus service and improved walkability were essential for successful TOD.

Recommendations

The study proposed several actionable recommendations to address these challenges:

- Mandate the incorporation of sea-level rise analysis in TOD planning.
- Invest in cities with existing transit-supportive land uses and street networks.
- Improve standardized, statewide data collection and provision.
- Support hiring transportation staff with expertise in land use and resiliency.

Conclusion

This comprehensive analysis of TOD challenges provided valuable insights and proposed actionable recommendations to enhance climate resilience and support car-lite living through improved transit and land-use planning. These measures are essential for ensuring the long-term viability and effectiveness of TOD initiatives in Connecticut.

More details on the study can be found of the project page here:
https://resilientconnecticut.uconn.edu/tod/

5. Shoreline Retreat and Housing Market Analysis

The "Real Estate Values, Tax Revenues, and Climate Change-Induced Retreat from Flood Zones" study by Dr. Charles Towe examines the effects of climate change and sea-level rise on real estate values and local tax revenues in Connecticut. The project evaluates the economic impact of flood risk and suggests retreat as a strategy to enhance coastal resilience.

Methodology

Researchers conducted a comprehensive analysis using data from Zillow's Transaction and Assessment Dataset (ZTRAX) and FEMA flood maps to study the housing market in Connecticut's coastal areas. Hedonic regression models were employed to estimate the impact of flood risk on housing prices, considering factors such as waterfront access, floodplain location, and property characteristics. Additionally, simulations assessed the economic implications of different retreat scenarios, factoring in tax revenue loss and potential benefits from increased property values in less vulnerable areas.

Findings

The study found that properties within the 100-year flood zone experienced a price discount of about 2.5%, while waterfront homes commanded a significant premium. Retreat scenarios indicated that although initial tax revenue losses are substantial, they can be partially offset by gains in property values and reduced emergency management costs. The analysis underscored the importance of considering long-term economic impacts and potential retreat benefits to enhance community resilience.

Recommendations

Policymakers should consider managed retreat a viable strategy to mitigate flood risks and enhance coastal resilience. Further research is necessary to refine the models and incorporate more detailed data on elevated structures and insurance premiums.

Conclusion

This project offers a thorough economic analysis of flood risk and managed retreat, providing valuable insights for policymakers to develop effective coastal resilience strategies. By considering the long-term financial impacts and potential benefits of retreat, communities can better prepare for and adapt to the challenges posed by climate change.

More details on the study can be found of the project page here: https://circa.uconn.edu/real-estate-values/

6. Extreme Precipitation and Riverine Flood Risk Analysis

This project, conducted by Dr. Xinyi Shen and PhD Student Kang He, aimed to understand and quantify flood impacts and damages in coastal areas particularly vulnerable to high streamflow and surge. The study utilized advanced hydrological and hydraulic models to simulate flood inundations and assess flood risks under various climate and land-use scenarios.

Methodology

The researchers combined the Coupled Routing and Excess Storage (CREST) model and the Hydrologic Engineering Center's River Analysis System (HEC-RAS) to simulate flood events. CREST provided hourly streamflow simulations using the National Land Data Assimilation System (NLDAS) weather data. This streamflow data was then imported into HEC-RAS for unsteady flow analysis, which included geometric and surge data from NOAA.

Findings

The study revealed that urbanization increases flood risks by raising streamflow and inundation depths. Simulations indicated that compound flood events, which combine high streamflow and surge, resulted in larger inundation extents than floods caused by a single source. The model's accuracy was validated using historical flood events, such as Hurricane Irene, demonstrating its effectiveness in predicting flood extents and depths.

Recommendations

The researchers recommend that flood management strategies account for urbanization's effects. High-resolution hydraulic modeling, particularly on marshes, is essential for detailed flood mapping. Additionally, hydraulic simulations should include parametrizations for compound events to support comprehensive flood planning under various scenarios.

Conclusion

This project provided valuable insights into the increased flood risks of urbanization and climate change. The findings highlight the need for comprehensive flood management strategies that consider the combined effects of high streamflow and surge to mitigate flood risks in vulnerable coastal areas effectively.

More details on the study can be found of the project page here: https://resilientconnecticut.uconn.edu/river-and-flood-risk-analysis/

7. Stakeholder Evaluation to Inform Large-Scale Resilience Planning

This project, conducted by Dr. Miriah Kelly, aimed to assess stakeholder engagement efforts for the Resilient Connecticut Project. It focused on gathering useful information to inform resilience planning, especially for socially and economically vulnerable populations.

Methodology

The researchers developed a utilization-based framework to assess stakeholder preferences and involvement in climate change adaptation planning. Data was collected through surveys and virtual/in-person summit events to understand stakeholder engagement and priorities.

Findings

The study found that most respondents preferred engaging with Resilient Connecticut through newsletters and summit events. However, many respondents were not currently involved in climate change adaptation planning. The most important planning priorities identified by stakeholders were public health and safety, infrastructure damage, and the needs of socially and economically vulnerable populations.

Recommendations

To improve stakeholder engagement, the researchers recommend focusing outreach efforts on highly interested respondents and those not currently adapting to climate change. Engagement should be aligned with organizations working on social justice and underserved populations. Additionally, topics such as shoreline change, social vulnerability, economic vulnerability, and communication of climate risks should be prioritized.

Conclusion

The project highlighted the importance of targeted stakeholder engagement and emphasized the need for continued focus on vulnerable populations to enhance resilience planning effectively.

More information on the overall engagement activities developed for the Resilient Connecticut project can be found on the project page here: https://resilientconnecticut.uconn.edu/engagement/.

8. Legal & Policy Tools for Climate Resilience

CIRCA's Legal and Policy team has worked in partnership with UConn Law School on climate related projects within the scope of the Resilient Connecticut Project. Starting in 2021, we produced a series of factsheets explaining new and existing law and how this authority can be used to further climate resilience; written memos and white papers analyzing legal issues; produced training materials and videos; and participated in a range of engagement activities with state, regional and local partners to promote the resources we have developed and reach stakeholders and decision makers.

Factsheets

Following passage by the Connecticut Legislature of P.A. 21-115, there was a need to produce easy to understand explanations of new and expanded climate focused provisions in state statute. We created a series of factsheets to provide local officials and stakeholders accessible information about how to create stormwater authorities in their towns and the benefit to the community for increased climate resilience funding of infrastructure and how the expansion of authority for Flood Protection, Climate Resilience, and Erosion Control Boards could further municipal climate resilience.

The first fact sheet, Stormwater and Climate Resilience, defined stormwater runoff, explained how stormwater is a climate resilience issue, described what stormwater authorities are and how they function. The factsheet had a step-by-step approach to establishing a stormwater authority, explained what types of projects can be funded with funds from stormwater fees, and provided a model stormwater enabling ordinance.

The second factsheet, Stormwater and Climate Resilience: Next Steps to Create a Municipal Stormwater Authority went into more depth about how to determine the appropriate fee model for a community, legal challenges to stormwater authorities, and provided an example ordinance from New London Connecticut with comments on how the ordinance could be tailored to the needs of other towns.

A third factsheet stemming from P.A. 21-115 discussed changes to Connecticut General Statutes affecting municipal flood prevention boards. This fact sheet, Implementing New Flood Prevention, Climate Resilience, and Erosion Control Boards addressed the four primary changes to this board which increase the range of actions the board can take to address flooding and erosion issues, including new financing mechanisms and ways to collaborate with other municipalities on issues affecting both. Additionally, this factsheet explains how to implement a Flood Board if the town does not have one and compares the legal authority of the board to other municipal boards that can take action on climate resiliency issues.

A larger project, to provide a library of climate resilience actions a Zoning Commission could take, stemmed from the passage of a zoning reform bill in 2021. Public Act 21-29 mandated training for local land use commissioners and we saw this as an opportunity to develop a Climate Resilient Zoning Library as a toolkit for zoning officials. Zoning is one of the most powerful legal authorities that municipalities have. The factsheet library combined with a three-part video training course served to provide zoning officials with a way to meet the statutorily mandated training requirement and learn about innovative ways to use zoning authority to address climate resilience and the intersecting problems of affordable housing, flooding, and increasing urban heat. Individual factsheets include topics on Transferable Development Rights, Minimum Lot Size, Maximum Lot coverage, Overlay Zones, Reducing Parking Minimums, Tree Protections and Landscaping Standards, Policies for addressing Urban Heat, Policies for Addressing Flooding and Design Standards. Video presentation of Modules 1-3 of the Resilient Zoning Land Use Commissioner Training closed captioned and fully accessible.

Additionally, the legal team produced another fact sheet, Conservation Commissions and Natural Resource Resilience as a companion document to the others because Conservation Commissions are another town board or commission having legal authority to act in increasing local climate resiliency. By protecting vulnerable natural areas serving as natural buffers to climate impacts as well as advocating for nature-based solutions to climate change and through local engagement, Conservation Commissions have a role in educating the community to the value of these natural resources for climate resiliency. The factsheet explains the role and function of the Commission, how it plays a role in climate resilience, what legal authority is invested in the Commission, and provides extensive resources for commissioners in ways they can use their authority to mitigate climate change impacts.

All four of these factsheets have been translated to Spanish to further extend the reach of these resources. The landing page for the Climate Resilience Zoning Library has also been translated into Spanish.

White papers and memos:

In 2021, a question about floodplain building standards for critical infrastructure arose when a municipality wanted to protect a wastewater treatment plant located in a coastal floodplain. Federal and state standards were unclear and possibly in conflict. After review and legal analysis, we produced the white paper Floodplain Building Elevation Standards for Critical Facilities and Activities in 2022, the fifth in the Sea Level Rise Policy white paper series begun in 2018 that clarified how municipalities should navigate these state and federal standards.

Additionally, we have produced a series of internal memos for CIRCA staff on important supreme court decisions impacting climate resilience including *Sackett v. EPA* and *WV v. EPA* and tracked state level legislative initiatives each year relating to climate change and reported on bill success or failure. And, to support other CIRCA work with the City of Norwalk, researched comparative land use strategies in coastal communities with inundated public infrastructure to determine how they addressed raising of roadways. Evaluating liabilities and utility of easements and overlay zones as solutions, in support of the Resilience Road Map Recommendations.

Legal Team Engagement activities

Legal team members presented at or moderated panels at the following conferences or meetings:

- **CIRCA Summit: A Climate Resilience Roadmap for Connecticut**. Dec. 1, 2023. Workshop on Climate Resilient Zoning.
- **Using Legal Authority to Foster Municipal Climate Resilience**, Speakers, Louanne, Kayla and Kirt. SNEAPA, Southern New England American Planning Association meeting. Oct. 5, 2023. Louanne introduced the concept of climate resilient zoning and the spoke about the library/toolkit topics and the “whole of town” approach to climate resilience. Kayla expanded this concept with Conservation Commissions as an example. Kirt spoke about municipal energy resilience and the possible funding sources available through the Inflation Reduction Act.
- **Climate Change in Connecticut**. Coordinated a class for UConn’s Adult Learning Program at Seabury on Sept. 26, Oct. 3 and 10, 2023. CIRCA Executive Director Jim O’Donnell, CIRCA Director of Resilience Planning John T. Joseph MacDougald, Director of Applied Research, Louanne Cooley, CIRCA Legal Fellow and Kayla Vargas, research technician spoke at the event. John gave an overview of the Resilient CT project, Kayla spoke on how towns can use existing authority on Conservation Commissions for climate resilience and Louanne spoke about how CIRCA works with towns to address issues like urban heat and how zoning regulations can be tailored to help adaptation efforts. Louanne spoke more about specific zoning concepts for increased climate resilience.
- **NVCOG Land Use Training**. Louanne and Kayla, speaking. Sept. 21, 2023. We presented the Climate Resilient Land Use Training materials for the first time covering six topics.

- **Ghana Institute for Management and Public Administration faculty visit**. Helped coordinate and host faculty visiting UConn Law and Global Affairs and gave a short presentation on UConn CIRCA. Aug. 14, 2023.
- **Climate Adaptation in Connecticut: Using the Law to Empower Local Action**. Speaker, Environmental Business Council of New England's Climate Adaptation Forum. June 2, 2023.
- **The Climate Change Crisis in Connecticut: The Impact on Low-Income Communities and What can be Done.** Speaker, Connecticut Bar Foundation Cooper Fellows Roundtable. Dec. 6th, 2022
- **Legal Considerations for Enabling Stormwater Authorities in Connecticut**, Speaker at Connecticut Association of Flood Managers annual meeting, Nov. 15, 2022.
- **Land Use Tools for Municipal Resilience: Heat**, presentation to Connecticut Governor's Council on Climate Change Public Health and Safety Working Group, Oct. 31, 2022.
- **Zoning Regulation as a Tool for Climate Resilience**, Poster session, 10th Anniversary of Hurricane Sandy Forum, UConn CIRCA, Oct. 28, 2022.
- Panel Moderator, UConn Law Review Symposium, **Climate and Environmental Justice in the 21st Century: A Just Transition**, Oct. 21, 2022.
- **Zoning Regulation as a Tool for Addressing Increased Heat Due to Climate Change**. UConn CIRCA Heat Webinar, Speaker, Sept. 27, 2022.
- **Legal and Policy Tools for Climate Resilience**. Webinar. June 25, 2021 Resilient Connecticut Research Webinar series.
- **Comparison of Coastal States Climate Resilience Policy**. State Agencies Fostering Resilience Meeting April 9, 2021.
- **Land Use Panel**. Cardozo Law School, Jan. 20, 2021.