Envisioning the Possible: Developing Multi-Jurisdictional Geospatial Databases and Conceptual Designs to Advance Regional Resilience

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ABSTRACT

Communities across the globe are grappling with identifying pathways to increase resilience to natural hazards due to increased frequency and intensity of hazards caused by climatic change. Regional collaboration among communities can be challenging but when successful, can leverage limited resources to achieve maximum benefit. The coastal area of the state of Connecticut, USA, encompasses 24 towns (approx. 45% of state's population) and was hard-hit during both Tropical Storm Irene (approx. $200M damages) and Sandy (approx. $360M damages). To envision and advance a resilient path forward, The Nature Conservancy engaged with core regional partners to develop regional frameworks for resilience. An essential component of these frameworks included a geospatial database populated with resilience-building projects, hosted on a public-facing website. This resource allows communities and individuals to visualize a suite of resilience-based projects across the entire region and promotes multi-jurisdictional and cross-organization collaboration and partnership, with implications for regional planning, environmental efforts, and funding opportunities. The geospatial database development identified numerous natural infrastructure projects that reduced risk to infrastructure, strengthened ecosystems, and enhanced a public amenity (i.e. "resilient triple bottom line"); however, many of these projects employed approaches that are still unfamiliar to the public, municipal officials, regulators, and practitioners. Conceptual designs were developed to both provide visualization of nonconventional alternatives and assist with obtaining funding for full design and construction of high-priority projects. This regional resilience framework approach has been implemented across the Connecticut coast, and the process can be readily adapted in other communities and scaled to the resources available to advance resilience both locally and regionally, in the USA, and internationally.

INTRODUCTION

The risk of natural hazards and climate change to communities across the globe is substantial and escalating. Average annual losses globally from earthquakes, tsunamis, floods, and tropical cyclones was estimated at $314 billion in 2015 (UNISDR 2015). Average annual flood losses alone are anticipated to increase from $6 billion in 2005 for the largest 136 cities to $1 trillion by 2050 due to impacts of climate change and land subsidence (Hallegatte et al. 2013). As a result, many coastal and inland communities around the globe are engaging in resilience-building efforts to reduce their vulnerability and reinforce strengths against natural hazards (Renaud et al. 2013; Renaud et al. 2016; Whelchel et al. 2018a.). Herein, resilience is defined as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or

disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning, and transformation." (IPCC 2014). The socio-economic, environmental, and political case for resilience building is strong, particularly when considering changing weather patterns due to climate change. The frequency and intensity of many natural hazards are projected to increase, including heavy precipitation events, droughts, severe storms, and coastal flooding (Hayhoe et al. 2018), leaving communities more vulnerable than in the past without meaningful interventions and frameworks (e.g. Sendai Framework for Disaster Risk Reduction (Kelman 2015), United Nations Sustainability Development Goals). Meanwhile, benefit-cost ratios for disaster risk reduction actions typically range between 3:1 and 15:1 (Shreve and Kelman 2014), with an average of 4:1 (MMC 2005), meaning for every $1 invested in hazard mitigation, communities can on average save $4 in future post-storm damages, or more.

Communities along the state of Connecticut's coast have elevated exposure levels to many natural hazards due to historical development patterns, starting with colonial settlements and dam construction along rivers for power supply and mills in the 1650s - 1700s, continuing with filling of salt marshes and floodplains during the 1800s for railway development, and interstate construction in the 1900s to accommodate the automobile resulting in further residential and commercial development along coasts and inland waterways. This persistent placement of infrastructure and associated development in topographically low-lying areas vulnerable to flooding, storm surge, and sea level rise has consistently increased the exposed asset portfolio over 375 years of development. Recently, communities across the state experienced the effects of natural hazards, with tropical storms Irene (2011) and Sandy (2012) causing damages upwards of $200 million (Hart 2011) and $360 million (Dixon 2012), respectively. This has increased the receptivity to both local and regional planning and community resilience building in Connecticut.

This risk along Connecticut's coast is not unique, with 4.47% of the global gross domestic product, representing more than $1.9 trillion, exposed to tropical cyclones in 2010 (UNISDR 2011). Many coastal communities across the globe are adapting to the increased risk of severe storms and sea level rise. Pre-disaster planning allows communities to reduce their risk before a disaster and leverage post-disaster funding opportunities to further increase their resilience (i.e. pre-planning is in fact post-disaster damage prevention), particularly if planning and response are regional in nature. Planning efforts take time; however, communities with existing plans are better positioned for implementation when funding is available, particularly if more regional approaches are employed to remedy risk and improve resilience.

Advanced planning also can create diverse and inclusive opportunities for engagement with stakeholders from various disciplines and favors solutions that more holistically evaluate and respond directly to risk. These opportunities make planning an ideal stage for NGOs and other interested parties to promote nature-based solutions which conceptually highlights the advantages of leveraging the resilient properties of ecosystems to adapt to extreme weather and climate change (Cohen-Schachuam et al. 2016; Nesshover et al. 2017) and in practice can be integrated to mimic natural systems and processes to reduce risk (i.e. Eco-engineering (reviewed in Whelchel et al. 2018b.)). In some cases, eco-engineering may be implemented in tandem with traditional engineered risk reduction approaches, often referred to as 'hybrid' approaches. Eco-engineering approaches that utilize natural infrastructure, such as floodplain restoration, living shoreline implementation, and/or green stormwater infrastructure installation, provide an opportunity to address multiple project objectives that allow communities to reduce risk while

also restoring habitat and enhancing a public amenity: the 'resilient triple bottom line' (Whelchel and Beck 2016; Whelchel et al. 2018b.). However, these approaches often incorporate innovative technologies, requiring significant coordination between stakeholders, permitting agencies, and funders as well as the development of appropriate design standards and performance metrics (Renaud et al. 2016; Whelchel and Beck 2016; Whelchel et al. 2018a.). Many communities around the world are already implementing eco-engineering projects, such as restoring coastal natural infrastructure to protect urban coastlines and floodplains (e.g. Room for the River, Floodplain by Design, Dockside Green (reviewed in Whelchel et al. 2018b.)).

Table 1. Summary of regional resilience framework development components for three regions in Connecticut.

Framework Region	Southcentral	Southeastern	Southwestern
# Municipalities	10 (pop.[1] 591,046)	9 (pop. 214,611)	5 full, 10 partial (pop. 500,714)
Visioning Phase	No discrete phase, leveraged strong collaboration and work on resilience between COGs, municipalities, NGOs, CRB[2] workshops.	Coalition building through one-on-one meetings, followed by regional, cross-sector resilience framework building workshops, CRB workshops.	Built from CRB workshops and Hazard Mitigation Plan update.
Resilience Project Geospatial Database Development	229 projects identified	54 projects identified	207 projects identified
Community Engagement Methods	CRB workshops, field reconnaissance, community-based workshops, priority project site visits, design charrettes, community design open houses	CRB workshops, regional workshops, one-on-one meetings, field reconnaissance, resilience working group	CRB workshops, one-on-one meetings with stakeholders, field reconnaissance
Conceptual Designs	20 projects	4 projects	2 projects
Available Resources/Budget	Highest	Intermediate	Lowest

[1]estimated populations for each region based on 2010 US Population Census.
[2]CRB = Community Resilience Building workshops (www.communityresiliencebuilding.org).

While many communities are beginning to plan for resilience, the rate and magnitude of climate change is often beyond local community capacity, particularly for critical systems and services that are often managed on a regional, state, and/or national-level (e.g. highway, rail, ferry, drinking water, sanitary, electricity supply, public health care, education, human services, climate migration and political refugees influx). To contend, some communities and geographic areas are beginning to explore regional approaches to resilience building (Bennett and Grannis 2017; Whelchel et al. 2018b.). Regional collaboration can provide significant benefits in information sharing, cost efficiencies, social cohesiveness, supportive/critical systems

management, and coalition building. However, there are also obstacles including established governing structures, financial norms and systems, hierarchies, and individual community versus regional interests. This paper outlines regional resilience building approaches employed in the state of Connecticut using community resilience building, geospatial databases, and conceptual designs to build frameworks to serve as a guide to advancing regional resilience elsewhere.

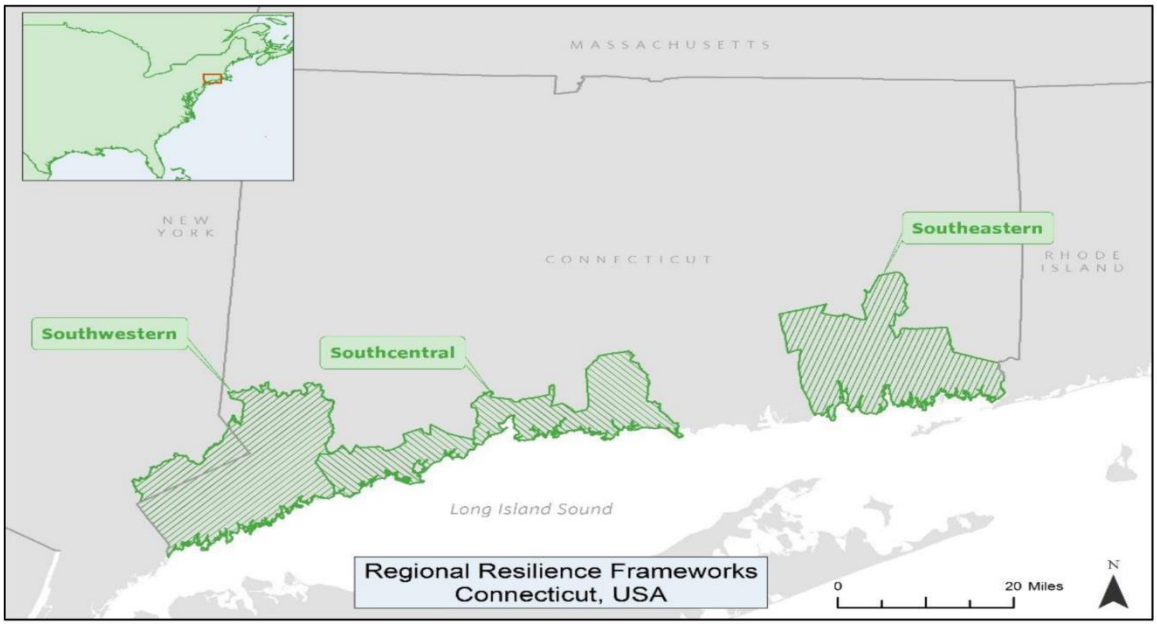

Figure 1: Three regional resilience frameworks were developed along coastal Connecticut, covering the geographical area shown.

Development of Regional Frameworks

A regional resilience framework approach was recently advanced in three regions in Connecticut (Figure 1). Table 1 presents a summary of the components included in each of the three frameworks presented herein. The framework origins stem from implementation of the Community Resilience Building (CRB) process (Whelchel and Beck 2016; Whelchel et al. 2018b.) as a foundational step to regionalization of resilience via individual, municipal-based CRB workshops. Foundational in the sense that each municipality's receptivity to a regional resilience framework process was advanced via an initial local focus on resilience through CRB workshops resulting in local action plans (e.g. CRB Summary of Findings - Stamford, CT (Whelchel et al. 2015)). Subsequently, the guiding question used to direct and build a regional resilience framework in all three regions was: "Given the context of extreme weather events, a changing climate, and fluctuating social and economic conditions – how can we best expand upon the region's strengths, take advantage of opportunities, improve upon weaknesses, and reduce threats?". A key focus was on current and forward looking "social and economic conditions" as a key to "everyday" resilience aside and separate from extreme weather events. Concurrently, the guiding principle across all three regions was: "Identify collective challenges and create collaborative solutions across the region to achieve resilience via strong and growing partnerships". Again, this placed and emphasis on expanding current strengths across the regions such as partnerships and highlighting examples of creative and collaborative resilience at the region scale including transportation systems and networks (municipal to state-maintained

roads), health districts, emergency response-mutual aid agreements, network of local and regional non-profit organizations, and community college networks. Consistency was continued during the development of three core objectives across the regional resilience frameworks: 1) surface collaborative solutions that communities and organizations can pursue to address regional challenges, 2) facilitate interactions amongst a diverse range of regional stakeholders and decision makers, and 3) strengthen the context for regional collaboration as informed by the concepts of resilience.

The Southern Connecticut Regional Framework for Coastal Resilience (Whelchel et al. 2017a.; Whelchel et al. 2018b.) (i.e. Southcentral (Figure 1, Table 1)) was the first regional resilience framework developed in Connecticut, encompassing ten spatially contiguous municipalities (Fairfield, Bridgeport, Stratford, Milford, West Haven, New Haven, East Haven, Branford, Guilford, and Madison) along the central portion of the state's coastline. This regional resilience framework was grounded in a decade of local engagement via the CRB process (Whelchel and Beck 2016; Whelchel et al. 2018b.) and fostered strong collaboration between two regional councils of government (COGs), the Connecticut Metropolitan COG and the South Central Regional COG, and The Nature Conservancy (TNC). There were three primary components of the process used to develop this framework: 1) identification, assessment, and cataloging of resilience projects into a geospatial database and presentation via online application; 2) community engagement to build partnerships and further define and prioritize projects; and 3) conceptual design development for the highest priority project that provided enhanced local resilience and served as catalytic examples of replicable regional resilience.

The main goal of the geospatial database component was to develop a comprehensive catalog of potential resilience projects across the participating municipalities (methods detailed below). With the community engagement component, the project team further strengthened relationships and trust across the ten municipalities, COGs, NGOs, and other supporting partners; secured a clearer understanding of local risks and resilience opportunities for municipalities; fostered identification and recognition of shared risks across the region; and facilitated evaluation of the projects included in the catalog for conceptual design development. There were three primary elements of this community engagement component: 1) initial stakeholder engagement workshop (built upon initial CRB workshops) to increase awareness of regional risks and identify local and regional project opportunities; 2) collective site visits for top-priority projects; 3) design studio workshop to reinforce consensus on top-tier project selection and begin generating conceptual designs for a select number of projects. In preparation for the site visits, each municipality selected their top-priority projects from the community-generated project catalogue with a focus on regional impact. Representatives from the municipalities and state permitting agencies collectively visited the sites to assess project feasibility and proposed design elements. The final component was conceptual design development, with cost opinions, for the projects selected in the community engagement component and presentation in a comprehensive design portfolio (Whelchel et al. 2017b.) (further details below).

The second regional resilience framework, Southeastern CT (Figure 1, Table 1), encompassed nine municipalities (East Lyme, Waterford, New London, Groton, Stonington, Salem, Montville, Ledyard, and Norwich) in partnership with Southeastern Connecticut COG, Southeastern Connecticut Enterprise Region - a regional economic development resource - and TNC (i.e. core team). The framework development process followed the same outline as Southcentral; however, a discrete, initial regional visioning process was added. During this visioning phase, the core team conducted initial meetings (one-on-one and small group) with

local land use and economic development planners to surface key opportunities and challenges for regional resilience and define regional knowledge gaps. The core team then convened two regional workshops to specifically identify main challenges and subsequent solutions for the region, respectively. These workshops drew upon the expertise of seventy-five regional professionals across the fields of environmental protection, regional planning, public works, utilities, business and commerce, health-care, agriculture, and emergency management, among others. The findings from these workshops (White and Whelchel 2017a.; 2017b.) provided standalone guides for regional resilience and content for direct incorporation into key regional documents: the regional master/comprehensive plan and the economic development strategy. This integration helped institutionalize the content and concepts of regional resilience.

The geospatial database development and conceptual design components for the Southeastern framework used the same methods as the Southcentral. However, the community engagement phase was structured differently. A regional resilience working group was utilized to advance the priorities generated during the visioning workshops. Regional resilience working group meetings convened a cohort of influential land-use planners, economic development specialists, environmental professionals, and others to advance tasks across a wide range of resilience-related projects and activities. Resilience-related tasks included reviewing economic resilience toolkits, strategizing on outreach efforts to local/regional businesses, reviewing and expanding projects in the geospatial database, and assessing local master plans for resilience activities. This working group served to further legitimize and normalize the regional resilience framework across the geography as well as within each municipality.

The Southwestern CT regional framework (Figure 1, Table 1) encompassed five coastal municipalities (Greenwich, Stamford, Darien, Norwalk, and Westport) and the adjacent watershed areas, which covered all or portions of the municipalities of New Canaan, Wilton, Weston, Fairfield, Easton, Ridgefield, Redding, Danbury, Bethel, Newtown, as well as portions of southeastern New York state. Most of these municipalities had recently conducted CRB workshops as part of a natural hazard mitigation plan update. The resilience project catalog and conceptual design phases were like those completed for the Southcentral and Southeastern frameworks. The community engagement phase of the Southwestern framework did not employ regional workshops and instead nested within the resilience catalog development via one-on-one and small group meetings with stakeholders and municipal officials.

One of the primary drivers for the differing scales and scope of the three regional resilience frameworks was availability of funding. The Southcentral framework was the most well-resourced, followed by Southeastern and then Southwestern. This is evidenced in the style and extent of the community engagement phase and the number of conceptual designs developed. For example, the funding resources for the Southcentral framework enabled dedication of geospatial, coastal engineering, and community engagement personnel to establish the framework.

While varying in structure, each of the community engagement phases provided an opportunity for regional partners and stakeholders to contribute to the framework development process and highlight the projects of greatest interest, both locally and regionally. The Southcentral framework approach was ideal for fostering multi-jurisdictional collaboration and shared regional risk evaluation, as stakeholders were brought together in several different venues to directly collaborate on framework development. The resilience working group approach of the Southeastern framework provided an efficient means to advance discrete projects with a small group of knowledgeable, influential, and motivated individuals representing municipalities

within a regional context. Finally, the one-on-one meetings with stakeholders utilized in the Southwestern framework was efficient, in that it was combined with outreach for the project catalog and geospatial database development, but still allowed stakeholders to provide information, insight, and feedback that was used by the project team to inform the conceptual design phase of the work.

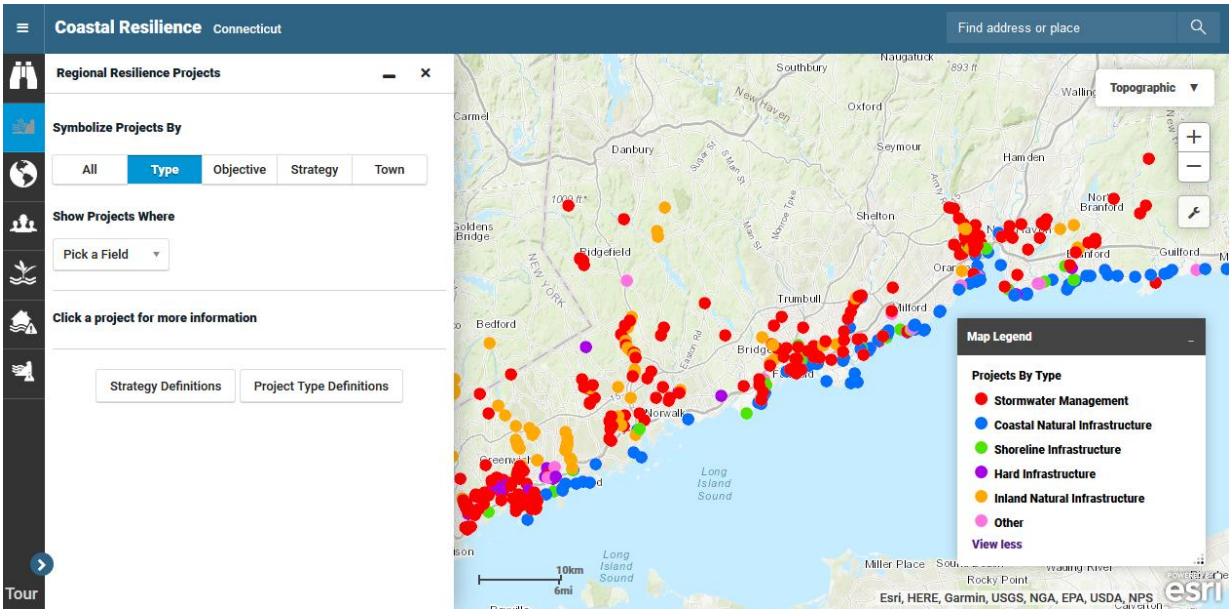

Figure 2. Regional resilience framework projects online application displaying projects classified by seven project types. Users can filter data by type, objective, strategy, and municipality, to locate projects that address their resilience goals and targets. Project entries display overviews and grant-pertinent information, such as low-to-moderate income percentage, flood zone, watershed, and other information like links to source documents and photos. Source: TNC's Coastal Resilience mapping portal (https://maps.coastalresilience.org/connecticut/).

Another distinct difference between these framework approaches were the visioning methods, which were scaled based on available resources and need for collaboration. The Southcentral and Southwestern frameworks did not include a discrete visioning phase, and instead relied upon existing collaboration between the municipalities and COGs and robust community engagement meetings (Southcentral) or recent CRB workshops (Southwestern). Southeastern required a visioning phase due to limited prior regional-scale engagement on resilience, which provided an opportunity for diverse stakeholders to form a shared vision across sectors.

Geospatial Databases for Regional Resilience

A key component incorporated into all three regional frameworks was a resilience project catalog. This involved the identification and assessment of projects that had the potential to improve community resilience across the region along with an aggregation of information into a geospatial database. The geospatial databases were incorporated into a project-viewing app on a public-facing website, allowing broad access to foster collaboration. Figure 2 provides a screen shot of the regional resilience project app on TNC's Coastal Resilience decision support platform

(Beck et al. 2013; Whelchel and Beck 2016; Whelchel et al. 2017a.). The process and outcomes for the geospatial database development were similar across all three frameworks. Development of the geospatial databases included three elements: 1) identification of potential resilience projects, 2) project assessment and site visits with data entry, and 3) geospatial overlay analysis to append grant-pertinent information to project entries and population of the online regional resilience project application.

Resilience projects were initially identified via existing documents and outreach to local stakeholders. Existing documents reviewed included natural hazard mitigation plans, master plans, watershed management plans, harbor management plans, parks and recreation master plans, CRB summary of findings, stormwater drainage studies, hydrologic and hydraulic studies, among others. Outreach to local stakeholders involved individual meetings, field reconnaissance and formal site visits, and/or workshops, depending on the region (Table 1). The identified projects were then qualitatively evaluated for risk reduction impact and classified based on the following parameters: type, objective, strategy, municipality, geo-location, address, description, funding (if available), green infrastructure (yes/no/hybrid), and primary and secondary asset exposed. Online links to project source or reference document were provided, if available. Project type, objective, and strategy classifications were standardized (Whelchel et al. 2017a.) to facilitate screening and evaluation of potential projects. The project descriptions provided a distilled project summary, which allows users to quickly ascertain an overview of a project via the online application. The data acquisition and entry system used was MS Excel and Access (Southcentral) and ESRI's Survey123 for ArcGIS (Southeastern, Southwestern). Ultimately, all data was exported to a file geodatabase in ArcMap.

Site visits were conducted for most projects to assess existing conditions. Photos of field conditions were collected and attached to project entries in the geospatial database. In Southcentral, site visits were conducted for most projects with green or natural infrastructure components, particularly the top-tier projects identified for conceptual designs. Many of these site visits included a multi-disciplinary team of coastal engineers, planners, natural resource specialists, and state/local regulators. In the Southeastern, site visits were conducted for all projects. When feasible, these visits included a representative from the municipality or partner organization. In the Southwestern, there were insufficient resources to visit all sites, so projects that were most likely of interest to multiple stakeholders or organizations were prioritized to create a robust user experience in the online regional resilience project app.

Once data entry was completed, an overlay analysis was conducted to append the following additional grant-pertinent information to the project entries: state's Natural Diversity Areas, Federal Emergency Management Agency's (FEMA) flood zone and base flood elevations, U.S. Department of Housing and Urban Development's (HUD) low-to-moderate income percentage (within block group), and U.S. Geological Survey's watershed (HUC-12). This information enhanced project-screening for potential funding sources and facilitate inclusion of individual and networks of regionally significant projects in grant applications.

The finished geospatial databases from each region were uploaded to a common platform on a public-facing website and are freely viewable (Figure 2). The online app serves as a central repository of resilience projects for all three regions, covering 85% or more of the state's coast as well as adjoining inland areas. The app functionality allows users to query and display the projects by municipality, type, objective, and/or strategy, and therefore, those that are most relevant to their goals of increasing resilience at the local and regional scale.

The project type classification is the broadest categorization (i.e. coastal natural

infrastructure, shoreline infrastructure, stormwater management, hard infrastructure, inland natural infrastructure, and other). This classification was intended for end users to select broadly based on their interests. For example, environmental NGOs can see what coastal or inland natural infrastructure projects are important to municipalities and identify potential collaboration opportunities within and across watersheds; COGs and state/federal agencies can identify priority hard infrastructure portfolios across jurisdictions to match pre- and post-disaster funding opportunities (e.g. HUD Community Development Block Grant – Disaster Recovery assistance). The project objective classification includes more specific subsets of the project types (e.g. bank protection, tide gate, culvert, etc.), and the project strategy classification covers the intended action (e.g. relocate, elevate, create, etc.). A full list of these descriptors and definitions for the type and strategy terminology can be found in the online app (Figure 2) or in the project report (Whelchel et al. 2017a.).

The intended audiences for the regional resilience project app include municipal officials, regional planners, federal and state agencies, NGOs, watershed and neighborhood associations, and community foundations, among others. Municipal officials and NGOs can use this app to learn about projects that are outside their organization to foster collaboration and resource sharing across regions, as many projects align the interests of both municipalities, COGs, and NGOs. Similarly, projects can be more easily slated for funding opportunities as grant-pertinent information is readily available, and linked reference documents allow interested parties to learn about the projects while compiling grant applications. From a regional perspective, the COGs and federal/state agencies are using the database to inform and populate multi-jurisdictional natural hazard mitigation plans and master plans with projects that will mitigate risk and advance resilience. Locally, the process of cataloging projects and coordinating with municipal officials has helped surface opportunities for partner organizations to provide value through conceptual designs and implementation.

Advancing Projects with Conceptual Designs

Once the geospatial database was completed, allowing stakeholders to visualize individual and portfolios of resilience projects, a few projects were selected in each region for conceptual design development. Conceptual designs are an integral component of all capital construction project processes and serve many purposes, including feasibility assessment, cost projection, and stakeholder buy-in facilitation. Robust conceptual designs are also particularly important for projects that have broad scopes or are relatively novel in nature, as the design development process can foster cross-discipline coordination and allow practitioners, regulators, and stakeholders with limited experience to understand and visualize the approaches incorporated in the design. The projects selected for conceptual designs had no previous conceptual designs developed and exemplified the ‘resilient triple bottom line’ of reducing risk (Whelchel et al. 2018b.) - strengthening ecosystems, improving a public amenity, and reduced risk as well as serving as a catalyst for regionally replicable resilient projects. These projects tended to be cross-disciplinary, incorporating planning, engineering, landscape architecture, ecology, community services, and social cohesion.

The conceptual design selection and implementation processes varied between the three regional frameworks. In the Southcentral, each participating municipality was able to select their two highest priority projects, with a focus on both local as well as regional resilience-building impact, given the availability of funding. This framework also incorporated small team design iteration meetings and several open-house, design charrette workshop with stakeholders.

Conceptual designs were finalized by consulting firms and academic institutions. The Southeastern and Southwestern frameworks had less funding and design projects were selected based on feedback from stakeholder outreach conducted during the geospatial database development. The conceptual designs were produced by TNC and consulting firms, with input from stakeholders, but without comprehensive design charrette workshops.

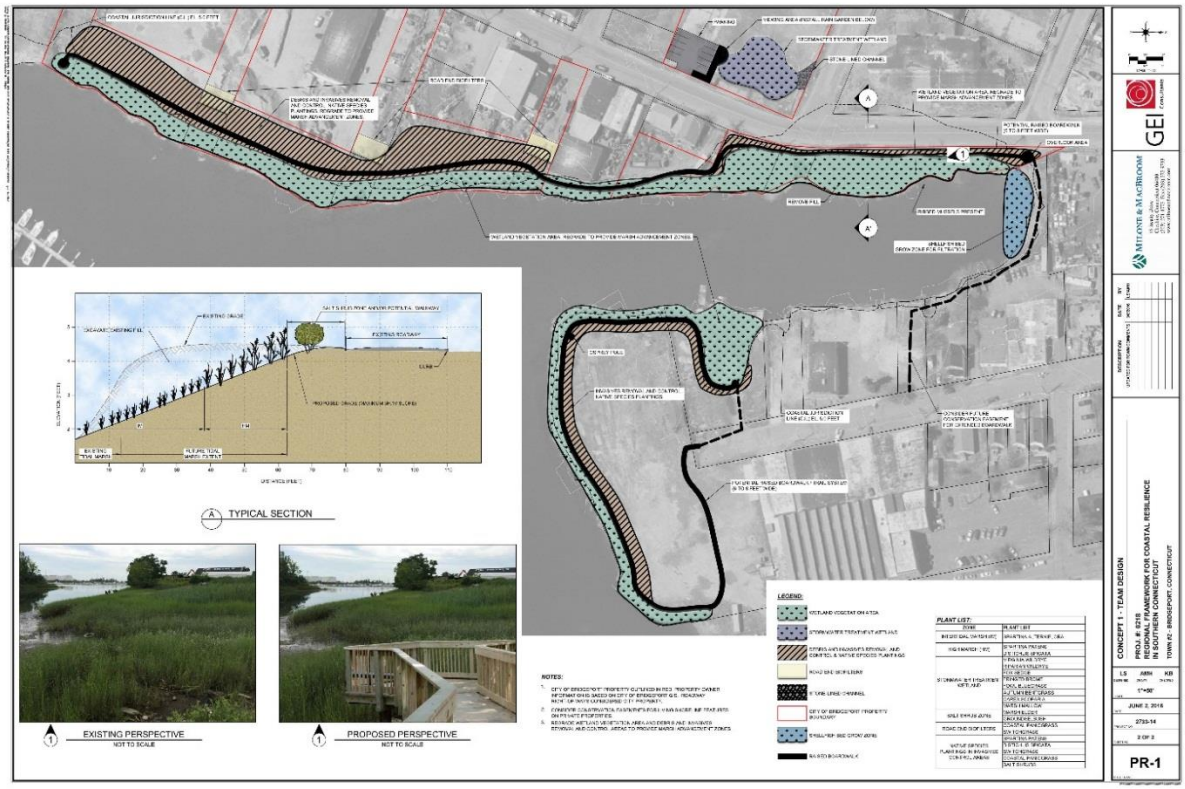

Figure 3. West Branch Johnson Creek, Bridgeport, Connecticut living edge conceptual design developed during regional resilience framework development (Whelchel et al. 2017a.). Project proposes to restore tidal marsh, provide public access, and modify bank slopes to reduce erosion along a highly urban waterfront via a resilient triple bottom line approach. Credit: Milone and MacBroom and GEI.

While all three frameworks fostered cross-disciplinary collaboration in the conceptual design process through diverse stakeholder engagement, the Southcentral process was the most robust in cultivating buy-in for the priority projects. Municipal officials from the region alongside state regulatory agencies were afforded the opportunity to visit each conceptual design site in the region (prior to initiating conceptual designs) and provide feedback on design elements and constraints. The stakeholders were able to learn and share projects and follow their development in the design workshops and final design review. This allowed for direct input from the state regulatory agents as to the initial permitting constraints of proposed project elements prior to conceptual design development.

Conceptual designs were used as a tool to advance regional resilience frameworks by accelerating priority resilient project development, facilitating stakeholder buy-in, and fostering funding opportunities. The Johnson Creek Living Shoreline project in Bridgeport, Connecticut exemplifies how the Southcentral framework (Whelchel et al. 2017b.) process was able to

identify a potential project during the geospatial database development, advance it with a conceptual design, and propel the project towards implementation. Previous planning efforts in the city identified the west branch of Johnson's Creek as a natural resource to be preserved and enhanced, in an area lacking public waterfront access (City of Bridgeport 2012). The conceptual design development allowed stakeholders to envision the potential improvements to the site, which included enhancing tidal wetlands, installation of a raised boardwalk and pedestrian path to provide community access to the waterfront and decreasing slopes of banks to reduce erosion and accommodate future marsh migration with sea level rise (i.e. 'resilient triple bottom line') (Figure 3). Since conceptual design development, the city and COG successfully solicited grant funding to complete the final design and are now exploring implementation funding opportunities.

Applying Regional Frameworks at Varying Scales

The regional resilience framework approach can be adapted to a scale that best suits the goals of and resources available to/from participating municipalities. The general steps for implementation as derived from the three regional resilience frameworks described herein are:

1. Identify framework guiding questions, principles, objective, and appropriate and manageable geographic scale;
2. Establish an inclusive, equitable resilience vision with supportive goals;
3. Clarify planning sectors/areas that cumulatively define regional resilience for framework;
4. Evaluate resilience projects and develop geospatial database expressive of actions to increase local and regional resilience;
5. Review projects via various community engagement approaches;
6. Develop conceptual designs to advance community-derived priority projects;
7. Normalize resilience at the local and regional scale via systemic integration into governance structure, planning activities, and capitalization/budgetary approaches.

The first step in implementing a framework process is identification of the guiding principle(s) and objective(s) for the pre-determined appropriate and manageable scale. This step can range from addressing location-specific hazards, such as flood reduction in a watershed including only a few municipalities; system-based risk reduction, such as state-wide transportation or agricultural production/distribution networks; or multi-sector, comprehensive risk reduction in a geographically delineated area. Selection of the objective and scale can be influenced by several factors including demonstrated needs of stakeholders and available funding opportunities. Determination of appropriate scale is critical and should be advantaged by contiguous, existing governance or planning constructs such as watersheds, coastal zones, food-sheds, islands, mountain ranges, and urban with adjoining suburban and rural landscapes. Once this step is satisfied, a common resilience vision can be created. A review of past resilience-building or hazard mitigation efforts for individual municipalities and entities within the pre-determined framework footprint can help inform the needed format and effort for this second step, which varied widely in the three frameworks. At the very least, inclusively convening stakeholders in a public forum can provide a prime vehicle to surface shared values. This then creates a foundation for collaboration and communication critical to creating a resilience vision and clarifying planning sectors/areas of focus that are all used to eventually build a regional resilience framework.

The geospatial database development effort can also be scaled to match available resources and the objective(s) of the framework. At a minimum, outreach to municipal officials to identify

priority projects should be completed. The degree to which additional stakeholders and existing documents are reviewed can be scaled to the needs of the framework objective(s), vision, and planning sector(s) scope. If capacity allows, in-depth field reconnaissance, planning meetings with informed and influential stakeholders, site visits with municipal staff and state/federal regulatory agents, and iteration on project scope/description development coupled with community-based, open houses and workshops are optimal activities to strengthen the eventual regional resilience framework development. This step contributes significantly to the final step of normalizing and systematically integrating resilience at a local and regional scale.

The step that is perhaps the most dependent on available resources is conceptual design. Without ample capacity there is often a tradeoff between the benefit of advancing priority projects via conceptual designs (Step 5 - 6) and investing more resources in earlier steps to enhance cross-jurisdictional collaboration and coordination (Step 1 - 4). Regardless of the scale and methods employed in the development of a regional resilience framework, stakeholder engagement should be inclusively and equitably woven throughout the process, to ensure that the end-product will provide value to the communities being served by the regional resilience framework.

CONCLUSION

The three regional resilience frameworks developed to-date in Connecticut have accelerated municipal and broader stakeholder engagement in cross-jurisdictional collaboration on resilience and advanced priority projects that reduce risk while also strengthening ecosystems and improving community amenities. The approach of developing resilience projects via geospatial databases and conceptual designs can be adapted in other communities as a key component of establishing regional resilience frameworks at varying scales. While these frameworks are now a resource for the participating municipalities, they are subject to the same challenges as other planning and governance constructs, namely ensuring that the frameworks are well resourced; tangible outcomes (i.e. project implementation) are realized and replicated; and therefore, resilience is normalized and systemically integrated at effective scales. Additionally, geospatial databases and conceptual designs can lead to the realization that place-based resilience projects often require progressive legal, regulatory, and policy adaptation to accommodate resilience at the local and regional scale. Ultimately, community resilience is built in layers of varying scales from individual neighborhoods and municipalities to state and national systems which must respond to various "gradients of resilience" (Whelchel et al. 2018b.) including urban to rural landscapes, wealthy to disadvantaged populations, and coastal to inland geographies. To best leverage and build on existing efforts, coordination between multiple scales and resilient gradients is critical.

Specific recommendations to assist with the development of regional resilience frameworks (as distilled from the three frameworks discussed herein) are as follows:

- Establish clear guiding question(s), principle(s), and objective(s) with focus on existing strengths and opportunities to advantage the development of strong and growing partnerships focused on regional resilience.
- Create greater awareness about existing examples of regional resilience and amplify across and within multiple planning sectors and associated partnerships (i.e. transportation, health, water, environment, food, education, public works, economy, etc.). What is already happening that strengthens regional resilience?
- Catalyze regional resilience building through well-constructed and facilitated community

engagement that provides a voice to the "whole" community (e.g. Community Resilience Building, regional challenges/solutions visioning workshops, open houses).
- Seek to build relationships and trust amongst diverse partners (engineering, planning, public works, etc.) via site visits and project reviews as a peer-to-peer network that exchanges knowledge longer term.
- Routinely discuss ongoing and future opportunities to realize regional resilience actions across municipalities, regional planning entities, NGOs, and state/federal agencies.
- Establish or broaden existing partner, political, or governance structures to accommodate actions related to regional resilience frameworks (e.g. working groups, regional climate coalition, etc.).

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