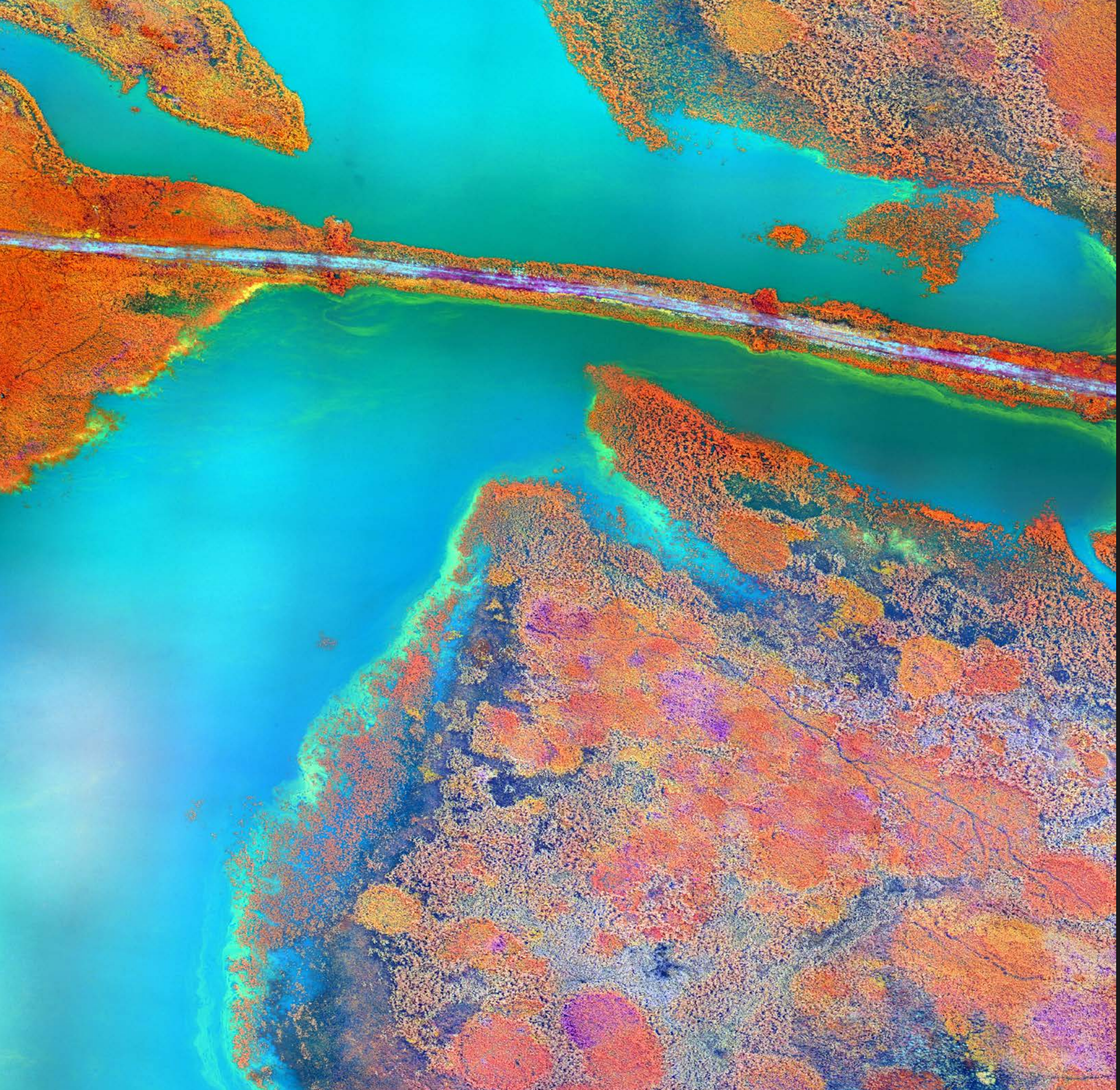
Resilience Design Toolkit

Resilience Design Integration
For Architectural Projects

AIA HKS



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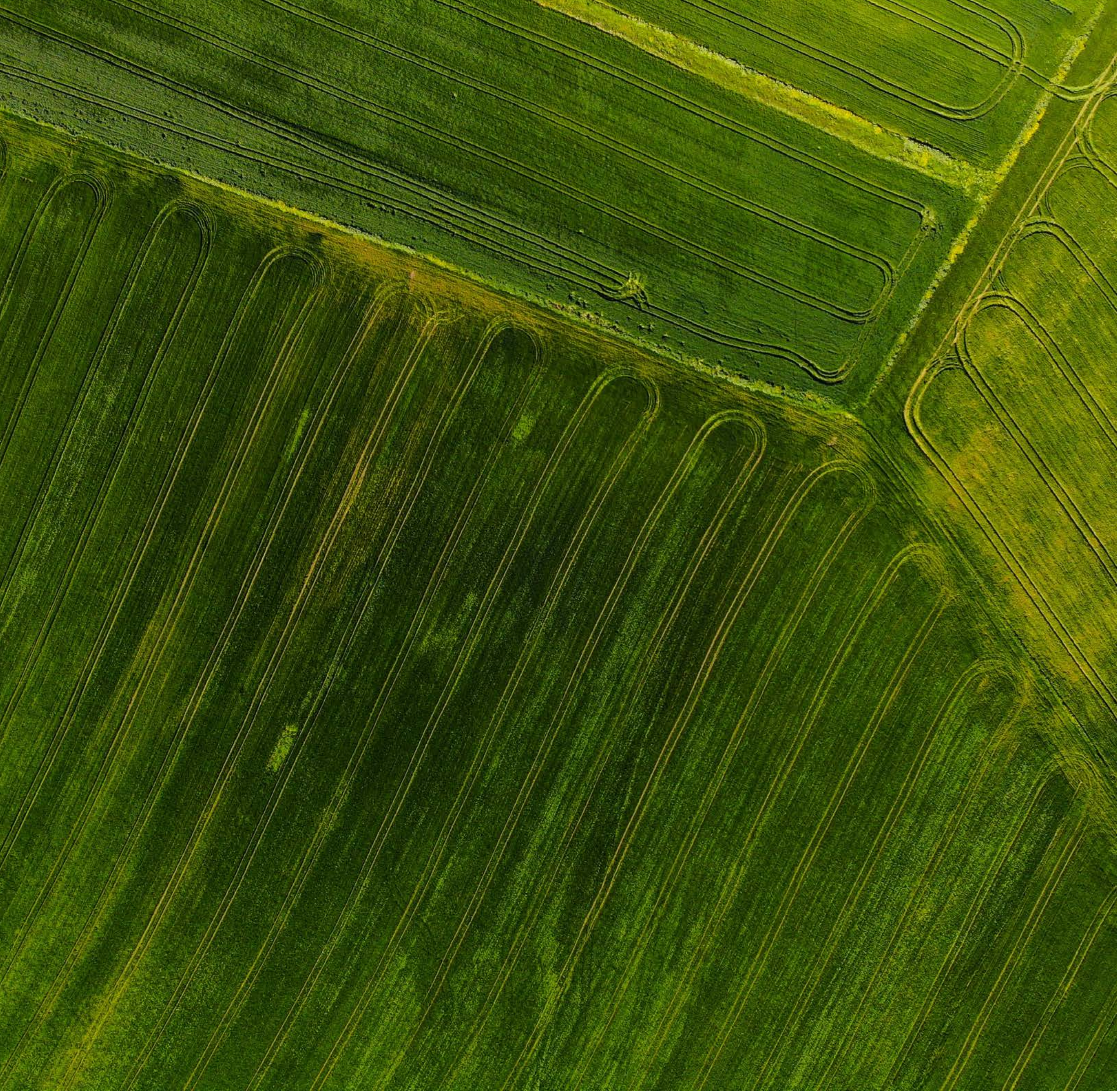


Executive Summary

The Resilience Design Toolkit is a resilience design guide specifically developed for architects to understand the steps to coordinate resilience studies for a project and a general method to integrate resilience design thinking into a design process.

The toolkit seeks to be a resource that provides relevant background information on the importance of resilience design and how to adopt or adjust a design method to fit a project's needs.

The toolkit was born out of a research study at HKS to better understand the impacts climate can have on a project's useful life and then determine how we can mitigate those effects with design.

The Resilience Design Toolkit uses a five-step process which is also the layout of this document. Resilience design strategies can be calculated and also understood financially. This helps to provide a more substantial case for design strategies in a project, aligning client requirements with design intent and developing high-performance buildings.

Executive Summary

Introduction: A Basic Understanding of Resilience Design

Step 1: Resilience Scope

Understand what your client and stakeholders require regarding resilience. Sometimes, architects may need to educate or identify resilience needs when the client is not familiar or knowledgeable on the subject.

Step 2: Align and Plan

Once the scope has been established, it is time to develop the team and the work-plan to achieve the project resilience goals.

Step 3: Identify Hazards

Begin the project investigations before design to uncover potential hazards and the associated risks and vulnerabilities. Primary and secondary impacts or cascading effects like hurricanes and power outages are important to consider as well.

Step 4: Integrate Resilience Design

With the hazards evaluated and the key risks identified, now the design team can develop resilience design strategies and test them for effectiveness using a Benefit Cost Analysis (BCA) and Choosing by Advantages (CBA) exercise.

Step 5: Operate + Evaluate

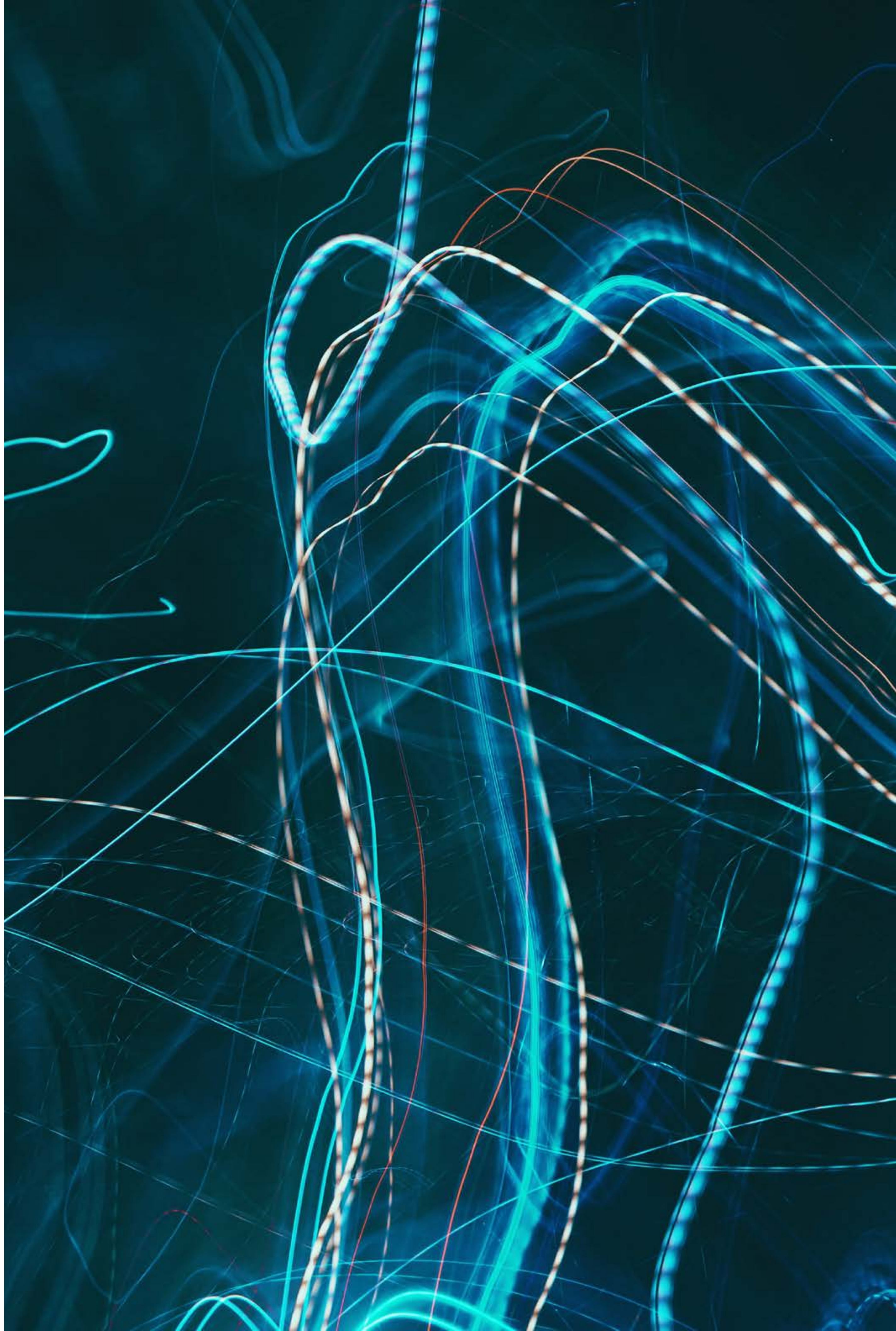
After construction is complete, following up with your client and the community can allow for Post Occupancy Evaluation (POE) to understand the project's successes and failures. This is also a good time to solidify becoming a trusted advisor to your client.

Conclusion: Next Steps and Major Take-Aways

As the connections between natural disasters, social unrest, and health emergencies continue to strengthen and impact communities more frequently, it is important to incorporate resilience design in projects and engage clients on the value of this work.

In some ways, resilience design has already become part of an architect's standard of care, such as requirements for emergency power in essential facilities.

In other ways, resilience design is missing requirements for passive survivability. The Resilience Design Toolkit provides an objective analysis process to balance subjective reasoning so that the value of resilience design strategies can be calculated and also understood financially. This helps to provide a more substantial case for design strategies in a project, aligning client requirements with design intent and developing high-performance buildings.



Introduction

From Research to Practice

Resilience is a broad term used to assess our ability to withstand and endure some of life's toughest moments, whether it is losing all your possessions in a fire or struggling to find food to eat. Resilience design strategies are critical to incorporate in our cities and communities today so that we can provide security, health, and wellness for all. This affects not just built forms, but people, wildlife, ecosystems and how these groups interact with the built environment.

Nature has evolved over time to create a symbiosis of climate and terrain that is self-sustaining and resilient to most any condition. How can we learn from our surrounding ecosystems to help develop more responsive and resilient communities?

Historically, affluent communities with access to technology and resources can adapt and recover faster following climate emergencies. Climate disasters impact both rich and poor communities. Those with limited access to resources need resilience planning and support the most. How can design equalize the gap and support the whole community?

Designing with communities requires the project team to know the people of the place, interact with their culture, understand their way of life, then design can be shaped and molded into a form that not only provides delight, but is more sustainable and resilient.

The toolkit process is a complementary tool that considers previous work in the resilience planning and design field. It uses research and leverages thinking from other processes and tools to create a focused method to integrate resilience thinking into project design.

The toolkit process is defined, yet intentionally designed to be flexible so that it may be useful for a project of any type in any location. Therefore this process is a suggestion, a starting point for your design process to integrate resilience design thinking early and effectively. The five-step process injects resilience thinking from the beginning of a project and continues it through post construction and maintaining a relationship with the owner and project stakeholders.

The process uses the AIA Framework for Design Excellence to understand the project place that initiates a further study to identify potential hazards of a site and assess the risk and vulnerability of stakeholders. FEMA derived Benefit-Cost Analysis (BCA) is used to quantify and qualify impacts and benefits for design strategies as they are developed and become part of the design.

Architects design with communities, not for them. We must be open to learning a culture, a way of life, a system for how our built environment operates before we can develop appropriate design strategies. This enriches the final product and naturally increases its resilience, both in its physical and environmental context as well as its social context.

Development of the Resilience Design Toolkit

The Resilience Design Toolkit was initially developed through an internal research incubator at HKS in 2021. A small taskforce developed a hypothesis on how to communicate the value of resilience to colleagues, clients, and communities so that resilient design could be integrated into projects. The taskforce studied HKS design teams to uncover current gaps in discussing and thinking about resilience in the design process through focus groups and surveys. This data was synthesized and compiled into the first version of the Resilience Design Toolkit.

In 2022, the AIA Resilience & Adaptation Advisory Group (RAd-AG) discovered this work and developed a partnership with HKS to bring the Resilience Design Toolkit to AIA members and provide knowledge of how to integrate BCA into design. The toolkit is the product of many minds, experts, and peer reviews that has shaped this process into a tangible and agile tool for design teams.

What resources do you need to communicate and incorporate resilience in your project?

Main Takeaways

Resilience needs to be incorporated early enough into design to provide effective solutions!

We need a tool to help teams navigate resilience design thinking and integrate into projects.

We had a wide range of what the definition of resilience is: We need a standard definition that all employees know.

We must show socially, environmentally and financially the value of resilience to enable our clients, communities and colleagues to truly support this effort.

Why Resilience?

***Resilience:* The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvements of its essential basic structures and functions. (IPCC, AIA)**

Resilience not only addresses the endurance and recovery from difficult situations or environments but also addresses the ability of our community to foresee these hardships and mitigate them with design. These risks can range from environmental events, such as earthquakes, flooding, pandemic, and extreme heat, to social and economic events, like civil unrest, utility disruption, aged infrastructure, and cyber-attacks. While resilience is a broad term, we have deciphered resilience into five major forms: *Health, Social, Infrastructure, Environmental and Economic Resilience.* Each represents a specific area of study that together, create a holistic view of resilience.

Health Resilience refers to the physical, mental, and social health of individuals in a community. Clean air, access to healthcare and security all increase health resilience. In the short term it includes the food, water, and shelter needed to sustain life before help arrives.

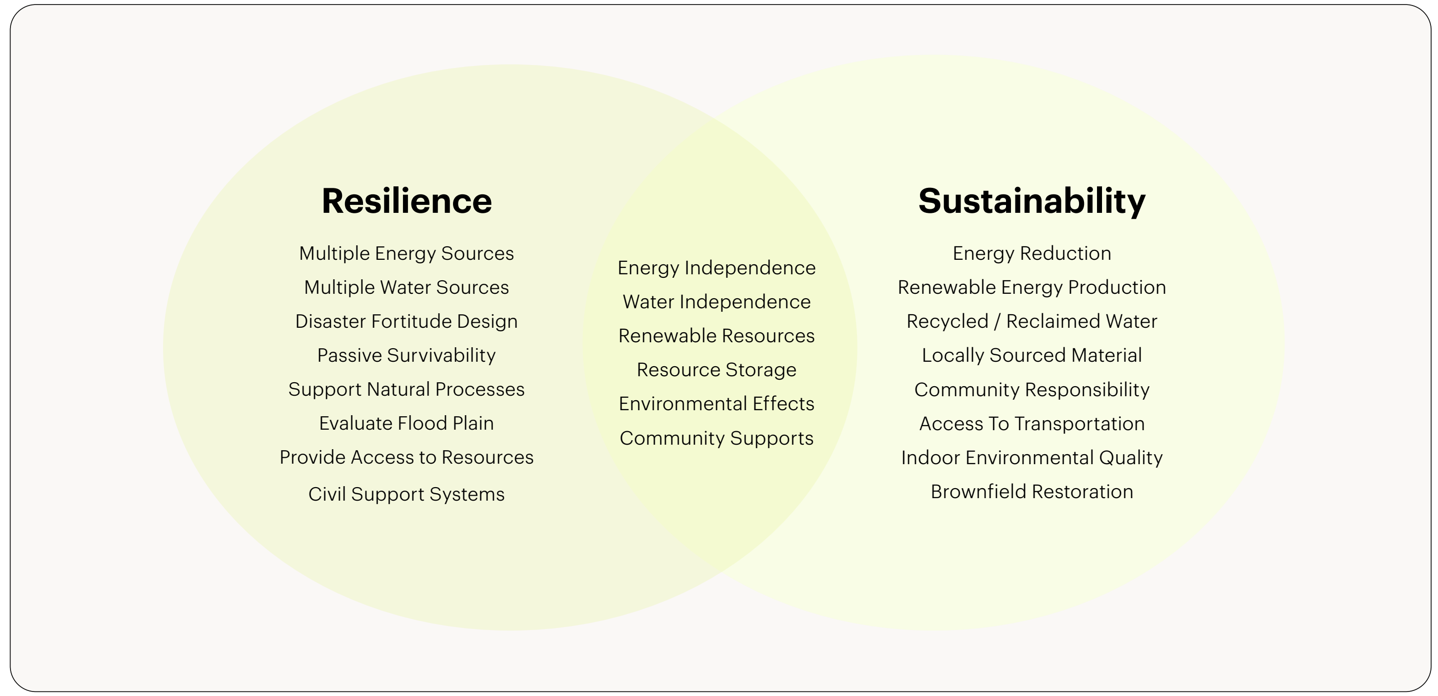
Social Resilience connects health resilience on the individual level to the community level to maintain cultural and historical traditions that can define a sense of a place.

Infrastructure Resilience focuses on the physical infrastructure of a campus and the local community and seeks to protect utility and transportation infrastructure as well as public services that protect the quality of life in a community.

Environmental Resilience includes climate and weather impacts on an ecosystem as well as all the native flora and fauna species of a place. Understanding the needs of these phenomenon and groups helps increase biodiversity and can provide nature-based solutions.

Economic Resilience provides a perspective to determine appropriate means to afford and operate a campus within a community. Determining the cost-benefit of a strategy enables analytical decision making and balances performance with cost.

Resilience is inherently interconnected with many aspects of our world. We cannot solve social problems without community resilience, and we cannot have community resilience if we do not address our climate and environment.



While there is no one-size-fits-all solution and resilience is different for each community and region, there is common ground for how we can communicate the need for implementation. The architectural and engineering industry is in a prominent position to advance the discussion of resilience and adaptation in the built environment. This will only be successful through active engagement from all stakeholders.

Difference Between Resilience and Sustainable Design

While both sustainable and resilient concepts are future-focused and can benefit from design, sustainability focuses on resource efficiency and environmental protection, while resilience focuses towards preparing for and recovering from future disruptions and disaster events.

Resilience Design – The architect anticipates change and hazards throughout the building's life and provides design features to mitigate risk and vulnerability.

Sustainability Design – The architect uses design to enable efficient building operation and minimize resource requirements to satisfy present needs without compromising the ability of future generations to meet their needs.

When resilience and sustainability design overlap, we can achieve independence from energy and water infrastructure, ideally through renewable sources, that support a thriving community with less environmental threats and impacts. Not all resilience strategies are sustainable and not all sustainability strategies are resilient, but these strategies can come together to create a better place.

Designing "Beyond Code"

The building code represents the minimum performance requirements a project must be designed to meet. It seeks to provide a building that protects the health, safety, and wellbeing of users in hazard egress events, but does not ensure the building or structure will be usable after the event.

For example, buildings in South Florida are required to be designed to meet hurricane wind loads to protect people during and after a storm. It is up to the owner to replace the building or design a building to minimize damage and quickly return to normal operations after a hurricane.

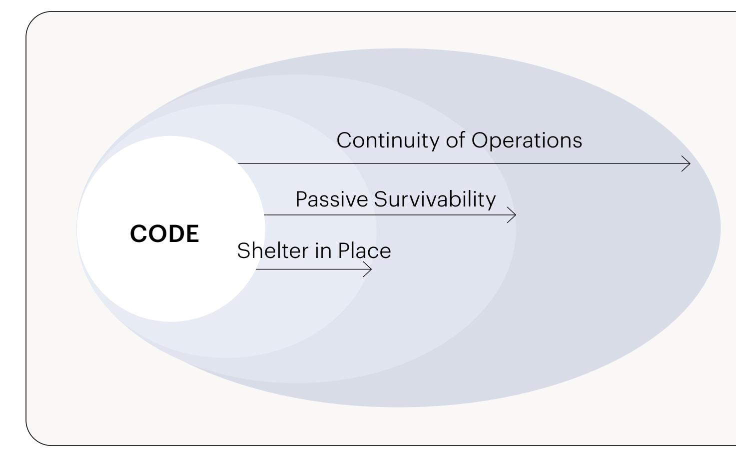
A beyond code building must also look to the future and anticipate potential changes in social norms, technology, and climate to enable the building to remain relevant and safe over time. Determining a project's usable life is critical to planning and designing for its future.

Designing for resilience considers societal and financial costs related to a disruption as well. Three levels of **'BEYOND CODE'** performance that architects might consider are:

Shelter in Place – ability to safely 'ride out' a hazard event inside a facility. While the building may not be able to function after the event is over, it will be sufficiently robust so that occupants will remain safe inside during the event itself. (AIA)

Passive Survivability – ability of a building to maintain reasonable, basic functionality after an event. The building needs to be intact and building systems like thermal, power, and potable water, should remain functional to allow occupants to remain in the building while critical services are restored (durability of the building, enclosure, materials, etc.). (AIA)

Continuity of Operations – requires a facility to withstand the impact of a disaster event and remain fully, or close to fully, functional before during and after an event. Typically, essential occupancy buildings - fire stations, hospitals, police stations, etc. (AIA)



Resilience Design

Designing for Resilience

The Resilience Design Toolkit is a methodology specifically developed for architects to integrate resilience design thinking into a building design process. It was developed with input from industry professionals, leverages processes and tools developed by distinguished groups such as FEMA, NOAA, AIA, Arup, and Perkins & Will; as well as peer reviewed by experts in the architectural and engineering industry.

A five-step process is common in resilience planning and coordination. NOAA has released two documents, the US Climate Resilience Toolkit and Steps to Resilience that both use five-step processes to show how resilience is tangible and accessible to a project or built condition. The Resilience Design Toolkit also uses five steps and has made the process highly specific to the architectural industry.

Step 1: Resilience Scope

Understand what your client and stakeholders require regarding resilience. Sometimes, architects may need to educate or identify resilience needs when the client is not familiar or knowledgeable on the subject.

Step 2: Align and Plan

Once the scope has been established, it is time to develop the team and the work-plan to achieve project resilience goals.

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With hazards evaluated and key risks identified, the design team can develop resilience design strategies and test them for effectiveness using a Benefit Cost Analysis (BCA) and Choosing by Advantages (CBA) exercise.

Step 5: Operate + Evaluate

After construction is complete, following up with your client and the community can allow for Post Occupancy Evaluation (POE) to understand successes and failures. This is also a good time to reinforce being a trusted advisor to your client.

Design is an iterative process that develops organically using structured information and intuition. Resilience design begins in the first interactions with a client or community and extends into building operation.

At the heart of the Resilience Design Toolkit is a design feedback loop to integrate project information with resilience design best practices to develop design solutions. These solutions are assessed using a BCA and CBA to help select the most appropriate solution for a project.

As billion-dollar disasters become more frequent and continue to test our physical, environmental, social, health and financial wellbeing, resilience design is becoming more important and requested in projects. We hope this tool helps provide knowledge so that you are able to start designing for resilience or provide new ideas to enhance your resilience design process. This toolkit has been developed to be agile and easily adaptable to fit any design process for any firm size or project typology. We hope this process helps demystify resilience design and makes it more accessible for your team and project.

The Resilience Design Toolkit Process x Typical Project Process

The Resilience Design Toolkit Five-Step process begins in the initial phases of a project during the pursuit to identify specific resilience design goals and objectives. The subsequent 4 steps endure through the planning phases into post-construction and operation. The graphic below outlines the five steps and provides a summary of intent and major activities in each.

Pursuit | **Planning** | **Pre-Concept** | **Design** | **Post-Construction**

1. Resilience Scope

Determine the client's understanding of resilience and the owner's project requirements. Develop an appropriate resilience scope for the project.

Perform:

Identify Client Understanding of Resilience

Assess Resilience Scope

2. Team Alignment + Planning

Develop a plan to integrate resilience in the project by identifying appropriate talent and process by creating a resilience design work plan.

Perform:

Create Resilience Design Workplan

Assemble Project Team

Resilience Design

Kick-off, Visioning, and Work Sessions

3. Identify Hazards

After the plan is set, identify project hazards, then assess risk & vulnerability. Discuss results with project team and stakeholders.

Perform:

Hazard Study

Risk & Vulnerability Assessment

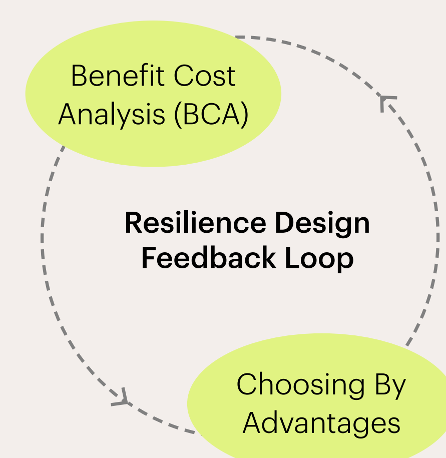
Determine Critical Hazards

Employ:

AIA Principles of Design Excellence Framework

4. Integrate Resilience Design

Mitigate project risk & vulnerability by integrating resilience design measures. Assess viability & feasibility of specific strategies through a Benefit Cost Analysis.



5. Evaluate + Nurture

Project close out and delivery. Assess building resilience performance and develop a case study after first year of operation.

Perform:

Post Occupancy Evaluation

Create:

Case Study & Apply Lessons Learned

Resilience Landscape

A variety of tools and processes exist to help guide resilience projects. Each has unique qualities to enhance projects, yet the Resilience Design Toolkit provides a range of tools and processes to determine gaps and introduce a methodology that fulfills a need in design.

US Climate Resilience Toolkit

In 2014, NOAA Climate Program Office launched the US Climate Resilience Tool Kit to improve government organizations and planners ability to understand and manage their climate-related risks and opportunities. The intent is to help make communities and businesses more resilient to extreme events. The toolkit uses a 5 step process to understand risk exposure, assess vulnerability, investigate options, prioritize, and plan, and take action for resilience.

AIA Resilient Project Process Guide

In 2022, the AIA released the Resilient Project Process Guide to provide a series of questions for architects to engage clients coupled with additional resources for architects to act upon. The document is organized by project phase and identifies points where resilience and climate adaptation goals can be layered into design solutions.

NOAA Implementing the Steps to Resilience

In 2022, the NOAA Climate Program Office published the Steps to Resilience (StR) risk assessment and decision support framework to help guide decision making and strategy development. The guide is written for climate adaptation and resilience building experts to analyze, facilitate and guide project development.

Living Building Challenge v4.0

Living Building Challenge is the most comprehensive and progressive green building certification system. It requires projects to enhance building performance through seven petals to create a regenerative building that innately uses resilience features.

REDi™ Rating System

The Resilience-based Engineering Design Initiative (REDi™) Rating System, developed by Arup's Advanced Technology and Research team, proposes a framework for owners, architects, and engineers to implement "resilience-based design." The REDi™ guidelines form a framework for resilience-based design for the built environment for earthquakes, extreme storms, and flooding.

RELi™ 2.0 Rating Guidelines for Resilient Design and Construction

The RELi™ 2.0 Rating System is a resilience-based rating system that combines design criteria with integrative design processes for neighborhoods, buildings, homes, and infrastructure. Developed originally in 2012 by Perkins & Will, RELi™ has entered version 2.0 and has synergies with LEED v4 pilot credits.

LEED v4/4.1 Pilot, LEED v5

LEED has been the standard for green building certifications for over 20 years and has included resilience as a Pilot Credit in v4/4.1. These elective credits integrate risk and vulnerability assessment into project goals. LEED v5 is currently in development and is believed to have more resilience requirements when released.

WELL v2 & Fitwel v2.1

WELL v2 and Fitwel v2.1 both have features and credits that require emergency operations planning for buildings. Both aim to enhance social and community resilience by making buildings more conducive to human health and performance.

FEMA Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning

FEMA developed tool that provides a four-step process to consider hazard mitigation planning for historic buildings. This guide is written for planners and emergency managers but has some relevance to resilience in the project process.

Autocase

Autocase is a web application subscription that quantifies and monetizes social and health benefits, whole life carbon footprint, and lifecycle financial impacts for the built environment. It uses a benefit cost analysis tool to evaluate projects using a triple bottom line approach and is a useful asset to understanding the impacts of resilient design.

ISO 14090, 14091, & 22301

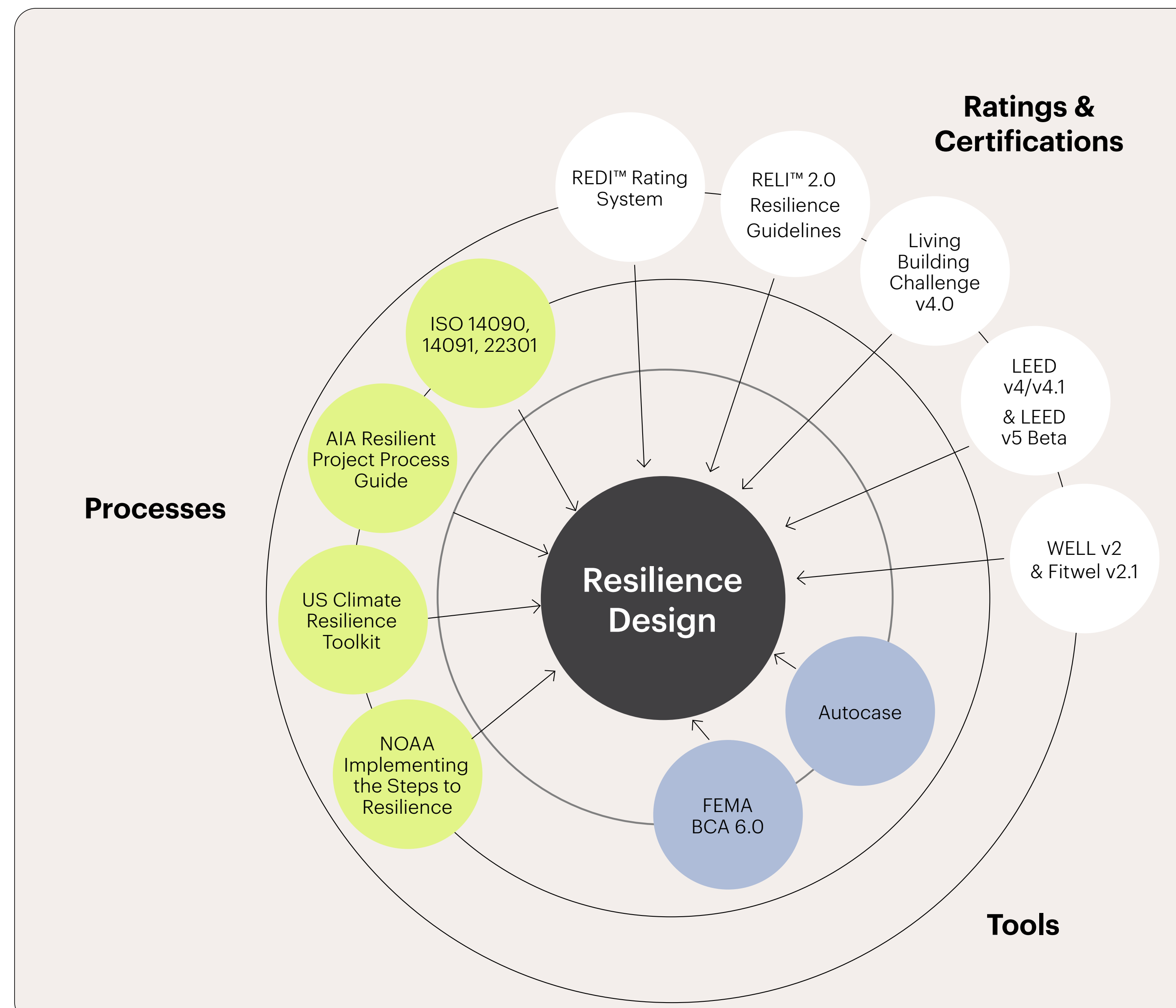
ISO has created standards to help define Adaptation to Climate Change with principles, guidelines and requirements for vulnerability, risk assessments, and how business continuity should be addressed.

FEMA BCA 6.0

FEMA has created a benefit-cost analysis tool through a plug-in feature to Microsoft Excel™ that can use formulas and user input to perform BCAs. This is a required assessment for federal projects.

Resilience Design Toolkit

This toolkit has been developed especially for architects and designers to integrate resilience design into projects. It uses insight from all of these tools and certifications to provide a comprehensive and agile process that can work for any project type, size or location.



Glossary of Terms

100-Year Floodplain – More accurately identified as a *1% Annual Chance*, Is a flood that has 1 in 100 chance of being equaled or exceeded in any 1 year and has an average recurrence interval of 100 years. (USGS)

The 50, 100. & 500-year flood terms are becoming less relevant and deceiving with the frequency of such flooding events happening more regularly and sometimes multiple times in a single year.

Adaptation – The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (IPCC)

Adaptive Capacity – The ability of a person, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change. (US Climate Resilience Toolkit)

Asset – People, resources, ecosystems, infrastructure, and the services they provide. Assets are the tangible and intangible things people or communities value. (US Climate Resilience Toolkit)

Base Flood Elevation (BFE) – The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The BFE is shown on the Flood Insurance Rate Map (FIRM). (FEMA)

Benefit Cost Analysis (BCA) – A method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs. The result is a Benefit-Cost Ratio (BCR). A project is considered cost-effective when the BCR is 1.0 or greater. (FEMA)

Benefit Cost Ratio (BCR) – This ratio is the present value of net project benefits divided by the project costs and is the result of a BCA. A ratio of 1.0 or greater indicates the project is cost effective; a ratio of less than 1.0 indicates the project is not cost effective. (FEMA)

Business Continuity – Capability of the organization to continue delivery of products or services at acceptable predefined levels following disruptive incident. (ISO)

Capacity – A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. (U.N. International Strategy for Disaster Reduction.)

Circular Economy – A systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature.

It is underpinned by a transition to renewable energy and materials. Transitioning to a circular economy entails decoupling economic activity from the consumption of finite resources. This represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

Climate Change – A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC)

Choosing by Advantage (CBA) – A decision-making system that supports transparent and collaborative decision-making using comparisons among advantages of alternatives. (LCI)

Climate Mitigation – A human intervention to reduce the sources or enhance the sinks of greenhouse gases that reduce hazard, exposure, and vulnerability. (IPCC)

Cradle-to-Cradle – Materials, systems, and products are part of a closed loop system that doesn't produce any waste.

Emission Mitigation – Measures to reduce the amount and speed of future climate change by reducing emissions of greenhouse gases (GHGs) or by increasing their removal from the atmosphere. (4th NCA)

Externality – A side effect or consequence of an external event or behavior on a system.

Exposure – The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Flexible – Position infrastructure and buildings to be adaptive to changing needs. (AIA)

Hazard – A potential source of danger caused by a naturally occurring or human-induced process or event with the potential to create loss. (AIA)

Life Cycle Cost Analysis (LCCA) – Method for assessing the total cost of facility ownership to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function. (WBDG)

Maintainable / serviceable – Design provides for maintenance access and regular improvements to building systems and envelopes. (AIA)

Mal-adaptation – Any changes in natural or human systems increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead. (IPCC)

Mitigation – The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. (IPCC, AIA)

Passive Survivability – The ability of a building to maintain reasonable, basic functionality after an event, specifically an event that includes an extended power outage. (AIA)

Recovery – Activities necessary to rebuild after a disaster. Recovery activities include rebuilding homes, businesses, and public facilities; clearing debris; repairing roads and bridges; and restoring water, sewer, and other essential services. (FEMA)

Redundant – Integrate duplicate systems that can support the operations of a structure for the well-being of occupants and reduce other negative impacts should a disruption/failure occurs.

Resilience – The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvements of its essential basic structures and functions. (IPCC, AIA)

Response – Activities to address the immediate and short-term effects of an emergency or disaster. Response activities include immediate actions to save lives, protect property, and meet basic human needs. (FEMA)

Risk – The potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood, and the associated consequences. (DHS)

Sensitivity – The degree to which a system, population, or resource is or might be affected by hazards. (US Climate Resilience Toolkit)

Shock – Hazard events typically associated with large scale disaster, sudden and acute events that impact a vulnerable system. (AIA)

Special Flood Hazard Areas (SFHAs) – An area having special flood, mud-flow or flood-related erosion hazards and shown on a Flood Hazard Boundary Map (FHBM) or a Flood Insurance Rate Map (FIRM). (FEMA)

Glossary of Terms, Continued

Stress – Gradual and perpetual disruption that often reduce a community's ability to recover when shocks strike. (AIA)

Social Stress examples – aged population, food scarcity, population growth, affordability, unemployment, growing wealth gap.

Physical Stress examples – ill-maintained infrastructure.

Natural Stress examples – environmental degradation, sea level rise, drought, melting polar ice, global warming.

Vertical Datum – A common vertical elevation reference point, usually in relation to sea level. (FEMA)

Vulnerability – The degree to which a system is susceptible to, and unable to cope with, adverse effects. (IPCC, AIA)

Acronyms

AIA – American Institute of Architects

ASCE – American Society of Civil Engineers

ASLA – American Society of Landscape Architects

BRIC – Building Resilient Infrastructure and Communities

CDRZ – Community Disaster Resilience Zones

DHS – Department of Homeland Security

DFE – Design Flood Elevation

FEMA – Federal Emergency Management Agency

FLASH – Federal Alliance for Safe Homes

HMA – Hazard Mitigation Assistance

IPCC – Intergovernmental Panel on Climate Change

ISO – International Organization for Standardization

LCI – Lean Construction Institute

NOAA – National Oceanic and Atmospheric Administration

NAVD 88 – North American Vertical Datum of 1988

NWS – National Weather Service

RCN – Resilient Cities Network

RFQ – Request for Qualifications

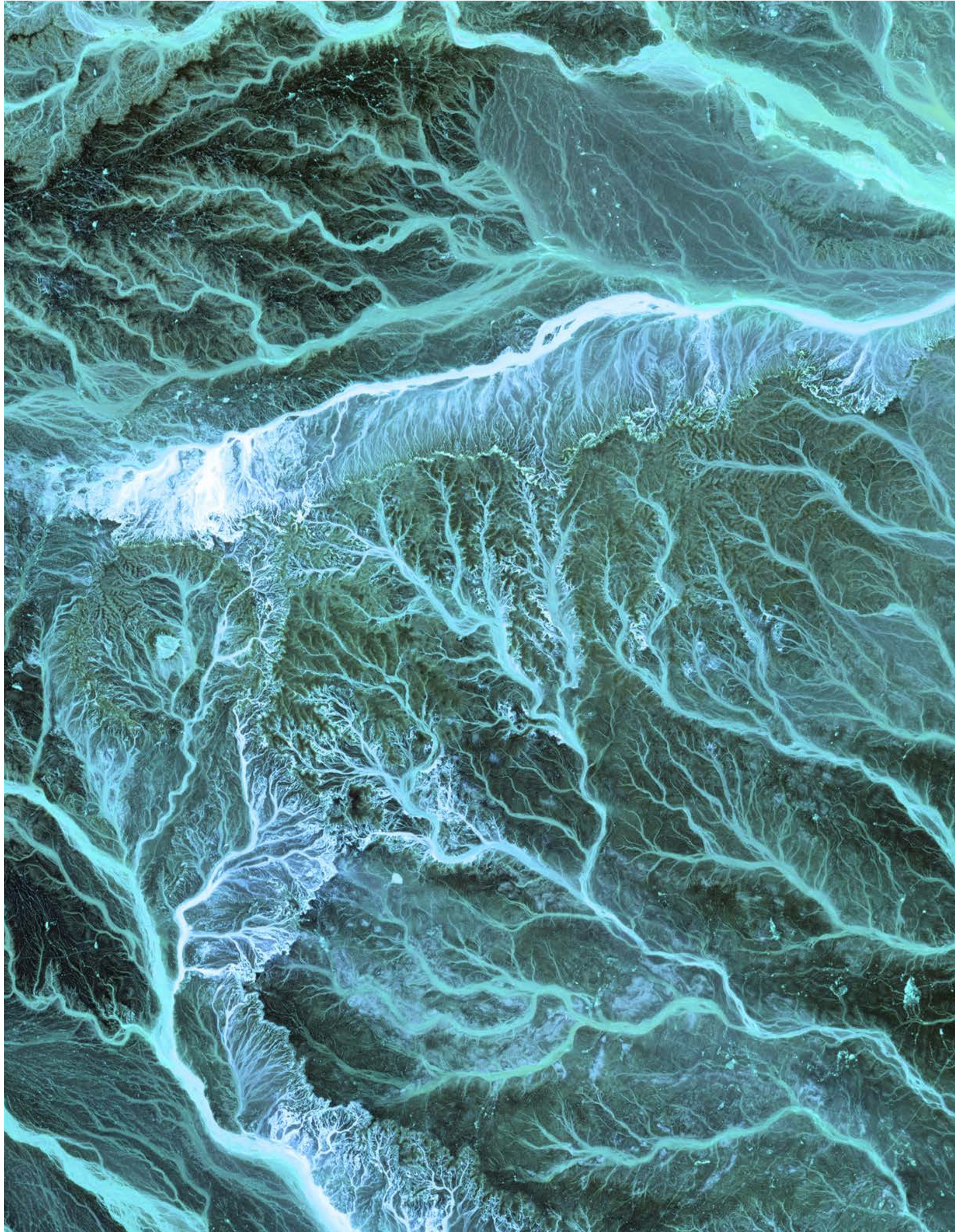
RFP – Request for Proposal

USGS – United States Geological Survey

USRC – US Resiliency Council (USRC)

WBDG – Whole Building Design Guide

WUI – Wildfire Urban Interface



1. Resilience Scope

Assessing Scope + Initial Conversations

Step 01 **requires individuals interfacing with potential clients, community groups, and other stakeholders to analyze information provided in the form of candid conversations, formal meetings, RFP/RFQs, or other means and methods the project requirements were communicated, for resilience scope in the design process. These individuals should work with the potential client to align on agreeable terms for resilient design so that a clear resilience workplan can be determined. This process can be very different depending on the type of project, location, interactions, and preferences from the client team.**

Understanding the Ask

Resilience is understood at various levels across communities. In areas where the effects of natural disasters and climate change are felt more acutely, stakeholders are often more in-tune or aware of how resilience design can help protect and mitigate potential hazards. In places that have not been impacted by natural disasters or other types of hazards in recent memory, resilience may not be something that is asked for or required in a project; however, no project is immune from potential hazards. It is the duty of architects and their consultants to perform due diligence for every project. We should communicate findings to project stakeholders whether they agree with the concerns or not.

Potential projects come from many different types of interactions like meetings, conversations, RFQ/RFPs, and postings from clients and stakeholders. Sometimes resilience requirements are clearly indicated, sometimes they are implied but need to be further defined. Other times they can be missing all together. Understanding the scope of resilience and what the client is looking for is critical for determining how to set fees and create a workplan. Sometimes it is as easy as a follow-up conversation, other times it requires the architect to perform research and critical thinking of how to respond and what to ask.

This section will help break down these interactions and provide insight on how to handle a resilient design request.

If you are new to resilience, the first step is to educate yourself on what resilience is and why it is important to consider as we develop the built environment. By reading through this toolkit you will receive a brief introduction to resilience design. Many resources, articles, case studies, and videos are available showing how resilience works and why it is important. The Resilience Landscape section includes resources that can help develop a foundation of resilience design tools and processes. One may also notice the need for resilience in their community and daily routine, which promotes social resilience. Resilience may be similar across many regions and areas but will always have a specific variation to the people, culture, form, and terrain of a place.

Knowing the basics of resilience; key terms such as hazard, risk, vulnerability and how they relate to each other will start the conversation, knowing where to look for site specific information will point you in the right direction. Being humble with your client by admitting not knowing about a topic, and committing to do research to follow up with a confident response helps contribute to a trusting relationship.

When you receive an ask for resilience design or something that alludes to resilience from a potential client, you will need to understand the client's requirements and deliverables like in any RFP. Resilience assessments are not typically part of base services for architects and should be treated as additional services or separate line items in a project contract. This includes scope for hazard, risk and vulnerability assessments, BCA, and CBA. Ideally, architects should be considering resilience design thinking in every project, and it is up to the discretion of the architect on how to charge for resilience design services. Specialized consultants may also be required to complete resilience design scope for a project. This will be further explained in Step 02: Team Alignment & Planning.

Architects should also be cognizant of potential risks and liabilities of resilience design scope in contracts and proposals. Additional insurance may be required to safely enter a contract. An insurance professional should be consulted for additional information on resilience design services.

When further clarity is needed to develop a proposal or proceed with a resilience design scope of work, it is always a good idea to develop questions to ask the potential client.

The AIA Resilient Project Process Guide is a good place to start. Client interactions could be a one-on-one conversation, at a public meeting, or in an email. The next section provides potential questions that could be asked by a client or used to understand a client's position or ask for resilience design services.

Resilience Conversations

Private Conversation

Word-of-mouth work and leads are effective ways to maintain a business. Speaking at conferences and participating in your community are also effective methods to advertise, lead with knowledge, and reinforce firm values for business development. Architects often become trusted voices to clients. If a client is curious about resilience and wants to know more about how resilience design can be beneficial for their project, the architect should be able to provide a confident response.

Embedded in RFP/RFQ

Architects typically receive an RFP for potential new work. Usually, the scope of work is clearly defined and presented so that the architect can assemble the appropriate team and fee. In the wake of recent disasters, resilience design requirements are becoming more common. The Resilience Design Toolkit aims to equip architects with knowledge and strategies to confidently respond to RFP/RFQs with resilience design requirements.

Added to an Existing Project

Scope will develop and may change through the life of the project. Architects may also uncover a previously unknown hazard during a project. These should be brought to the client's attention with care and effective solutions discussed with the project team. A project change directive from the client could request a resilience design add service. To better serve the client, architects will need to be knowledgeable about resilience design.

Community Meeting

Community meetings can be an essential part of a project development and approval process especially for public projects. Community meetings may not be required for private projects, but community interests should be considered in design. We can learn what is important to a community from comments and statements provided at community meetings. Resilience may arise in public feedback and could impact how the client team addresses requests for resilience design.

Identifying Your Client's Knowledge of Resilience

Understanding your client's knowledge of resilience may help guide the type of interactions you should pursue with your client. Some methods like discussing BCA may be more effective with a highly knowledgeable client versus one that is just beginning to understand needs for resilience. The following section highlights four general levels of knowledge a client may have on resilience and some suggested methods to guide a resilience discussion.

Unaware

An unaware potential client may not have thought about resilience design for their project. The client may be unaware of the potential hazards their project could experience and level of risk they could incur from the impacts. As a professional, you may be more aware of potential issues with the project and see a distinct need for resilience design. This type of client could provide an opportunity to lead with knowledge and establish their understanding of resilience design.

Recommended Interactions: One-on-one conversations and/or focused discussions on resilience using relevant examples and descriptions of the five-forms of resilience.

Exploring

The client may be just beginning to understand resilience with some pre-conceived notions and may need someone to lead them through the learning process. In this case the architect and project team may want to have a focused discussion on vulnerability, risk, how resilience could be integrated into their project along with what value it may bring. When speaking to a client at this level or a subsequent level, it is important to assess the client's current position on resilience to better serve and answer possible questions.

Recommended Interactions: Inquisitive questions to gauge the client's level of resilience knowledge and how that has shaped their requirements for resilience design in the project if provided. Make tangible connections of resilience design strategies to their project to show value and benefit.

Evaluating

Clients that are evaluating resilience may already know what they want and have an appropriate deliverable in mind. They may not know exactly how resilience design works but understand the base concepts and why they are important. It is critical to evaluate your client's expectations and frame conversations or deliverables with their expectations in mind. This will help assure them that you can deliver a resilient project and be an asset to the project team.

Recommended Interactions: Focused discussions or examples of how you plan to address resilience in their project, the benefits and value of these strategies. This should also be coupled with an explanation of how the resilience design strategy will function, and how it addresses resilience requirements without revealing too much information if the project has not yet been awarded. This is up to the discretion of the architect.

Embedded

When resilience is clearly embedded in an RFP and the client knows their resilience goals, there is often a recent experience the client has endured or knows of where resilience was needed and/or incorporated, with a clear value proposition. This type of client has a specific deliverable in mind, and it is good practice to discuss the previous experience with the client to better understand their thinking. This will also help assemble a competent project team with experience and ability to provide resilience design services that match the deliverables.

Recommended Interactions: Before engaging with the client, be sure to research previous experiences where the need for resilience may have arisen such as a natural disaster or social unrest. In focused discussions or general pre-interview questions, confirm previous experiences with the client. Address the project requirements directly in the proposal document and provide key explanations to show you understand their needs and how to deliver a final product that meets or exceeds their requirements.

As hazards and threats continue to impact our communities and built environment, tremendous opportunity exists to lead with knowledge on resilience design in all projects. The concepts in resilience design are not hard, but it takes a keen understanding and critical eye to integrate design strategies into a project that mitigate risk and create a higher performing project. The next three steps in the process will enable you to quickly pick up basic skills for resilience design and provide these services for your clients.

Developing the Resilience Scope of Work

With information gathered from the client through various interactions as previously described, the architect should decipher the project requirements. An Owner's Project Requirements (OPR) document and exercise could be used to formalize and track key project requirements. This document should include a section for resilience components. The OPR is a document established in the pursuit phase and should be updated in every subsequent project phase. If an OPR is not used in the project, a simple statement or guiding principle of the resilience requirements should be developed and used to guide project and design development throughout the life of the project. This statement will also be used to determine the appropriate project team as defined in Step 02.

Client Characteristics

Unaware	Unaware of resilience as an issue Resilience may have not been mentioned in an RFP/RFQ or come up in conversation. Opportunity to lead with knowledge May not have an appetite for resilience
Exploring	Aware of resilience as a concern but may not know what it is totally about or how it is performed Needs guidance in understanding on how hazards might put their project at risk Could be an opportunity to lead with knowledge Need to understand client's position on resilience
Evaluating	Client has a position on resilience and understands base concepts Client has an idea on what they want in the project Project team needs to build confidence in the client that they can provide resilience design services
Embedded	Client is familiar with resilient design and knows what the final deliverable should be Project team should determine the capabilities of the team and ability to provide desired services for the client

Questions + Answers

The knowledge level of resilience varies from client to client, and they will often look to the architect or project team to help educate on resilience. The questions below are potential interactions between the project team and the client. Study both the question and answer to familiarize yourself with potential conversation points. The AIA Resilient Project Process Guide also provides an extensive background of information and questions to ask an inquisitive client. Through the conversation, it is helpful to be thinking on how you would answer the following questions based on what you have learned about the client's knowledge of resilience.

What is the client's understanding of resilience? Do they know what they want or have communicated their risk tolerance?

What is the client's experience with resilience? Have they experienced a disaster event that tested their resilience in their organization or assets? Is the client looking for the project team to help them understand resilience?

Have exposure to hazards and risk assessment already been identified in the RFP/RFQ? Are there specific requirements that need to be included in the design solutions?

What are the opportunities for resilience design in the project? If resilience is critical, will the client need special hazard and risk assessments from an expert prior to setting scope?

Potential questions

Helpful Answers

What is the importance of developing projects to be resilient from the onset, instead of just adding resilient features after the project is built?

- Comprehensive and holistic building design integration compared to one single program added at a later time
- It is more expensive to add resilient features after the project is built
- Resilient measures are more effective when they are integrated into the business model
- Helps maintain business continuity during certain events

What are some ways your company is building or has built projects to be resilient?

- Redundancy of critical building systems (power, MEP)
- Durable enclosure systems
- Flood planning - building above the base flood elevation (BFE)
- Ecological based solutions like living shorelines and greenspace

Is building a project to be resilient more expensive? If yes, how so?

- Although it may have initial cost premiums, the ability to continue business during and recover from an event could save money in damages, reduce insurance premiums and better serve your users
- Resilient design can add value to a project by commanding lease premiums, less operational costs and the ability to remain operational or more quickly recover after a disaster

Potential questions

Helpful Answers

What sort of return on investment can owners who build resilient buildings expect once they open their doors? How does the design and architecture team's work during the process help achieve those goals?

- Maintain business operations during a stress or shock and higher lease rates / resale value
- Throughout the design process the team should be thinking of effective ways to integrate resilience design
- Design excellence study / vulnerability and risk assessment / eco and resilience charrettes

What is one of the biggest challenges of building a resilient project? How can we overcome such challenges?

- The biggest challenge is the uncertainty of what will happen in the future, yet planning for future events and being prepared for them is invaluable
- One major event can cost millions so let us show you how we can find a way to protect you from these risks

What is one of the biggest opportunities of building a resilient project?

- Being able to handle stressors and shocks more effectively
- Being able to stay open in disasters
- Less repair cost and time and less value being lost
- According to the U.S. Department of Labor, more than 40 percent of businesses never reopen following a catastrophic event and companies without a recovery plan have a survival rate of less than 10 percent

Why don't you think more developers are building resilient projects from the onset? What work do you think the industry needs to do in order to get more developers on board? How can architects help to get more buy-in from developers?

- Governed by initial costs rather than looking at life cycle costs and what this can do to their investments and properties
- As the impacts and costs from natural and man-made disasters increase, the business case for resilience measures also increases
- A BCA can show you the simple economics of resilience

What are the potential consequences, if any, for not creating resilient standards in the building process?

- Ignoring resilience design increases the level of risk for your project. Being unprepared for a disaster may cost significantly more resilience design solutions and will incur higher insurance premiums

2. Team Alignment + Planning

Project Management and Planning

***Step 02* requires project leaders to begin forming the appropriate project team by using the agreed upon resilience scope of work to determine which specialties and roles will be needed in the project, as well as what the scope of work will mean for how the project team will operate. This also requires a work plan to be developed that outlines the task and their operator to help provide clarity and transparency to the greater project team.**

Once the scope of a project is formalized, the next step is to identify which team members will need to be engaged to achieve the resilience design goals. Step 2 - Team Alignment, helps determine who will need to be involved and when they need to be there. The selected team will also need to align with the scope of work and determine the specific goals and methods to achieve them.

Assembling the Project Team

A critical component of designing a resilience project is bringing the appropriate team together. Resilience may not be the only guiding principle of a project, however most consultants on the project team will play a role in achieving the project's resilience goals. Experience in resilience or willingness to advocate and incorporate resilience design strategies in their work will be helpful throughout the process. When creating the project team, ask about resilience experience and notify potential project consultants of the client goals for resilience.

Specialty Consultants

Specialized resilience consultants and experts may be needed to achieve project goals. For example, projects located in delicate ecosystems could benefit from ecological consultants specialized in biodiversity and ecological design. Large coastal projects may warrant a coastal and marine expert to identify specific challenges and aid the design team with developing solutions that minimize impact to aquatic ecosystems while maintaining a level of resilience to storms and sea level rise.

Depending on the project delivery method, specialized consultants may be under a contract with the architect, contractor or directly with the owner. Consultants contracting with the owner could be a method to help promote a third-party, neutral assessment of the project if desired. When assembling the team, be sure to discuss contract and scope options with the ownership group to minimize confusion and align project delivery strategies.

Architects are obligated to discuss resilience directly with clients to uphold the interests of our communities, clients, and the environment per the AIA Code of Ethics. Resilience is considered an additional service in most architects' standard of care. Depending on the location of the project, some aspects regarding resilience may already be a building standard for example, emergency power requirements for hospitals and other buildings with essential services. Specific resilience requirements outside of the standard of care should be an additional service such as a risk and vulnerability assessment.

Designing for resilience and other resilience design services such as a risk & vulnerability assessment may open an architect and the project team to additional liabilities in a project. If insurance policies do not insure architects for services outside their specific standard of care, the architect could be liable for damages if a suit is filed. If an architect is operating outside of their area of expertise, this could also open a new position of risk.

For example, an architect would not take on the scope of a structural engineer on a complicated project, if an architect cannot confidently provide a formal risk and vulnerability assessment, a qualified consultant could more efficiently and effectively provide this service and should be engaged. Insurance professionals should be consulted on any policy modifications needed to cover the architect and project teams before signing a contract for resilience design services. Ideally, resilience design scope should be complimentary and integrated to an architect's typical design scope, thus becoming a standard of care. This section is not meant to discourage resilience design but to make sure an architect has the necessary means to protect themselves legally. More information on integrating resilience design can be found in Step 04.

Resilience Kick-off, Visioning, & Workshops

Before beginning design or resilience work, it is best practice to host an integrative design charrette with dedicated time to discuss resilience. A key component of a successful project is to have the team aligned and coordinated around specific goals. The integrative design charrette should include other topics specific to the design, sustainability, and building performance to connect these conversations and discussions to the greater design narrative and enable holistic design thinking. It is paramount that the project team knows the specific design challenge and design requirements.

The next sections outline the process to align the project team around resilience design.

Typical Project Team - Resilience Scope

Consultant	Role In Resilience Project
Architecture	Coordinate resilient strategies with building design features, integrate BCA into design strategy development
Civil Engineering	Develop site infrastructure and stormwater design with resilience strategies
Landscape Architecture	Design site solutions to accommodate resilience features and promote biodiversity
Mechanical, Electrical, Plumbing, Fire Protection Engineering	Develop building system design with resilience requirements, plan for power, potable water and process water emergency and back-up systems for the desired self-sufficiency period, support resilience design strategies and future retrofit opportunities, conduct project energy models and assess project performance
Structural Engineering	Design building structure to accommodate potential seismic, wind and other structural hazards, design site structures and coordinate infrastructure design
Interior Design	Design interior spaces to support resilient features and requirements
Contractor	Provide feedback on what is feasible in construction
Cost Estimating	Provide cost estimates for design components and strategies
Facility Management	Provide feedback for building operations and incorporate design strategies in building operation

Specialty Consultants - Resilience Scope

Consultant	Role In Resilience Project
Geo-Technical	Provide site assessment and information regarding potential geographical hazards and opportunities
Urban Planning	Assess site infrastructure and integration with current and future planning projects within the local community
Urban Design	Develop connection to the urban form with resilience strategies
Environmental. Social, & Governance (ESG)	Coordinate project sustainability requirements with resilience strategies, connect green building certifications to resilience design, incorporate Justice, Equity, Diversity, & Inclusion (JEDI) principles to resilience strategies
Transportation	Develop transportation solutions to support resilience design requirements, alternative transportation options and protection for existing infrastructure
Coastal & Marine	Develop solutions to support aquatic ecosystems and coastal infrastructure with resilience strategies
Government	Advise on solutions pertaining to government systems and infrastructure projects, emergency management protocol and operations
Public Health	Advise on resilience solutions regarding public health impacts, disease prevention and control, wellness community support, health maintenance programs
Resilience	Coordinate resilience planning and strategy development, administer resilience rating system, facilitate resilience workshop and visioning
Technology	Advise on technology solutions regarding resilience strategies
Ecology	Advise on solutions regarding natural ecosystems, explore potential opportunities to integrate biodiversity and natural systems into resilience strategies
Asset Management	Develop strategy, asset management, and investment strategies for capital and operational expenses to mitigate project hazards
Climate & Data Science	Provide comprehensive analysis of future impacts from climate change and connect project data to climate and resilience initiatives

Planning

Smaller projects can utilize a focused meeting with direct conversations. On large and complicated projects, a visioning workshop will require detailed planning and coordination. A collaborative session led by a qualified facilitator could more efficiently communicate resilience requirements and objectives to the team. Often a dedicated resilience consultant or member of the design team is best equipped to lead the resilience session.

The resilience session could be conducted in a variety of ways such as one inclusive meeting or a meeting series that incorporates a “Kick-off” to introduce the greater project team to resilience ideas and design; “Visioning session” to set initial project resilience goals and objectives; or a “Workshop” to allow the team to connect and develop resilience strategies as a group. It may be beneficial to discuss resilience design with sustainability and building performance topics to determine efficiencies and overlap between topics for a project.

Content

The resilience sessions should provide a comprehensive and holistic approach to resilience design while also integrating with other components of the design. The facilitator and/or project team may elect to perform an analysis of the AIA Principles of Design Excellence measures on the site or an initial hazard assessment for the project. Results of these studies should be presented to the project team within in the resilience sessions.

Alternatively, if a combined sustainability, resilience, and building performance approach is preferred, the AIA Principles of Design Excellence can be used as a framework to guide initial site research and then develop potential strategies using elements and challenges identified in the ten Principles of Design Excellence. For example, a potential Integrative Design Charrette agenda could be the following:

Proposed Meeting Attendees

- Client Team
- Complete Project Team (Architect, Engineers, Consultants)
- Contractor team if available
- Any specialty consultants such as ecological, cost estimating, etc.

Proposed Meeting Agenda

- Introductions (familiarize the team with people on the meeting)
- Goals and Objectives (Align participants on goals and objectives for the meeting)
- AIA Principles of Design Excellence presentation (Present research in each design excellence principle area to the project team and begin to determine appropriate design challenges and potential design strategies to mitigate the challenges as a team. This could involve brainstorming potential baseline, best practice, and stretch goals for each design excellence principle.)
- Determine Next Steps (reconnect on the meeting discussion topics and set action items for meeting participants)
- Adjourn

The team can adjust the meeting agenda to fit their desired method. Case studies can communicate the value of resilience features and the team can identify similar risks and benefits in the client’s project that could be useful for discussion and conversation. The facilitator should record the session and capture any notes for future reference as well as develop a meeting report.

Kick-off

A dedicated resilience design Kick-off should discuss specific requirements regarding project resilience goals. Key requirements include building life expectancy, essential building services or systems that must be always maintained, allowable disruption or downtime typically in hours or days, emergency operation plans and procedures, community support strategies like shelters, specific hazards to be considered, and any financial or insurance requirements. The Kick-off should also investigate the client’s past experiences with resilience, previous losses, and topics on top of mind for the project stakeholders. A dedicated resilience design kick-

A dedicated resilience design kick-off meeting could follow-up after and build upon an integrative design charrette as described in the previous section.

Proposed Meeting Attendees

- Client Team
- Complete Project Team (Architect, Engineers, Consultants)
- Contractor team if available
- Any specialty consultants such as ecological, cost estimating, etc.

Proposed Meeting Agenda

- Introductions (familiarize the team with people on the meeting)
- Goals and Objectives (Align participants on goals and objectives for the meeting)
- Confirmation of critical project requirements (The team should discuss specific project resilience requirements such as allowable period of disruption, quantities of emergency power, water, food, and supplies, etc. The client team should provide detailed answers or agree to provide this information to the project team at a later date)
- Determine Next Steps (reconnect on the meeting discussion topics and set action items for meeting participants)
- Adjourn

Visioning

The resilience visioning component builds on the kick-off by incorporating identified requirements into a set of goals and objectives for the project. It is important for the greater project team to provide input into proposed goals and objectives for the project so that goals are comprehensive and holistic to the project. The team should decide how goals will be achieved and who on the project team will lead those efforts. A resilience rating system like REDi™ or RELi™ may be proposed to help guide the resilience approach and resilience performance metrics for the project.

The visioning meeting should inform an official resilience plan that will be used to guide the team through design. The resilience plan document is created by the project team and should be approved by the owner. The resilience plan identifies each resilience objective, what the expected outcome should be, how will it be achieved and who will be tasked to complete the task. The resilience plan should be a living document and updated as needed in response to project needs and changes.

The resilience plan may identify specific tasks to be completed by the project team which could include formal hazard identification, risk and vulnerability assessments, facility analysis, emergency operations planning, and others. These tasks may be subject to additional services and require specialized consultants to complete.

Proposed Meeting Attendees

- Client Team
- Complete Project Team (Architect, Engineers,

Meeting types	Time	Accomplishments
Kick-off	1-2 hours	Discuss Resilience Goals
Visioning	1-2 hours	Develop a Resilience Plan
Workshop	1-2 hours or Series of Meetings	Team Collaboration and Development of Resilience Strategies

Consultants)

- Contractor team if available
- Specialty consultants such as ecological, cost estimating, etc.

Proposed Meeting Agenda

- Introductions (familiarize the team with people on the meeting)
- Goals and Objectives (Align the participants on the exact goals and objectives for the meeting)
- Confirmation of critical project requirements (As discussed in the Resilience Design Kick-off)
- Review of Integrative Design Charrette or Principles of Design Excellence Study (As discussed in the Integrative Design Charrette if Applicable)
- Development of resilience design goals and objectives for the project (Resilience Design Goals can be at various scales of the project such as a larger regional plan, overall building strategy, or a building operation procedure)
- Determine Next Steps (reconnect on meeting discussion topics, set action items for meeting participants, and subsequent workshop meeting schedule to develop design strategies to fulfill project vision)
- Adjourn

Workshops

As the team begins the resilience scope of work, a series of resilience workshops should be planned to enable team collaboration and development of resilience design strategies to meet project goals. Workshop meetings could bring the greater team together and be part of a routine Owner-Architect-Contractor (OAC) meeting or become a separate meeting series. As design develops, resilience workshops will likely become more focused and require decision making from project leadership. An appropriate amount of time should be reserved for team collaboration and workshops in the work plan.

Time

A comprehensive and integrative design charrette with a resilience component could take 6-8 hours or more for large projects to provide adequate time for discussion of topics and ideas. The resilience component will likely need 1-2 hours of presentation and discussion. These meetings can be separated into smaller meetings if logistics and time are constraints. Separate kick-off, visioning, and workshop sessions will likely take 1-2 hours each.

Who

All project team members should be invited to an integrative design charrette, resilience kick-off, and/or visioning sessions, including ownership, facilities management team, specialty consultants as applicable, and the contractor if available. Enabling all team members to voice opinions and buy-into the project goals not only creates a productive team chemistry but enrichen the design process and product. Inclusivity and transparency are important for team chemistry and developing great ideas.

Outline Your Approach to Resilience

Resilient design projects may have a combination of specific components to help fulfill the client or stakeholder's requirements and the project's resilience vision. These components will adjust in duration and fee based on the project size, complexity, and scope of work. Project managers should coordinate with team members to determine appropriate time and fee for each component necessary to complete the project.

Framework

The AIA Framework for Design Excellence provides a comprehensive and holistic framework to begin exploring a project place and community. Specifically, Measure 9: Design for Change, looks at resilience and how a project addresses future risks and vulnerabilities from social, economic, and environmental change. Adaptation and anticipation of future growth and technology are part of the change measure. Resilience design strategies and impacts can have impacts on the other nine Principles of Design Excellence, for example, emergency power from renewable sources like solar, wind, or hydro can impact other design measures as follows: provide redundant power (Design for Change), provide clean energy (Design for Energy), and mitigate air pollution (Design for Wellness) just to name a few. Resilience can weave into just about every Principle of Design Excellence which is a primary goal of the framework.

Two resilience rating systems available for projects are REDi™ and RELi™. These systems are similar in that they provide guidance on specific strategies and components to incorporate into projects to increase their overall resilience. Each has a different approach, RELi™ emulating the LEED process with one rating system for all building types and REDi™ offering a comprehensive approach based major hazard types, Earthquakes, Extreme Windstorms, and Flooding. Reference guides for each rating system are available on-line for review and determination of which rating system is most appropriate for you project.

The ESG or resilience consultant typically has expertise to administer and facilitate an AIA Framework for Design Excellence, REDi™ or REli™ project administration. Architects are also well equipped to conduct a Principles of Design Excellence Assessment. REDi™ and REli™ may require a separate additional service to administer the rating system to the project from ownership to cover fee and reimbursable costs for reviews and certification assessments. A specialty consultant may also be available to administer this scope if requested from REDi™ through Arup.

Analysis

Analysis begins with understanding potential hazards that a project could endure. FEMA's National Risk Index is a great place to start for US projects. Identified hazards should be comprehensive to the five areas of resilience, Social, Health, Infrastructure, Financial & Environmental. Hazards are often accompanied by compound effects like power outages after a hurricane or poor air quality during a wildfire. For example, a coastal site may have the threat of tropical storms and hurricanes. A subsequent risk and vulnerability assessment takes the identified hazards and evaluates them for their potential to occur, *risk*, and susceptibility of the project to those hazards, *vulnerability*. Further explanation on how this process works is located in Step 03: Identify Risks.

The ownership team may request to hold a third-party contract with a separate resilience consultant. Upon receiving recommendations from a third-party resilience consultant, the project team should plan to meet and review results and discuss mitigation strategies with the ownership team.

Component	Task
Framework	AIA Framework for Design Excellence, REDi, RELi
Analysis	Hazard, Risk & Vulnerability
Design	Design Feedback Loop, BCA
Documentation	Design Documentation, Case Studies

Design

Detailed in Step 04: Integrate Resilience, this is where information and data acquired in the analysis process is distilled by the project team into workable solutions to increase overall resilience performance of the project. This step requires collaboration between resilience leaders, design team members, and the ownership team to find feasible solutions, evaluate them using a BCA and choose appropriate strategies using CBA. This collaborative process is a feedback loop where ideas can be developed, tested, and evaluated quickly, then reworked as needed through the feedback loop. This process is designed to be agile and flexible to any design process or project type.

This component could be time intensive, however, adequate time should be allocated to this process to enable the development of effective and comprehensive solutions. Resilience solutions may also be components of or impact other building systems. Resilience strategies that also support other building performance metrics or project requirements are more difficult to remove in value engineering exercises and increase overall project value to stakeholders.

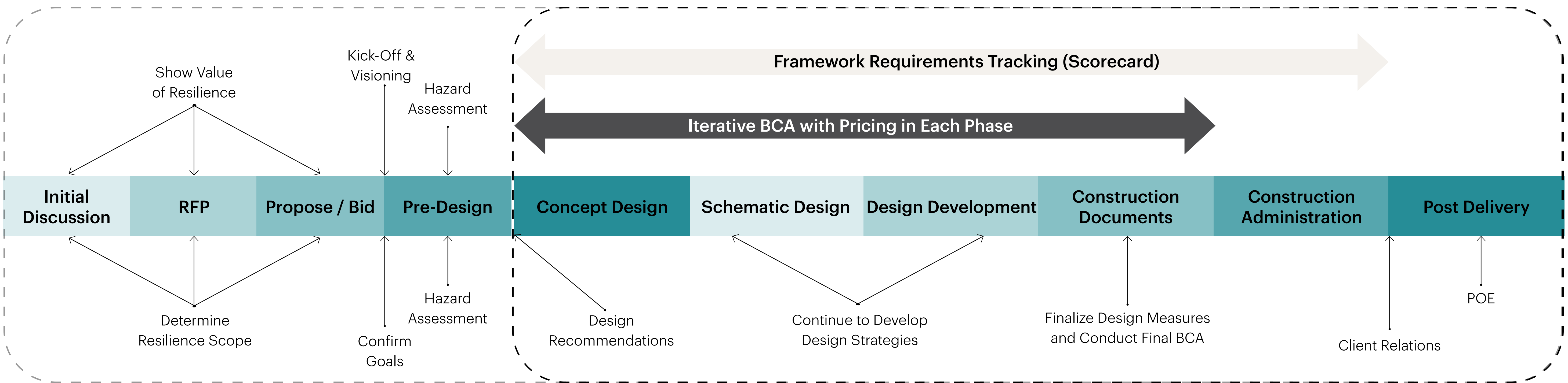
Documentation

When design has been set and the project team begins assembling construction documentation, it is important to make sure resilience strategies remain in the design intent. It is critical for resilience strategies to be included in project models and drawings. Resilience, ESG, and other specialty consultants may need or request to review drawing sets throughout design phases. These consultants may also coordinate with commissioning agents during and after construction to be sure that resilience strategies have been properly built and are operable for the building.

In some situations, a Post Occupancy Evaluation (POE) may be performed. This usually occurs 10 months to 2 years after construction is complete and allows the project team to assess performance of the project as well as allow the owner to troubleshoot building issues. This process is further detailed in Step 05: Operate & Implement and is another additional service for the project outside the base architectural services.

Case studies are also a good tool to document a project's design work, educate future teams on how to administer a resilience project, and communicate the value of resilience design. Project teams are encouraged to create resilience project case studies that focus on how their project accomplished project requirements using resilience design strategies and share these with their architectural peers, market them to potential clients and present them to industry professionals.

Resilience Design Coordination Timeline



3. Identify Hazards

Identifying the Risks and Vulnerabilities

Step 03 **– Identify Hazards begins the formal hazard assessment for the project site in the pre-concept phase of a project after the resilience kick-off and visioning meetings have occurred. The resilience team lead should direct an investigation on potential hazards using a variety of sources and the five forms of resilience. Hazard asset couples should be identified to determine vulnerability and risk. A final report of risk priorities should then be compiled and shared with the team.**

What are the top risks and vulnerabilities?

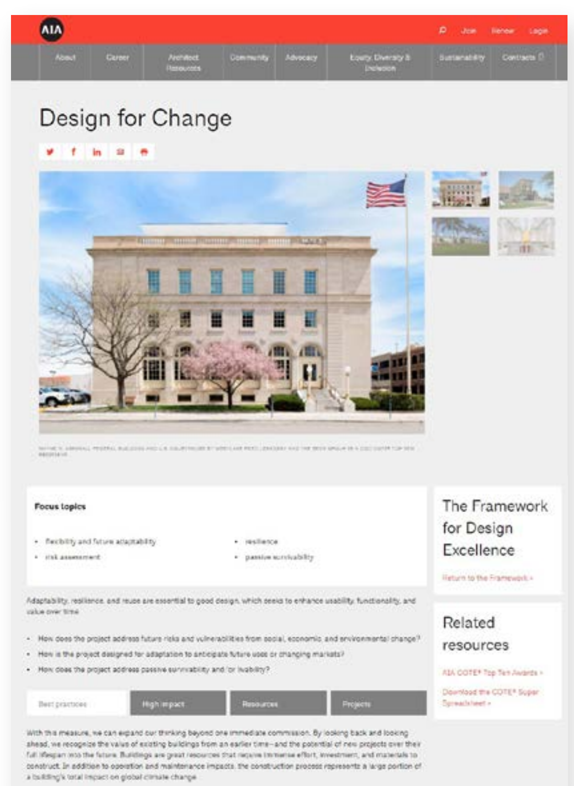
Hazards are the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. Hazards must be identified for a project before the *risk*, potential for an unwanted outcome to occur, or *vulnerability*, susceptibility of a project for a hazard, can be assessed. The position of exposure, or presence of project assets in places that could be adversely affected by hazards, that a project has may also determine the types of hazards and severity of risks the project may have.

A risk and vulnerability assessment identifies the most acute challenges for a project. FEMA has created a process to perform risk and vulnerability assessments outlined in the diagram below. The intent of this step is to identify potential hazards with a magnitude of consequence to help define resilience design recommendations to be developed in Step 04. The process in this step incorporates elements from the US Climate Resilience Toolkit and Steps to Resilience process guides created by NOAA. The three main steps to assess risk and vulnerability of a project are as follows:

1. Identify hazards and assets associated with the project.
2. Understand and grade the risk and vulnerabilities of the project to the hazards.
3. Create a list of risks and vulnerabilities for the project.

Several tools can be used to identify potential hazards for a project and site. The FEMA National Risk Index (NRI) provides a county-level mapping of the US with assessed risk based on eighteen-natural hazards, community resilience calculations and social vulnerability. The NRI provides a starting point to assess potential hazards.

It is important to keep a neutral and objective approach when investigating hazards. Hazards may present themselves in a multitude of ways and compound impacts when different events occur.



AIA Framework for Design Excellence

Design for Change measure challenges architects to critically think about the project, site and community to identify potential challenges and hazards that could affect future operation, use, and potential of a project. Design for change provides the basics of a hazard assessment. This measure is focused on four main concepts to lead the investigation: (1) Flexibility and Adaptability, (2) Risk and Vulnerability Assessment, (3) Resilient Design, and (4) Passive Survivability and Livability.

The design team could then use this information in the Step 4 to develop solutions that utilize adaptive capacity, future flexibility, redundant infrastructure, and carbon footprint reductions.

"Design for Change" - Thoughts vs. Reality

Change is unpredictable, therefore it is difficult to plan for	⟶	**There are signs and trends and if we pay attention to it, we can see it**
For change to be considered progress it must be all-in or all-consuming	⟶	**Change is a process and can happen in stages**
If we design to accommodate today's climate conditions, we have met our responsibility to address sustainability concerns	⟶	**As designers, we have to do our due-diligence to protect stakeholders, as an investment to our clients and communities**
Creating a plan that accommodates change is all that is necessary	⟶	**You need leadership and vision to implement the plan**
Addressing future climate conditions is hard to justify because it doesn't benefit the project now	⟶	**We owe it to our clients to provide them with information that will help them make informed decisions about their investment both now and in the future; Projects are assets over time (longevity and value)**

Understanding Exposure

Hazards can be assessed on a time and impact scale using the terms *stress*, or long-term pressure or tension on a community, and *shock*, a short-term event or hazard that puts pressure or tensions on a community. Organizing potential hazards into stresses and shocks can help determine priorities and identify exposure to hazards. Hazards are typically caused by climate and weather or humans. Both can be exacerbated by climate change.

For instance, a community stressor could be a lack of employment opportunities that can increase poverty and force residents to move away. Lower incomes decrease the ability for communities to prepare, endure and recover from disaster events.

A shock would be an acute event that disrupts daily life like a hurricane or public shooting. If a shock extends into a long-term situation like a pandemic, it can become a stress on a community. Shocks and stresses do not have to be climate related and likely could fall into one of the five forms of resilience. To properly identify potential hazards, it is useful to envision stresses and shocks a community and project could experience.

Hazards are often tied to specific assets in a project and create a hazard-asset pair. For instance, let's look at coastal erosion specifically as it affects structures and areas on a typical beach, which could include beach ramps, dunes, the beach itself. The hazard would be coastal erosion and the asset would be the beach ramps, dunes, and beach itself, creating the hazard-asset pair. Coastal erosion can come from multiple sources such as seasonal tides to hurricanes. Hazards assessments can be technical and complicated.

Assessment

Understanding the exposure of a specific hazard can be difficult due to many variables and impacts that could alter or change how the hazard interacts with the site and project. The assessor must keep an open mind for cause-and-effect relationships in their assessment of a site and project. Often an historical event or decision such as racial segregation or gerrymandering can create distrust and impact social factors like unequal share of resources. This also propagates biological factors like malnutrition and disease, that can reduce community resilience. Both segregation and gerrymandering's impacts increase sensitivity in the community to climate change and disaster events while also reducing the adaptive capacity of a community. It is important to understand the history and culture of a place so that one can develop conscious strategies in design.

Define Parameters

Before starting a hazard assessment, refer to the resilience kick-off and or visioning meetings to define the extent of the project, site, or place that will be studied in the assessment. This will be helpful to focus efforts and identify exposure and subsequent hazards. Existing interdependencies should also be assessed and quantified in the study as well as the value of services provided in the project when operational, and replacement value of the building and its contents.

Damaging Components

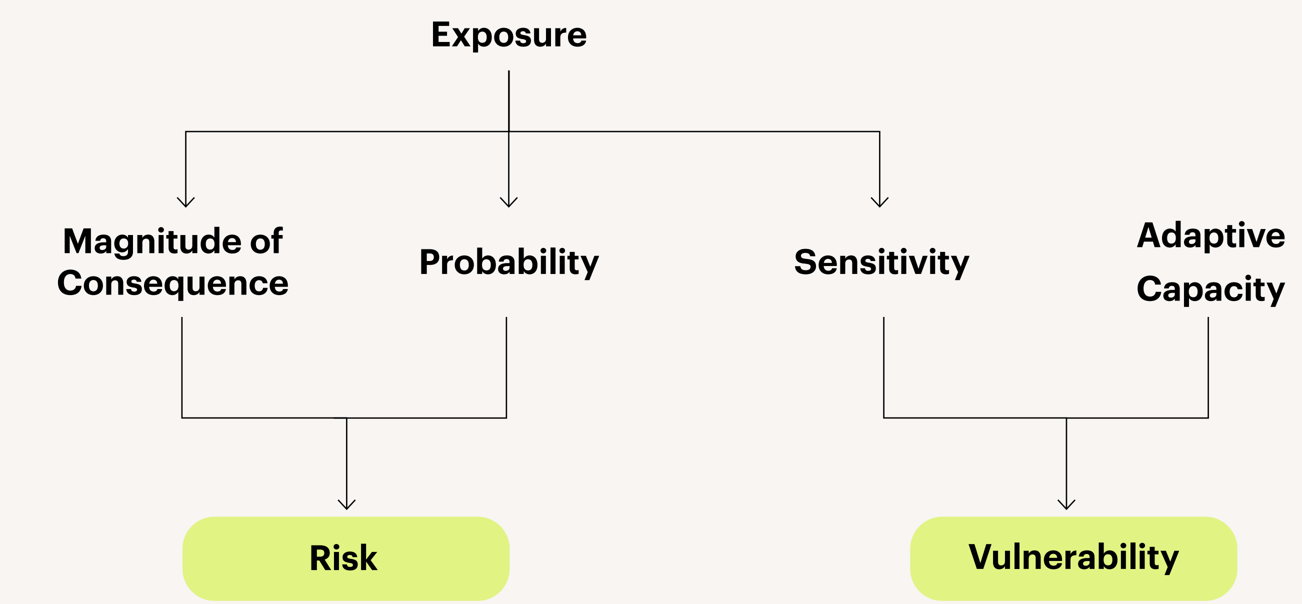
A natural hazard causes direct damage through interaction of its damaging components with a building. Wind pressure and hydrodynamic pressure from storm surge are damaging components of a hurricane. Social hazards also cause direct damage to a building in many forms including damage and looting in riots, contamination in a pandemic, or loss of business during a public scandal. Damaging components are easier to identify when primary hazards have been selected.

Impact Modifiers

Impact modifiers are situational qualities of a place that can alter the impacts of a hazard. For example, deep waters and bathymetry near shore result in fast flowing storm surge and high waves during hurricanes, while shallow waters and a low sloping continental platform result in a slower flowing storm surge and lower waves during hurricanes.

Performance Modifiers

Design characteristics of buildings such as discontinuities in the building envelope, structural eccentricities, type of foundations, roof shape, soft stories, building height, ratio of building length to width and others govern the effects and combinations of



Components of Risk & Vulnerability
Sources: US Resilience Toolkit, Step to Resilience, NOAA

loads that are generated as the building interacts with a hazard, this in turn determines how the building will perform under the impact of the hazard. These design characteristics are known as *performance modifiers*.

Characterize Impacts

For example, you are conducting a vulnerability assessment for a 20-story reinforced concrete building on a beach-front site at risk from the impact of hurricanes. You would use velocity of flow of storm surge, projected sea level rise, and projected storm surge height to characterize expected impacts during the projected 50-year service life.

We can perform assessments in a variety of ways to help meet the needs of the client and be sensitive to community stakeholders as well. When possible, a site visit to observe firsthand can provide a holistic picture of the situation and people of the place. Use the AIA Framework for Design Excellence to assess a place like observing people, what they do and how do they travel in the area; look at the natural feature and water ways if applicable; observe infrastructure and its condition. Pictures, observations, conversations with people of the place will also provide a deep understanding of the site and could potentially reveal challenges and hazards. Site assessments are part of the design process and architects should observe these conditions.

When site visits are not practical or impossible, a wealth of information is available on the built environment. Traveling though Google Earth can provide the foundational information of the site. Tools like FEMA's NRI, the 4th National Climate Assessment, and NOAA's Sea Level Rise and Storm Surge Prediction viewers also provide useful information to assess potential impacts to a site or region. Historical data from the National Weather Service and USDA can help understand previous impacts and identify potential future impacts. It is also useful to investigate regional plans, climate action plans, and master plans developed by a community or governing body, because they may list key community resilience needs and goals.

Determining Hazards

Asset-Hazard Pairings help determine which hazards are more prone to a specific region, terrain, condition, or community. Assets are the owned and managed property of the project that can include the building itself, the site, building systems, services provided in the building, architectural features, equipment, and people. The hazard tables on the following pages have specific areas of concern that identify assets that could be at risk and are part of a project. Use the following tables to determine which hazards are possible for your project. The FEMA National Risk Index (NRI) can also be used to identify eighteen-specific natural hazards associated with a site at a US county or parish level. Social hazards should also be considered as well. Hazards should also consider historical events and potential future events that have yet to occur. Predictive climate models may help understand potential future hazards. Awareness of political and social challenges can also help predict current and future hazards.

The NRI uses social vulnerability and community resilience along with risk to provide a comprehensive assessment of each US county's natural hazard risk. These components are derived from economic loss, property value, and demographic data.

Social Vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood.

Community Resilience is the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions.

Data Tools to Assess Hazards

Although there are numerous tools to assess potential hazards, here are some tools and applications to provide a jumping off point for your hazard assessment.

Flood Factor

The First Street Foundation created Flood Factor to provide a comprehensive and easy to use resource that communicated the hazards associated with flooding. It uses leading researchers to assess and calculate impacts and probability for the US. There is a fee to use this service.

4th National Climate Assessment

The 4th National Climate Assessment was released in 2018 and brings the research and information from US federal government agencies such as the EPA, DOE, and USDA to provide a holistic and comprehensive assessment of climate challenges.

Climate Mapping for Resilience and Adaptation

The CMRA tool provides real time information for climate related hazards for US counties. A future projections feature allows assessment of future impacts for the project site.

FEMA National Risk Assessment

FEMA has created the National Risk Assessment (NRI) to provide holistic risk assessment by US county on 18 hazards using community resilience, social vulnerability, and expected annual loss data.

NOAA Sea Level Rise Viewer

The NOAA sea level rise viewer tool shows the impacts of sea level rise on coastal communities and allows different representative concentration pathways (RCP) from IPCC assessment reports (AR) with adjustable water depths that provides a look into potential sea level rise damaging components.

Avalanche

	A large mass of snow traveling down an inclined slope
Causes	Snowstorms, heavy snowfall, human activity, vibration, steep slopes, warm temperatures
Concerns	Recreational activity, property damage, burial
Damaging Components	Velocity, weight

Coastal Flooding

	Sea water flooding of coastal, low lying regions
Causes	Waves, tides, storm surge, heavy rainfall, sea level rise
Concerns	Reoccurring minor flooding, property / infrastructure damage, water contamination
Damaging Components	Depth of water, flood inundation duration, velocity of surge

Cold Wave

	A rapid fall in temperature within a 24-hour period affecting much larger areas than blizzards, ice storms, and other winter hazards
Causes	Winter temperatures, polar vortexes, shift in jet stream
Concerns	Pipes bursting, livestock harm, ice and frost, fuel and electric demands, dangerous roads, agriculture harm
Damaging Components	Rapid freezing, ice on roads, winter weather

Drought

	An extended period of decreased precipitation and stream-flow
Causes	Land temperatures, reduced snow-pack, human demand, circulation patterns, lack of stored water, increasing temperatures
Concerns	Agriculture irrigation, water demand from populace, ecosystems
Damaging Components	Water infrastructure strain, agriculture losses, dry foliage/ fires

Earthquake

	A sudden and violent shaking of the ground, due to tectonic movement
Causes	Volcanic Activity, Tectonic Movement, Geological Faults, Landslides, Explosions
Concerns	Structural Damage, Tsunami, Rockfalls, Liquefaction
Damaging Components	Landslides/Mudslides, Avalanches, Shaking Vertical/Horizontal Displacement, Compromised Adjacent Structures with Fall Risk

Hail

	Pellets of frozen rain
Causes	Strong updrafts, cold upper region of thunderstorm
Concerns	Vehicle/ roofing/ window/ gutter damage, agriculture, bodily harm
Damaging Components	Size of hail stone, frequency, amount in a given storm

Heat Wave

	A period of time where there are abnormally high temperatures compared to the average
Causes	Trapped air circulation, high pressure system, heated, stagnant air
Concerns	Lack of awareness, outdoor work related tasks/jobs, health issues
Damaging Components	High heat, extreme exertion on body, drought conditions

Hurricane

	A rotating low pressure system with maximum sustained winds greater than 74 mph
Causes	Warm water, moist air, light upper winds
Concerns	Warmer waters, storm surge, flooding, tornado, water contamination, tree falls
Damaging Components	Flooding, winds, tornadoes, storm surge, pluvial flooding

Ice Storms

	A storm of freezing rain that leaves a coating of ice
Causes	Freezing rain, near freezing temperatures
Concerns	Road conditions, weight on trees/roofs, utility damages
Damaging Components	Weight of ice, slick conditions for roads, freezing

Landslide

	The sliding down of a mass of earth or rock from a mountain or cliff
Causes	Disturbances on slopes, rapidly accumulated water, destruction of vegetation
Concerns	Disruption of Utilities, Road Blockage, Rapidly Moving Water and Debris
Damaging Components	Mass and Velocity of Debris, Rockfalls

Lightning

	An electrical discharge caused by imbalances between storm clouds and the ground
Causes	Electrical imbalances, thunderstorms
Concerns	Fires, utility interruption
Damaging Components	Fires, direct strikes to humans, electrical malfunction

Riverine Flooding

	Rivers break their banks and water covers the surrounding land
Causes	Heavy snow-melt, excess rain, king tide, ice jams, human intervention, storm surge
Concerns	Road conditions, property damage, water contamination, pathogens, disease, wildlife displacement
Damaging Components	Water depth, velocity, pluvial and fluvial flooding

Strong Wind

	Atmospheric pressure variation that causes air to rush to fill low-pressure zones
Causes	Hurricanes, jet stream activity, large storm fronts, derecho
Concerns	Trees falling, air infiltration, downed utilities, property damage
Damaging Components	Intense gusts, tree/limb falls, flying debris

Tornado

	A mobile, destructive vortex of violently rotating winds
Causes	Warm humid air, cold/dry air, updrafts, varying wind speeds/direction
Concerns	Fire from power-lines, utility disruption, property damage, flying debris
Damaging Components	Intense circulating wind, flying debris, lightning

Tsunami

	A long high sea wave
Causes	Volcanic activity, earthquake, landslides, seafloor movement, surface impact
Concerns	Drowning, debris, water contamination, erosion, disease, flooding, strong currents
Damaging Components	Velocity, Impact, Height, Strong Currents, Debris

Volcanic Activity

	When magma rises through cracks or weak-spots in the Earth's crust
Causes	Pressure of earth gas, surplus of magma, buoyancy of magma
Concerns	Off gassing, explosion, lava flows, earthquakes and landslides, fires
Damaging Components	Explosions, fires, lava flows

Wildfire

	A large, destructive fire that spreads quickly over woodland, brush, or developed areas adjacent to woodlands and brush
Causes	Human intervention, lighting strikes, heat drought
Concerns	Overgrown vegetation, extreme weather droughts/ high winds, property damage, smoke, adequate evacuation roots
Damaging Components	Fire spread, smoke inhalation

Winter Weather

	Weather encompassing snow, blizzards, and ice storms
Causes	Storm fronts, cold local temps, time of year
Concerns	Icy roads, disruption in services and transportation, broken pipes
Damaging Components	Winds, freezing temperatures, weight of snow, freezing rains

Pandemic / Endemic

	Infectious disease outbreak across the world
Causes	Viruses, poor hygiene, contaminated air
Concerns	Sever disease could be debilitating, death, disruption of travel and social gatherings
Damaging Components	Vector-borne, airborne, transmission through touch

Social Unrest

	Expression of anger and dissatisfaction about an issue
Causes	Political conflict, inequality, racism, rapid social or governmental change, hate, disorder
Concerns	Violence, war, physical and mental harm
Damaging Components	Political will, physical force, acts of war

Vulnerability

Exposure, sensitivity and adaptive capacity are the components of vulnerability. Sensitivity refers to susceptibility for impacts to a project or community. Adaptive capacity addresses the ability for a project to adjust to and accommodate an emergency, absorb potential impacts, remain intact and continue to serve its community following a disaster event. Both components can be subjective and difficult to quantify numerically. When assessing sensitivity and adaptive capacity, it is important to review supporting information regarding the hazards identified. It could be useful to have a resilience expert provide insight or perform a formal vulnerability assessment for the project before entering design. The table below shows how high sensitivity and low adaptive capacity could be problematic for a project and could be impacted from an elevated level of exposure.

Risk

The probability of the hazard occurring, and the magnitude of impact are the components of risk. Probability can be assessed through historical data for a site such as flood probability and rainfall amounts. A changing climate makes calculating probability difficult, however new predictions and weather files are available to help make educated predictions. The *magnitude of consequence (MoC)* refers to the impacts sustained from a hazard. Historical loss data may help provide an idea on what to expect for a particular hazard on a given site or project. Future predictions are again difficult and predictive modeling can help assess potential impacts.

Magnitude of Consequence

MoC varies by hazard type, location, time period, and can be affected by impact modifiers present on site. It is critical to assess site vulnerability to be able to understand potential consequences on site. From there, determine their impact on the site and building operations, physical form, and quality of life. Then gather or anticipate financial and social cost impacts that could be experienced if the specific hazard occurs. Hazards can also compound impacts through multipliers like power outages during a disaster event that augment primary and secondary impacts. It is important to consider these impacts during the risk assessment.

With MoC and probability calculated, begin to plot the asset-hazard pairs on the Risk Assessment Matrix. The units for the MoC and Probability should reflect the range of possibilities for the project, often in dollars and time. The range can be further categorized into low, medium, or high to group more acute hazards together. Asset-hazard pairs in the High-High or High-Medium areas of the matrix represent highest potential impacts and should be prioritized in design.

Assessing Risk

1. Develop Hazard Asset Pairs. Assess potential hazards to the site and associated impacts on project assets by understanding project vulnerabilities or the susceptibility to a hazard with the adaptive capacity.

2. Determine Hazard Probability. How likely is the hazard to occur at the project location? How frequently has it occurred in the past, and is that frequency increasing due to climate change? FEMA's National Risk Assessment and HAZUS can provide probability for some hazards.

3. Assess Magnitude of Consequences. Would the hazard cause a major disruption for many people for an extended period? Would it require large amounts of money and time to recover from an event? As professionals in the built environment, use your expertise to make predictions on potential cost and impacts from damages. A resilience consultant can help make an informed assessment of the project. A cost estimator or the client may provide actual or predicted value and cost information.

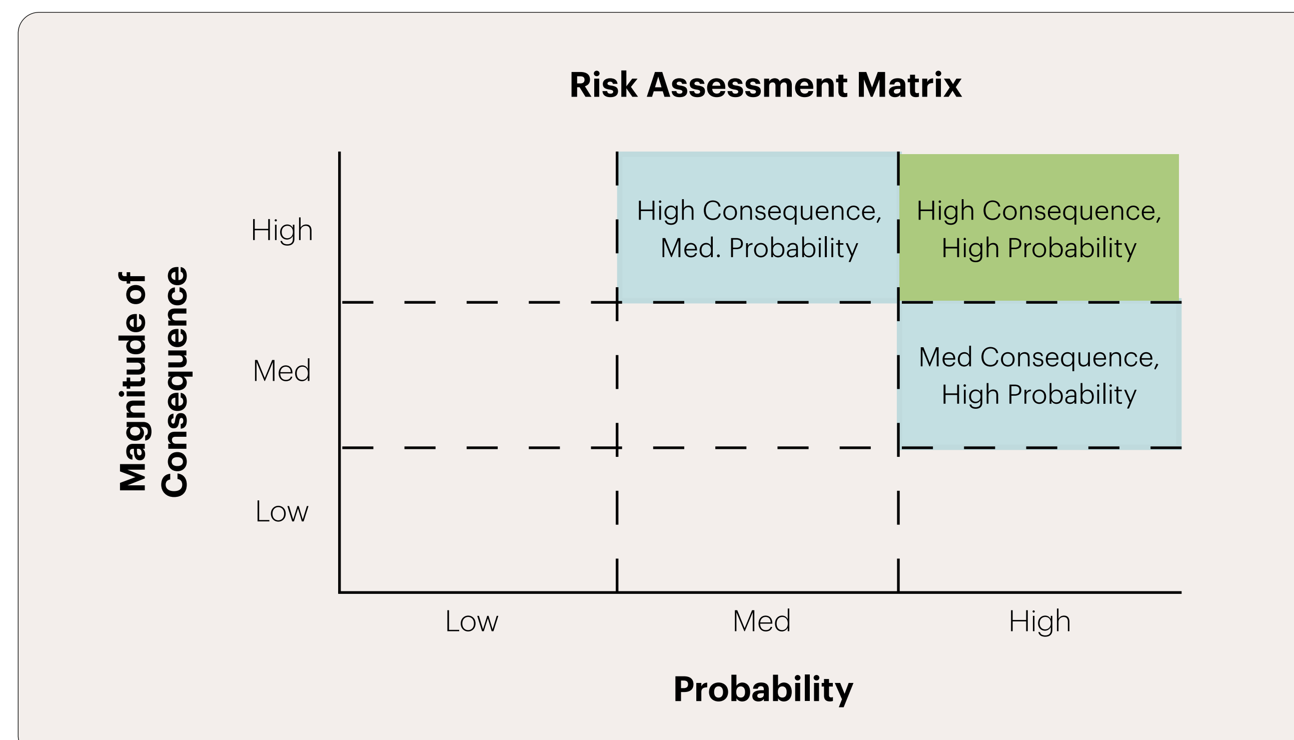
4. Plot Hazards on the Risk Assessment Matrix. Now we have data to make an informed assessment of the hazard impacts on the project assets. Hazards in the top right most areas of the chart should be prioritized in design.

Example - Assessing Flood Vulnerability

Sensitivity Level	Sensitivity	AC Level	Adaptive Capacity
High	Site at sea level	Low	Low lying area with minimal area for stormwater or storm surge collection
Medium	Site 10-20' above sea level	Medium	Adjacent water systems often flood, stormwater infrastructure in place
Low	Site 30'+ above sea level	High	Stormwater infrastructure in place, minimal flooding

Example - Assessing Flood Risk

Level	Probability	Magnitude of Consequence
High	.01% Annual chance flood event	Major flooding, roads un-passable, buildings un-occupiable
Medium	1% Annual chance flood event	Severe flooding, some buildings and roads are compromised
Low	10% Annual chance flood event	Heavy flooding, standing water and difficult travel



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Large Coastal Project Example

This section illustrates a theoretical project to demonstrate the Resilience Design Toolkit process. The project is a new-construction, hospitality project on a coastal site.

The client has incorporated the following in the Owner's Project Requirements (OPR):

- 60-year Life Expectancy
- $300M Construction Cost
- Maintain Operations 24/7/365
- 4-Star Hotel, 180 Keys

The project team has conducted a hazard assessment for the project and has concluded that the major hazards for the project are:

- Lightning
- Coastal Flooding
- Hurricane
- Tornado
- Sea Level Rise

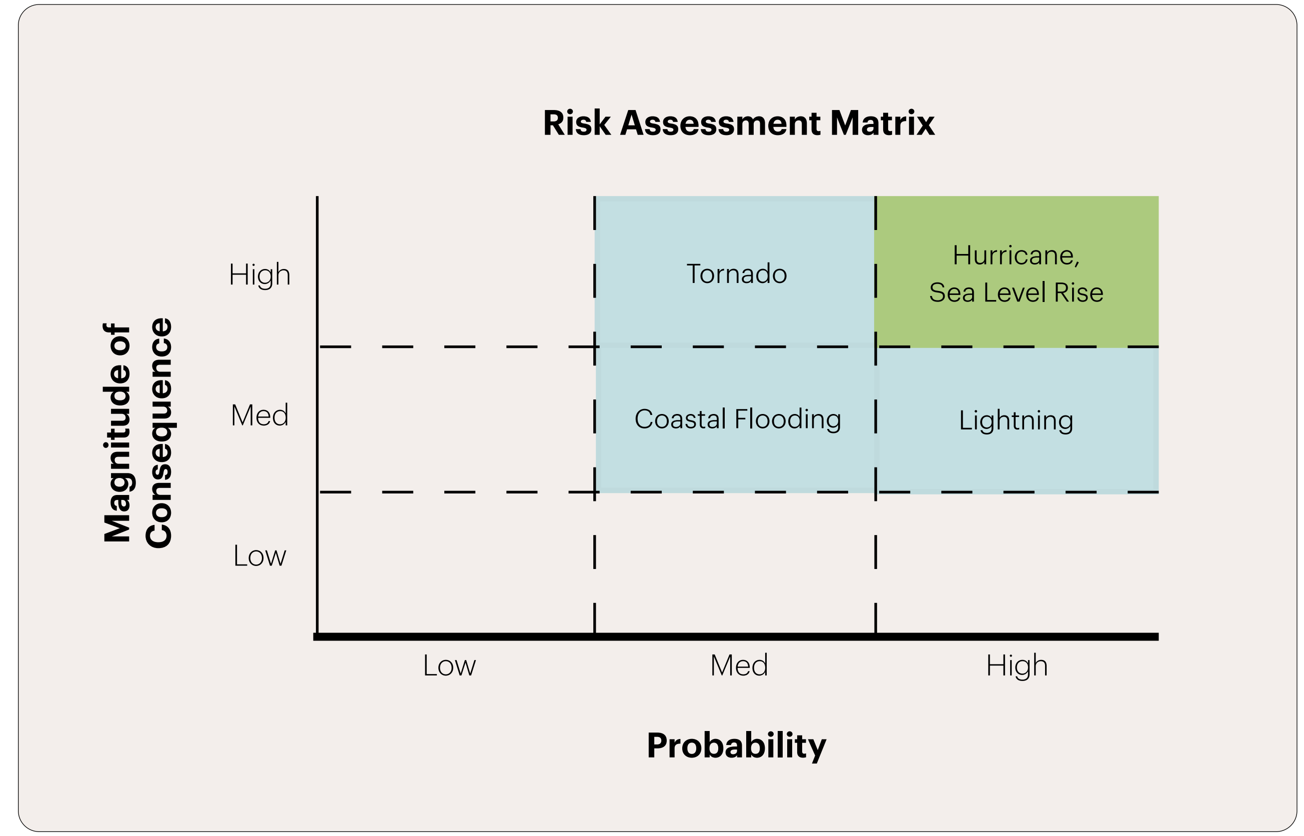
The project team created a hazard-asset pairs list for the project to connect building components to potential impacts.

Using data sources such as the FEMA NRI, the team determined the probability of each hazard. To calculate the magnitude of consequence, probability was multiplied by potential losses assessed from the client. Then hazards were plotted in a risk assessment matrix.

Hazards with the highest magnitude of consequence are hurricanes and sea level rise. These are identified in the upper right quadrant of the risk assessment matrix. With this data, the team agreed to further investigate all identified hazards, but prioritize hurricanes for the project.

Both critical hazards have potential for extreme losses however, they each have a different time horizon impact on the project. Hurricanes are relatively quick events that can happen periodically during the year, this short-term event can be characterized as a shock. Sea Level Rise is happening gradually over time and intensifies slowly. Impacts may not come for another 15 years but may be catastrophic in 30-40 years. This is characterized as a stress.

The time horizon is important to consider when developing mitigation strategies. For instance, if an owner is only interested in the project service life to be 10 years, sea level rise would likely not be any concern to the owner. If building service life is 100 years, sea level rise and hurricanes are major concerns to consider.



Hazard-Asset Pairs

Identified Hazard	Assets Impacted
Lightning	Building enclosure, structure, electrical system, communication equipment
Coastal Flooding	Beachfront access, building access, exterior areas, pool deck, lower levels with un-protected building systems
Hurricane	Building enclosure systems, utility service (power, data, water), also consider coastal flooding asset pairs
Tornado	Building mechanical, enclosure and structural systems, utility service (power, data, water)
Sea Level Rise	Beachfront access, building access, exterior areas, pool deck, lower levels with un-protected building systems

Magnitude of Consequence

Identified Hazard	Probability	Losses ($)	MoC (Probability x Loss) per $100M
Lightning	143.9 events per year	$2.10 per $100M	$302.19
Coastal Flooding	2.1 events per year	$7.59 per $100M	$15.93
Hurricane	0.3 events per year	$59,000 per $100M	$17,700
Tornado	1.3 events per year	$2,000 per $100M	$2,609
Sea Level Rise	0.3-0.5 inches of rise per year	N/A	High

Recording Hazards, Risks, and Vulnerabilities

With hazards identified; risk and vulnerability assessed; we can begin to document key dynamics that expose the project to risk. In this exercise we want to list all hazards identified and begin to assess any impact modifiers or secondary impacts, and their effect on the project. Use the chart as an example to begin constructing your specific project hazard chart.

The large coastal project example has hurricanes as a major hazard. There is not a minimum or maximum number of hazards that can be experienced on a site or project. It is up to the project team to determine the most important and critical hazards to the project.

The chart on the right shows the primary hazard and related primary and secondary impacts. The project team should identify hazards and then work through all possible impacts to the site, building, people, and surrounding area. The chart helps identify key areas for the project team to develop solutions for in Step 04.

Sometimes hazards can have similar impacts or can be augmented by effects of multiple hazards occurring at the same time. The project should consider compound effects of hazards on the building. Project teams can make educated predictions of magnitude of consequence, risk and vulnerabilities. A resilience professional may be required for a formal assessment.

Per the Hazard and Risk Assessment, the project team should prioritize resilient design strategies to mitigate hurricane, sea level rise, lighting, tornado, and coastal flooding impacts to the site. The primary and secondary impacts of each hazard should be presented to the project team for incorporation to project design challenges.

Hurricane

	A rotating low pressure system with maximum sustained winds greater than 74 mph
Causes	Warm Water, Moist Air, Light Upper Winds
Concerns	Warmer Waters, Storm Surge, Flooding, Tornado, Water Contamination, Tree falls
Damaging Components	Flooding, Winds, Tornadoes, Storm Surge, Pluvial Flooding

4. Integrate Resilience Design

Designing for Resilience

Step 04 **is where hazard assessment results from Step 03 connect to design components of the project. Understanding primary and secondary impacts from project hazards help guide design strategy development to mitigate impacts and preserve the integrity of the site. Multiple design strategies may be developed. The team can leverage BCA to assess effectiveness of multiple strategies and perform a CBA exercise to aid decision making by selecting valuable strategies.**

Designing for Resilience

With resilience goals aligned; hazards, primary, and secondary impacts identified; risks and vulnerabilities assessed, the team is ready to begin developing resilience design strategies. These assessments should be completed before concept design begins to inform design strategy development. It is good practice to present this information to the greater project team in a concept design charrette. This is where resilience thinking integrates into design. The AIA Resilient Project Process Guide can provide more details on critical questions to discuss with clients and stakeholders as the project progresses through design.

Step 04: Integrate Resilience uses the design integration feedback loop to develop design strategies, assess them with a BCA, then add them to a list of feasible options or repeat the process until the Benefit Cost Ratio (BCR) yields a positive performance. Once a list of options is compiled that have a viable BCR and meet owner requirements, a CBA evaluation should be performed to help select more effective strategies within the list of options based on the owner's priorities rubric.

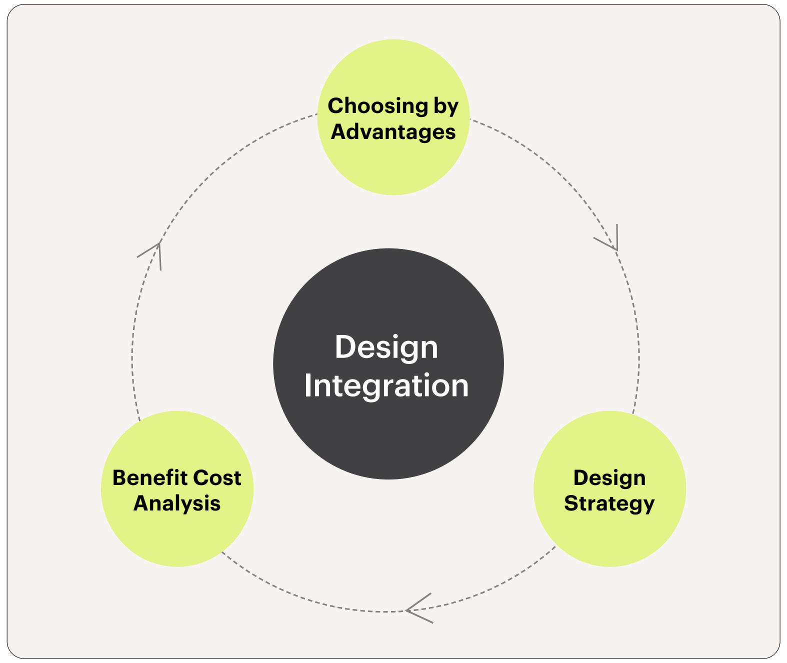
Once resilience strategies have been evaluated for effectiveness, selected, and are integrated into the building design, then the project can complete the implementation drawings and proceed through construction.

Design Integration Feedback Loop

Step 04 is defined by a feedback loop that collects viable resilience design solutions developed by the project team, evaluates them using a benefit-cost analysis (BCA) to calculate a benefit-cost ratio (BCR), and select appropriate solution options based on project or owner priorities in a rubric using a choosing-by-advantages (CBA) assessment. This process can be repeated indefinitely until a desired out come is achieved.

Resilience Design

Design to help prepare, protect, and help our communities recover more quickly from catastrophic events and situations.



Hazards to Solutions

Developing solutions requires critical thinking and a wealth of perspectives from the project team. Approaching holistic and comprehensive ideas for effective resilience may require thinking about the following concepts.

Systems Thinking

It is important to consider the entire system of components and human behaviors that can be affected by a hazard. The effects on the system components may indicate possible challenges that are not apparent when only considering a central component. For instance, consider building power systems. Most buildings have an electrical grid connection using transmission lines and transformers, as well as a natural gas connection. The building uses electricity or natural gas to power building HVAC systems, lighting, equipment, plug loads, etc. Identifying all the variables allow the project team to consider points of failure and bottlenecks to building operations. A power failure not only renders building equipment not operable, but could also take down data infrastructure, also rendering battery operated equipment unusable such as security systems.

Externalities are outside impacts on a system and are often out of a project's ability to control. It is important to consider externalities so that failures outside of a project site can be anticipated and mitigated through design. Using the same power infrastructure example, damaged above ground transmission lines can be circumvented with redundant electrical grid connections or on-site energy generation. Depending on an owner's tolerance for being not operational, redundant power systems may be required.

Weak Links

Building resilience relies on a system of components to function in unison so that building services are maintained. As defined by Arup, system integrity is dependent on the components functioning correctly and is only as strong as its weakest link. For example, a building that has back-up power, drinking water, food, and supplies may still have to close if water for fire suppression equipment is not available. It is important to design resilience strategies that consider each component, determine potential weak links, and develop methods to maintain operation.

Equitable Communities

New growth and development often increase property values which can gentrify communities and displace residents and businesses. Social welfare and security are key components for thriving communities and should also be considered in resilience strategies. Solutions should also consider the culture, beliefs, and history of a place. Projects are often dependent on the local community to support their business or use, without a healthy community, business could suffer.

Solutions should seek to be supportive of community goals and culture. Key topics to consider include avoiding disparities, strengthening community groups, allowing for community ownership of a solution or process, providing accessibility, stimulating economic growth while minimizing gentrification. These topics can be sensitive to community groups and should be appropriate discussed with community leaders. In some situations, pre-existing stressors like food deserts, lack of affordable housing or access to community resources can exacerbate inequalities that can become compound effects during a disaster event.

Vernacular Design

Resilience design should also consider the methods, aesthetic, and function for design of the place. Communities often develop using methods that represent the resources available and people of a place. Resilience design strategies should consider locally sourced materials assembled using typical means and methods of construction. This is especially critical in areas with vulnerable and under-resourced populations who will have to use and maintain the project components. Often, local materials and construction means and methods have evolved from disaster events and provide insight into more efficient and sustainable design strategies. Understanding vernacular design of a place is a goal of a AIA Principles of Design Excellence exercise.

Policies & Operations

Not all hazards require a designed solution. Sometimes it is more effective to mitigate a hazard through employing a protocol or process to operate the building so that an impact is minimized. For instance, an office building may require tenants and workers to work from home to minimize need for extended periods of emergency power fuel and potable water supply. The owner could also put in place contracts to deliver fuel and power for the building with utility providers to ensure minimal disruption. These operational policies can have positive benefits for tenants who are interested in a building with this type of policy and provide a better economic opportunity for local food & beverage retailers to maintain customers if nearby offices are not effected by an adverse event. These types of situations should be identified and discussed with the ownership and project team early in design.

Ecological Solutions

Using natural processes from native and adapted ecosystems can provide efficiencies in building performance. Natural processes often self-regulate and require minimal interaction to function when critical ecosystem components are provided and protected. For instance, vegetation can naturally filter and mitigate stormwater without needing expensive infrastructure. Vegetation can also help clean the air, reduce urban heat island, and inject biophilia for a project. An ecological solution can support an integrative approach.

At the same time, a well-kept and beautiful landscape can also attract more affluent populations, gentrifying an area and pushing less-affluent residents away. *Mal-adaption*, or actions that can increase risk or unwanted consequences, should be considered when developing solutions. Benefits should be weighed against known impacts to help create more equitable communities.

Time

Climate change projections are less accurate the further they project into the future, thus, predicting exactly when catastrophic impacts could affect a project are hard to calculate. We can identify risk thresholds and work backwards to mitigate those impacts in design. This allows an owner to determine if a specific level of risk is acceptable for a project.

For instance, sea level rise experienced on a project site may be negligible today but could be significant or debilitating for a project in 20 years. If the site can accommodate 2′ of sea level rise, but will endure flooding with any further rising water, the threshold is 2′ of sea level rise. When sea level rise exceeds 2′, the project will have reached its tipping point. The project team should discuss with the owner to determine if this is an acceptable level of risk or if further mitigation or adaptation is required.

Since the tipping point will be difficult to accurately predict, the threshold should be adjusted to mitigate risk. Extra site capacity for water, elevated buildings and systems, a new project site all together could be employed to minimize expected risk for the owner. These strategies should be developed and evaluated for effectiveness. To assess long-term viability of a resilience strategy, it is good practice to stress test a solution over a range of scenarios to understand adaptability to variations in the future. Strategies that can accommodate a variety of impacts and are responsive to what could be experienced provide more value to clients and the community.

Small Residential Project Example

Regardless of how big or small the project is, potential hazards should be considered in the development process. A single-family residence in mountain regions vulnerable to winter weather and wildfires, for example, should invite a similar process to assess the hazards and identify the priorities for mitigation.

To ensure the safety and well-being of occupants, as well as the durability and sustainability of the structure, these considerations should include envelope design, material selection, structural design, energy efficiency, and site design.

Because winter weather and wildfires are two very different threats that often require either sheltering-in-place or evacuation respectively, there is the added challenge of designing multi-function mitigation features. For example, material selection is paramount in maintaining a water-tight thermal barrier to protect against blizzard conditions. These materials should also be chosen for their durability and resistance to fires. Likewise, the HVAC system can be designed to be resilient against cold temperatures on top of having features to be resilient against and protect occupants from heavy smoke caused by fires.

Designing for resilience is also an opportunity for innovation. In this instance, certain features not typically seen in an average residence can be considered as components to further the discourse. An example of this could be multi-level access meant to make the house adaptable to access and evacuation needs. It could be the inclusion of a “safe room” that is fire rated for emergency retreat to support sheltering-in-place.

Primary Impact-Asset Pairs : Winter Weather

Primary Impact	Assets Impacted
High Winds	Damage to enclosure components that could compromise durability and integrity
Freezing Temperatures	Disruption of water supply, freezing of building systems
Snow Weight	Structural overload of roof
Freezing Precipitation	Icing of enclosure components and landscape features impeding egress or access

Primary Impact-Asset Pairs : Wildfire

Primary Impact	Assets Impacted
Fire Spread	Burning of enclosure components that could spread to interior spaces
Smoke Inhalation	Compromised air quality outside and inside of a building

Secondary Impact-Asset Pairs : Winter Weather

Secondary Impact	Assets Impacted
Utility Disruption	Damage to utilities by the weight of snow-pack and/or sub-freezing temperatures that disrupt services to the site
Infrastructure Disruption	Roads and access to the site may be disrupted by icy conditions, impassable snow-pack, or downed elements (i.e. power-lines)
Mental and Physical Harm	Extreme snow cover can result in having to shelter in place for an extended time. Physical health can be effected by extreme temperatures and lack of resources
Financial Impacts	Substantial losses and damages can become a large financial burden after this event

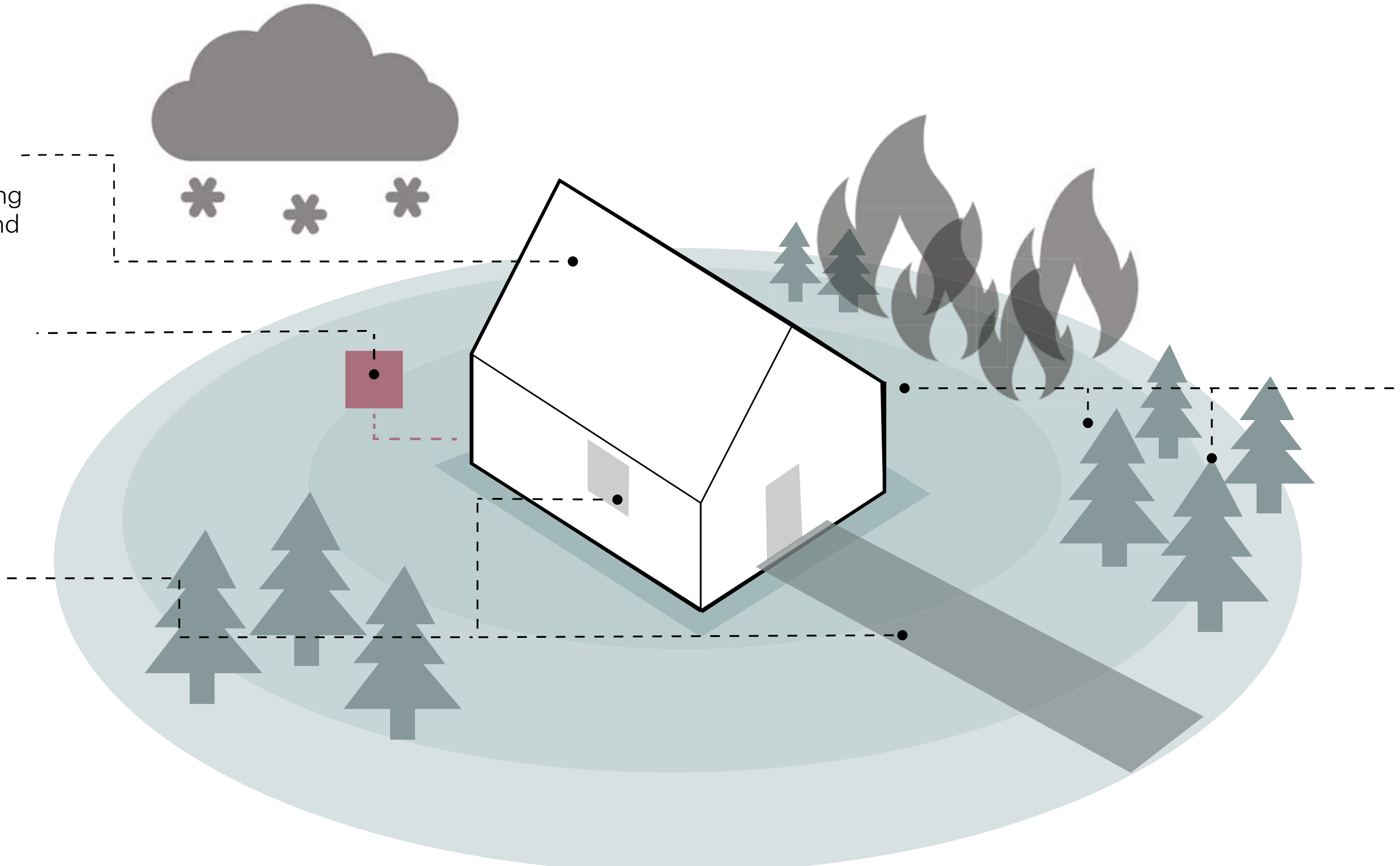
Key Building Components to Consider

Enclosure	Roofs, opaque wall, glazing, curtain wall, seismic joints
Mechanical / HVAC	Air handlers, cooling towers, chillers, roof top units, fan units, dehumidification systems, exhaust, and intakes
Electrical / Data	Lighting, emergency power, process loads, electrical gear, renewable energy systems, transformers, vertical circulation, low voltage, data, communications
Plumbing	Water supply fixtures, wastewater systems, filtration systems, pool pumps, cisterns, potable water storage systems
Site	Landscape areas, pool deck, building entry, loading dock, waste collection, amenity lawns, building connections

Reinforced Roof Structure
Robust structural design is crucial in ensuring house can withstand snow accumulation and prevent structural damage.

Emergency Power & Water Supply
Inclusion of standard back-up power measures along with energy efficient design can help keep a house habitable during a shelter-in-place event. Back-up water supply can be used to mitigate fires.

Multi-Modal Access/Exit
Having multiple access points that are on different levels would mean having access points should one be blocked. It would also mean evacuation.



Defensible Zones

Buffer between building and vegetation on property to slow or stop the spread of wildfire. Protects home from catching fire from embers, direct flame contact, or radiant heat.

Allows firefighters a space to work in defending a home.

Resilience Design

Designing for winter weather involves creating a robust building envelope that can withstand heavy snow loads and minimize heat loss. This can include adequate insulation, air-tight construction, and moisture-proofing measures like air and water barriers to minimize ice dams, and mildew.

Appropriate structural design is critical to enable the roof to withstand the weight of snow accumulation and prevent structural damage or collapse.

Wildfires resistant design requires careful consideration of fire-resistant materials for the building envelope, such as non-combustible siding, roofing, and windows.

Creating a defensible space around the home by removing flammable vegetation and debris helps minimize flame spread to the home.

Increased filtration of inside air helps keep air clean and free of smoke. Screening of building openings and vents prevent ember intrusion.

Incorporating a robust and reliable water supply, along with access to emergency power and evacuation routes, help prevent loss of life and property if evacuation is required.

Design for Energy

Energy efficiency is an important consideration for resilient homes in both winter weather and wildfire-prone areas. Designing passively to maximize efficiency requires less operational energy from a power grid or renewable energy sources during an emergency when energy resources are precious or not widely available.

Self-sufficient energy design can allow a home to operate independently during utility disruptions, keeping the space habitable and comfortable even during prolonged power outages or fuel shortages. This may allow sheltering in-place if appropriate and reduce strain on community resources like shelters and goods.

Design for Resources

The choice of materials can be particularly important in building resilient homes for winter weather and wildfire. Use of durable and fire-resistant, non-combustible building materials, such as metal, clay or stone roofs; fiber cement, stone or stucco siding; and fire-rated windows can help protect a home against rapid combustion and provide more time for occupants to escape. Natural materials are often carbon sinks that have less embodied carbon impact and have longer lifespans. A hardened enclosure with appropriate amounts of insulation and air-tightness can minimize heat loss during blizzards and winter weather. This is particularly important if heating systems are disrupted.

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Large Coastal Project Example

Continuing with the large coastal hotel example from Step 03, in Step 04 we can begin to connect primary and secondary hazards with building components. In this example we will focus on just hurricanes for simplicity. The same process should be conducted for each identified hazard to provide a comprehensive assessment for the project.

The project team should also compare project hazards with the owner's objectives. These should be identified early in the pre-planning process. Sometimes, the hazard assessment may help inform or further develop owner project requirements. Comparing identified hazards to project requirements will help identify which priorities to consider first.

To develop appropriate design solutions for this hospitality project, the project team should consider the building structure, enclosure, mechanical, electrical, and plumbing systems, space programming, landscape design, stormwater capacity, redundant systems, and infrastructure.

The project team should also consider if there are any larger design drivers that the owner or design team wishes to pursue that may not be represented in the charts. A holistic design theme or concept could be an effective method to also drive resilient design concepts.

Primary and secondary impact studies identify components of the building that are subject to damage from the identified hazards. Design of these building components should incorporate resilient thinking to help mitigate potential impacts by determining key dynamics associated with the building components and adjusting the design to better withstand impacts. For example, critical building systems such as HVAC or electrical gear that could be damaged from flood waters and storm surge should be lifted above the storm surge prediction level and placed inside the building in areas protected from strong wind and potential stormwater velocity.

Placement of these components and the types of systems used can have a significant impact on the resilience and performance of the system. Utilizing passive building strategies that do not require active inputs may function even when other building services are disrupted; for example, operable windows rated for hurricane force winds may survive a storm and then can be opened after a storm passes for natural ventilation if building utilities are disrupted. Strategically placing operable windows in the building could provide a natural ventilation strategy to keep the building interior spaces comfortable and prevent mold and mildew growth.

Key Building Components to Consider

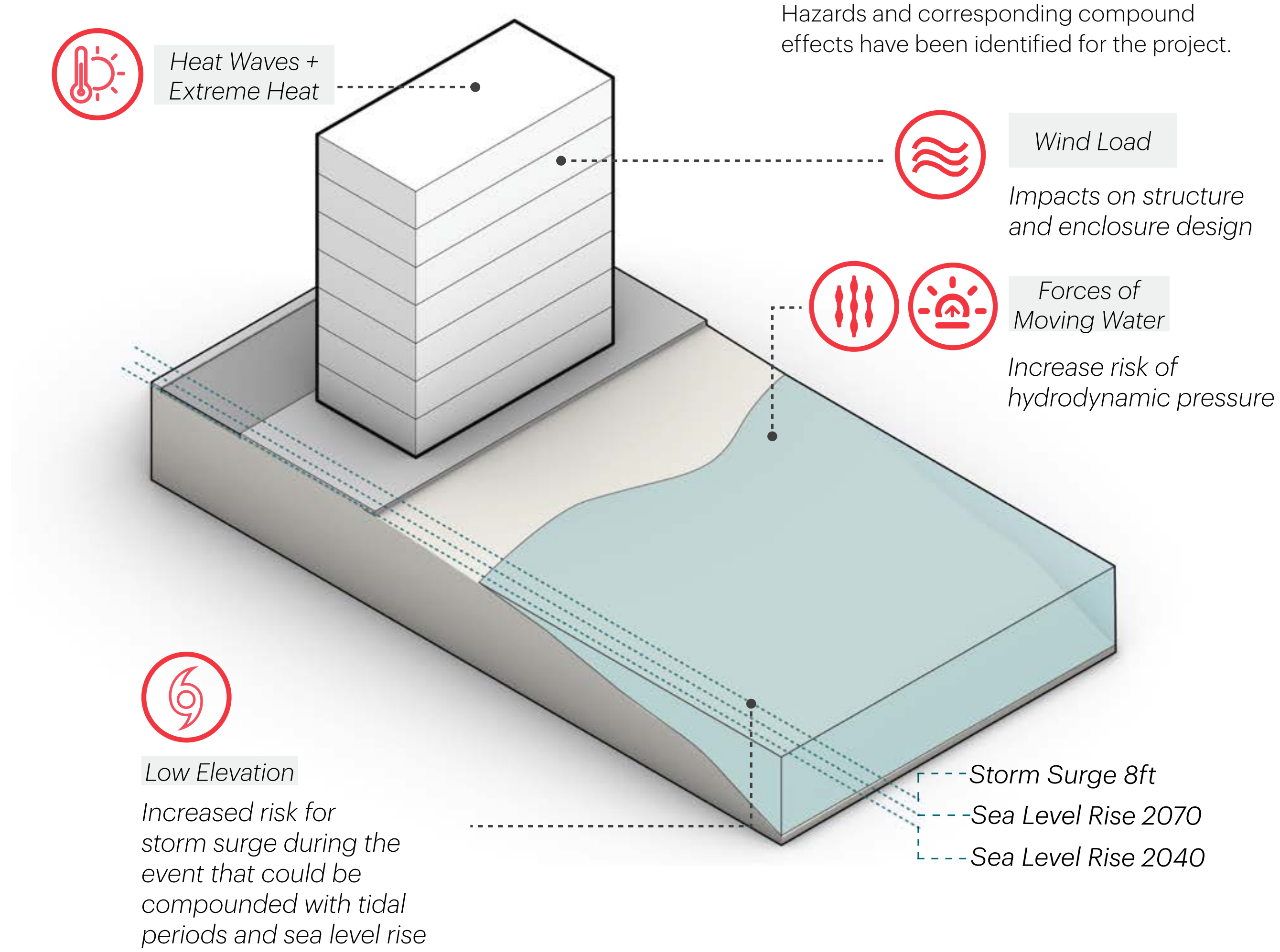
Enclosure	Roofs, opaque wall, glazing, curtain wall, seismic joints
Mechanical / HVAC	Air handlers, cooling towers, chillers, roof top units, fan units, dehumidification systems, exhaust, and intakes
Electrical / Data	Lighting, emergency power, process loads, electrical gear, renewable energy systems, transformers, vertical circulation, low voltage, data, communications
Plumbing	Water supply fixtures, wastewater systems, filtration systems, pool pumps, cisterns, potable water storage systems
Site	Landscape areas, pool deck, building entry, loading dock, waste collection, amenity lawns, building connections

Primary Impact-Asset Pairs for Hurricanes

Primary Impact	Assets Impacted
Storm Surge	Damage to beach front access, exterior areas and amenities, impact to building access, inundation of building lower levels, damage to un-protected building systems on lower levels (electrical, mechanical, plumbing, communications)
Flash Flooding	
Strong Wind	Damage to building enclosure systems, disruption of utility service (power, data, water, gas), down trees, inhibited travel to and from site
Tornado	Severe damage to most building components, space to shelter in place required

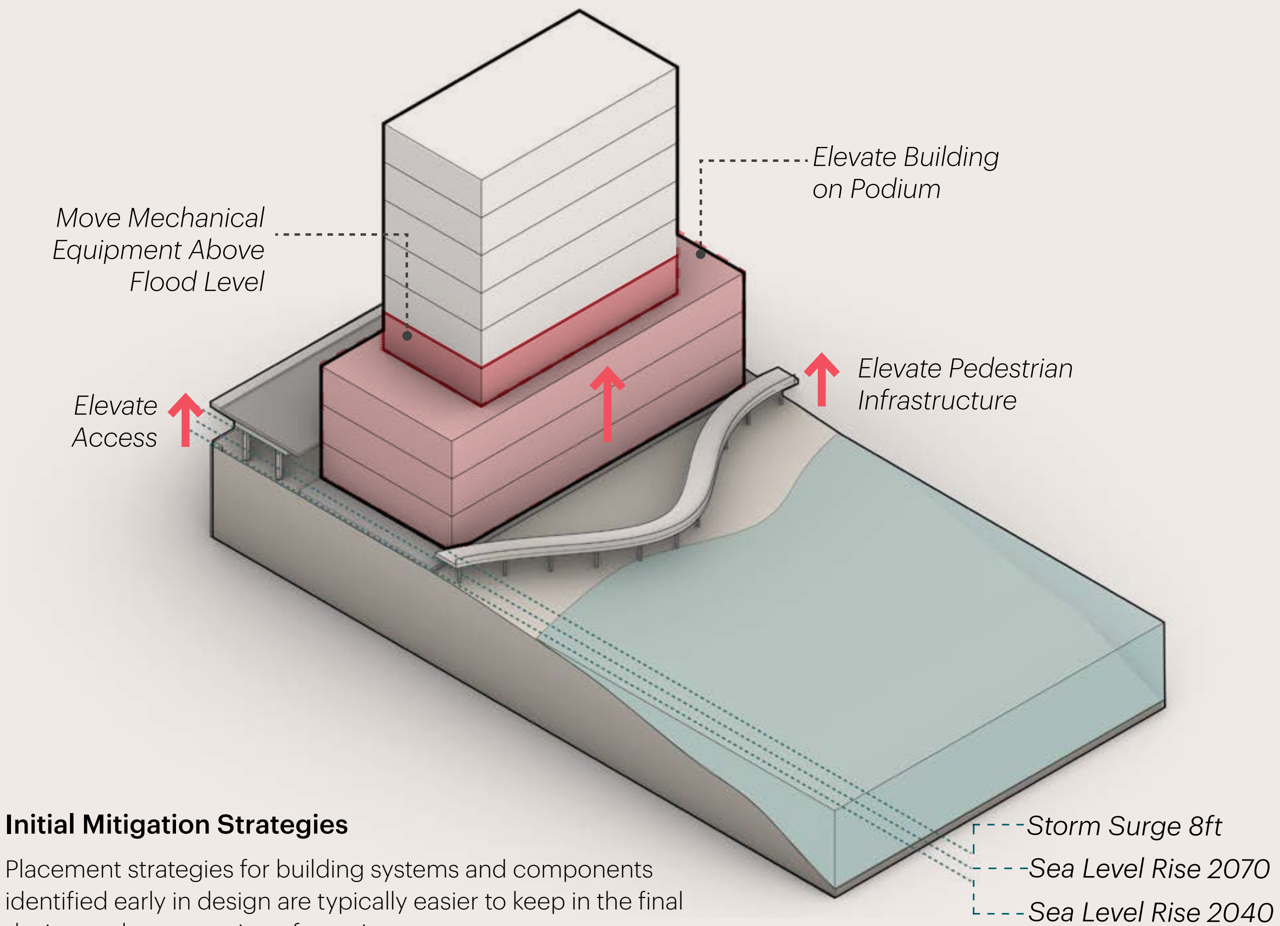
Secondary Impact-Asset Pairs for Hurricanes

Secondary Impact	Assets Impacted
Water Contamination	Storm debris, flooded fuel tanks, chemical spills, sewage overflow, and other pollutants enter local water ways and municipal water systems damaged by a hurricane
Utility Disruption	Damage to electrical, natural gas, data, communications, and water grid infrastructure can disrupt services to the site
Infrastructure Disruption	Flooded and debris strewn roadways impede travel which can prevent resources and emergency services from reaching the site
Mental and Physical Harm	Extreme conditions create risk to physical and mental health through physical objects and experiences. This creates liabilities for the ownership group and increases exposure to risk
Financial Impacts	Substantial losses and damages inhibit business operations which impacts capital debt payments, employee salaries, maintenance, and more



Hazards Identified

Hazards and corresponding compound effects have been identified for the project.



Initial Mitigation Strategies

Placement strategies for building systems and components identified early in design are typically easier to keep in the final design and construction of a project.

Resilience Design

When designing for resilience, sometimes the best way to start is to just jump headfirst with an idea to see where it goes. In the process, considerations and supplementary ideas will help shape design. There is not one correct way to put a building together and this is where it is up to the design and project team to take the information provided and make the process theirs.

It is beneficial to incorporate the AIA Framework for Design Excellence into the design process to help coordinate design concepts with the ten measures. This will help maintain a thorough assessment of the design and help provide documentation needed for AIA award submissions. The hospitality project example uses the AIA Framework for Design Excellence to illustrate how the ten measures could be incorporated into design solutions.

Design for Water

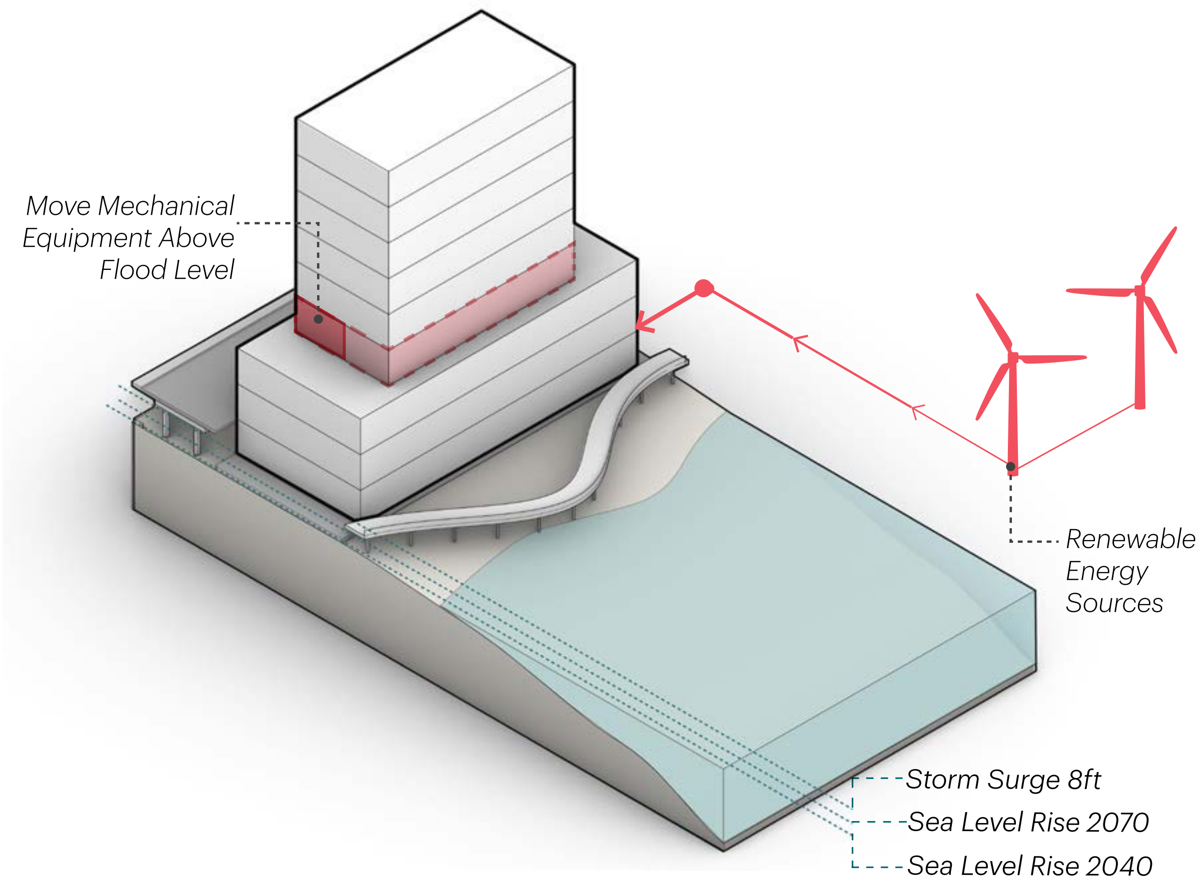
Fortifying sewer and drinking water systems helps protect these systems during a storm. Blue roofs and bio swales can mitigate flood waters and help keep elevated transportation infrastructure open.

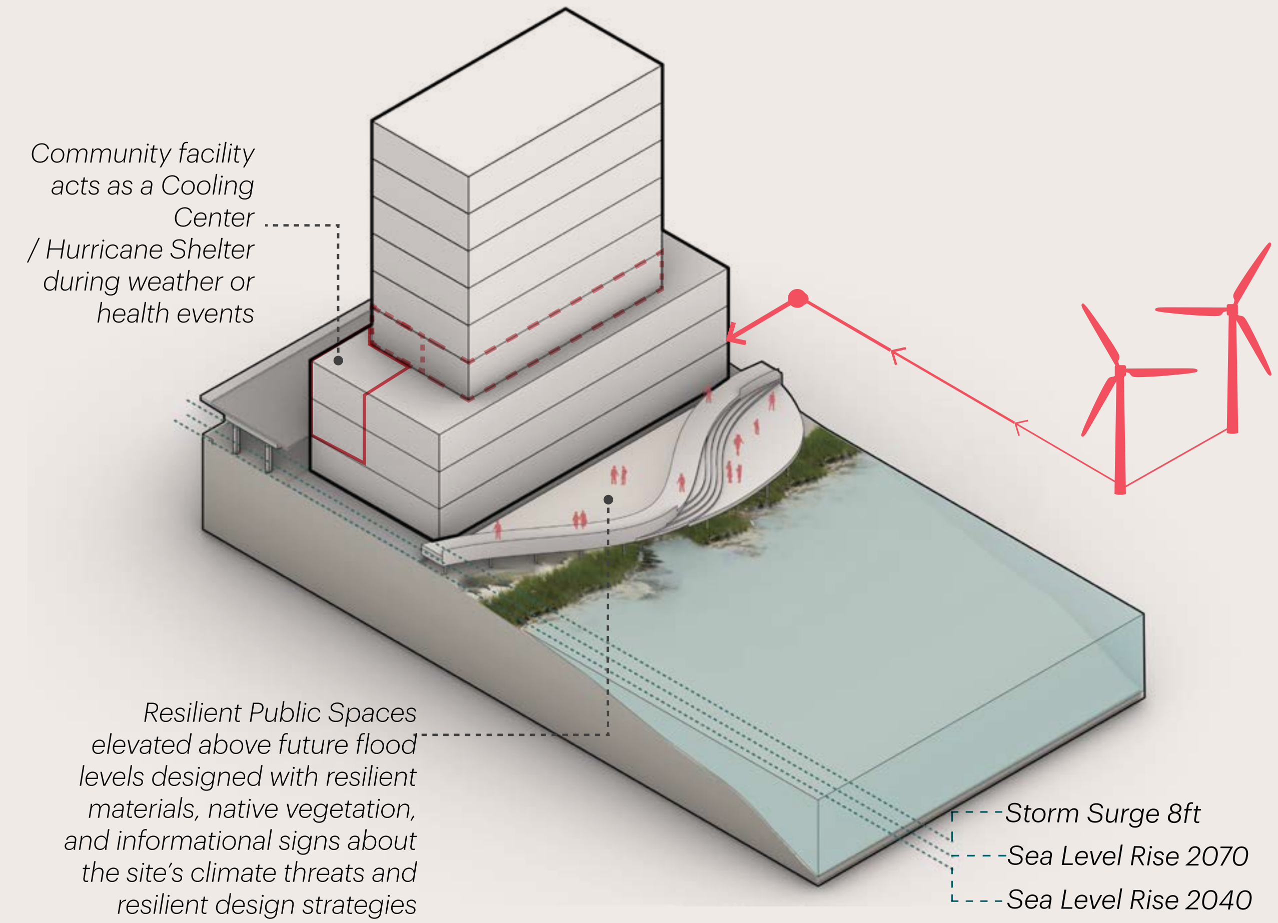
Design Concepts

Raise building on a podium above the storm surge level, base flood elevation, and allow for “wet” levels that can accommodate water inundation with minimal damage.

Raise infrastructure connections and critical building systems above storm surge level and base flood elevation to maintain operation during flooding inundation.

Plan for potable water storage on-site for building users in the case municipal water connection is compromised.





Design for Energy

Redundant and elevated power, data and communication systems protect building components and mitigate risks for storm surge. This is especially critical for essential buildings like hospitals and residences.

Design Concepts

Redundant and protected energy systems (Raised equipment floors from flood level).

Flexible power systems.

Micro-grid power delivery.

Reducing energy consumption by cool paving/roofs (by reflecting more solar energy and enhancing water evaporation) not only cools the pavement surface and surrounding air but can also reduce stormwater runoff and improve nighttime visibility. Can reduce ambient temperatures by 80 degrees and reflects 85-90% of radiation on site.

Design for Equitable Communities & Wellness

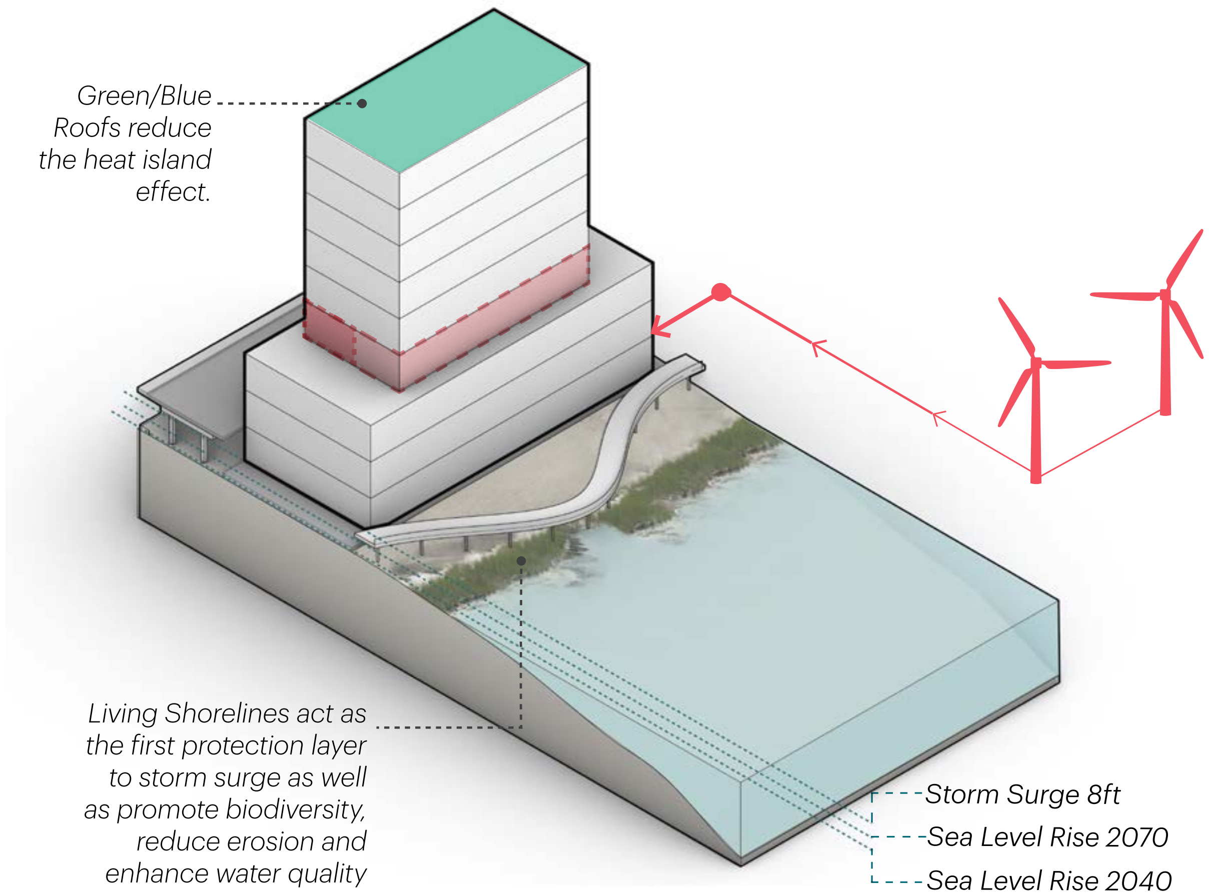
More resilient buildings allow more residents to shelter in place and minimize the need to evacuate. This benefits a community's mental health and quality of life which can improve equity and social resilience.

Design Concepts

Communities benefit from previously mentioned strategies that protect quality of life and maintain water quality, minimize power disruption, protect dwelling units, and maintain security, this allows us to continue to go to work and school and acquire financial security.

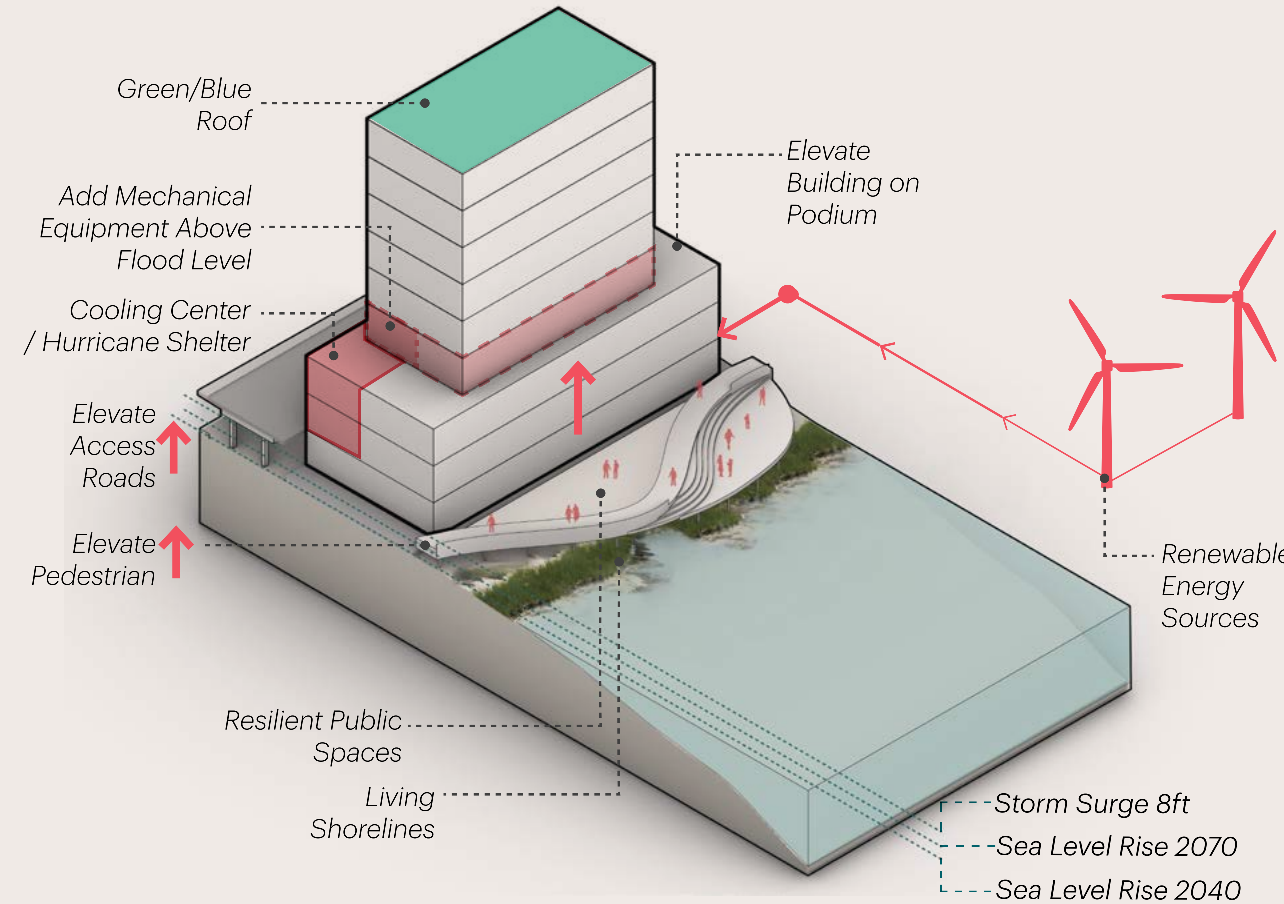
Resilient public spaces ensure equitable access to public spaces.

Cooling centers are resilient spaces that are open to communities during extreme heat events. These spaces can double as hurricane and storm shelters.



Resilience Design Strategies

The diagram above collects the previously developed resilience design strategies together for evaluation.



Design for Ecosystems

Natural solutions can often provide more effective solutions to environmental concerns. Vegetative buffers on the coast can mitigate storm surge and flooding while promoting biodiversity that can be an asset to the ecology of a place as well an aesthetic asset for communities.

Design Concepts

Living shorelines and vegetated coastal buffers better resist erosion and promote biodiversity on land and under the water.

Vegetated landscapes better control storm water, clean pollutants from run-off water, promote biodiversity, reduce urban heat island, and promote biophilia which helps promote healing and control stress.

Resilience Design Assessment

The diagram above collects the developed resilience design strategies together for evaluation. In your project you may have multiple ideas to satisfy design objectives or mitigate hazards. A value engineering process may also jeopardize the ability to keep some concepts in the design. Resilience design strategies naturally require a systems approach that help us think about several different types of building systems, concepts, and features to create an integrative and holistic design idea. A building design solution that touches many parts of the building is harder to value engineer or remove from the project. For example, if solar brise soleil reduce visual glare, shrink the size of mechanical equipment, and can be used as hurricane shutters for windows, it may be harder for the project to remove them to save cost. The existence of the brise soleil help reduce cost of other items in the project.

When a more objective analysis is needed to determine if an option is viable to keep in a project or to help decide between multiple different ideas, a BCA can be used. The next section introduces the concept of a BCA and performs one for the hospitality project example.

Benefit-Cost Analysis

To help create effective solutions for the project, we should quantitatively evaluate each solution based on cost benefit and feasibility. Benefit-Cost Analysis (BCA) is a specific analysis method to evaluate the benefit of a solution with the cost to implement the solution. It yields a Benefit-Cost Ratio (BCR) ratio that when calculated above 1, indicates a positive ratio and therefore an effective solution. BCR should be balanced with feasibility defined by the ability to incorporate the solution into the design, maintain the design aesthetic, and uphold the design intent.

FEMA has developed a BCA process to help quantify the effectiveness of a resilience measure for a specific project using 5 steps and requires a BCA to enable a project to receive federal money. A BCA provides an effective decision-making tool for a project by utilizing the risk & vulnerability assessment previously completed and applying economics. It requires developing a base understanding of the value of the building and its assets.

Autocase can also perform a BCA however uses a method that evaluates value using a triple bottom line approach. Autocase can be useful to show the impact on the project and local community using the social and environmental lens that is often hard to quantify.

This example will integrate a generalized version of the FEMA BCA tool with guidelines provided in the AIA Resilience Course available on AIAU.aia.org.

Overall, every $1 spent on a resilience strategies during design results in $4 of savings or more from potential project perils.

National Cost Benefit Ratio Per Peril	Beyond Code	Federal Funding
Overall Hazard Benefit-Cost Ratio	**$4:1**	**$6:1**
Riverine Flood	$5:1	$7:1
Hurricane Surge	$7:1	N/A
Wind	$5:1	$5:1
Earthquake	$4:1	$3:1
Wild-land-Urban Interface Fire	$4:1	$3:1

Estimates are rounded and based on hypothetical Hazard scenarios. Natural hazard mitigation saves $6 on average for every $1 spent on federal mitigation grants, according to an analysis by the National Institute of Building Sciences. An earlier (2005) study by NIBS found a benefit-cost ratio (BCR) of 4:1. (FEMA, June 2018).

Benefit Cost Analysis Steps

Step 1	Step 2	Step 3	Step 4	Step 5
Data Collection and Project Information	Determine value of building and its assets	Characterize Hazard Impacts and determine Damages	Hazard mitigation analysis: Identify mitigation alternatives and associated benefits	Calculate benefit-cost ratio

AIA Resilience Course, Module 7 "Business of Resilience" (AIA, 2018)

Step 1. Collect Project Data

- Building Service Life or project useful life
- Level of protection as determined by desired level of building performance
- Hazard Data (Hazard specific resources; HAZUS MH)

Step 2. Determine the Value of Building & Assets

- Building Service Life Cycle Analysis
- Property value, initial cost, operation and maintenance repairs, cost of replacement, residual value (resale or disposal)
- Tax assessment, real estate comparable, city credit rating

Step 2. Determining the Value of Building Contents

- Building contents: furniture, equipment, intellectual property, appliances
- Sources of information: insurance records, appraisals, receipts, estimates

Step 3. Characterize Impacts and Determine Damages

- Physical Damage Estimates: building contents, vehicles & equipment, site impacts, infrastructure.
- Loss of Function impacts: facility or material type, customers served, functional downtime and loss of function, loss of public services, displacement costs

Step 4. Hazard Mitigation Analysis

- Create an inventory of potential hazard mitigation strategies
- Document damages avoided per hazard mitigation strategy
- Provide cost analysis for each strategy: design & construction, maintenance

Step 5. Calculating Benefit-Cost Ratios (BCR)

- BCR is numerical expression of cost effectiveness of a project
- BCR = Benefits / Costs
- BCR > 1.0 = Effective
- Benefits = Expected annual damages before mitigation - expected annual damages after mitigation
- Expected damages before mitigation are damages per year over life of project
- Expected annual damages after each/or collective mitigation strategies vary depending on effectiveness and degree of risk
- Benefits are a best guess based on hypothetical events

To begin a BCA, specific information regarding the building life expectancy, value of historic losses, prices for each solution and potential loss information is needed. The project address will be required to use the FEMA BCA 6.0 tool. The geographical data is important to the BCA because it connects previous losses of the parcel from a federal database. For international projects, other sources will need to be used. HAZUS is a plug-in program to Arc GIS to connect historic loss data and hazards with GIS maps to streamline the BCA process.

One Time Event vs. Investment

Resilience design solutions can be evaluated over a period or on a per event basis. The number of disaster events or probability for disaster events to occur can significantly impact the BCR and project numbers. We will again use our large coastal hotel example to assess the probability of a major hurricane over the life expectancy of the project. The hotel is new construction, although the process can be used for renovations and expansions as well.

Example Limitations

The figures used in this example are not actual and are for demonstration purposes only. A qualified cost estimator or contractor should be engaged to determine actual numbers for your project. This example also removes the Discount Rate (DR) and Net Present Value (NPV) from the calculations for simplicity. When anticipating future costs and value, DR & NPV should be considered.

Repeat

These are rough numbers that the design team can use to help guide resilience design strategies in the project to help aid decision making. As the design progresses these numbers can become more detailed. This process is applicable to any project size and type.

Choosing by Advantages

Design is an iterative process. If more than one set of design solutions are developed that are both effective in their own way, selection between the two or more strategies can be aided by a CBA process. This process utilizes predetermined project metrics or desires established by the client and design team. These metrics or desires can include anything from being able to operate 24/7/365 or maintain a certain program area in the design.

The design team should work with the client to appropriately weight these metrics so that they can be inserted into the CBA tool that can come in the form of an excel sheet or Online application. Then the design team must rank how each solution effectively solves for the metric and the software will calculate the most appropriate solution based on the ranking and weighting of the desired metrics.

According to the example CBA exercise, if each of the 3 options are viable for the project, Option C meets most of the project requirements and should be selected for the project. Although this example does not show weights on the score, an option to weight the metrics higher or lower than others is possible. For instance, if Financial Stewardship was to be weighted at a factor of 2, lower the cost is better, then option A should be selected since it outperforms option B in almost every area. Final decisions should be made by the owner; however we can provide analysis of options to help aid decision-making where appropriate.

Step 1: Project Data

- 60 year life expectancy
- $300M construction cost
- Maintain operations 24/7/365
- 4-Star hotel, 180 Keys
- Major hurricanes incidence expected, 5.4 events in 60 years

Step 2: Determine Value

- Property value with building - $320 Million USD
- Property value of contents - $100 Million USD

Step 3: Characterize Impacts and Determine Damages

- Hurricane potential damage estimates $5 Million USD per storm
- Major hurricane potential damage estimates $15 Million USD per storm
- Potential loss of revenue if the facility is closed: $47,000 per day

Step 4: Hazard Mitigation Analysis

To the right are the resilience design solutions identified for the project.

Not all of the resilience design solutions are intended to protect the building from a major hurricane. Those solutions could be calculated separately outside of a major hurricane scenario. For demonstration purposes, we will keep the BCA only for a major hurricane event. The same process can be used to evaluate other scenarios and design solutions as well.

The intention of the resilience design solutions is to minimize damage and reduce downtime of the project. In this case we will reduce the impacts for damages as follows in the table.

Damage forecasts are reduced by 1/3 and the property is able to re-open 20 days sooner allowing for revenue to begin flowing more quickly. Impacts to local infrastructure, roadways, airports, etc. should be considered when the facility is able to operate.

Step 5. Calculating Benefit-Cost Ratio (BCR)

BCR Calculations:

BCR = Benefits / Cost

$$\frac{\$38{,}421{,}000 \text{ (Benefits from Resilience Design)}}{\$34{,}000{,}000 \text{ (Cost of Resilience Design Solutions)}}$$

BCR = 1.13 > 1.0

Impacts from One Major Hurricane (Base Code Construction)

Type	Cost
Property Damage	$15,000,000
Lost Revenue (30 days)	$1,500,000
Insurance Premium	$1,800,000
Total	**$18,300,000**
5.4 Major Hurricanes in 60 Years	**$98,820,000**

A BCR of 1 or higher is considered an effective ratio and should be implemented into the design. To keep the BCR at 1 the resilience solution should not exceed $38,421,000.

Since a major hurricane likely will not strike every year and may never strike, this calculation represents a worst-case scenario. The owner will likely need to weigh the cost of the resilience solutions with the insurance premium and potential position of risk.

Impacts from a Major Hurricane

Type	Base Building Code	Resilience Design
Property Damage	$15,000,000	$10,000,000
Lost Revenue (30 days / 10 Days)	$1,500,000	$540,000
Insurance Premium	$1,800,000	$645,000
Total	**$18,300,000**	**$11,185,000**
x5.4 Major Hurricanes in 60 years	**$98,820,000**	**$60,399,000**
Difference / Project Benefit	**-$38,421,000 (61% potential cost reduction)**	

Owner Resilience Strategy Rubric

Resilience Strategy	Benefit Cost Ratio (BCR) of 1+	Financial Stewardship	Reserves 30% or More of Site as Open Space	Resilience Education Opportunities
Living Shoreline Option A	1.2	$5,000,000	31%	Yes
Living Shoreline Option B	1.0	$4,350,000	28%	Some
Living Shoreline Option C	1.5	$7,100,000	35%	Yes
Best Selection	**Option C**	**Option B**	**Option C**	**Option C**

Resilience Design Solutions

Solution	Cost
Living Shoreline	$3,000,000
Elevated Building above BFE & Storm Surge Line	$4,000,000
Back-up Power Systems for 7-days	$15,000,000
Back-up Water Systems for 7-days	$8,000,000
Resource Storage for 7-days	$500,000
Green / Blue Roofs	$1,500,000
Elevated Pedestrian Space	$2,000,000
Renewable Energy Systems	$7,000,000
Native & Adaptive Species Landscape Design	$1,500,000
Total for Resilience Design Solutions	**$58,500,000**

Resilience Design Solutions for a Major Hurricane

Solution	Cost
Living Shoreline	$3,000,000
Elevated Building above BFE & Storm Surge Line	$4,000,000
Back-up Power Systems for 7-days	$15,000,000
Back-up Water Systems for 7-days	$8,000,000
Resource Storage for 7-days	$500,000
Elevated Pedestrian Space	$2,000,000
Native & Adaptive Species Landscape Design	$1,500,000
Total for Resilience Design Solutions	**$34,000,000**

5. Evaluate + Nurture

A Resilient Building

Step 05 - Evaluate + Nurture is where the relationship with the client and the performance of the project come together, hopefully in a positive form. We should always seek to know failures and successes of our past projects so that we can learn and perform better on the next project.

Post Construction

Successfully achieving the project's resilience goals presents post occupancy opportunities. After the certificate of occupancy has been earned and the contract requirements have been fulfilled, the project likely is considered complete. This is a perfect time to follow up on Return-on-Investment (ROI) of the project as appropriate with the client and stakeholders. This could be assessed more comprehensively through a Post-Occupancy Evaluation (POE). Lessons learned in the POE may be useful content for a project case study or other publication that describes both failures and successes.

It is incredibly valuable to be able to assess project performance so that we can determine which design strategies functioned as intended or were not worth the investment. The comprehensive yet highly specific design strategies that could be developed for resilience design may be unique to the project and site. Design elements could be used in subsequent projects and a database of successful and not so successful strategies can help provide direction in the future.

Case studies are a great vehicle for documenting project work and the resilience design strategies included in the design. Developing a case study template that is clear and direct helps make project work highly sharable and can also be used for marketing and business development.

Clear and tangible building operations and maintenance manuals are critical for the building to function as designed and maintain its resilience features. Building operations manuals are developed and building operations staff are trained on how to properly operate the building. This is typically performed by commissioning agents and MEP engineers on the project. These training manuals should have sections on building resilience systems.

Through this process, it also provides an opportunity to remain in a trusted position with the client. Maintaining a relationship with a client and their organization may provide opportunities for future work and the ability to follow-up on past projects.

Post Occupancy Evaluation

Within the first year of operation, it is best practice to engage the owner with the opportunity to perform a post occupancy evaluation (POE) for the project.

"Post occupancy evaluation" is a term widely accepted and used across the industry for evaluating design after it has been put into service. The depth of analysis and tools used can vary quite widely in a POE.

POE is an evaluation conducted during the operations phase of a project after completion of design and construction. The scope of POE can differ dramatically by project type, client interest, and the skills and experience of the design team. A POE is executed to answer crucial questions about a building's performance. It can address questions such as:

Does the building perform as it was designed?

Does the building meet the users' needs?

What corrective measures can be implemented to improve performance?

How can building features be designed more effectively in the future?

Quantitative and qualitative measurements taken in a POE study ultimately allow designers and clients to review the effectiveness of design features and building performance.

When

It's important to give the operations team sufficient opportunity to calibrate the building after it is fully occupied, which typically occurs 10-18 months after project completion. Also, work teams, managers and individuals need to adapt to their new spaces, discover what works and doesn't work for them, and run through all processes.

You should start thinking about a POE at the very beginning of the project. A similar evaluation can also be provided prior to the start of a project to document a baseline condition, identify issues or concerns to be addressed with the new design, or help the owner and design team identify project goals and priorities.

Who

Simple tutorials can be provided to help project team members gather quantitative data. When it comes to interviews, surveys, and other qualitative responses, careful consideration in phrasing questions or input prompts will help collect unbiased and more useful responses. In identifying user groups and respondents to the POE, the first consideration is the type of information or feedback desired. Typical stakeholders could include building engineers and facility mangers, residents, team leaders, tenants, specialized work groups, students, faculty, nurses, patients, managers, staff, and executives. There are external tools and resources available to help define a more customized POE to address specific concerns or client needs.

Why

The POE provides validation of design strategies and/or construction implementation, and helps track to meet initial goals. Evidence from previous projects, including examples and impacts, makes it even easier to justify or bolster design solutions on future projects.

For the client, the POE proves the value of design and performance enhancements (daylight, biophilia, acoustic control, lighting, individual control, thermal comfort, etc.). The end user gains better understanding of the physical space they occupy and the design considerations.

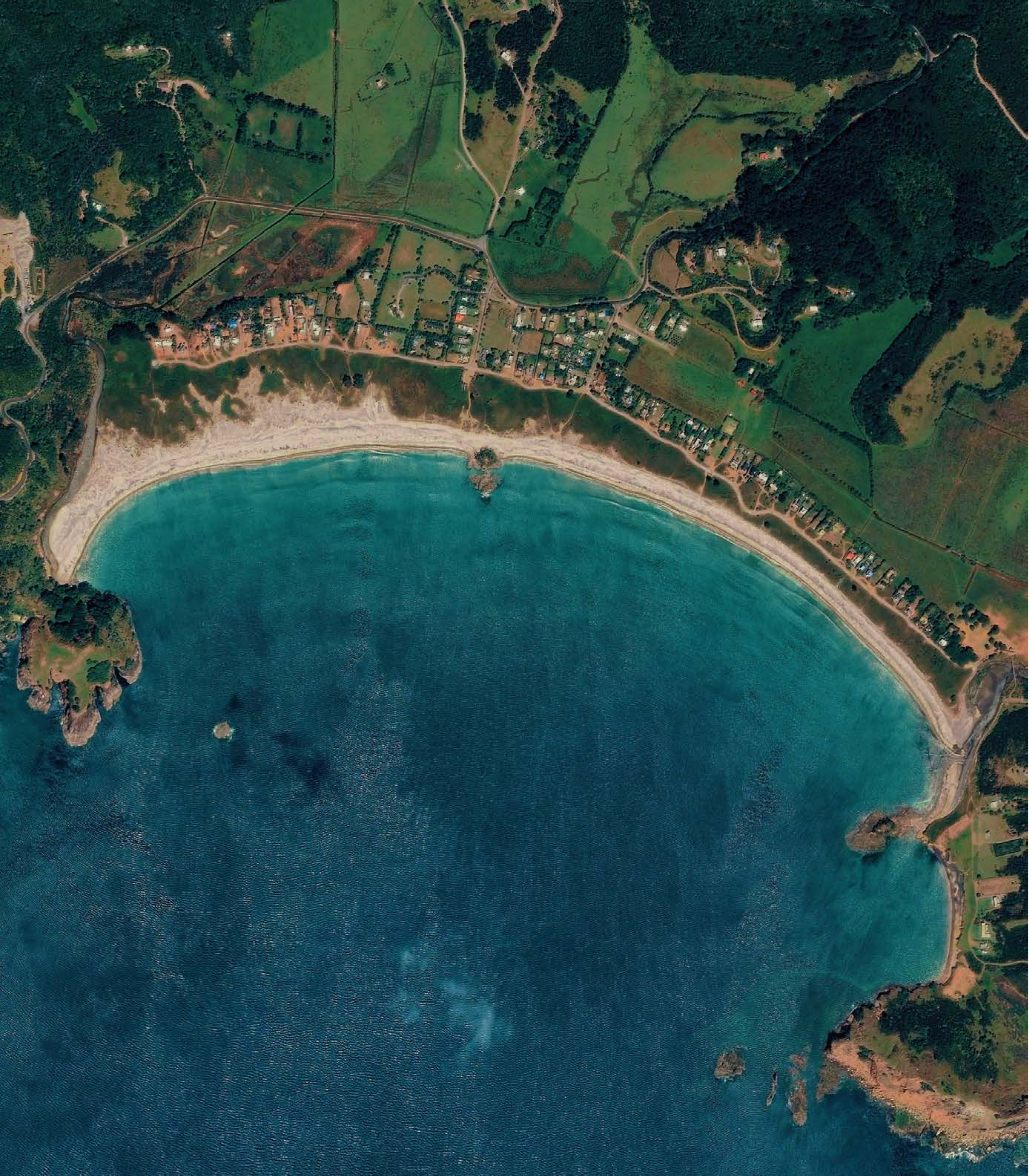
A POE could also be used to demonstrate to an owner the impact of higher quality design features, including higher quality materials.

Follow-up After a Disaster

Inevitably when a disaster occurs, we should all lend a helping hand where we can. After the situation has stabilized, a discussion with an owner may be welcomed on how the building or project endured the disaster event and how the project team can help navigate issues with the building. This may help reveal how the owner has perceived resilience design features which may provide both objective and subjective responses. Having a relationship with the owner can help make these conversations more fluid and may reveal feedback on resilience performance. Sometimes the conversation may not be welcomed, it is up to the project team to assess the situation.

Other Ways to be Involved

The AIA Disaster Assistance Committee provides organization and training for architects to help their communities after a disaster event. The Safety Assessment Program (SAP) uses the California Office of Emergency Services training program for structure assessments after earthquakes, flooding, and extreme windstorms. Architects and Engineers can complete the training and be placed on a list of volunteers to help with damage assessments after a disaster event. This program can provide firsthand experience of the potential damage and hazards, relief process, and protocols that can affect communities, which can help with resilient design development.



Conclusion

A Resilient Future

As our communities continue to endure and overcome disaster events, designing for resilience is becoming increasingly relevant and valuable. FEMA and other government agencies have provided various tools and datasets to help quantify and calculate the value of resilience and the cost of not incorporating resilience thinking into a building or community. Communities are feeling the impacts of disasters and are asking for designers, architects, engineers, professionals in the built environment to help design communities to withstand potential hazards so that safety and quality of life are not degraded but enhanced.

You may have encountered a project request for proposal or qualifications that has asked about resilience and sustainability, this toolkit seeks to provide you with resources and information that can help you provide a confident response. Industry professionals and resilience consultants can also help provide the skill sets needed to deliver projects that can enhance resilience capacity for clients and the communities.

According to the federal government, designing for resilience can save \$4 to \$7 for every dollar spent on a resilient design strategy. The return on investment for these strategies can be quite high over the life of the project. It will be critical to balance initial costs with mitigation of risk over time. A benefit-cost analysis helps provide data to show the value of resilient strategies to clients and stakeholders so that they may integrate resilient strategies where possible.

This Resilience Design Toolkit provides basic components to begin designing for resilience. The process is flexible and modifiable to fit your project. As technology and information continues to grow, this process will continue to develop to remain relevant and useful. Architects have a duty to protect community health, safety, and welfare. Designing for resilience is another tool and skill we can leverage to increase quality of life for generations to come in the face of climate change, social unrest, and other potential hazards.

Acknowledgment

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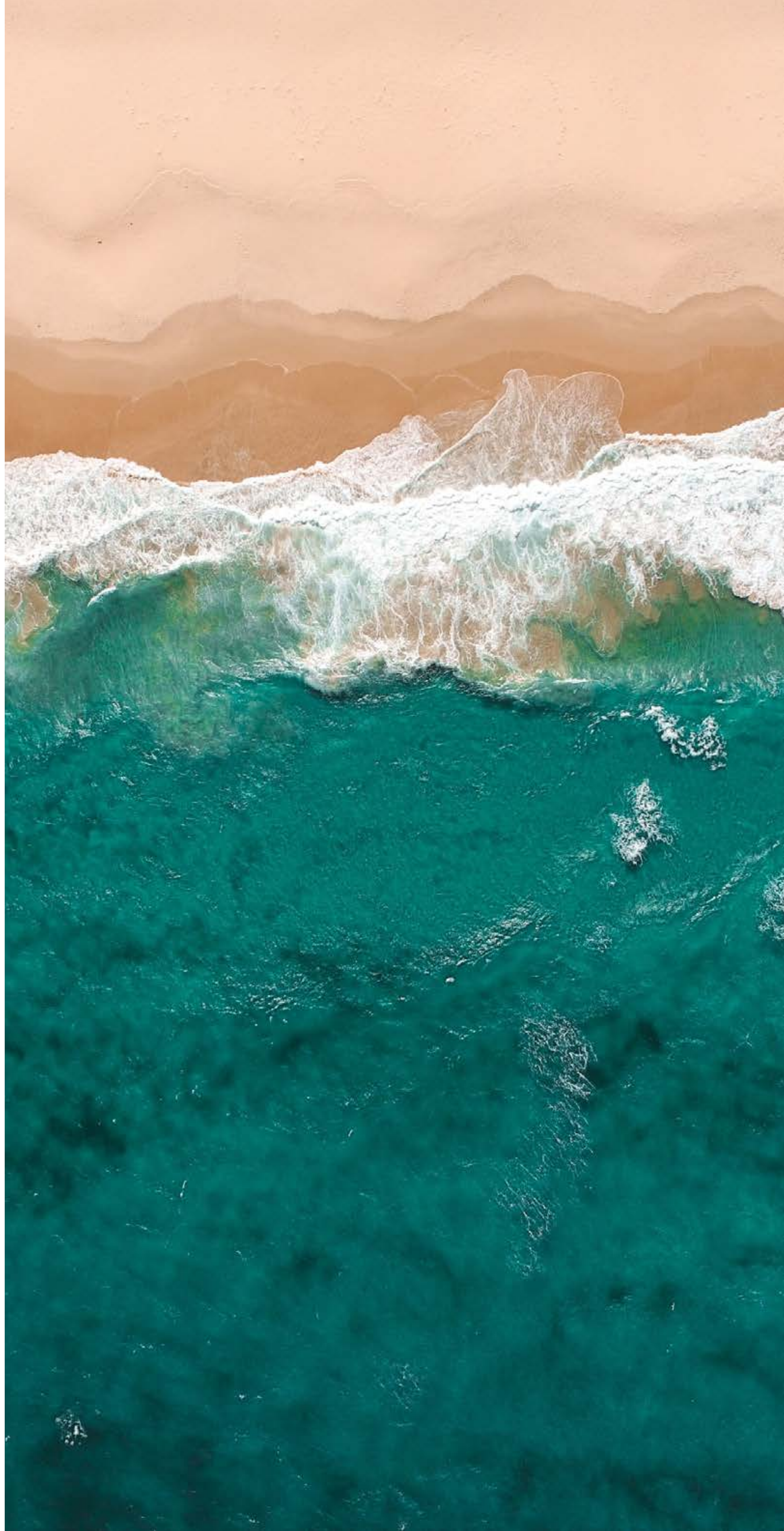

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