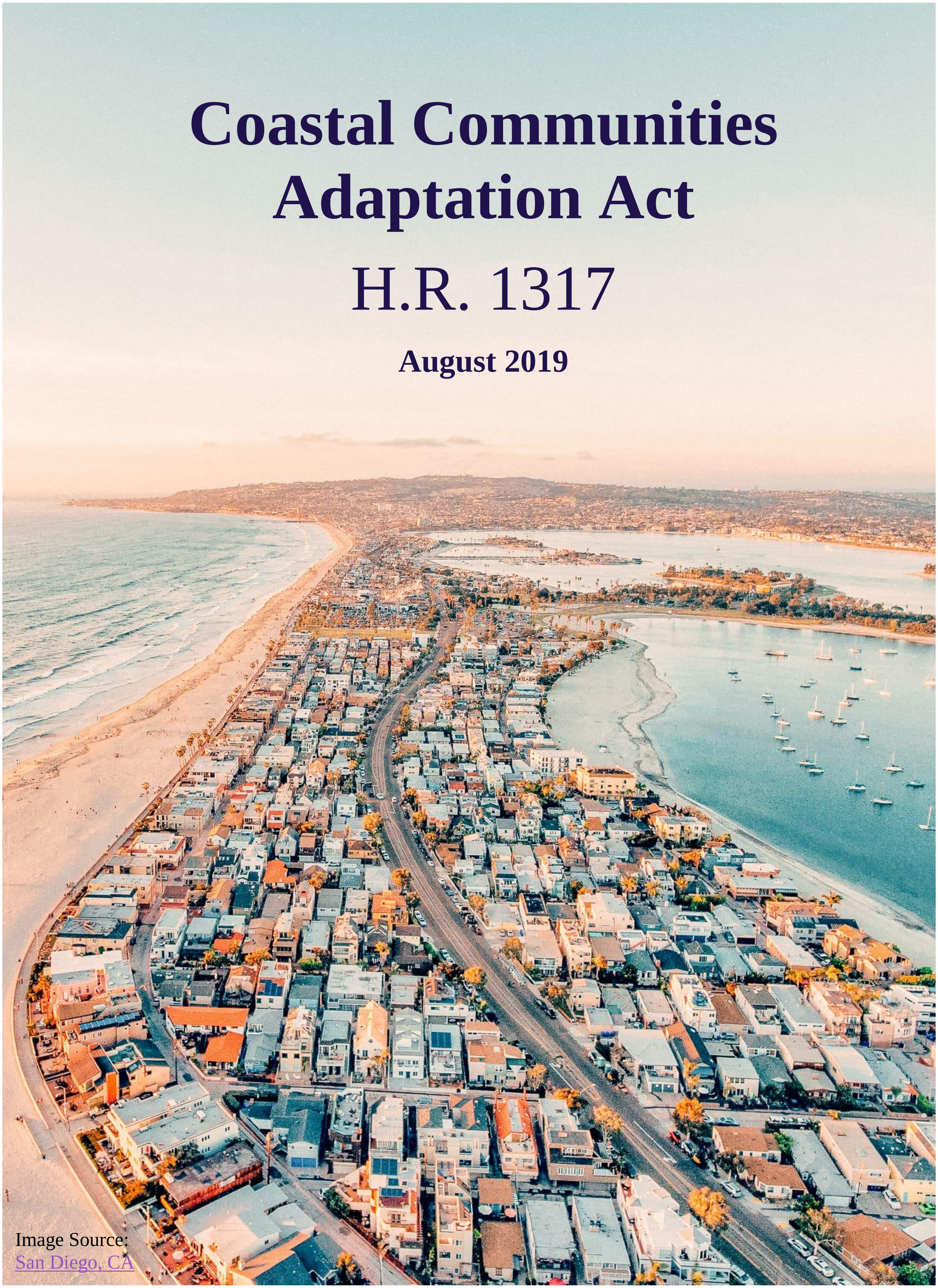
Coastal Communities Adaptation Act

H.R. 1317

August 2019



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COASTAL
COMMUNITIES
ADAPTATION ACT

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EXECUTIVE SUMMARY

In February 2019, Representative Harley Rouda (D-CA) introduced the Coastal Communities Adaptation Act (CCAA), which would create funding streams for coastal states to improve resiliency to climate change and coastal storms. CCAA defines a coastal state as any U.S. territory or state that is in, or borders, an ocean or a great lake. Nationwide, there are more than 126 million people living in counties directly on the coast (NOAA, 2015). These coastal areas also provide 56 million jobs and generate more than $8.3 trillion in goods and services (NOAA, 2015). Lack of attention to the environmental problems faced by coastal states not only jeopardizes human safety and health, but also negatively impacts economic growth. The bill focuses on conducting research, providing grants, and cataloging current resiliency projects to aid coastal states in implementing solutions to these problems (HR 1317, 2018).

CCAA would require agencies to evaluate the economic, social, and environmental impacts of sea level rise and storms on coastal communities. The bill would establish research programs and grants at the National Institute of Standards and Technology, the National Science Foundation, and Department of Housing and Urban Development to improve resilience. Prize competitions would also be held to spark innovative ideas for resiliency. These can include (1) nature-based features, including seawalls and living shorelines; (2) natural features, such as wetlands, sand dunes, and coral reefs; or (3) nonstructural measures, comprised of various policy measures. CCAA would also create a semipostal, “Built to Last Stamp,” which will contribute to funding for these projects. The U.S. Postal Service would issue the stamp, and money from its sales will be deposited in the Build To Last Stamp fund. Furthermore, collecting information on existing infrastructure within cities will enable local governments and nonprofits to identify the most effective technology for future sites, and streamline funding to these projects. Additionally, CCAA would establish a revolving fund for coastal communities to acquire the resources needed when addressing resiliency issues (HR 1317, 2018). This report will focus on both the science and technology for coastal adaptation techniques.

The resiliency challenges facing coastal communities are primarily caused by sea level rise and coastal storms, which negatively imact communities through erosion, high speed winds, and flooding. Coastal storms can cause billions of dollars in damage to coastal communities, and storms are expected to become more intense as climate change continues. For example, Hurricane Sandy in 2012 caused $65 billion in damages and Hurricane Katrina in 2005 caused $161 billion dollars in damages (Manuel, 2016).

The bill proposes the use of nature-based features, natural features, and non structural measures to improve resiliency. Gaining a better understanding of these environmental issues and adaptation practices can help coastal communities save lives and money. As each solution comes with opportunities and drawbacks, CCAA seeks to provide the resources needed to properly research and develop infrastructure to better prepare coastal communities for the many ramifications of climate change and coastal storms (Brown, 2018).

ENVIRONMENTAL PROBLEMS

Climate Change

Continued increase of the amount of greenhouse gases in the atmosphere causes the global average temperature to rise. Subsequently, climate change drives sea level rise, coastal erosion, flooding, and more intense coastal storms, which damage cities located along the coast.

Sea Level Rise

Two of the primary natural systems driving sea level rise are deglaciation and thermal expansion. In particular, meltwater from glaciers, ice caps, and ice sheets increases oceanic volume, resulting in sea level rise (Kahn, 2019). Thermal expansion also increases the volume of existing oceanic mass. The increase of greenhouse gases in the atmosphere traps more heat, which raises the overall temperature of the ocean, causing oceanic volume to increase (Church, 2013). Sea levels have been rising incrementally over the past century. Figure 1 shows the amount of sea level rise occurring across the U.S. coastlines in the past 55 years, with many coasts facing sea level rise of greater than eight inches. Scientists expect the rate of sea level rise to accelerate given the current emissions trajectory. By the end of the century, scientists project that global sea levels will rise 26 inches, putting more than 126 million Americans living along the coasts at risk (NASA, 2018).

Rising seas will cause flooding in many coastal areas. Sea level rise puts infrastructure at risk, such as homes, power plants, transportation networks, water supplies, and sewage treatment plants (NOAA, 2008). Business activities and tourism in large cities will be impacted by sea level rise. These communities generate roughly 58% of U.S. national gross domestic product (EPA, 2017).

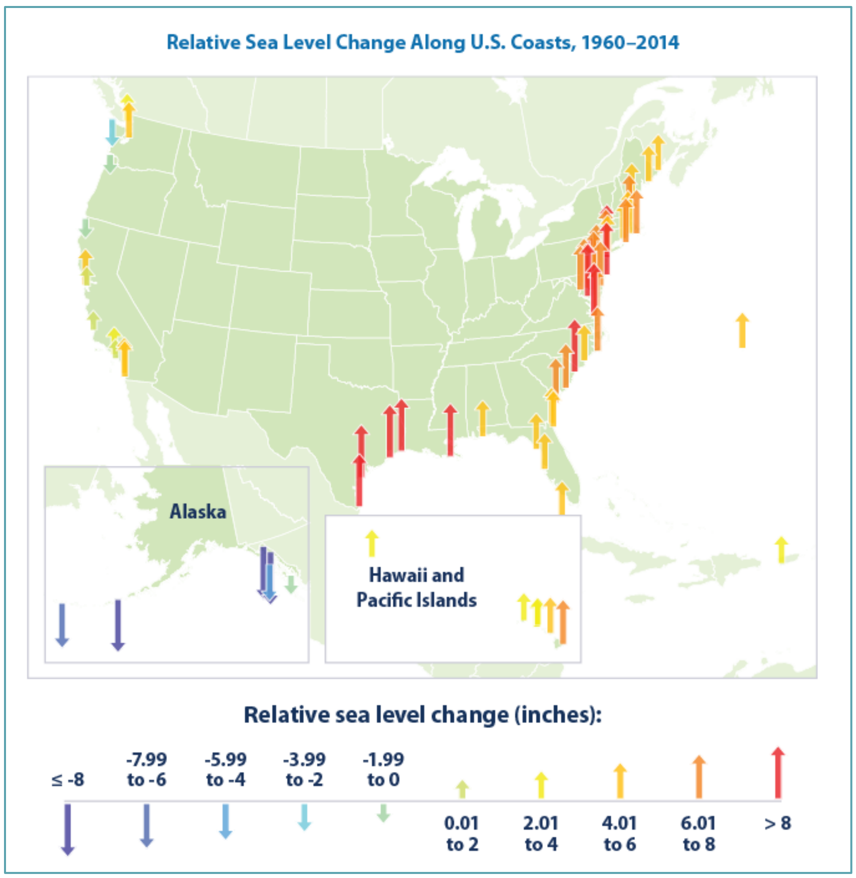

Figure 1. Releative sea level rise on US Coasts, 1960-2014
Image source: NEEF USA

Scientific Controversies Related to Climate Change and Sea Level Rise

The scientific community agrees that sea levels will rise (Church et al., 2013). However, scientists use several models for climate analysis, known as Representative Concentration Pathways (RCPs), which estimate varying projections of sea level rise (Church et al., 2013). In the best-case scenario, RCPs estimate emissions will be capped in 2020 and decrease to nearly zero by 2080 (Vuuren et al., 2011), estimating a sea level rise of 1.4 feet by 2100 (Church et al., 2013). Conversely, if emissions continue growing along the current trend until 2070, scientists project sea levels to rise more than five feet by the end of the century (Jevrejeva, Moore, & Grinsted, 2012).

Scientists also dispute Antarctica's role as a contributor to sea level rise, particularly because Antarctica has insufficient data for climate models (Jones, 2019). In 2017, scientists reached a consensus that the melting West Antarctic Ice Sheet caused sea levels to rise, with the East Antarctic Ice Sheet remaining stable and even increasing in mass (Church et al., 2013; Shepherd et al., 2018). The following year, new satellite images containing data from the past 40 years revealed a different interpretation of the data, showing that the East Antarctic Ice Sheet accounts for 20% of the continent's runoff (Rignot et al., 2019). Furthermore, the East Antarctic Ice Sheet holds 10 times as much ice as the West Antarctic Ice Sheet, and some scientists believe that the edge of the East Antarctic Ice is at risk of melting this century. If this model holds true, sea levels could rise an additional 13 feet more than most existing models project (Jones, 2019). Accurately projecting the extent of sea level rise is crucial in the consideration of how to implement adaptation measures.

Coastal Erosion

According to the U.S. Environmental Protection Agency (EPA), between 80% and 90% of U.S. beaches have been eroding for decades (The Environmental Magazine, 2008). As sea levels rise, greater amounts of sediment or bedrock wash away from the shoreline, leading to increased rates of erosion. Additionally, erosion does not occur at a uniform rate. Certain low-lying areas of the country, such as the Gulf Coast, are likely to experience a disproportionate loss of sediment. High levels of sediment loss cause landward displacement. Factors such as local wind patterns can also cause greater levels of coastal land loss (Moss, et. al., 2017).

As sea levels encroach further onto the shore and rates of beach erosion increase, valuable coastal properties become more vulnerable to regular instances of flooding, storm surges, and hurricanes. The U.S. Climate Resilience Toolkit (USCRT) estimates that coastal erosion is currently responsible for nearly $500 million per year in property damage or loss (USCRT, 2016). Sea level rise changes sediment disposal in coastal areas and accelerates erosion (EPA, 2019). Erosion also degrades natural storm barriers, including wetlands.

Wetland Destruction

Coastal wetlands are important because they provide critical ecosystem services, including:

- Serving as a buffer zone to protect the inland areas from storm surge and erosion;
- Providing habitats for fish and wildlife in coastal ecosystems; and
- Cycling nutrients to mitigate the negative impacts of agricultural runoff.

According to the U.S Fish and Wildlife Service, more than 80,000 acres of coastal wetland are lost annually, which is the equivalent of losing seven football fields every day (Dahl and Stedman, 2013). Coastal wetlands are highly susceptible to the effects of sea level rise. Wetland accretion, in which plants trap sediment, increases the elevation of the surface and wetland area. Historically, wetlands in the U.S. have naturally been able to adjust to changing sea levels. However, because of climate change, sea levels rise faster than the natural accretion rate of wetlands, causing wetland loss.

Coastal Storms

Coastal communities face issues related to flooding and high speed winds because of intensifying coastal storms.

Flooding

Coastal flooding occurs because of sea level rise, storm surges, and heavy precipitation periods. The inundation of normally dry land with large volumes of water can cause loss of life, destroy infrastructure, or impact natural systems along the coast, as shown in Figure 2. In 2017, Hurricane Harvey made landfall in southeastern Texas and created unprecedented levels of flooding that have "less than a 0.1% chance of occurring in any given year," (Blake and Zelinksy, 2018). According to the USCRT, coastal regions have been at a higher risk of flooding since 1900, and climate change will worsen flooding events over time (Marra, et. al., 2014). Recurring minor floods, or nuisance floods, occur when water levels rise about 1.5 feet over the historical maximum daily high. Until recently, nuisance floods would only occur once every two years during storm events, but now these floods have substantially increased in frequency.

Figure 2. Flooding during Hurricane Harvey
Image source: New Scientist

Data from NOAA shows that the number of flood days per year has increased in dozens of cities across the U.S. over the past 50 years. Increasing instances of flooding degrades stormwater systems and increases the likelihood of freshwater contamination. In addition to sea level rise, storm surges are becoming more severe and frequent, which exacerbates flooding along the coast. On average, the number of days per year that coastal regions experience flooding has doubled in many cities in the U.S. within this century, with some now experiencing flooding nearly 50 days per year (NEEF, 2019). Flooding can threaten human health by damaging water infrastructure and contaminating drinking water, while also putting lives in direct danger.

High Speed Winds

Intense winds are another concern for coastal communities, especially during hurricane season from June to November. Figure 3 illustrates high speed winds during Hurricane Irma, which occurred in August 2017. Air moves from higher to lower pressure areas, creating gusts of various speeds. Climate change increases the amount of heat and water in the atmosphere. Along with warmer sea surface temperatures, this provides fuel to increase wind speeds, creating more intense storms. According to the Beaufort Wind Scale, winds are considered "high speed" when they exceed 74 miles per hour. Wind speeds that reach up to 100 miles per hour can produce a damaging path that extends for hundreds of miles (NOAA, 2016). High speed winds cause many hazards, including fallen branches, uprooted trees, and damaged power lines.

Figure 3. Winds during Hurricane Irma
Image Source: Sun Sentenial

The most powerful recorded hurricane in the U.S., Hurricane Katrina, had wind speeds of up to 175 miles per hour, which destroyed or seriously damaged nearly 800,000 homes (NOAA, 2018b) and displaced more than 1 million people in the short-term (Allianz, 2005). Furthermore, Hurricane Katrina caused more than $160 billion in overall damages throughout the Gulf Coast (NOAA, 2018).

Scientific Controversies Related to Coastal Storms

Models show disagreement as to how climate change will affect the frequency and severity of storms. Social scientists argue that media attention of coastal storms, as well as the migration of people into more storm-prone regions, causes many people to believe that the frequency of natural disasters has increased. Data aggregated from both government agencies and non-governmental sources confirm this public perception, showing an increase in natural disasters per year, from 78 in 1970 to 348 in 2004 (Than, 2005).

Alternative data gathered by George Twelioudis, a research scientist at the NASA Goddard Institute for Space Studies (GISS) and Columbia University, projects a potential inverse trend between climate change and storm frequency. Twelioudis predicts that the warming climate will decrease the difference between the temperatures at the poles and the equator, resulting in a lower frequency of coastal storms (Earth Observatory, 2005).

Despite the debate over the future frequency of storms, scientists generally agree that storms will occur with greater intensity. Oceanic trapping of heat provides more fuel for storms, leading to increased wind speeds in hurricanes, and more significant storm surges (Earth Observatory, 2005) (Woth et al., 2006).

PROPOSED SOLUTIONS

The bill categorizes potential solutions to the threats faced by coastal communities as follows:

1. Nature-Based Features
2. Natural Features
3. Nonstructural Measures

Nature-Based Features

CCAA defines a "nature-based" feature as a risk reduction measure created by human design, engineering or construction, that functions "in concert with natural processes," (H.R. 1317, 2019). Examples of nature-based features include seawalls and living shorelines.

Seawalls

Seawalls are physical barriers installed along shorelines to reduce flooding and coastal erosion. As shown in Figure 4, these structures are generally built parallel to the shore to stabilize the land and control the flow of water, blocking land and infrastructure from storm surges and waves (U.S. Army Corps of Engineers, 2013). Depending on the average wave height and proximity to the water, engineers typically make seawalls out of concrete, masonry, timber, or vinyl sheets. The height should cover the difference between the beach level and the mainland, but seawalls tend to be higher in order to prevent waves from going over the walls. Recently, engineers have implemented sloped seawalls in order to reduce the amount of wave energy that the barrier reflects (European Union RISC-KIT, 2019). Seawalls can be particularly useful in coastal communities with small natural buffer zones positioned between a body of water and valuable infrastructure.

Figure 4. Seawall in Santa Barbara, California
Image Source: CNN

Waves overtopping seawalls have the potential to erode the area behind the wall and cause other forms of water damage (Climate-ADAPT, 2015). Vertical seawalls tend to reflect wave energy rather than dissipate it, causing more turbulence in coastal waters. While seawalls can serve as an effective barrier between marine environments and coastal communities, hard coastal barriers can accelerate erosion on adjacent beaches.

A 2017 study of coastal water management showed that a seawall could cause up to 20 meters of landward erosion (Balaji, 2017). Seawalls are also expensive to build. It is estimated that creating seawalls to protect all coastal cities in the United States from basic storm surges by 2040 would cost more than $400 billion (Flavelle, 2019).

Living Shorelines

Living shorelines are broadly defined as an innovative and cost-effective technique for improving coastal resilience (NOAA, 2017). Unlike hard coastal infrastructure, living shorelines promote plant growth rather than impede it. This tool combines wetland plants and natural materials to stabilize shorelines—Figure 5 displays the way in which living shorelines prevent erosion using these features. Oyster reefs, for example, only need 4.6 meters of reef to absorb half of the incoming wave energy. (NOAA, 2017). The presence of coir logs supported by oyster bags in front of wetland plants prevents bank undercutting, which inhibits land loss. Although similar to wetlands, living shorelines are not naturally occurring and require the engineering of natural infrastructure by humans. The introduction of rocks or oyster bags creates a rocky habitat in which crabs, oysters, fish, and other marine organisms thrive.

By 2100, one third of U.S. shorelines will be hardened, resulting in decreased fishing and biodiversity. Some states have made significant progress in constructing living shorelines. The Maryland legislature, for example, passed the Living Shorelines Bill in 2008, which requires certain Maryland property owners to utilize living shorelines for shore protection (Walker, 2011).

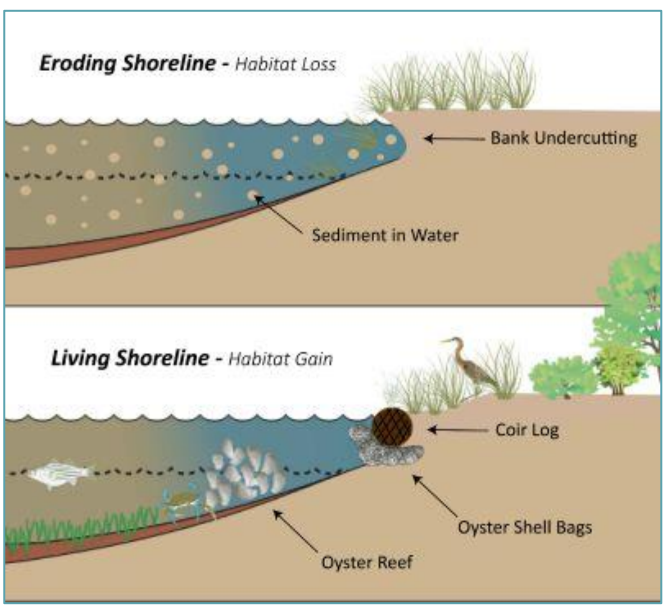

Figure 5. Living Shoreline diagram
Image Source: DNREC

Research shows that living shorelines contain many benefits that address the drawbacks to seawalls. Living shorelines support the natural habitat of marine life, which allows coastal ecosystems to flourish. But, environmental scientist Rachel Gittman states that miles of natural shoreline would be required to protect the coast from an intense storm, making seawalls a more sufficient mechanism in certain scenarios (Bennington-Castro, 2017).

Natural Features

As outlined in CCAA, three types of natural features that are beneficial in mitigating the negative impacts of natural disasters and sea level rise are wetlands, coral reefs, and sand dunes.

Wetlands

Coastal wetlands provide a critical interface between terrestrial and marine environments. Wetlands' dense root systems dissipate energy from waves and ocean currents, absorb surface flood water, and bind soil and sediments (EPA, 2018). The low topographic position of wetlands, relative to uplands, helps store and slowly release floodwater. Trees and other vegetation, such as sea grasses and mangroves, act to impede the movement of water and distribute the water more slowly over floodplains. The stems and leaves of wetland vegetation also increase the stability of the sediment by trapping it (Thomas, 2000). Furthermore, the dense vegetation and shallow water of the coastal wetlands prevent erosion and act as buffers against wind, rain, and wave action. Figure 6 shows Freshkills Park, where 360 acres of wetlands were restored at what used to be a landfill site.

Figure 6. Wetlands in Freshkills Park
Image source: Freshkills Park

Agencies, such as the EPA and the U.S. Fish and Wildlife Service, have worked in partnership on wetland restoration. Although wetland laws and regulations have significantly slowed wetland loss, various stressors continue to impact coastal wetlands and make them less efficient. For instance, hydrologic modifications (e.g., tidal restrictions and dams) fragment wetland ecosystems, making wetlands less able to store floodwater. Agricultural modifications also put stress on wetland ecosystems through the conversion of wooded or shrub swamps to cultivated bogs and the incremental filling of wetlands (EPA, 2015).

Wetlands mitigate damage from flooding, ultimately protecting people, roads, homes, and businesses in coastal communities. States along the Atlantic that had coastal wetlands present at the time of Hurricane Sandy in 2012 experienced 11% less damage on average than states without wetlands (Beck, et. al., 2017). Cities, such as New York and Miami, which are particularly vulnerable to damage as a result of sea level rise and natural disasters, have allocated significant funding for wetland restoration. The U.S. Department of Agriculture has spent more than $4.2 billion dollars on wetland restoration in the last two decades (Hansen, 2015). The National Oceanic and Atmospheric Association (NOAA) values the benefits of wetland storm drainage services at $23 billion per year (NOAA, 2019).

Coral Reefs

Coral reefs are underwater structures comprised of coral and other organisms, such as algae. In addition to ecological and cultural value, coral reefs also play an important role in coastal protection. Coral reefs can mitigate potential damage from flooding, natural disasters, and erosion. Functioning as breakwaters, reefs serve as coastal buffers (NOAA, 2018). After waves hit both the reef's crest and flat, about 97% of the incident wave energy is dissipated (Ferrario et al, 2014). Depth of water, coral morphology and reef surface roughness affect the reef's ability to break waves (Beck & Lange, 2016). One study found that coral reefs provide more coastal protection than many other marine ecosystems (Harris et al, 2018). The EPA has proposed various coral reef restoration and conservation projects to protect reefs and maintain these valuable ecosystem services (EPA, 2018).

Unfortunately, ocean warming and acidification continue to reduce the amount of coral in oceans around the world. Since 1990, the Great Barrier Reef in Australia has experienced a 14% decrease in coral growth (Death, 2009). Because of the global scale threats to coral reefs, it is difficult to estimate the average cost of maintenance of reefs for coastal resiliency purposes. There are a number of coral reef restoration and conservation projects, including NOAA's Coral Reef Restoration Project, that conducts research and provides grant funding for additional research and restoration plans (NOAA, 2019).

A report by the U.S. Geological Survey, which studied populated coral-reef-lined coasts of U.S. states and territories, found that coral reefs provide more than $1.8 billion in flood protection benefits annually (Storlazzi, 2019). In the absence of coral reefs, the estimated annual damage in these areas would double, and flooding would increase by 69% (Beck, et. al, 2018).

Sand Dunes

Coastal dunes protect beach communities from elevated water levels and wave erosion associated with coastal storms (Sallenger, 2000). Two basic requirements for the coastal dunes are the availability of well-sorted beach sands and the onshore winds that help to move sand. Beach grasses and driftwood strengthen the dunes by trapping sand and preventing it from blowing away. (Pye, 1983). Sand dunes have three components: foredune (facing the ocean), sand plain (located at the top of dunes when present), and backdune (facing the land). Plants that grow on the foredune include Ammophila Arenaria, Honckenya Peploides, Cakile Maritima, and Spartina Coarctata. These plants are tolerant to salt spray and strong winds, and effectively accumulate sand (Martinez, 2004). In addition, the sand dune plants "adapt to moving substrate, desiccation, and unpredictable changing temperature" (Esler, 1970). However, managing coastal dunes is challenging because the dunes are vulnerable to environmental challenges, such as wind, wave, tides, sediment supply, and rainfall.

When Hurricane Sandy hit in 2012, communities with robust natural dunes fared significantly better than communities without dunes. Dune restoration is considered to be cost-effective, and many coastal communities have undergone dune restoration programs. Cities install beach grass and sand fences to help to stabilize the sand and capture windblown sand (USCRT, n.d.). For example, Bradley Beach, New Jersey constructed 15-foot high dunes for about $10,000 in 1996 (Navarro, 2012). In addition to utilizing grass and fencing, the town also incorporated Christmas trees into the dunes to further stabilize the sand (Navarro, 2012). It is estimated that Bradley Beach incurred $3 million in damages when many neighboring towns incurred much greater damage. In comparing the financial costs of only $10,000 versus the benefits (only $3 million in damages), creating resilient structures is a successful investment (Navarro, 2012).

Nonstructural Measures

CCAA defines nonstructural measures as modifications to public policy and management practices that seek to reduce the harmful impacts of flooding. Two examples of nonstructural measures are flood warning systems and resilient building codes.

Flood Warning Systems

Flood warning systems notify the public and emergency personnel about impending floods, allowing residents enough time to prepare for emergencies and evacuate if needed (Carsell, 2004). Flood warning systems are implemented to reduce the loss of life and property damage from flooding events (U.S. Department of Commerce & NOAA). The National Weather Service began using Integrated Flood Observing and Warning Systems since the late 1970s, and they have proven to be effective in improving the safety of residents (U.S. Department of Commerce & NOAA). The cost of implementing flood warning systems depends largely on the scale of the system (national, state, county, or city level). Federal and state agencies make grant funding available for communities to create flood warning systems (NOAA, 2012).

Building Codes

Resilient building codes set standards for construction, requiring specific design elements to promote structural resilience to natural disasters. After recent natural disasters, many coastal communities adopted new resilient building codes, such as a minimum elevation requirement (Department of Homeland, 2013). Following Hurricane Sandy, New Jersey updated its building codes to require any new or reconstructed buildings to be elevated if the buildings are located in a floodplain, or if they were declared substantially damaged by Hurricane Sandy (NJDEP, 2013). New York City also recently adopted a new building code requiring hospitals and nursing homes in flood zones to have emergency equipment to maintain electricity and heating during a natural disaster (Navarro, 2013). The cost of implementing updated building codes typically falls on the regulated entity.

Resilient Building Codes

Nonstructural methods do not modify anything physical, but instead modify behavior through public policy. Given the increase in development in flood prone regions, additional safety measures are required. In addition to nature-based and natural features, buildings need to be constructed to higher standards to withstand climate change. The image below is a home in Mexico Beach, FL, in the aftermath of Hurricane Michael. The hurricane decimated most properties in the area except for this one, which was built to higher standards than those required by local code. The building is placed above pilings, with blow away walls. This design allows flood water to wash safely below the building without damaging the support of the structure (ABC News, 2018). Resilient building codes require the cooperation of policy makers, engineers and construction teams to be most effective.

Figure 7. Resilient Building Codes in Mexico Beach, Florida after Hurricane Michael
Image Source: [ABC News]

MEASURING SUCCESS

Decision-makers must be able to measure the success of the proposed solutions. Key measurements in determining the success of the solutions include the amount of erosion observed, flood levels, and property damage. These measurements can be quantified using the methodology below (Figure 8).

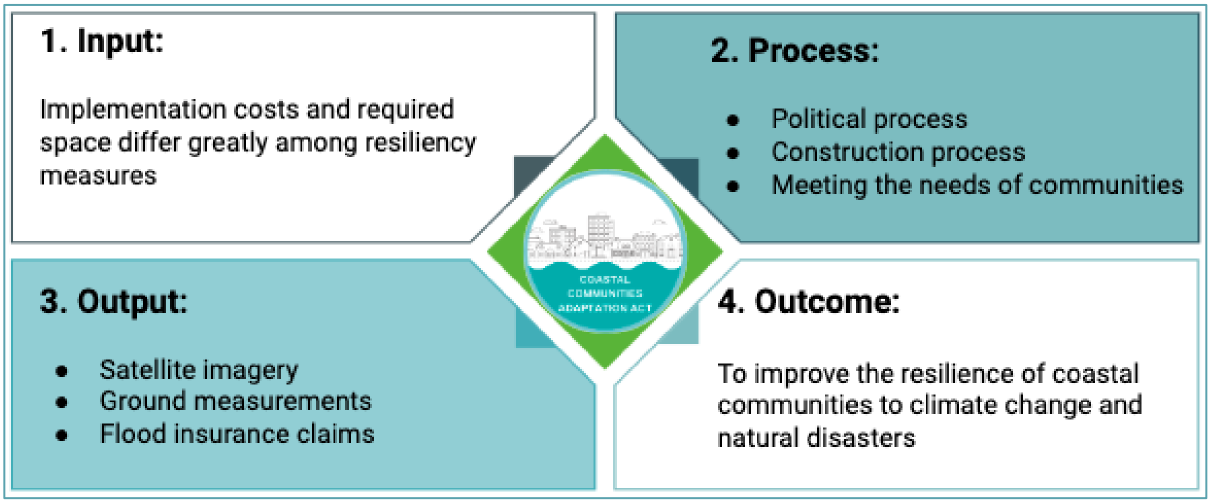

Figure 8. The Four Steps in Measuring Success

Inputs

The cost of improving resiliency varies widely, depending on the type of measures and scale of the project. Overall, boosting coastal resilience requires significant investment. For example, San Francisco estimates that the cost of updating an existing seawall along its shores could be as high as $3 billion (Lin, 2016), whereas a wetland restoration project in Shellbine, Georgia could cost about $5 million (U.S. Fish & Wildlife Service, 2019a). In addition to funds from CCAA, governments may directly finance coastal resiliency projects using local budget allocations, or utilize grants from government agencies. These agencies include the U.S. Army Corps of Engineers, U.S. Fish and Wildfish Service, and the EPA. Most resiliency projects require a combination of funding sources.

Process

The U.S. contains diverse coastal communities and ecosystems. A city like San Francisco has very different needs and constraints than a less densely inhabited area, like a natural wetland in Shellbine, Georgia. These differences impact the types of resiliency solutions selected by coastal communities as well as their funding sources. San Francisco is in the process of allocating funds to upgrade its seawall, which is more than one century old (Rogers, 2018). Whereas Georgia requested a $1 million grant from U.S. Fish and Wildfish Service to restore wetlands in Shellbine (U.S. Fish & Wildlife Service, 2019b). Coastal communities may consider many sources of funding when implementing resiliency measures.

Outputs

The outputs are the proposed solutions, implemented to protect coastal communities from flooding, erosion, and reduce damage to infrastructure. The effectiveness of a solution can be measured using the following tools: satellite imagery, ground measurements, and property damage.

Satellite Imagery

Remote sensing scans Earth's surface to creating satellite images. To determine erosion over time, remote sensing quantifies shoreline position, sandbar migration, and rip-channel formation. Satellite imagery also can show wave run-up occurring on the beach, as well as currents on the shore and nearshore bathymetry (USGS, n.d.). Satellite imagery can be useful in measuring the extent of flooding by producing images before and after a storm, ultimately quantifying the turbidity and volume of water encroaching the land (EOMAP, 2018). Before and after satellite images help to estimate levels of flooding and erosion prevented by living shorelines, wetlands, sand dunes, coral reefs, and seawalls. Figure 9 is an example of satellite image, representing how scientists can monitor erosion from space.

Figure 9. Coastal Zone Monitoring from Space
Image Source: [European Space Agency]

Ground Measurements

Ground measurements of erosion over time can evaluate the success of living shorelines and wetlands. Decreased erosion rates and intact living shorelines after a storm event quantify the success level of living shoreline. For example, a study published by the U.S. National Institutes of Health measured the effect of vegetation on coastal erosion over a three-year period. Using stakes placed at varying distances from the shoreline, scientists compared the lateral and vertical rates of erosion for coasts with vegetation and without vegetation. The study found that coasts without vegetation experienced higher rates of lateral erosion, particularly when underground biomass was removed because biomass stabilizes the shore (Silliman, et. al., 2019). The experiment showed that living shorelines have long-term benefits in preventing coastal erosion and enhancing coastal resiliency.

Policymakers should also consider the level of erosion before and after a storm event to determine the effectiveness of adaptation techniques. For instance, after Hurricane Irene hit North Carolina in 2011, scientists quantified shoreline erosion at marshes with and without oysters and rocks. Measurements of marsh surface elevation and marsh vegetation density were taken at various plots before and after Hurricane Irene (Gittman, 2014). The study used leveling rods as a tool to evaluate the difference in land heights between points. To assess the marsh vegetation density, scientists measured the plant stem density by species within plots (Gittman 2014). In this case, it was found that plots with oysters and rocks faired better than those without.

Property Damage

Building codes help ensure that infrastructure in communities will withstand coastal storms. The monetary value of flood insurance claims is an indicator of the property damage caused by a storm. This data can assist a coastal community in weighing the cost effectiveness of an implemented resiliency solution. To quantify the difference in flood insurance claims between a building with resilient building codes and one without, the cost of property damage incurred before the introduction of building codes can be compared to those after the standards are introduced. Publically available data on insurance claims related to floods shows differences in flood insurance claim costs, as shown in Figure 10 (FEMA, 2019). This map demonstrates that states with the most flood insurance claim payments are on the coast. Measurements of flood insurance claims can also be used to measure the effectiveness of seawalls, living shorelines, wetlands, coral reefs, and sand dunes.

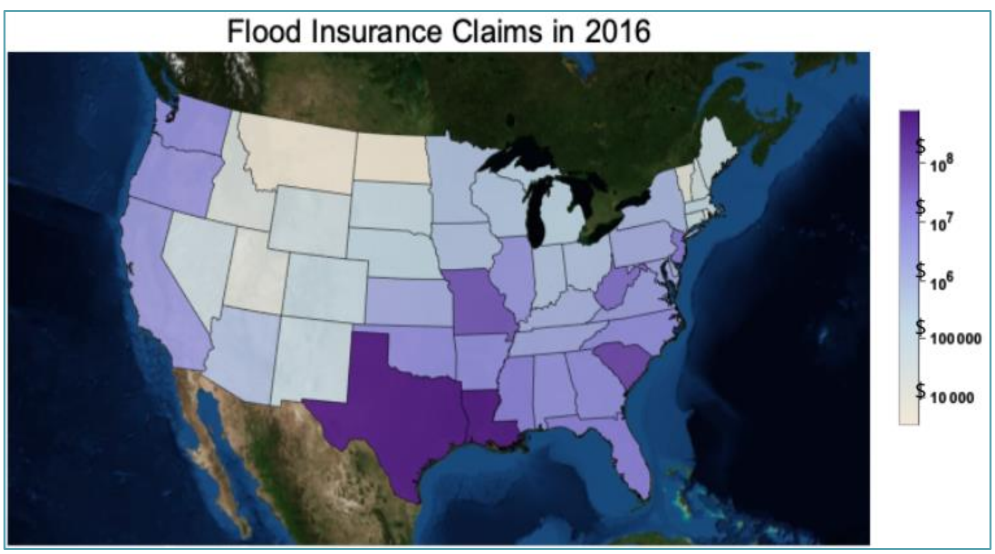

Figure 10. Flood Insurance Claims in the U.S. in 2016 Image Source: Maya Fuller, 2019; Data: FEMA

Constructing a seawall should also prevent flooding, thereby decreasing associated property damage. It is difficult to measure the impact of seawalls because the success of permanent structures is highly variable, based on the quality of design, coastal climate, storm history, and other factors (Balaji, 2017). Despite this, scientists survey the percentage of seawalls damaged after a storm as well as the property damage (NOAA, 2015). For example, Hurricane Hugo, which struck Charleston, South Carolina, destroyed 58% of the seawalls that were surveyed (Thieler and Young, 1991). The number of seawalls that remain intact after a storm measures a correlation with property damage in the wake of a storm. Hurricane Hugo, for example, cost roughly $7 billion in property damage (National Academic Press, 1994).

Outcomes

The desired outcome of CCAA is to improve coastal community resilience to climate change and natural disasters. Different coastal communities have different characteristics, and thus require a variety of solutions; there is no single solution that would work for every city. Implementing measures of success helps each community along the coast find the most cost-efficient way to adapt to challenges presented by sea level rise and intensifying coastal storms.

CONCLUSION

CCAA seeks to protect coastal communities to the threats presented by climate change and coastal storms. Funding solutions to these problems will help solve economic, social, and environmental issues confronting cities and towns along the coast.

Recent severe coastal storms, such as Hurricanes Sandy, Harvey, Katrina, and others, paint a clear picture of the consequences if action is not taken. Coastal communities in the U.S. must take steps to address their resiliency to rising sea levels and severe coastal storms. CCAA provides potential solutions for adaptation. The degree to which environmental problems will impact communities along the coast varies. Scientists debate how much sea levels will rise and which implementation tools most efficiently safeguard cities. Communities are also affected differently depending on the location and type of existing infrastructure, elevation, and exposure to more intense storms.

The bill provides for prize competitions to award innovative research on how to best prepare cities for the impacts of sea level rise, coastal erosion, flooding, and high speed winds. The solutions outlined in this report are nature-based features (seawalls and shorelines), natural features (wetlands, coral reefs, and sand dunes), and nonstructural measures (flood warning systems and building codes). Depending on the coastal community, a living shoreline rather than a seawall, for example, might serve as the best tool for mitigation against environmental challenges when there is more space to build one. Natural features benefit ecosystems while protecting coastal communities, though there are uncertainties as to which adaptation measure works best in the face of a storm. Nonstructural measures are also an important component of resiliency because of their focus on protecting residents.

Measuring the success of each of each tool will be essential for governments when deciding which solution to use. Across the U.S., many of these structures and policies already exist. As such, this bill suggests cataloguing the tools in place and collecting information on which technologies prove to be the most effective based on location, geography, and available funds. The Built to Last Stamp, along with revolving funds established through this bill, will allocate money to projects that provide the most benefit to coastal populations and infrastructure.

Government action is essential to protecting coastal states and ensuring resilience of built and natural environments to climate change and coastal storms. Improving infrastructure requires significant funding and coordination between multiple levels of government, nongovernmental organizations, and coastal residents. That is the ultimate goal of CCAA.

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