Urban Land Institute

THE BUSINESS CASE FOR RESILIENCE

IN SOUTHEAST FLORIDA

Recommended bibliographic listing:

Urban Land Institute. *The Business Case for Resilience in Southeast Florida: Regional Economic Benefits of Climate Adaptation*. Washington, DC: Urban Land Institute, 2020.

Urban Land Institute
2001 L St., NW, Suite 200
Washington, DC 20036-4948

ISBN: 978-0-87420-463-6

This report was reviewed for consistency and accuracy of the original economic analysis.

THE BUSINESS CASE FOR RESILIENCE

IN SOUTHEAST FLORIDA

Regional Economic Benefits of Climate Adaptation

PROJECT TEAM

URBAN LAND INSTITUTE

PROJECT MANAGERS

Alec Bogdanoff
Local Project Manager, ULI; Principal, Brizaga

Leah Sheppard
Manager, Urban Resilience Program

PROJECT TEAM

Mallory Barker
Senior Associate, ULI Southeast Florida/ Caribbean

Katharine Burgess
Vice President, Urban Resilience Program

Billy Grayson
Executive Director, Center for Sustainability & Economic Performance

Julie Medley
Executive Director, ULI Southeast Florida/ Caribbean

Ellie White
Associate, Center for Sustainability & Economic Performance

AECOM

Anne deBoer
Sustainable Economics Practice

Aaron McGregor
Sustainable Economics Practice

Lauren Swan
Resilience Planning

SOUTHEAST FLORIDA REGIONAL CLIMATE CHANGE COMPACT

Katelyn Cucinotta
Palm Beach County

Samantha Dunchuk
Broward County

Rhonda Haag
Monroe County

Katherine Hagemann
Miami-Dade County

Megan Houston
Palm Beach County

Jennifer Jurado
Broward County

Jason Liechty
Broward County

Jim Murley
Miami-Dade County

Galen Treuer
Miami-Dade County

STAKEHOLDER GROUP

Irela Bagué
Bagué Group

Ana Benatuil
Gensler

Sheri Brown
Community Foundation of Broward

Kareen Boutros
Broward Workshop

Isabel Cosio Carballo
South Florida Regional Council

Jaap Donath
Beacon Council

Jacqueline Gonzalez Touzet
Touzet Studio

Dennis Grady
Chamber of Commerce of the Palm Beaches

Rob Kornahrens
Advanced Roofing Inc.

Michael Laas
Sustainable Futures Group

Ina Lee
TravelHost Media Group

Dan Lindblade
Greater Fort Lauderdale Chamber of Commerce

Angelica Rosas
Community Foundation of Broward

Lauren Ordway
Institute for Sustainable Communities

Jack Seiler
Seiler, Sautter, Zaden, Rimes & Wahlbrink

Greg West
CEO, ZOM Living

ULI PRODUCTION TEAM

James A. Mulligan
Senior Editor

Sara Proehl
Publications Professionals LLC, Manuscript Editor

Brandon Weil
Art Director

Lea Mayer
Marketing & Outreach Associate, Brizaga

Ana Fiotte
Designer and Associate, Brizaga

Craig Chapman
Senior Director, Publishing Operations

ABOUT THE URBAN LAND INSTITUTE

The Urban Land Institute is a global, member-driven organization comprising more than 45,000 real estate and urban development professionals dedicated to advancing the Institute's mission of providing leadership in the responsible use of land and in creating and sustaining thriving communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and the Asia Pacific region, with members in 80 countries. More information is available at uli.org. Follow ULI on Twitter, Facebook, LinkedIn, and Instagram.

ABOUT AECOM

AECOM is the world's premier infrastructure consulting firm, delivering professional services throughout the project lifecycle—from planning, design, and engineering to program and construction management. We partner with our clients in the public and private sectors to solve their most complex challenges and build legacies for generations to come. On projects spanning transportation, buildings, water, governments, energy, and the environment, our teams are driven by a common purpose to deliver a better world. AECOM is a Fortune 500 firm and its Professional Services business had revenue of approximately $13.6 billion in fiscal year 2019. See more at aecom.com and @AECOM.

ABOUT THE COMPACT

The Southeast Florida Regional Climate Change Compact (the Compact) is a partnership between Broward, Miami-Dade, Monroe, and Palm Beach counties to work collaboratively to reduce regional greenhouse gas emissions, implement adaptation strategies, and build climate resilience across the Southeast Florida region.

For more than a decade, the Compact counties have successfully collaborated on mitigation and adaptation strategies, built bipartisan support for climate action, and forged partnerships with key stakeholders including federal, state, and municipal governments and agencies; economic development entities; community-based organizations; and the academic community, enabling the development of a regional voice and vision for future prosperity in Southeast Florida.

ABOUT THIS REPORT

This summary report was created by ULI. Technical support for this study was provided by AECOM's Sustainable Economics Practice and is presented in *The Business Case for Resilience in Southeast Florida*, a technical report prepared for the Urban Land Institute and Southeast Florida Regional Climate Change Compact. Findings from the technical report are distilled here in addition to supplemental content and narrative provided by ULI. The project has been supported by a coalition of local partners, including Broward, Miami-Dade, Monroe, and Palm Beach counties; the Florida Department of Environmental Protection; the Beacon Council Foundation; Broward Workshop; Community Foundation of Broward; Greater Fort Lauderdale Chamber of Commerce; and Greater Miami Chamber of Commerce.

PROJECT PARTNERS

CONTENTS

PREFACE

During the development of this economic analysis and the creation of this coinciding summary report, the world was hit with the brunt force of the COVID-19 pandemic, which continues to lead to tragic loss of life, economic downturn, and many changes to the way people live, work, and interact with each other.

The sudden shock of the pandemic offers everyone, particularly the Southeast Florida region, a harsh reminder of the importance of preparing for both known and unknown risks. Coastal hazards arising from the impacts of climate change, such as increasingly intense storm events and sea-level rise, present major risks to the well-being of residents and to the safety of businesses, property, and infrastructure. These risks have only been compounded by the consequences of the pandemic, particularly given reduced municipal resources and the vulnerability of many communities to both COVID-19 and climate-related disruptions. Although the exact implications of the pandemic have yet to be realized, the need for the region to continue to prepare for the long-term challenges of a changing climate, even in the face of unexpected shocks, has become pivotal.

Flood events cause an increasing number of disruptions to the Southeast Florida economy through property damage and the loss of business continuity, threatening long-term economic decline. This opens a door for the real estate and land use industries to be more verbal on the issue of climate adaptation and to be a part of a conversation that has had no easy answers.

Developers have control over the confines of their own parcels; but, they could be faced with negative consequences from reduced investor interest and lack of financing and insurance—if this is the case, it may be too late to recover. Though financial assets are at risk, this is also the time for the real estate industry to coordinate with the public sector on resilience planning initiatives and co-create new models for partnerships, policy, and funding to help the region to continue to thrive.

The real estate industry has an opportunity to achieve a positive return on investment by futureproofing developments and investing in community-wide resilience infrastructure over time to build incremental solutions that protect people and property. This report explores and quantifies this business case for resilience in Southeast Florida.

We are grateful for the support and collaboration of our project partners, including the Southeast Florida Regional Climate Change Compact and the Regional Stakeholder Group, representing the region's local business community. We also want to thank AECOM for preparing the original technical report, which this report summarizes for an industry audience.

Scott MacLaren

President, Stiles
ULI Southeast Florida and Caribbean Advisory Board District Council Chair

Greg West

Chief Executive Officer, ZOM Living
ULI Center for Sustainability and Economic Performance (CSEP) Global Advisory Board Member
ULI Global Governing Trustee

THE BUSINESS CASE FOR RESILIENCE IN SOUTHEAST FLORIDA

QUICK FACTS AND FIGURES FROM THE ECONOMIC ANALYSIS

THE REGION

4 Counties **1** Climate Compact

Nation's 7th largest metro area in the country, with **6,147,269** people.[a,b]

$359 billion the region's GDP contributes over **⅓** of the state's total.[c]

Tourism alone is responsible for contributing **$91 billion** to the state GDP.[d]

The region covers **6,055** square miles,[e] ranging in average elevation from **4.8–20 ft** above sea level.

WHAT'S AT RISK

The region could see **17 inches** of sea-level rise by **2040** and **40 inches** of sea-level rise by **2070**.[f]

More than $4.2 billion in property value could be lost due to daily tidal inundation by 2040.

Permanent sea-level rise could affect **720 jobs** and cause **$28 million in sales, property, and tourism tax losses** by 2040.

$3.2 billion in **property damage** could be caused by a 10-year storm tide event in 2040.

$1.8 million in sales and tourism tax losses could result from a single 10-year storm tide event in 2040.

IN 50 YEARS

Daily tidal inundation could expose **$53.6 billion** of property value, affect **17,800 jobs**, and cause **$384 million** in fiscal losses.

Over 294,000 parcels and nearly **500 miles** of major roadways* could be affected by a 10-year storm tide event in **2070**.

*Major roadways include all functional classes except for local as provided in state-wide data set (functional classes 9 and 19).

THERE IS A COMPELLING BUSINESS CASE FOR THE REGION TO MAKE INVESTMENTS IN RESILIENT INFRASTRUCTURE NOW

Building-level and community-wide adaptations provide greater benefit than cost to the region. These strategies must be integrated together to safeguard Southeast Florida.

Community-wide adaptation can offer **$37.9 billion** in economic benefits for the region and support **85,000** job years.*

For every **$1** invested in community-wide adaptation strategies, the region will see about **$2** in benefits.

Examples:
Beach nourishment
Seawall construction
Dune restoration

2:1
Benefit-cost ratio for **community-wide adaptation**

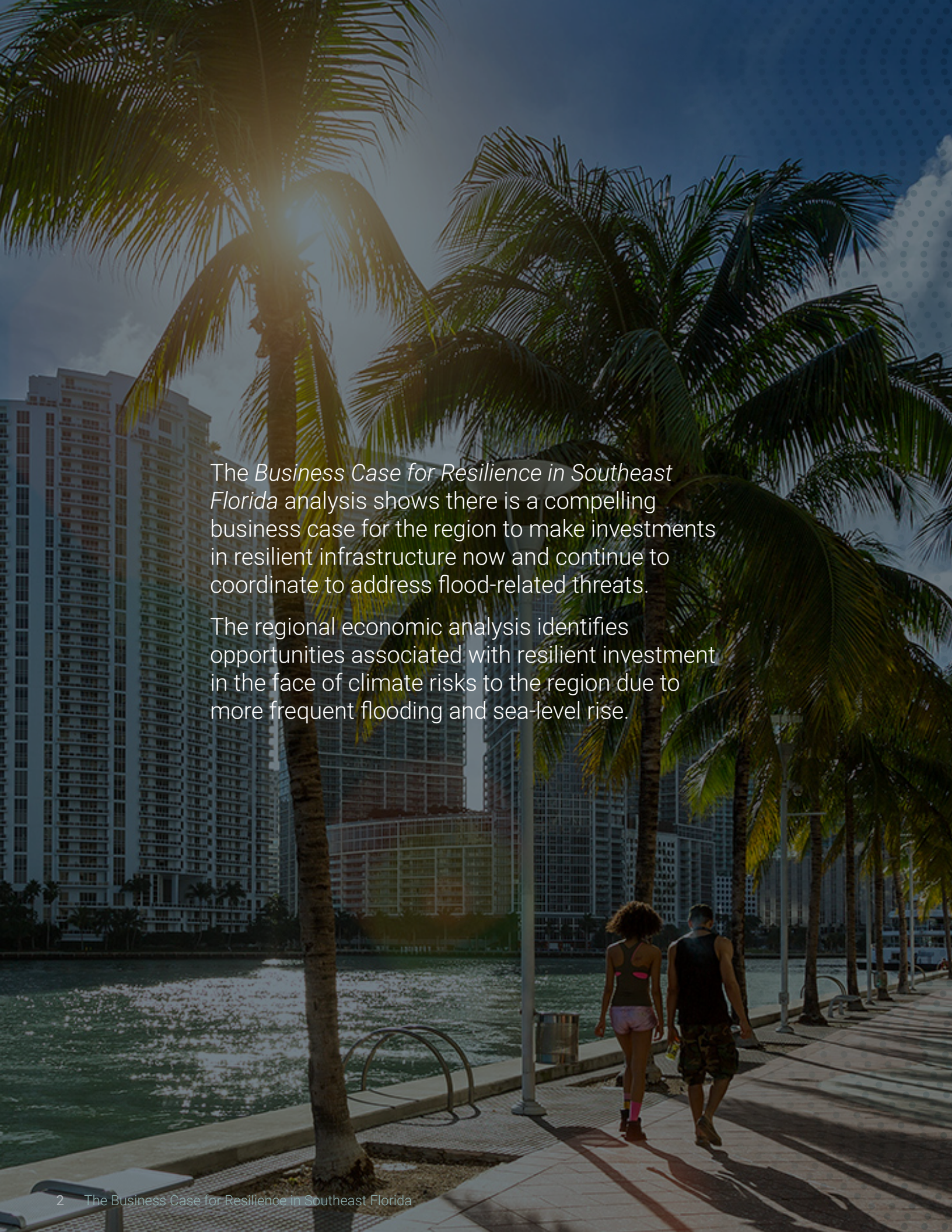
4:1
Benefit-cost ratio for **building-level adaptation**

Building-level adaptation can offer **$17.6 billion** in economic benefits for the region and support **56,000** job years.*

For every **$1** invested in building-level adaptation strategies, the region will see about **$4** in benefits.

Examples:
Elevating structures
Floodproofing

Key assumptions and context for findings can be found in Notes.
*A job year is one year of work for one person.



The *Business Case for Resilience in Southeast Florida* analysis shows there is a compelling business case for the region to make investments in resilient infrastructure now and continue to coordinate to address flood-related threats.

The regional economic analysis identifies opportunities associated with resilient investment in the face of climate risks to the region due to more frequent flooding and sea-level rise.

EXECUTIVE SUMMARY

The counties in the Southeast Florida region, including Broward, Miami-Dade, Monroe, and Palm Beach, are currently among the most proactive in the nation in planning for climate change. Local leadership within the counties created the Southeast Florida Regional Climate Change Compact (the Compact), and together have taken a leading role planning for the substantial risk associated with the impacts of climate change, including sea-level rise and stronger storms.

The Compact, along with local business and nonprofit communities, partnered with the Urban Land Institute (ULI) to comprehensively assess the economic impact of investment in resilience in the region. The findings illustrate the region's vulnerability to the impacts of climate change and the shared interest for action by both the public and private sectors when it comes to investing in proactive flood protection and climate adaptation measures. The economic modeling study found that climate adaptation measures are forecast to offer a significant return on investment for the region, protecting communities, jobs, and properties.

This *Business Case for Resilience in Southeast Florida* analysis presents estimates of the economic consequences to coastal counties in the region if local governments and business communities fail to take action to mitigate the impacts from tidal flooding and frequent coastal storms, compounded by sea-level rise. The analysis takes a regional perspective, considering the impacts to the region given the interconnected economies across all four counties. In addition, the study estimates the economic benefits from certain types of adaptation actions designed to mitigate the coastal hazard risks. These adaptation actions could all make a difference, but some of these actions are more suitable for some counties than others and each county may need a customized approach to address its own unique resilience challenges.

The research presented in this study builds on past work completed in the region and leverages a robust economic modeling tool, called REMI PI+, to estimate cascading economic impacts at multiple geographic scales. The findings present an important opportunity for the government and business community to contextualize and advance investment in resilience measures.

Coastal storms and sea-level rise have wide-ranging societal, economic, and environmental effects that extend beyond the borders of any one community. Accordingly, this study assesses the four counties and interconnected economies represented by the Compact. This region accounts for about 30 percent of the population of Florida and generates about 35 percent of the state's gross domestic product.[1]

Each coastal community in Southeast Florida has its own unique geography, its own set of challenges to confront (not limited to coastal hazards), and varying amounts of resources to address those challenges. At the same time, coastal communities in the region share many similar characteristics, especially with respect to their primary industries and revenue sources.

To advance economic resilience at the regional scale, the counties should avoid a divided approach to adaptation that fails to account for the complex interdependencies between local and regional economies and the critical role that regional infrastructure plays.

Developing an understanding of the economic consequences from current and predicted coastal hazards is critical to inform decision-making around how to best protect the communities, businesses, and natural resources that make coastal communities in Southeast Florida a strong business environment and world-class leisure destination.

WHAT WAS INCLUDED IN THE ANALYSIS

This study is a regional economic evaluation of flood risk and exposure, with the inclusion of predicted heights of sea level in 2020, 2040, and 2070. Coastal conditions modeled include the average daily high tide, or mean higher high water (MHHW), the king tide (one-year tide), and the 10-year storm tide. More frequent events were examined as part of this study because those events are less likely to be insurable in the future. Through catastrophic risk modeling, the region has a robust understanding of its risks from high-impact, less-likely events, such as strong hurricanes, which were not included in this study. In addition, the analysis does not incorporate flooding from precipitation or rising groundwater.

The study analyzed impacts avoided and cumulative costs of certain adaptation strategies and resulting benefit-cost ratios for both community-wide and building-level adaptation strategies from 2020 to 2070.

To account for broader regional dynamics, the REMI PI+ modeling platform was used to evaluate the effect of these high-frequency flooding events on the economy of Southeast Florida and the rest of the state. Not every strategy included within the analysis is applicable to all areas within the Compact.

During the development of this study, the region, country, and world were hit hard by the global COVID-19 pandemic. The pandemic led to tragic loss of life, economic downturn, and many changes to the way communities live, work, and interact with each other. These changes that arose from this sudden shock are a harsh reminder of the importance of preparing for both known and unknown risks. The region must continue to prepare for the long-term challenges of a changing climate, even in the face of unexpected shocks of events, like COVID-19.

WHAT IS THE SOUTHEAST FLORIDA REGIONAL CLIMATE CHANGE COMPACT?

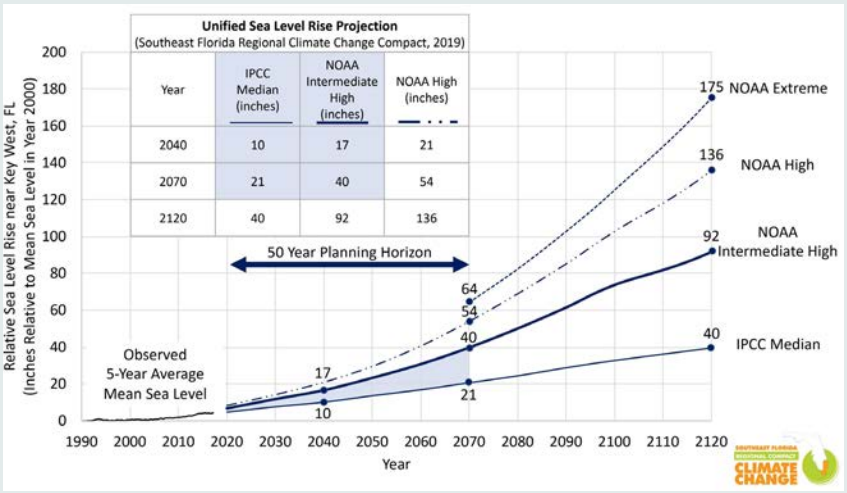
The Southeast Florida Regional Climate Change Compact is a coalition of the four counties of Southeast Florida—Monroe, Miami-Dade, Broward, and Palm Beach—that advances climate mitigation and adaptation strategies throughout the region. The Compact works collaboratively to address vulnerabilities caused by climate change and sea-level rise, to implement adaptation strategies, and to build climate resilience across municipal and county lines. The Compact represents a new form of regional climate governance, creating the first case in the United States where counties voluntarily committed to a joint regional effort to address climate change.

WHY 2020, 2040, AND 2070?

In this analysis, the 2017 National Oceanic and Atmospheric Administration (NOAA) Intermediate-High projections were selected for the planning time horizons of 2020 (existing conditions), 2040, and 2070, which align with the updated Southeast Florida Regional Climate Change Compact recommended regional sea-level rise projections. The Intermediate-High projections are recommended for high-priority projects, including evacuation routes, energy infrastructure, critical government fatalities, and infrastructure that may stay in place beyond a design life of 50 years.

These time horizons are important for near-, mid-, and long-term infrastructure planning and investments that are necessary for incremental steps to address sea-level rise impacts expected to occur over the coming century.

SOUTHEAST FLORIDA REGIONALLY UNIFIED SEA-LEVEL RISE PROJECTIONS SFRCCC, 2019



In 2019, the Compact released the third update to its Unified Sea-Level Rise Projections for the Southeast Florida region. (Southeast Florida Regional Climate Change Compact)

THE BUSINESS CASE FOR RESILIENCE: ASSUMPTIONS

In this study, the adaptation strategies evaluated only focused on high-level actions that are applicable across the four counties in Southeast Florida and that provide regional-scale protection from sea-level rise and high-frequency coastal storms. The study does not address the unique coastal hazard flood and stormwater risks and opportunities at a local scale.

The adaptation strategies selected present better cost benefit in certain areas, including dense areas with high-value properties. As such, not every action is viable in each county, but they serve as a test case to determine whether adaptation is cost-beneficial at the regional scale. Therefore, local cities and communities may consider developing a comprehensive adaptation plan that also examines the contextualized flood risk for the area, in addition to recognizing the regional flood protection strategies described in the study.

A phased approach to adaptation investment is assumed in the study, whereby the implementation of infrastructure meets specified modeled conditions in future years, as will likely be the case in practice.

KEY STUDY QUESTIONS

1. What vulnerabilities and threats will communities experience in the future due to coastal storms and sea-level rise?

2. What are the costs and benefits of different adaptation actions?

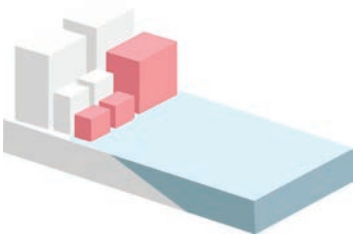
3. What actions can be taken today to promote resilience?

UNDERSTANDING AVOIDED DAMAGE

VISUALIZING DAMAGE WITH AND WITHOUT RESILIENT ADAPTATION

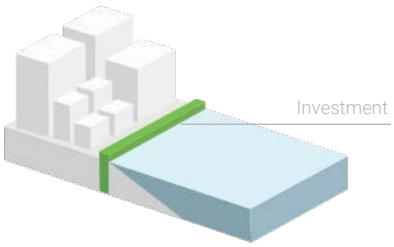
DAILY TIDE IN 2040
Without Adaptation Action

Without adaptation action, rising seas coupled with daily high tides threaten buildings and infrastructure.



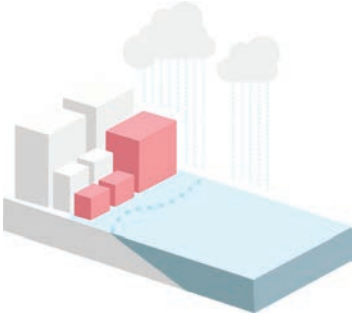
DAILY TIDE IN 2040
With Adaptation Action

With adaptation actions, buildings and infrastructure are more protected from rising seas and daily high tides.



COASTAL HAZARD IN 2040
Without Adaptation Action

Without adaptation action, a coastal hazard (storm) causes widespread damage to buildings and infrastructure.



COASTAL HAZARD IN 2040
With Adaptation Action

With adaptation actions, buildings and infrastructure are more protected from coastal storms.

WATER LEVEL CONDITIONS EVALUATED

MEAN HIGHER HIGH WATER (MHHW)
Average of the highest of the two high tides occurring each day, also referred to as daily tidal inundation.

1-YEAR TIDE
The highest annual tide, also referred to as the king tide.

10-YEAR STORM TIDE
A tide with a 10 percent chance of occurring in any given year. This event represents high-frequency conditions of temporarily elevated water levels due to coastal storms.

Additional definitions can be found in Key Terms on page 41.

OVERVIEW OF FINDINGS

A compelling business case exists for investing in climate adaptation in Southeast Florida. However, it will take a collective and coordinated approach to advance resilience throughout the region.

The analysis shows that it is cost-effective for the four-county region to make investments in resilient infrastructure now. These measures include community-wide infrastructure investments and building-scale adaptation measures that enhance resilience.

LACK OF ADAPTATION INVESTMENT AND INFRASTRUCTURE NOW WILL HAVE MAJOR CONSEQUENCES FOR THE FUTURE ECONOMIC WELL-BEING OF THE REGION

Investments in community-wide adaptation strategies could safeguard sales, tourism, and property-tax revenue and mitigate an economic ripple effect.

Key to promoting economic resilience is ensuring the continuity of business activity, which is heavily dependent on the function of community lifeline assets (e.g., utilities, roads).

Interruption to business activity, be it from direct or indirect coastal hazard impacts, can slow recovery and affect the creditworthiness of businesses and government (which rely on revenues generated from the business community), and can further constrain the ability of these entities to raise needed capital for investments in adaptation or other purposes.

In 2040, daily tidal inundation could expose **$4.2 billion** in property value, and one 10-year storm tide event could cause **$3.2 billion** in property damage.

In 2070, daily tidal inundation could expose **$53.6 billion** in property value, and one 10-year storm tide event could cause **$16.5 billion** in property damage.

Sunny-day flooding in Fort Lauderdale disrupts travel and services and causes damage to infrastructure.

DAMAGE AND LOSSES CAN BE REDUCED

Investing in adaptation provides direct benefits in the form of avoided losses to property, as well as the potential for indirect benefits such as reductions in insurance premiums, and stabilization or enhancement of property tax values and associated tax revenues. With an investment in flood infrastructure, businesses can mitigate property damages and employment impacts and continue to realize the value of business continuity.

COMMUNITY-WIDE ADAPTATION PRESENTS NET BENEFITS FOR THE REGION

Community-wide adaptation strategies such as sea walls, dune restoration and beach nourishment, and berm construction or raising[2] will protect property and communities beyond the asset level from gradual sea-level rise conditions. This type of protection provides significant benefits in the form of avoided property, sales, and tourist-development tax losses and broad economic benefits to the community due to reduced impacts to both property and infrastructure.

In this study, the benefit-cost ratio (BCR) for community-wide adaptation strategies implemented throughout the region is 2.06.

> In 2040, one 10-year storm tide event could cause a **$2 million** loss in sales and tourism tax revenue, and daily tidal inundation could cause **$28 million** in tax revenue loss.
>
> In 2070, a 10-year storm tide event could cause an **$8 million** loss in sales and tourism tax revenue, and daily tidal inundation could cause **$384 million** in tax revenue loss.

PROPERTY AND REAL ESTATE VALUES CAN BE PRESERVED AND INCREASE IN VALUE WITH BUILDING-LEVEL ADAPTATION

Adaptation is critical to supporting assets retaining their long-term value. Building-level strategies include elevating or floodproofing structures. Beyond protecting properties from damages, resilience investments can reduce insurance premiums and avoid losses or enhance property values and, therefore, reduce associated tax revenues.

The BCR for individual adaptation strategies at the asset level examined in this study is 3.97.

If effective partnerships and incentives are created to lead to more widespread market adoption of resilient development and design, an opportunity exists for property owners and developers to make current and future buildings more resilient at the asset level.

JOBS AND ECONOMIC ACTIVITY CAN BE PRESERVED AND GENERATED

Investing in adaptation at both the building and community-wide levels now is critical given the region's significant vulnerabilities to climate change.

Investments in adaptation can provide benefits to the region beyond the avoided impacts. For example, these investments can support construction, operations, and maintenance jobs.

INDUSTRIES MOST AT RISK

INDUSTRIES WITH HIGHEST SALES OUTPUT LOSS UNDER 2070 10-YEAR STORM CONDITIONS:

- Hospitality and food services
- Wholesale trade
- Retail trade

This resort in Palm Beach embarked on a dune restoration project to protect the property from coastal hazards.

BENEFITS OF ADAPTATION

ADAPTATION STRATEGY BENEFIT-COST ANALYSIS FOR THE REGION

The following table shows the estimates for the cumulative impacts avoided and the cumulative cost of adaptation, net impacts, and resulting benefit-cost ratios for community-wide and building-level adaptation strategies for all four counties combined. To maximize adaptation benefits to the region, both community-wide and building-level adaptations must be intrinsically implemented throughout.

	BENEFITS (avoided losses)	**COSTS** (of adaptation)	**BENEFIT–COST RATIO**	**NET NEW JOB YEARS**
COMMUNITY-WIDE ADAPTATION	$37.9 billion	$18.2 billion	2.08	85,000
BUILDING-LEVEL ADAPTATION	$17.6 billion	$4.4 billion	3.97	56,000

Note: Results presented in net present value terms using a 5 percent discount rate over the period of the analysis from 2020 to 2070. Estimated job years supported by direct investment in adaptation strategies in the four counties. Individual results at the county level vary.

WHAT IS BCR?

The benefit-cost ratio (BCR) presents the value of the benefits conveyed by adaptation, divided by the total present value of the costs of adaptation. A ratio greater than one implies a return on investment.

ADAPTATION PLANNING IN THE REGION

The physical effects of climate change present grave risks to the health of Southeast Florida residents and communities and to the safety of businesses, property, and infrastructure.

The region has an opportunity to build on ongoing initiatives, like public policy, and infrastructure and building-level interventions to protect communities and businesses from the threats brought on by climate change.

Enhancing resilience throughout the region should incorporate principles that consider climate, economic, and social aspects.

CLIMATE RESILIENCE

Climate resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events related to climate change—from the stresses induced by more gradual changes such as sea-level rise or weather patterns to the acute shocks of intense and frequent weather events including hurricanes, heavy rainfall, and wildfires.

ECONOMIC RESILIENCE

Economic resilience is the capacity to prevent, withstand, recover from, and otherwise bounce back better from natural or human-caused shocks or disruptions to the economy. In this report, economic resilience accounts for the ability of communities and the region to

- prepare for and withstand climate and coastal risks, and
- respond and recover when these risks manifest.

SOCIAL RESILIENCE

Social resilience is the ability of a human community to cope with and adapt to stresses such as social, political, environmental, or economic change. Social resilience is critical to addressing climate risk for low-income communities and communities of color, which are disproportionately impacted by climate change.

The Pérez Art Museum's first level is elevated more than 20 feet to protect art from flood risks.

RESILIENCE PLANNING IN THE REGION

The Southeast Florida region is one of the nation's champions in planning for the effects of more frequent flooding and sea-level rise. For more than a decade, the region has been working collaboratively to develop plans to address a changing climate. Through the Compact, the region has a Climate Action Plan, which sets a strong foundation for action. Miami-Dade County, Miami, and Miami Beach came together under Resilient305, and were the first group of local governments to collaborate on a shared resilience strategy for the 100 Resilience Cities program of the Rockefeller Foundation.

Beyond the collaborative efforts, seawall ordinances have been put in place across the region to mitigate the impacts of tidal flooding. The City of Fort Lauderdale and Broward County have seawall ordinances that have become the models for the region.

Eight local governments in Palm Beach County have come together under a Coastal Resilience Partnership and are currently performing a regional vulnerability assessment.

Monroe County is actively determining how best to raise roads in the county and is planning for stormwater and road improvements for future flooding conditions. These are a few examples of the significant number of planning and infrastructure projects in the region, some of which are profiled in this report as **ADAPTATION IN ACTION** case studies.

COMMUNITY-WIDE AND BUILDING-LEVEL ADAPTATION

COMBINED ADAPTATION STRATEGIES PRESENT MAXIMUM BENEFITS FOR THE REGION

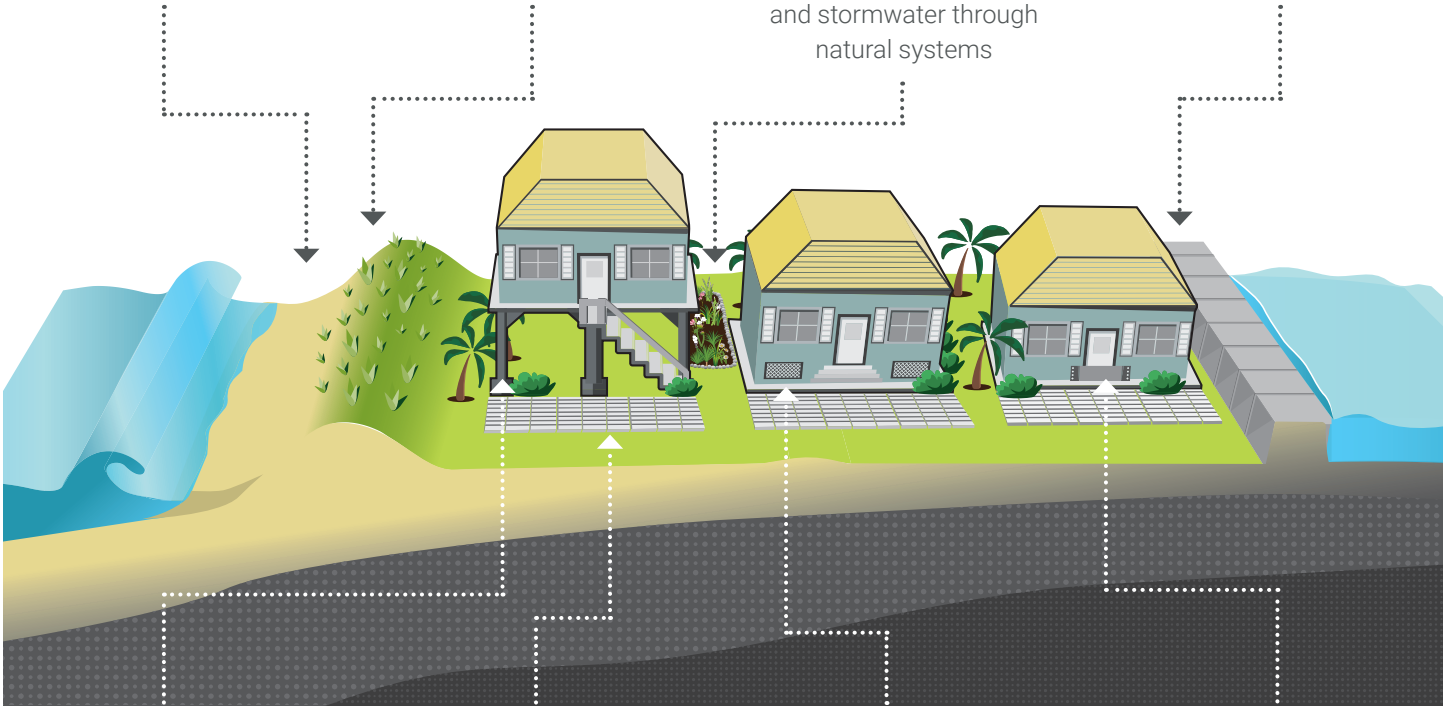
COMMUNITY-WIDE ADAPTATION STRATEGIES

BEACH NOURISHMENT
is the addition of sediment to beaches to replenish land loss from erosion

SAND DUNES
are natural barriers that protect against coastal storms and beach erosion

GREEN INFRASTRUCTURE,
like bioswales and rain gardens, is intended to capture and drain floodwater and stormwater through natural systems

SEAWALLS
are constructed shoreline structures that protect property from flooding



BUILDING-LEVEL ADAPTATION STRATEGIES

STRUCTURE ELEVATION
is physically raising a structure above flood-risk levels

PERMEABLE SURFACES
allow flowing water to infiltrate through the surface into the ground below

WET FLOODPROOFING
allows uninhabited portions of a structure to allow floodwater to enter and exit

DRY FLOODPROOFING
is watertight flood protection at the base of a structure to prevent floodwaters from entering

RECOMMENDATIONS

ENHANCING ECONOMIC AND CLIMATE RESILIENCE

Alongside the economic analysis, the study provided high-level recommendations for Southeast Florida local governments to create an environment conducive to investment in climate adaptation.

The communities in the Southeast Florida region should evaluate and advance their capacity for economic and climate resilience by considering the following strategies.

INCREASE CLIMATE RISK AWARENESS

Fundamental to resilience is increasing climate and flood risk awareness. Information about climate-change risks and their knock-on effects is not incorporated into most policies that govern public and private institutions. As a result, risky behavior is often incentivized or subsidized. Both the public and private sectors play a role in risk disclosure, through policies such as mandatory seller disclosure forms, loan terms, and technical assistance programs. Already, local government and planning initiatives are underway, such as Resilient305 and the Southeast Florida Regional Climate Change Compact.

DEVELOP ACTIONABLE FUNDING AND FINANCING PLANS TO PAY FOR RESILIENCE

The risks posed by a changing climate are too great for any one sector to take on alone. Therefore, investments in climate resilience should be made by both public- and private-sector actors, with an eye toward ensuring that all entities would benefit from such investments.

Opportunities to weave adaptation investments into ongoing infrastructure and capital improvement projects should be pursued to streamline processes and implement them efficiently.

Mangroves, as seen here in Key Largo, buffer wave action, prevent erosion, and absorb floodwaters, and they can play an important role in protecting waterfront property during tropical storms.

INVEST IN KEY VULNERABLE AND EMERGING INDUSTRIES

The analysis found that the retail, accommodation and food services, and wholesale industries are particularly vulnerable to coastal hazards. Vulnerabilities can stem from operating near the coast and from the interdependencies between industries. Efforts should be made to protect vulnerable industries like these, and promote economic diversification and innovation in the region, particularly those that operate near the coast.

The public sector should identify and invest in economic clusters of businesses and industries that make the region competitive for jobs, private investment, and emerging fields related to adaptation. Examples include industries in clean technology, life sciences, and information technology. Early investments in research and development can help with long-term economic opportunity for adaptation innovation-related industries.

DEVELOP AN OCCUPATIONAL ROAD MAP TO RESILIENCE

Certain workers may be more vulnerable to coastal hazards, such as workers in vulnerable industries, workers with less adaptable skillsets, lower-wage workers, and workers who travel far to get to work. At the same time, recovery efforts and adaptation investments will favor certain occupations over others, such as emergency responders and construction workers.

Business clusters and organizing bodies, such as business improvement districts, should develop coordinated business continuity plans that account for physical and economic impacts, and they should develop workforce and economic development initiatives to grow the local labor pool that provides the services needed to prepare for and recover from coastal hazard events. Doing so will keep more recovery funds in impacted communities, decrease the burden on supportive infrastructure, expand job skills training and potential future income-earning potential, and provide faster recovery after an event.

ENGAGE WITH AND PROVIDE SUPPORT TO THE SMALL-BUSINESS COMMUNITY

When small businesses are subject to the impacts of coastal hazards, they often lack the capital reserves, access to financing, or insurance coverage necessary to absorb a loss of income and the additional expenses that come with rebuilding. Streamlined access to capital and financing is critical to ensuring continued operations and related financial outcomes. Engaging with small businesses may be difficult given competing demands, but improved communications through digital platforms can help to exchange information both within business communities and between the public and private sectors.

MAKE MITIGATING SOCIAL VULNERABILITY A PRIORITY DURING ADAPTATION DECISION-MAKING

Historically marginalized communities, including low-income communities and communities of color, will be most significantly affected by climate change. To advance future infrastructure investments using cost-benefit analysis alone—considering property value, tax dollars at risk, and other monetary factors—would unfairly disadvantage these groups.

Marginalized communities also have faced the greatest risk during the COVID-19 pandemic, compounding climate-related and other vulnerabilities.

In addition, the growing income gap in the region and lack of living-wage jobs disproportionately challenges vulnerable communities' ability to address public and mental health concerns and the threat of pandemics and the risk from flood events.

Future decision-making needs to consider both economic impact and strategies for protecting communities with the highest needs, who have historically been discriminated against in land use and planning policies advanced at the federal and local levels.

PRIORITIZE PROJECTS STRATEGICALLY AND MONITOR EQUITY AND EFFICACY

Given the finite financial resources available for adaptation, communities and regions will be faced with difficult decisions regarding where investment should be directed, what types of adaptation projects should be pursued, when these investments should be made, and how much money should be borrowed to accelerate investments in resilience in a way that is commensurate with expected risks. When investments are to be made on adaptation projects, they should be developed through transparent evaluation frameworks that address societal vulnerabilities and ensure that the project plans incorporate a holistic approach to resilience, including offering benefits beyond protection from disruptive events such as economic development, workforce development, land use, and capital improvements.

Extensive dune rebuilding efforts were conducted in the aftermath of Hurricane Irma in 2017. The Broward County Shore Protection Project placed 413,000 cubic yards of sand along the 8.9 miles of shoreline reaching north from Fort Lauderdale, according to the U.S. Army Corps of Engineers.

The Palm Beach intracoastal hosts boat traffic year round. The marine industry has about a $2 billion annual impact in Palm Beach County, according to a study for the Marine Industries Association of South Florida.

Community lifelines such as energy, water, transportation, and communications infrastructure should be protected to avoid far-reaching direct and indirect consequences. To ensure that future adaptation projects provide their intended return on investment, the effectiveness of implemented adaptation strategies should be evaluated where feasible.

MAXIMIZE ADAPTATION INVESTMENTS BY COORDINATING BENEFITS

In a best-case scenario, resilient investments should leverage opportunities to maximize benefits to social, environmental, and economic outcomes. For example, investments in physical infrastructure intended to protect a community from hazards should strengthen a community against potential shocks, but also contribute to addressing stresses like flooding and to enhancing the region's economic development potential, or social cohesion. Local examples include beach nourishment in Miami Beach and Palm Beach County's Living Shorelines Program.

Local and regional governments, as well as property and business owners, will eventually need to invest in property development and redevelopment, infrastructure, and related public necessities. Therefore, an opportunity exists to design investments in adaptation to provide co-benefits to people, the economy, and the environment that address current needs.

UNDERSTAND AND PREPARE FOR REPUTATION RISKS AND ASSOCIATED ECONOMIC IMPACTS

The Southeast Florida region is already facing reputational risk; coastal hazards and the region's vulnerability to sea-level rise have received significant national coverage in the U.S. popular media.[3] Vulnerability to coastal hazards now and in the future can result in reputational risks and associated impacts such as property devaluation, insurance premium increases, bond-rating downgrades and increased borrowing costs, decreased tourism and associated spending, decreased public support, and risk from increased liability. Without sufficient, proactive investment in resilience, the region is at risk of further reputational damage, which could have ripple effects on investment and economic development.

Modeling reputational impacts, such as perceptions of future climate-change risk, was beyond the scope of this analysis. Yet, these are important and relevant considerations when interpreting the potential outcomes of the modeled project alternatives. Future research and analysis may provide additional quantitative insights into variations of this approach, and if this occurs, these findings should be updated.

CONDUCT FURTHER IN-DEPTH ANALYSES AT THE COUNTY AND PROJECT LEVELS TO OPTIMIZE BENEFITS AND COSTS

This study examined Southeast Florida from a regional perspective, considering interconnected infrastructure systems, economies, and social networks, but also recognizing very specific differences across the four counties. Further studies will be required for more granular assessments of risk at specific sites of interest. Each project or investment has a unique context that should be considered on a project-by-project basis to allow for more specific design considerations and hopefully more optimal return on investment.

At the municipal and regional level, future analyses can develop project-level roadmaps for action at a smaller geographic scale to better formulate adaptation and resilience strategies to meet community needs and to provide optimal returns to all parties.

Maximize resilience investment benefits by addressing other community needs, like incorporating a bike path into a seawall.

RESOURCES FOR ENHANCING SOCIAL RESILIENCE IN A CHANGING CLIMATE

Resilience investments can help to minimize the shocks from coastal hazards, but they will not address underlying chronic stresses such as social equity, poverty, unemployment, and the lack of industry diversification that affect capacity of communities to respond to and recover from coastal hazard risks and shocks and stresses. The region must identify the structural factors that will affect its ability to be resilient to changing climate and flood conditions and, therefore, can enhance the livability and prosperity of the Southeast Florida region.

It is critical to not overlook the value of investing in communities most in need of support—primarily communities of color and low income. The study focused on assessing the economic impacts and the costs and benefits conveyed by certain specific adaptation measures compared to inaction. Although these reporting metrics are indicators of economic vulnerability, they do not explicitly account for community characteristics that may indicate social vulnerability.

To broaden decision-making considerations related to investments in adaptation and resilience, communities should consider the use of social vulnerability indices and other tools that can illustrate, in a standardized manner, the relative vulnerability of different populations to a range of shocks and stressors, both natural and human caused. Such resources incorporate indicators (e.g., age, poverty, vehicle access) that can help illuminate the social vulnerability of a community and its potential to be resilient in the face of disasters.

Helpful resources and frameworks include the following:

- Georgetown Equitable Adaptation Toolkit
- Institute for Diversity and Inclusion in Emergency Management (I-DIEM) resources and trainings
- Urban Sustainability Directors Network Resilience Hubs initiative
- Groundworks USA Climate Safe Neighborhoods plans
- Centers for Disease Control and Prevention Social Vulnerability Index

THE REGION'S ECONOMIC AND CLIMATE CONTEXT

Southeast Florida is a hub for the trade, logistics, health care, and creative industries, and a world-class tourist destination. The regional economy has experienced successful growth over the past decade until the recent disruption from COVID-19. Alongside the challenges of the pandemic, the local government and business community recognize the urgency and severity of a changing climate, and its current and future impacts to the region and its economy. Even in a time with many other urgent challenges, it is critical to remain focused on climate change, which presents both short-term and long-term threats to residents' public health and the region's economic vitality.

Although Southeast Florida has taken noteworthy steps to mitigate climate risks proactively through planning and public investments, the region must accelerate its efforts to drive climate adaptation.

This study illustrates that advancing economic resilience requires action by both the public and private sectors at various geographic scales, and that a shared interest in partnership exists for both communities. The study also shares lessons learned and best practices from other local governments addressing resilience by leveraging similar economic analyses.

ECONOMIC BACKGROUND

Southeast Florida is regarded as a world-class destination for business and leisure purposes alike. Over the past 50 years, the region's diverse and growing population has developed the region into a prosperous hub for tourism, health care, international banking and finance, supply chain and logistics, creative industries, and technology.

The region's economy is deeply interconnected among counties, cities, and communities. Residents and visitors work, play, and live across jurisdictional boundaries, providing reason for a coordinated effort to tackle climate change as a region.

POPULATION GROWTH

Florida has been experiencing steady population growth since the 1970s, making the state the third largest in the nation.[4] Overall, the population has tripled in the past 50 years. The Southeast Florida region alone is home to more than 6 million people, a population larger than more than half of other U.S. states.[5]

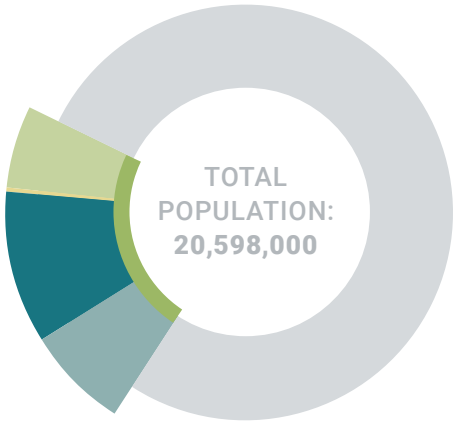
Though the Sunshine State has traditionally been thought of as a destination for snowbirds, studies show a growing trend of young professionals relocating to Florida. New employment opportunities in the state's strong job market attracted more than a third of new residents.[6] The largest group of incoming residents (40 percent) still cite retirement as their main motivation, however, the new influx of working adults feeds a robust workforce attracted by the strong economy.

Continuous emigration of Cuban, Caribbean, and Latin American populations to the region creates the diverse and vibrant culture for which the region is known.

POPULATION

STATE VS. SOUTHEAST FLORIDA REGION

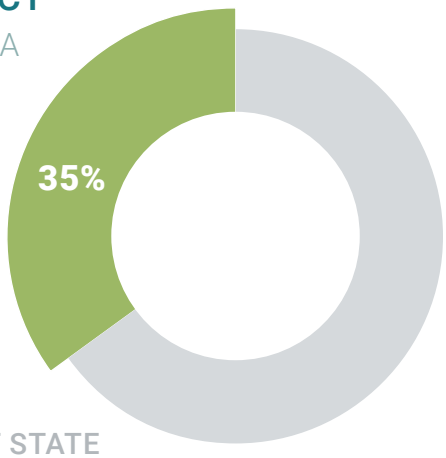
SOUTHEAST FLORIDA: 6,147,269
PALM BEACH: 1,446,277
MONROE: 76,325
MIAMI-DADE: 2,715,516
BROWARD: 1,909,151



GROSS DOMESTIC PRODUCT

STATE VS. SOUTHEAST FLORIDA REGION

SOUTHEAST FLORIDA: $359 billion



SOUTH FLORIDA'S WORKFORCE

FIRMS AND EMPLOYEES BY COUNTY

BROWARD
259,431 FIRMS
719,985 EMPLOYEES

MIAMI-DADE
468,185 FIRMS
1,000,931 EMPLOYEES

MONROE
14,413 FIRMS
31,065 EMPLOYEES

PALM BEACH
175,919 FIRMS
539,591 EMPLOYEES

REGIONAL ECONOMY

Southeast Florida's economy has continued to strengthen in the past decade. In 2018, the region generated more than $350 billion in gross domestic product (GDP), contributing 35 percent of the state's total GDP.[7] In the same year, Miami-Dade, Broward, and Palm Beach represented third-ranked counties in the state, respectively, for GDP growth.[8] Compared with the rest of Florida, the Southeast has the largest labor pool, and the most cruise and trade ports.

The region's largest sectors and primary economic drivers are tourism, international trade, financial and professional services, health care, and real estate. Its status as an international business headquarters and a leading global real estate market is a major economic driver for the region, with the city of Miami being the second largest international banking center in the United States, behind New York City. The Greater Miami and Beaches area hosts more than 700 multinational companies.[9]

WATERFRONT AND OCEAN-RELATED ECONOMIES

Southeast Florida's waterfront is a key part of the economy—home to many residents and attractions, it creates opportunities for many key industry sectors, such as tourism and logistics. In 2016, total trade out of the Miami Customs District, which includes seaports and airports, reached a record $102.18 billion.[10]

Despite a strong economy, the region faces challenges due to a high cost of living, lower educational attainment, and low average wages. For example, Miami-Dade's middle class has shrunk from 65 percent of local households to 43 percent in the past 50 years.[11]

Port Miami, a critical part of the region's waterfront economy.

TOURISM AND NATURAL RESOURCES IN THE REGION

Tourism is the state's largest industry and the fourth largest employment sector, representing 12 percent of all jobs. Driven by Florida's coastlines and its warm climate, natural landscape, and beaches, tourism has direct benefits to the local counties, state, and beyond, with a total statewide economic impact of more than $90 billion, including $12.3 billion in state and local tax revenue alone (2018).[a]

Florida's natural landscape—including beaches, wetland areas, and coastal and ocean habitats—provides opportunities for recreational activites that attract tourists from around the world.

Visitors looking to explore and experience these areas constitute a significant portion of the region's annual tourism. A study on the economic impact of beach tourism in Palm Beach County found that out-of-county visitors spent nearly $200 million in connection to beach visits in a single year.[b]

Ecotourism—tourism focused on visiting natural areas, observing wildlife, and supporting conservation—is directly reliant on the health and vitality of these areas, and accounts for a significant portion of the region's tourism, with 2.9 million people visiting South Florida's national parks in 2019 alone, spending $242.5 million during their visits, and providing a net benefit of $352 million to the region.[c]

This direct spending benefits the local economy, and is largely subject to taxes that fund the operations and service provisions of state and local governments.

Tourism is Florida's top economic driver

$91 BILLION

tourism's contribution to gross state product in 2018[d]

Ocean-related tourism contributed

$24.7 BILLION

and over 70 percent of total jobs (about 395,000) in 2018.[e]

In addition to the economic benefits from tourism, Southeast Florida's beaches also provide important protection from coastal storms. Historically, the region has invested in beach nourishment and other forms of beach management practices to combat erosion and maintain the size and quality of beaches.

Given the fundamental tie between a strong tourism industry and beaches, these investments can provide rolling benefits in the form of mitigating coastal flooding conditions while also maintaining the quality of beaches that are a key draw for visitors who make significant contributions to local and state economies.

A kayaker navigates around mangroves in Everglades National Park.

UNDERSTANDING THE REGION'S FLOOD RISK

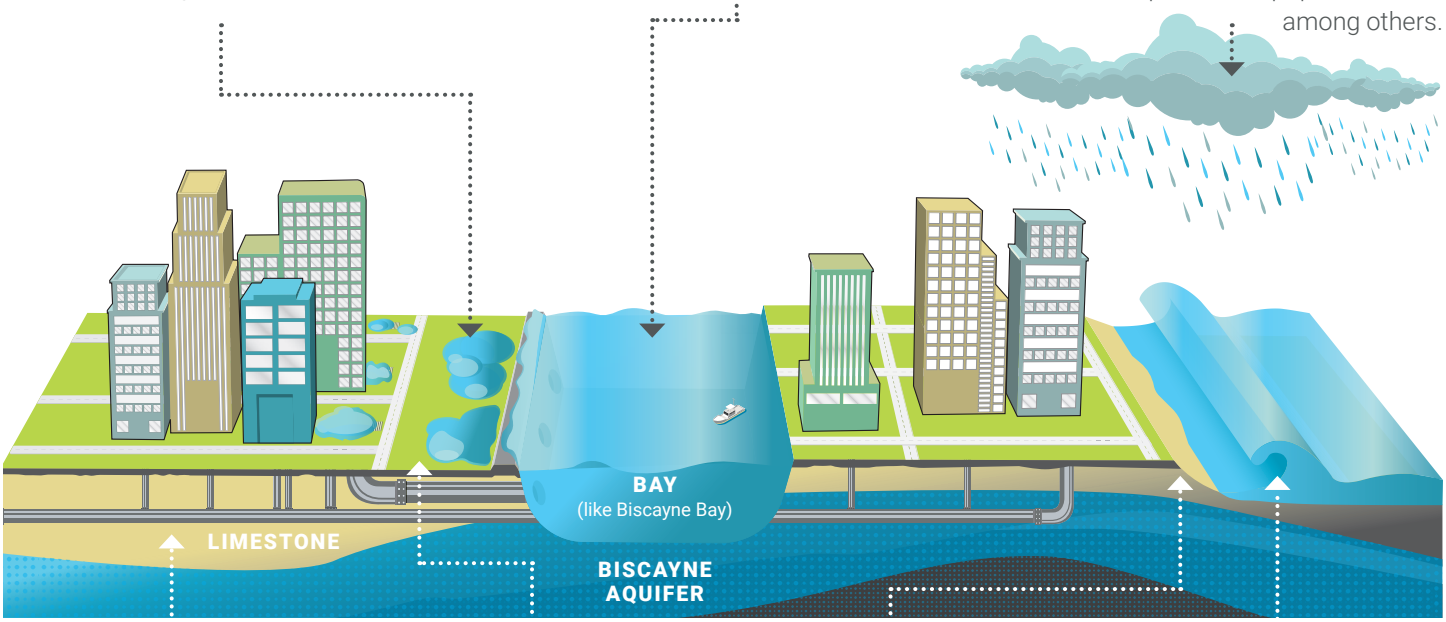
As the Southeast Florida region continues to grow and develop, so too do the region's unique flooding challenges that are heightened by increasing precipitation rates and storm activity, rising seas and groundwater levels, flat topography, and impervious land uses, as noted in the graphic below. As sea levels increase, it no longer takes a strong storm to cause flooding throughout coastal communities. Flooding now occurs at high tide for many locations due to a combination of sea-level rise, smaller storm events, onshore wind flows, and changing offshore current patterns that cause water to pile up along the shoreline.

Frequent flooding can cause damage, disrupt businesses and transportation, and corrode infrastructure over time. These environmental risks can lead to much broader socioeconomic impacts, such as loss or impairment of public services and infrastructure, decreases in property values and local government tax bases, increases in insurance costs, and displacement of disadvantaged and marginalized frontline communities.

TIDAL FLOODS
or "sunny-day floods" are above-normal tide events that cause water to overtop seawalls and waterfront barriers, seep through porous limestone, and infiltrate into the stormwater and sewage networks.

SEA-LEVEL RISE
along the Southeast Florida coasts adds to water levels caused by seasonal tide fluctuations and weather-based events.

HURRICANES
are a regular event in the region during the storm season (June–November). These large storms can have massive economic and social impacts in terms of damages, insurance, business and service disruptions, and population loss, among others.



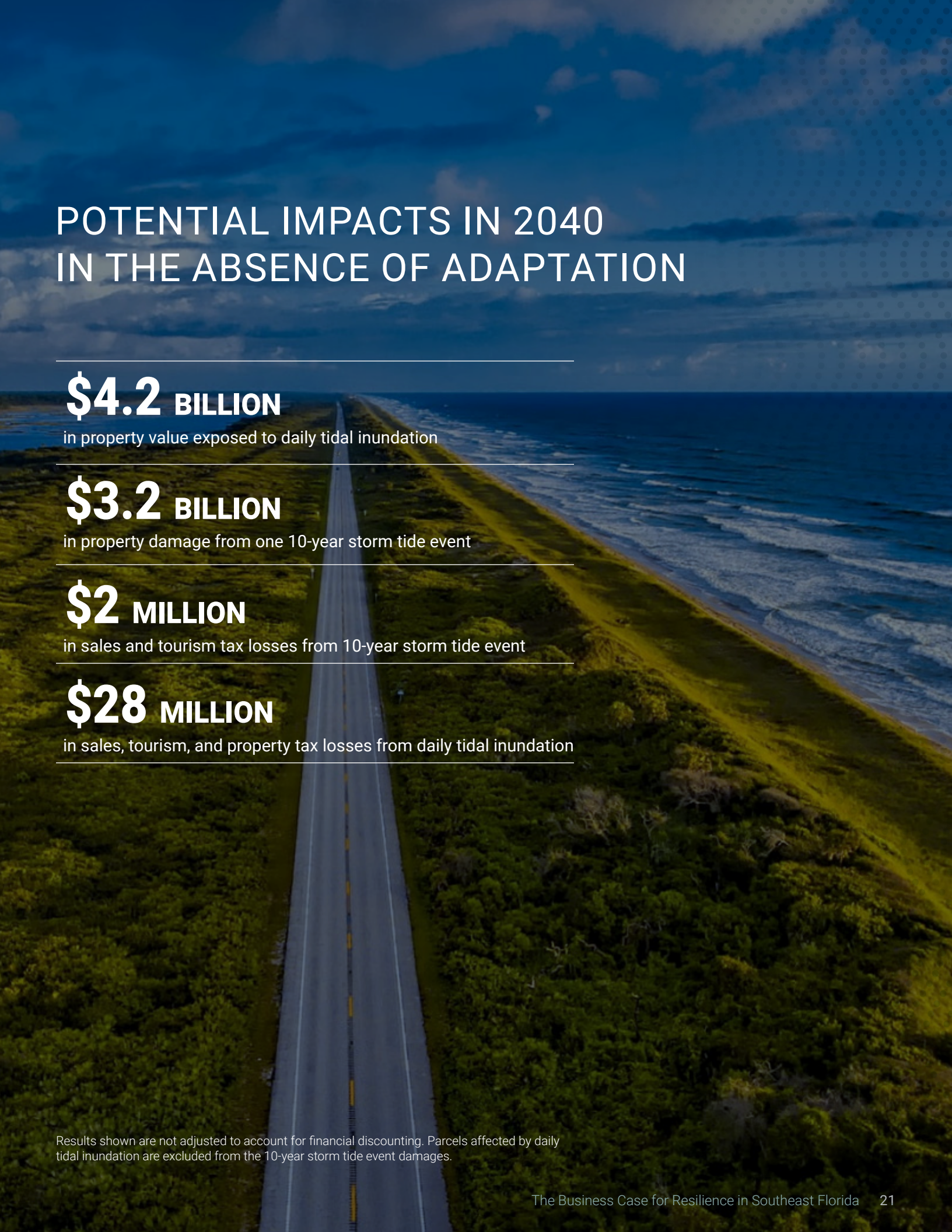
POROUS LIMESTONE GEOLOGY
allows salty sea water to penetrate inland and push already-high groundwater levels closer to the surface.

LOW-LYING GEOGRAPHY
averages an elevation of about six feet above current sea levels, with a limestone ridge that reaches an average of about 11.5 feet as the only natural high ground.

COASTAL EROSION
lowers the region's defense against storms by reducing the natural beach and dune areas that act as a buffer between storm waves and coastal property and infrastructure.

STORM SURGE
the rise in seawater level during a storm, is one of the greatest threats to life and property. Storm surge impacts could be exacerbated by tidal flooding events and heavy rainfall.

The region is expected to experience an increase in rainy season months and more frequent storm events. In 2017, Hurricane Irma, one of the strongest hurricanes ever recorded in the Atlantic Ocean, struck South Florida, dropping four to twelve inches of rain and inundating some areas with three to five feet of seawater. The Category 4 hurricane left 65 percent of the state without power and caused more than $50.5 billion in damages in the Florida Keys alone.



POTENTIAL IMPACTS IN 2040 IN THE ABSENCE OF ADAPTATION

$4.2 BILLION
in property value exposed to daily tidal inundation

$3.2 BILLION
in property damage from one 10-year storm tide event

$2 MILLION
in sales and tourism tax losses from 10-year storm tide event

$28 MILLION
in sales, tourism, and property tax losses from daily tidal inundation

Results shown are not adjusted to account for financial discounting. Parcels affected by daily tidal inundation are excluded from the 10-year storm tide event damages.

ANALYSIS FINDINGS

SOUTHEAST FLORIDA'S BUSINESS CASE FOR RESILIENCE

The avoided losses to property in Southeast Florida through building-level and community-wide adaptation strategies outweigh the costs 4:1 and 2:1, respectively.

The analysis shows that it is cost effective for the region to make investments in resilient infrastructure now. These measures include community-wide infrastructure adaptation investments and building-scale adaptation investments to enhance resilience in the region.

Investment in actions that can reduce coastal hazard risk and support adaptation to changing conditions can help to protect people, property, businesses, and infrastructure and reduce the amount of resources and investment needed to respond to and recover from coastal hazard events over the long term.

In addition, the study shows that regional action is critical as coastal storms and sea-level rise can have wide-ranging direct, indirect, and induced effects that extend beyond the borders of any one community.

A primary goal of investing in economic resilience is to ensure that communities can adapt to coastal hazard events when they do occur, so that shocks are manageable and not disruptive. By understanding the strengths and weaknesses of local and regional economies, opportunities for improving business-as-usual practices arise so that communities do not just survive but are best positioned to thrive.

INVESTMENT STRATEGIES AND BUSINESS CASE DIFFER DEPENDING ON COUNTY-SPECIFIC FACTORS

No single solution for adaptation will work across all jurisdictions and for every community. This study explores regionally consistent adaptation solutions across all four counties, referred to as the community-wide adaptation approach and building-level approaches. One of the challenges with analyzing the community-wide adaptation approach is that even within the Southeast Florida region, there is diversity in the local site and water conditions that would lead to different proposed adaptation solutions. Some measures evaluated are not as applicable in certain jurisdictions because of unique geographical factors. Each county and municipality will need to determine the exact adaptation options available given the local conditions.

Specifically, the types of solutions examined appear to be more cost beneficial for more densely developed areas of the mainland, like those in Broward County, Miami-Dade County, and Palm Beach County. Given the highly regulated growth and environmental resource management process, adaptation measures in Monroe County will be unique and hardened shorelines may not be feasible. Also, because Monroe County has very little beach or dune areas, those measures are less applicable. This analysis underestimates cost benefit in less urban areas of the region or those with more coastal environmental resources, like Monroe County, because different solutions would be used in those areas to better proactively address climate resilience given local conditions.

LACK OF ADAPTATION INVESTMENT AND INFRASTRUCTURE NOW WILL AFFECT REGION'S FUTURE ECONOMIC WELL-BEING

Investment in resilience actions can reduce coastal hazard risk and support adaptation to changing conditions. It can also reduce the amount of resources and investment needed to respond to and recover from coastal hazard events over the long term. Overall, investing in adaptation now can result in a positive economic return for the region.

Without an investment, the region risks experiencing cascading effects such as the following:

- Foregone property, sales, and tourism taxes
- Increased cost and/or barriers to access insurance coverage and mortgage financing
- Loss of wealth and/or income for property and business owners
- Downgrades to municipal bond ratings

These cascading effects could fundamentally alter the desirability of living and working in coastal communities, which in turn could result in the redistribution of populations and public and private investment, all of which can have significant impacts on local, regional, and state economies.

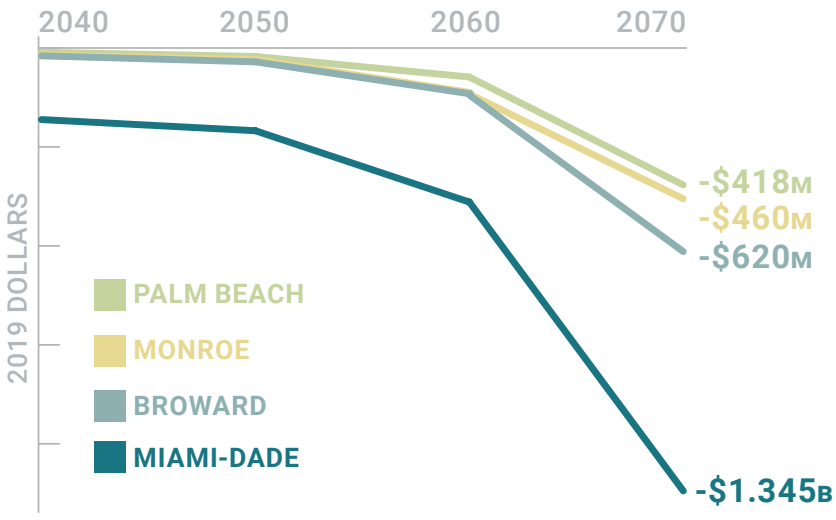
The study found that the failure to safeguard property from rising seas could result in significant property, sales, and tourism tax revenue losses, which are critical to local governments. Reductions to this revenue stream could hinder the ability of the public sector to fund its operations and invest in core community services and infrastructure, including adaptation.

The graph below shows the estimated property-tax revenues that could be lost over the next half century, based off property identified to be vulnerable to permanent sea-level rise and the modeled daily high-tide conditions. Further overview of fiscal impacts that might be realized by the counties are summarized below.

Long-term tax losses can deplete the region's ability to finance public goods and services and its ability to bounce back from shocks and stresses.

CUMULATIVE PROPERTY TAX LOSSES FROM SEA-LEVEL RISE
(MHHW)

The chart at right shows the estimated cumulative property tax revenues losses over the next half century. Cumulative property tax losses were estimated for each county by estimating the approximate year in which properties will be subject to daily high tides in the future.



Note: Impacts only account for parcels where 25 percent or more of the parcel footprint is exposed to the modeled coastal conditions. Results are not adjusted to account for financial discounting.

BUSINESS COMMUNITY CAN EXPERIENCE AVOIDED DAMAGES AND LOSSES

Increasing risks from sea-level rise and tidal flooding have the potential to undermine the strength of Florida's real estate market. The study found that $53.6 billion in regional property value will be exposed to daily tidal inundation under 2070 conditions.

Increasing evidence exists that projected flood inundation can decrease property value.[12] Previous studies show Miami-Dade properties at higher elevations in flood-risk areas appreciate at a higher rate than than properties at lower elevations.[13]

Population redistribution and investment in areas that face less risk to flooding due to their higher elevation can be a signal of climate gentrification, a situation in which properties become more valuable than others due to their ability to better accommodate settlement and infrastructure in the face of climate change, potentially pushing lower-income residents out of their neighborhoods.[14] Overall, studies show that the prices of tidally exposed properties tend to appreciate at lower rates than comparable properties not exposed to tidal flooding.

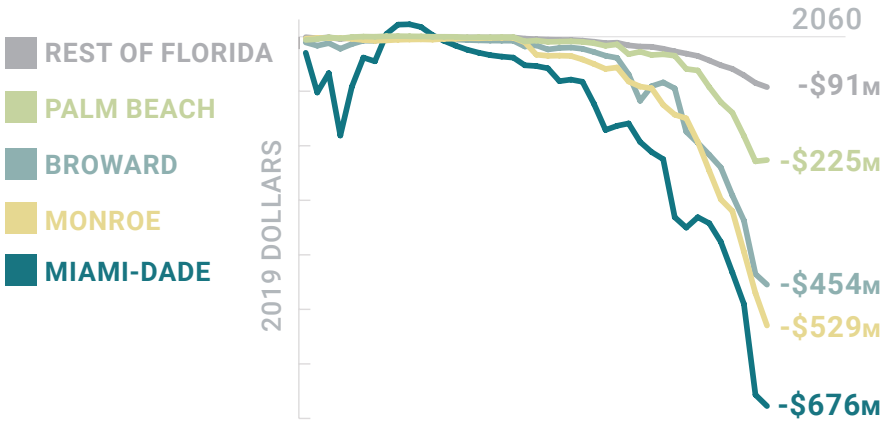
A storm event can cause structural damage and months of wage losses and associated job impacts that make doing business in the area more difficult, and potentially encourage relocation.

Implementation of the evaluated adaptation measures at both levels can deter flood impacts for the business community, like property damage and employment impacts, and maintain economic health.

GDP CHANGES DUE TO SEA-LEVEL RISE

NO-ACTION SCENARIO (MHHW)

If no action is taken, each county in the Southeast Florida region will experience a deterioration in GDP from tidal and storm events by 2060.



TOTAL LOSSES BY COUNTY IF NO ACTION IS TAKEN

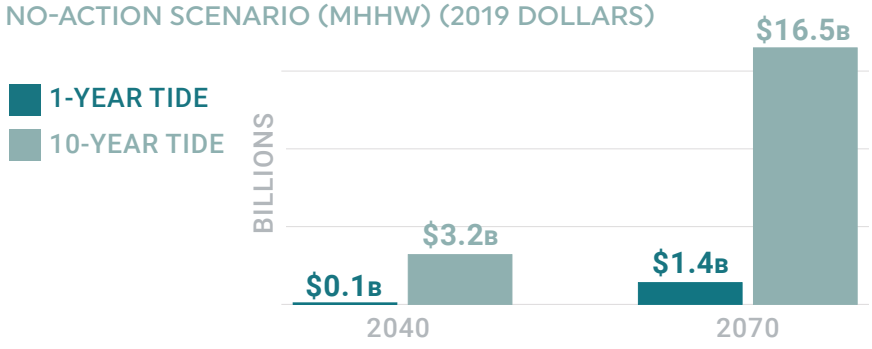
2020–2070 CUMULATIVE LOSSES (2019 DOLLARS)

	PROPERTY IMPACTS	SALES OUTPUT IMPACTS	SALES & TOURISM TAX IMPACTS	PROPERTY TAX IMPACTS
BROWARD	$63.911B	$5.279B	$161M	$825M
MIAMI-DADE	$106.5B	$8.354B	$361M	$2.388B
MONROE	$20B	$8.560B	$567M	$674M
PALM BEACH	$29.6B	$2.117B	$82M	$548M
REGION	$220.1B	$24.310B	$1.171B	$4.435B

Note: Results are not adjusted to account for financial discounting.

STRUCTURE AND CONTENT LOSSES FROM A SINGLE STORM

NO-ACTION SCENARIO (MHHW) (2019 DOLLARS)



ADAPTATION CAN YIELD LASTING BENEFITS FOR SOUTHEAST FLORIDA

The implementation of certain community-wide and building-level adaptation strategies could help to minimize the devaluation of real estate and mitigate a variety of economic and social effects. In general, community-wide strategies mitigate impacts from both temporary coastal storms and permanent sea-level rise to all inland assets while building-level strategies can mitigate impacts for individual assets that are exposed to temporary coastal storms and not permanent sea-level rise.

COMMUNITY-WIDE ADAPTATION PRESENTS NET BENEFITS FOR THE REGION

Overall, the community-wide adaptation strategies would increase GDP and employment for the four counties. Community-wide adaptation measures, if implemented with best practices, have the potential to mitigate nearly all modeled coastal impacts. Community-wide adaptation strategies have the potential to protect the broader community and provide further benefits to individual property from gradual sea-level rise conditions.

PROPERTY AND REAL ESTATE VALUES CAN BE PRESERVED AND GENERATE VALUE

Investing in adaptation provides direct benefits in the form of avoided losses to property, as well as the potential for indirect benefits, such as reductions in insurance premiums, stabilization or enhancement of property values, and associated tax revenues. It is common knowledge that coastal property is priced at a premium compared with similar property not located by the coast. However, living near the coast comes with the risk of potential impacts from coastal hazards. Hazard risks have been shown to be capitalized in the value of property; in particular, properties subject to hazard risks are often sold at a discount compared with similar properties not subject to these risks, all else considered equal.

Adaptation to coastal hazards can be designed to offer benefits to the community in the form of an amenity, like this park in downtown Miami.

With proper incentives and partnership opportunities for the private sector, property owners and developers should make investments to develop/redevelop current and future buildings to be more resilient at the asset level. A regionally funded program that offers such incentives can support retention of long-term asset value and protect people.

JOBS AND ECONOMIC ACTIVITY CAN BE PRESERVED AND GENERATED

Adaptation avoids economic challenges, and it can create additional jobs and boost economic activity. Investments in adaptation can provide benefits beyond the avoided impacts, as described previously. For example, the construction industry would be expected to benefit from investment in adaptation. This major increase in construction spending can result in increased employment in the area for the construction industry as well as related industries. Funds used to construct a seawall will result in direct job gains for the construction industry, as well as downstream indirect (e.g., supply chain) and induced (e.g., spending by directly and indirectly affected workers) job gains.

Over the next 50 years, investments in community-wide adaptation could support 85,000 job years, and investments in building-level adaptation could support 56,000.

RETURNS ON INVESTMENTS IN ADAPTATION

A COMPELLING BUSINESS CASE FOR BUILDING-LEVEL AND COMMUNITY-WIDE ADAPTATIONS

The analysis shows that there is a regional business case for the local governments and business communities of Southeast Florida to start making investments in resilient infrastructure now, with phased investments over the coming decades. To develop an understanding of the costs and benefits of adaptation, the direct impacts on real and personal property under a no-action scenario were estimated and compared with the costs and benefits of community-wide and building-level adaptation strategies. The tables below show estimates for the cumulative impacts avoided and cumulative cost of adaptation, net impacts, and resulting benefit-cost ratios, which range from about 2 to 4. A benefit-cost ratio greater than 1 implies that the economic benefits outweigh the costs.

The economic benefits from both building-level and community-wide adaptation provide greater benefit than the cost to the region. However, these strategies must be integrated together to safeguard the region.

RETURN ON INVESTMENT: BUILDING-LEVEL ADAPTATIONS

CUMULATIVE 2020–2070 (NET PRESENT VALUE)

	CUMULATIVE IMPACTS AVOIDED	CUMULATIVE ADAPTATION COSTS	NET IMPACTS	BENEFIT-COST RATIO
BROWARD	$4.5 billion	$1.5 billion	$3 billion	3.04
MIAMI-DADE	$9.2 billion	$1.8 billion	$7.5 billion	5.18
MONROE	$459 million	$598 million	-$139 million	0.77
PALM BEACH	$3.3 billion	$545 million	$2.8 billion	6.08
FOR THE REGION	Benefits $17.6BIL	÷ Costs $4.4BIL	= Benefit-Cost Ratio 3.97	Job Years Supported 56,000

RETURN ON INVESTMENT: COMMUNITY-WIDE ADAPTATIONS

CUMULATIVE 2020–2070 (NET PRESENT VALUE)

	CUMULATIVE IMPACTS AVOIDED	CUMULATIVE ADAPTATION COSTS	NET BENEFITS	BENEFIT-COST RATIO
BROWARD	$9.601 billion	$4.128 billion	$5.473 billion	2.33
MIAMI-DADE	$19.461 billion	$2.101 billion	$17.360 billion	9.26
MONROE	$3.182 billion	$7.669 billion	-$4.487 billion	0.41
PALM BEACH	$5.613 billion	$4.325 billion	$1.288 billion	1.30
FOR THE REGION	Benefits $37.9BIL	÷ Costs $18.2BIL	= Benefit-Cost Ratio 2.08	Job Years Supported 85,000

Notes: Results account for structure, content, land, and relocation impacts. Results are presented in net present value terms using a 5 percent discount rate over the period of the analysis from 2020 to 2070. For both the community-level and building-level adaptation strategies, the benefits outweigh the costs for all counties except Monroe. This does not imply that adaptation is not a cost-effective investment for Monroe County. Rather, the selected adaptation solutions examined in this study would not be the appropriate strategies to apply in Monroe County.

ECONOMIC BENEFITS FROM INVESTMENT IN SELECTED TYPES OF ADAPTATION MEASURES THROUGH 2040 (2019 DOLLARS, $MILLIONS)

There is a compelling case for investing in both community-wide and building-level adaptation in the Southeast Florida region. The table below shows the economic benefit from investments in community-wide and building-level adaptation strategies in 2020 and 2040 , which are the years when investment would take place as part of the phased adaptation approach in this study. Overall, both adaptation scenarios present a general positive impact on GDP and employment for the region.

	COMMUNITY-WIDE ADAPTATION INVESTMENT		BUILDING-LEVEL ADAPTATION INVESTMENT	
INVESTMENTS IN:	**2020**	**2040**	**2020**	**2040**
Economic Impact	*Combined difference from baseline*		*Combined difference from baseline*	
BROWARD				
Job years	6,780	5,280	2,530	15,010
GDP	$660 million	$780 million	$240 million	$1.97 billion
MIAMI-DADE				
Job years	15,200	9,550	3,190	18,470
GDP	$1.6 billion	$1.38 billion	$350 million	$2.67 billion
MONROE				
Job years	19,370	9,320	2,560	5,600
GDP	$1.26 billion	$810 million	$180 million	$530 million
PALM BEACH				
Job years	9,470	9,910	1,270	7,020
GDP	$730 million	$1.17 billion	$120 million	$880 million
REST OF FLORIDA				
Job years	-15,050	-11,320	300	1,130
GDP	-$1.34 billion	$1.23 billion	$30 million	$140 million

Jobs rounded to nearest 10. GDP rounded to nearest $10 million. Job years is equivalent to one year of work for one person; for example: a new construction job that lasts two years will equate to two job years. Results are not adjusted to account for financial discounting.

CONCLUSION

The Southeast Florida region is a bustling hub for business, tourism, and culture that faces a unique set of coastal hazards and economic challenges. This study identifies opportunities associated with resilient investment in the face of climate risks to the region due to more frequent flooding and sea-level rise. There is a clear shared interest among all stakeholders to take action.

To advance economic development and climate resilience throughout the region, the Compact counties will need to continue to push forward with a coordinated effort among public and private sectors and identify funding for investment in climate adaptation at the building and community scales.

Together, local governments and the business community have an opportunity to build critical physical and social infrastructure that will protect the region's robust economy. Investing in these processes now will not only reduce vulnerabilities, but also grow the economy of Southeast Florida in the years to come.

ADAPTATION IN ACTION: CASE STUDIES

EXAMPLES FROM SOUTHEAST FLORIDA

A1A IMPROVEMENTS PROJECT
Broward County
Building resilience into a post-hurricane emergency roadway reconstruction project

LIVING SHORELINES PROJECT
Palm Beach County
Implementing natural resilience and habitat restoration

NORTH MIAMI STORMWATER PARK
Miami-Dade County
Converting a repetitive loss property into a community stormwater park

STORMWATER RESILIENCE PROGRAM
Miami-Dade County
Managing stormwater at the community level in Miami Beach

SEAWALLS AND WATERFRONT ACCESS
Miami-Dade and Broward Counties
Implementing widespread adaptation requirements in Miami-Dade and Broward counties

FINDING THE BUSINESS CASE: PEER PROJECTS IN THE U.S.

CALIFORNIA
Protecting municipal land, and maritime and aviation operations

HAWAII
Directing adaptation among state agencies

LOUISIANA
Leveraging university partnerships to inform resilience investment

TAMPA BAY
Quantifying the cost of doing nothing

BROWARD COUNTY

A1A IMPROVEMENTS, POST-SUPERSTORM SANDY

CONSTRUCTED:
2014

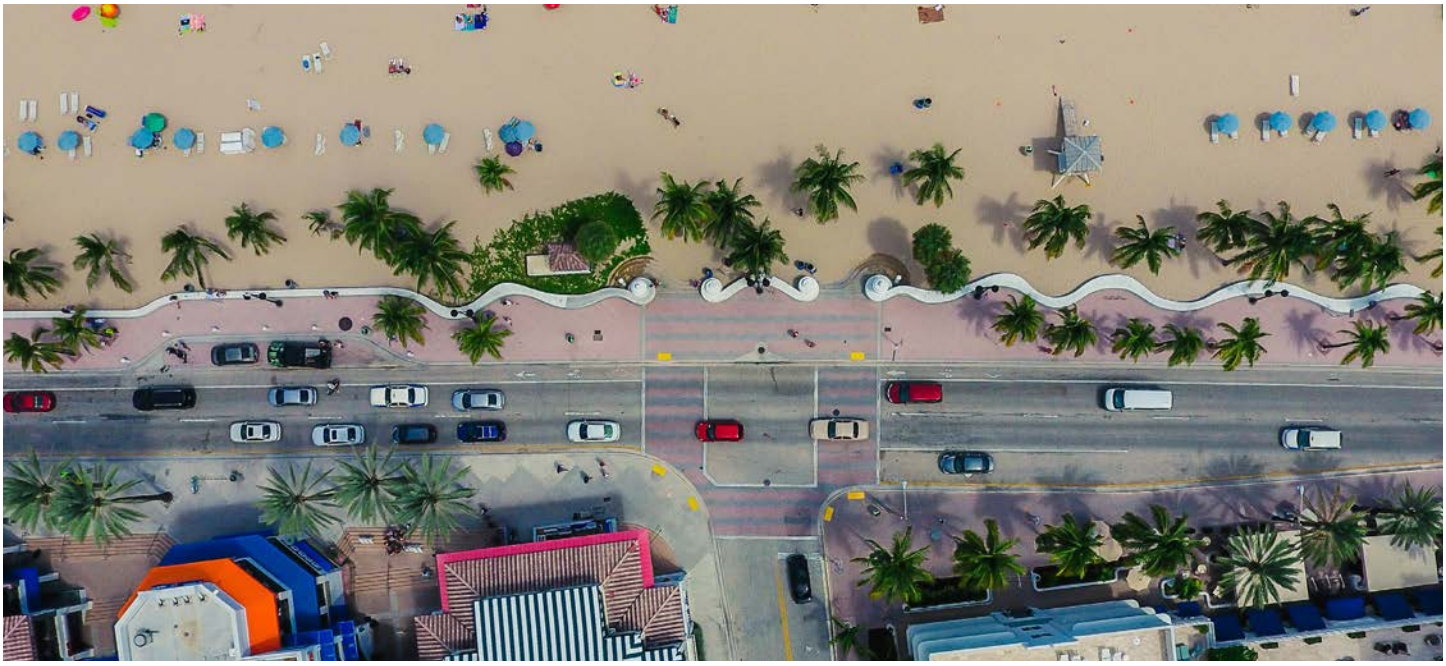
SIZE:
0.988 miles

COST:
$20.1 million

In 2012, Superstorm Sandy moved along the eastern U.S. seaboard, causing devastating erosion that stretched for miles along Fort Lauderdale's beaches. The destruction that came with Superstorm Sandy undermined roadways and coastlines alike, causing sand and saltwater to encroach well past the shoreline and to infiltrate the thoroughfare. Whereas natural disasters, such as hurricanes, are readily abundant in Florida, our rapidly changing climate is worsening the frequency and severity of these events.

The City of Fort Lauderdale, Broward County, and the Florida Department of Transportation worked together to improve the resilience of the emergency repair reconstruction project. As a result of the damage caused by Superstorm Sandy, this project increased adaptation efforts by incorporating additional resilience into existing structures, as well as building completely new essential infrastructure. Notably, one of the improvements to Fort Lauderdale's State Road A1A was the installation of a sheet pile that is 40 feet deep and designed to withstand 15 feet of scour. Several other reconstruction improvements included raising the roads two feet, building a one-foot-higher wall, and installing new backwalls.

On Sunrise Boulevard, a back wall was added to prevent sand and saltwater from reaching the roadways. This back wall served a multitude of purposes by also preventing marine wildlife from entering the roadways and subsequently reducing light pollution from nearby traffic. The improvements made during this project were necessary and, therefore, not considered "new money." Resilience was deemed an imperative part of the overall project, reflecting the urgent need to continuously improve roadways and other public infrastructure amidst our changing climate.



PALM BEACH COUNTY

LIVING SHORELINES PROGRAM

Palm Beach County is home to a wide array of ecosystems, both natural and man-made, all of which may thrive in urban environments when suitable sediment, habitat, and water-quality conditions exist. Over the course of several years, the Palm Beach County Living Shorelines Program focused on reinforcing ecological resilience in these communities. Living shorelines have become an increasingly viable method of natural resilience and habitat restoration, while also being cost-effective, sustainable, and aesthetically pleasing. These shorelines act as natural barriers to wave energy and storm surge and create crucial habitats for native wildlife.

In 2012, Palm Beach County prioritized the creation of natural habitats for wildlife, as well as the development of green infrastructure that encouraged educational and ecotourism activities, for the South Cove Natural Area. Expanding on the existing seawall, a mangrove planter was installed to soften the edges and create a more natural shoreline within this urban estuary. Moreover, South Cove had historically been used as a dredge hole site. The dredge hole had slowly been filled in with organic matter, which when re-suspended can negatively impact water quality. This project enabled the creation of critical tidal islands, seagrass habitat, and oyster reefs by filling the existing dredge hole with clean sand, thus capping the organic matter at the bottom of the hole. In all, this project created six acres of mangrove, seagrass, and oyster habitat in the middle of downtown West Palm Beach complete with an elevated boardwalk and observation deck.

Five years later, the county, alongside the City of West Palm Beach, worked to rehabilitate the shoreline of Currie Park by using the habitat-restoration methods employed successfully in the South Cove Nature Area. The Currie Park project created seven mangrove and spartina planters alongside a concrete seawall. Similar to the South Cove Natural Area, Currie Park's living shoreline was constructed of limestone rock and filled with clean sand to create planters and soften the edges along the linear seawall. In addition, this project was centered around the local community, involving residents in volunteer opportunities, such as planting and cleanup events, as well as ongoing recreational activities within the park.

All of the resilience measures prioritized in each restoration project supported an enhanced ecosystem where countless native species can thrive for generations to come.

An oft-overlooked but key component of these types of projects is the beneficial reuse of existing suitable materials to create the various habitats. Clean rock and sand are often generated in urbanized estuaries through the management and operation of both the working waterfront and the adjacent navigational waterways. Handling and disposal of this material is usually costly and results in the loss of the material within the system. By partnering with public and private entities that generate clean rock and sand through dredging and excavation projects, living shorelines can make use of this material at a significant cost savings to all parties, resulting in habitat improvements and coastal resilience while supporting the local marine community.

PALM BEACH COUNTY DEPARTMENT OF ENVIRONMENTAL RESOURCES MANAGEMENT

MIAMI-DADE COUNTY

CONVERSION OF A REPETITIVE-LOSS PROPERTY TO STORMWATER PARK

COMPLETED:
2019

SIZE:
13 blocks, 0.62 miles

COST:
$80,000

DEVELOPMENT TEAM:
City of North Miami, Van Alen Institute, Department Design Office, local residents and stakeholders

The Arch Creek Basin is a low-lying area within the City of North Miami that regularly suffers from flooding and includes multiple FEMA-designated repetitive-loss properties (parcels that have filed for flood insurance twice in a 10-year period). Several of these sites have remained vacant for years.

The city reimagined a pilot site that transformed a repetitive-loss property into additional storage and retention for its stormwater management system through the creation of a stormwater park. The North Miami Stormwater Park was previously owned by an individual whose home flooded multiple times within a 10-year period, generating a claim from the National Flood Insurance Program (NFIP). This claim enabled the city of North Miami to "buy out" the property. It was vacant for several years until the city's initiative transformed it into a space where community members can cherish its beauty as well as its functionality.

The conversion from a repetitive-loss property to a requisite stormwater management system allowed the City of North Miami to strengthen its resilience efforts. The absorbent natural landscaping significantly increased the pilot site's ability to mitigate problematic flooding. The park also includes artistic elements like public art and colorful educational signage to create a sense of place and enhance curb appeal. The innovative use of this land has made it possible for all residents of North Miami to enjoy a shared space that emphasizes a sense of social and environmental resilience.

Repetitive-loss properties are increasingly disruptive to many communities—causing excessive flooding not only on the specific parcel, but also on neighboring properties.

North Miami Stormwater Park is intended to provide a community-oriented space that increases stormwater retention capacity, supports local habitats, and increases public outreach and awareness of climate-related issues.

During a recent rainstorm, the city anecdotally noted that the stormwater park flooded, as it was designed, and the areas surrounding the site experienced reduced flooding. This is a co-benefit of buying out repetitive-loss properties and transforming them into an integral tool of stormwater management. In addition, revamping of sites such as the Good Neighbor Stormwater Park allows homeowners to move to a safer location, and at the same time lessens the burden on NFIP by reducing the amount of flood-damage claims.

MIAMI-DADE COUNTY

MIAMI BEACH'S STORMWATER RESILIENCE PROGRAM

The City of Miami Beach has shown a commitment to addressing flood vulnerabilities, including identification of funds other than federal and state monies and execution of the initial phases of an integrated stormwater management program that will also incorporate quality of life improvements such as mobility and green infrastructure.

In 2019, through a multidisciplinary procurement process, the city selected ICF Inc. to conduct a business case analysis of its stormwater resilience program. The purpose of the analysis was to assess the effectiveness of infrastructure investments throughout Miami Beach at the individual, neighborhood, and citywide level to protect against flooding from high tides, storms, and sea-level rise. Miami Beach's stormwater management efforts included the installation of improved drainage systems and new water treatment systems and elevating roads and public seawalls.

This pilot study researched stormwater investments through data analysis and catastrophe, drainage, and economic modeling, focusing primarily on the potential benefits related to lowered flood risk, increased property values, and reduced flooding. The study examined the benefits of targeted resilience investments and how they can lead to substantial economic and societal advantages.

Through the study, ICF found that the city's investments can positively affect property values in two ways: by elevating surrounding roads and by reducing flood depths at individual properties. The study found that parcel elevation and nearby road elevation have a strong positive effect on property values in Miami Beach. The study also emphasized the need for private-property-owner investments. In study neighborhoods, for example, every $1 that residents invest in storm-surge protection returns nearly $3 in benefits.

ICF conservatively estimates that on the basis of a high-level analysis of property damages and property values alone, citywide public and private resilience investments of up to $2 billion could be justified: $1 billion for storm-surge protection and $1 billion for stormwater system improvements to reduce flood depths from king tides and heavy rain events.

Overall, the pilot study demonstrated that the city's targeted investments in stormwater and infrastructure improvements significantly outweigh their costs and they provide substantial benefits to the residents, businesses, visitors, and government of Miami Beach.

MIAMI-DADE AND BROWARD COUNTIES

SEAWALLS AND WATERFRONT ACCESS

The waterfront is an essential part of Southeast Florida's economy and lifestyle. With hundreds of miles of waterfront, countless access points, and rising seas, the region's communities must address options for adaptation, considering physical protection and economic development from the real estate and marine industries. Across Southeast Florida, communities are learning how to proactively address tidal flooding that overtops seawalls and other waterfront infrastructure.

The City of Fort Lauderdale has instituted one of the most progressive seawall ordinances, establishing fundamental triggers for upgrades or modifications. The ordinance sets the old maximum seawall height of 3.9 feet NAVD88 as the new minimum height (NAVD88 is North American Vertical Datum of 1988, a reference frame to compare measurements globally); sets the maximum seawall height as the base flood elevation, which is around five to seven feet NAVD88 for much of the coastal areas in Fort Lauderdale; and creates mechanisms for repair or replacement of the seawall.

Specifically, seawalls must be repaired or replaced when individuals fail to maintain a seawall in good repair, if major changes are made to the property or seawall, or if tidal waters enter their property and affect other properties or the public right of way.

Other cities in the region are using the innovative Fort Lauderdale ordinance as an essential template for their own seawall ordinances.

Similarly, the City of Miami Beach increased its requirements for minimum seawall height and now requires new private and public seawalls to be constructed at a minimum elevation of 5.7 feet NAVD88, up from 3.2 feet NAVD88. A seawall that is not being repaired or replaced can remain as is, as long as it

meets the four feet NAVD88 minimum and can structurally support up to 5.7 feet NAVD88 in the future.

In Broward County, a new land use amendment has introduced consistency for tidally influenced properties across the county. Notably, tidally influenced municipalities must adopt an ordinance that uses the regionally consistent top elevations for seawalls, banks and berms, and other waterfront infrastructure within the next two years. The county also passed an ordinance that applies to unincorporated Broward County. In addition, the new regulation applies to waterfront infrastructure, such as boat ramps.

To address the challenges of direct water access, the City of Hollywood upgraded the Hollywood Marina boat ramp to address frequent tidal flooding in the area. The project received a grant from the Florida Department of Environment Protection to aid with the cost of the project. This project is an example of the importance of waterfront infrastructure upgrades to reduce flooding likelihood and to increase access to the water for the general public.

Seawalls are a primary coastal defense for Southeast Florida and have become an integral part of our flood protection infrastructure. The decisions made today will affect the resilience of the community for decades to come. Proactive changes now, which add minimal construction cost, will reduce the need for substantial changes at higher cost down the road.

FINDING THE BUSINESS CASE: PEER PROJECTS IN THE U.S.

Determining the cost/benefit analysis for investment in resilient infrastructure is an emerging strategy for local governments that has been piloted in a small number of regions. A few examples highlighted below used such analyses to help steer decision-makers at state, regional, and district scales.

CALIFORNIA

The state of California enacted more than 300 statutes granting sovereign public trusted lands to local municipalities with stipulated uses like, ports, harbors, airports, or other means to facilitate commerce, navigation, recreation, and open space. Granted lands and assets are overseen and maintained locally but are governed by the California State Lands Commission. In 2015, the California Leislature adopted AB 691, also known as the Proactively Planning for Sea-Level Rise Impacts bill, to assess the impact of sea-level rise on those lands.

As a public trust land grantee, the Port of Oakland developed its sea-level rise assessment to comply with the bill and to better understand the port's economic vulnerability to future permanent tidal inundation as well as temporary storm events. The port has three business lines, including maritime, aviation, and commercial real estate, that collectively generate about $9.3 billion in business revenue and support more than 84,000 jobs in the region. The port's related impacts support more than 1 million jobs nationally (data is pre–COVID-19). The Port of Oakland creates cascading economic activity throughout the San Francisco Bay Area that contributes about $118 billion to the local economy each year.

The analysis evaluated fiscal impacts of damage to infrastructure and core port facilities, operational disruptions, and effects to recreational open spaces and natural habitats. The vulnerabilities assessments' process has led to considerations around future terminal retrofits and opened dialogue on the topic with other grantees and nearby maritime and aviation operators for knowledge sharing and coastal adaptation best practices. In addition, the Port of Oakland learned that planning for projects that will protect our lands from storm surge and sea-level rise is dependent on building and maintaining long-term trusting relationships with key stakeholders and surrounding communities. Those relationships need to be fostered so that successful collaboration and coordination are possible for multiyear planning and implementation of necessary infrastructure to mitigate for rising waters.

HAWAII

In 2017, the Hawaii Climate Change Mitigation and Adaptation Commission published the Hawai'i Sea Level Rise Vulnerability and Adaptation Report detailing sea-level rise projections and including discussion of considerations to address economic, land management, and infrastructure challenges that the islands may face in the future, given land conservation needs. The projections include an aggregate sea level that includes passive flooding, storm surge, coastal erosion, and ground water flooding. The directive for adaptation planning among state agencies was set legislatively in 2014. Recommendations, specific to each agency, outline how to foster natural resources, conduct critical infrastructure, identify where development needs to either relocate or adapt, and how to maintain traditional Hawaiian culture and water quality. The report findings are supporting ongoing initiatives to update permitting processes and building setback regulations.

San Francisco Skyline and the Port of Oakland.

LOUISIANA

The state of Louisiana is addressing major coastal land-loss challenges due to land subsidence, relative sea-level rise, and related flood risks—about 2,000 square miles of land have been lost over the past century and that amount may be doubled in the next 50 years. Economists at Louisiana's public universities have partnered with the public sector to study the state's risks from flooding and related economic implications in the coastal regions and the state. Initiatives in 2015 and 2017 were designed to bring economic context into the planning process and to spark a policy discussion around coastal resilience and investment.

In 2015, researchers from Louisiana State University (LSU) and the RAND Corporation released *Economic Evaluation of Coastal Land Loss in Louisiana*, a comprehensive assessment of the potential economic losses from sea-level rise, coastal erosion, local infrastructure projects, and the compounding complexities of storm events at a statewide level, on behalf of Louisiana's Coastal Protection and Restoration Authority (CPRA). CPRA is tasked with leading recovery from the Deepwater Horizon oil spill in 2010 and is directed to balance funding streams to support immediate needs for coastal restoration, but also understanding the economic need to protect the region from other coastal hazards.

In 2017, LSU built on the 2015 findings to take a more regional approach, specifically analyzing how coastal erosion, land subsidence, sea-level rise, and the compounding risk of storm surge can affect New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles' economic viability and the potential economic benefits to the regions yielded by the state's continued investment in coastal restoration and protection. The study, called the Regional Impacts of Coastal Land Loss and Louisiana's Opportunity for Growth, supports the region's cause for state funding assistance and informs decision-making for developing strategic long-term planning documents and communicating the economic links between direct impacts to coastal regions and economic implications further inland.

Tampa's downtown as seen from Plant Park, a 6.9-acre park overlooking the Hillsborough River.

TAMPA BAY, FLORIDA

In 2017, the Tampa Bay Regional Planning Council (TBRPC) published the *Cost of Doing Nothing: Economic Impacts of Sea-Level Rise in the Tampa Bay Region* analysis that assessed the direct and indirect impacts of sea-level rise on the regional economy by 2060 and evaluated the effect of sea-level rise on property, jobs, tax revenue, and income from tourism. The report found that impacts of seas rising as much as 2.9 feet over the next 40 years would accumulate to $162 billion in the region's GDP. TBRPC conducted the analysis to make the connection between climate change and economic viability. In addition, the study helped generate interest in regional climate action plans that were underway and eventually it sparked support for additional studies to further understand coastal risk and opportunity for resilience in transportation planning at the project level. Since then, a regional coalition of local governments throughout the greater Tampa Bay region, companies, and utilities has formed to prepare a Regional Action Plan.

APPENDIX A: PROCESS AND METHODOLOGY

The analysis summarized in this report included a multistep modeling approach to estimate results of:

- the economic risks of flooding and the augmentation of that risk due to rising sea levels,
- the economic benefit of a resilience action as a function of risk reduction,
- the economic opportunities associated with resilience investments, and
- recommended strategies to incentivize and improve resilience for the Southeast Florida community.

HAZARD SCENARIO SELECTION AND EXPOSURE ANALYSIS

The first stage of the analysis involved a selection of high-frequency coastal conditions, accounting for water levels that accounted for projected sea-level rise expected in 2020, 2040, and 2070.

Water level conditions evaluated included: the average daily high tide, represented by the mean higher high water level (MHHW); the 1-year tide level, which could occur one to two times each year; and the 10-year tide level, representing a small coastal storm.

Using these modeled conditions, an exposure analysis was conducted for major categories of assets. Exposure mapping was conducted across parcels and core community infrastructure assets (e.g., parcels, roadways, hospitals) that are necessary for life safety or public and private service continuity, or that could pose a significant social consequence if damaged.

Asset exposure was evaluated using readily available mapping layers from the University of Florida's Sea Level Scenario Sketch Planning Tool; the leveraged mapping layers represent an extension of water surface at the shoreline over inland topography, accounting for a variety of high-frequency storm conditions and sea-level rise. The maps show a high-level screening assessment of the timing and the extent of potential shoreline overtopping and asset exposure due to rising sea levels.

ECONOMIC MODELING OF AVOIDED LOSSES AND BENEFITS

Avoided losses were estimated for the region and compared with the cost of specific adaptation measures to develop an understanding of the return on investment from taking action to mitigate coastal hazard risks. The following outlines the key steps applied to calculate the benefits of taking action:

- Estimate the consequences to assets directly exposed to the modeled coastal hazard conditions in a no-action scenario.
- Estimate the consequences to assets directly exposed to the modeled coastal hazard conditions in scenarios where investments in adaptation are made.
- Subtract the estimated consequences in scenarios with adaptation from the estimated consequences in a no-action scenario.

Two sets of adaptation strategies were analyzed: building-level (e.g., floodproofing, elevating) and community-wide (e.g., dune restoration, beach nourishment, and berm and seawall construction).

Categories of potential consequences (direct property impacts, business employment impacts, and fiscal impacts) from coastal storms and sea-level rise were selected. The impacts range depending on the type of risk endured (i.e., temporary impacts from coastal storms or permanent impacts from sea-level rise).

The combined community-wide and building-level strategies were modeled using a phased approach whereby the design features meet the specified modeled conditions in future years. For example, constructing a seawall in 2020 that will provide benefits through 2040 and that can be further elevated in 2040 to provide protection through 2070. In this example, the benefits provided by the seawall are assumed to begin accruing in the base year of the analysis (i.e., 2020) and to continue to accrue until the end year of the analysis (i.e., 2070).

All measures were modeled for the four counties as a region, however, some of the adaptation actions are more suitable for some locations than others because of unique issues or geography. Several flood consequences were evaluated for different types of coastal flood hazards. The economic consequences calculated in a no-action scenario are representative of event-based impacts that could be expected if the modeled hazard events were to occur in each of the Southeast Florida counties today.

This portion of the analysis only tells one part of the story of how coastal hazards can affect the economies of Southeast Florida. Given the interconnectedness of regional economies, ripple effects are likely—for example, business closure or displacement due to property damage can result in an increased cost of goods, decreased worker productivity, or a decline in the regional labor force. Or, after a coastal storm, money will likely be directed to rebuilding damaged property, which would result in positive gains to the construction industry. To account for these complicated economic responses the REMI PI+ model was used to estimate changes in GDP and the creation of job years.[15]

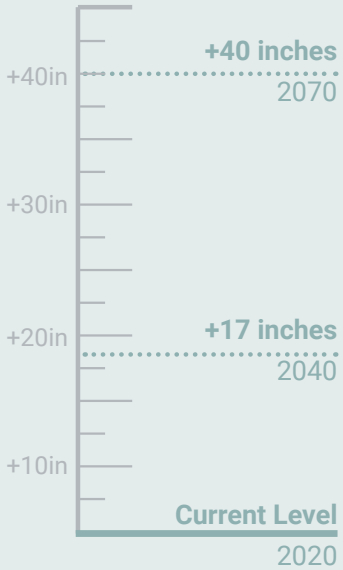
With an understanding of the avoided losses as well as the economic benefits of adaptation strategies, a benefit-cost analysis was also conducted to estimate the cost effectiveness of the building-level and community-wide adaptation strategies. The benefit-cost analysis was focused on accounting for the primary effects to society at large.

WHAT IS REMI PI+?

The REMI PI+ model is a robust economic analysis modeling platform that estimates the impact of public policy on local economies throughout the United States. This tool is useful because it helps users understand links between demographic and policy variables and the potential cascading effects in the economy. This economic impact modeling platform accounts for the common functions of an input-output model in addition to price elasticities and changes in consumer or industry behavior.

JOB YEARS

2019 COMPACT UNIFIED SEA-LEVEL RISE PROJECTIONS



The selected water-level conditions for the study were based on the 2019 Southeast Florida Regional Climate Change Compact Unified Sea Level Rise Projections. This graph shows the sea-level rise projections selected for the study.

PROJECT MODEL: ECONOMIC IMPACTS OF SEA-LEVEL RISE AND COASTAL STORMS ANALYSIS IN DANIA BEACH

In 2018, the city of Dania Beach commissioned an economic study to analyze the effects of sea-level rise and coastal storms on the local business community and the benefits conveyed through adaptation actions.

The analysis looked at direct property impacts, displacement impacts, business and employment impacts, and fiscal impacts. Cumulative damages from coastal storms were estimated at $719 million from coastal storm events and $1.2 billion from sea-level rise between 2030 and 2070 (applying a 5 percent discount rate over the period of analysis).

In addition, the analysis looked at several different types of adaptation responses including relocation, fortification (seawall construction), and accommodation (building elevation) to understand the costs and benefits associated with different investments in respect to property and asset values, tax base, and the local workforce. A survey sent to the business community informed more policy-oriented and qualitative discussion on preparedness, awareness, and vulnerability to changing climate conditions.

The study's findings support resilient land use design and development at a microeconomic level. The study's success encouraged the Compact to scale this model up for the Southeast Florida region and informed the process for the *Business Case for Resilience* economic analysis.

TEMPORARY AND PERMANENT IMPACTS

Core to this four-county analysis is the concept that temporary storm events (i.e., one-year tide, 10-year storm tide) and permanent sea-level rise (i.e., daily tidal inundation) cause various impacts to properties, businesses, and community revenue streams. As sea levels rise and flood events occur more frequently, some of these impacts may become irreversible.

	TEMPORARY IMPACTS (coastal storm)	PERMANENT IMPACTS (sea-level rise)
DIRECT PROPERTY IMPACTS	Structure damage	Property value loss
	Content damage	
	Relocation costs	
BUSINESS & EMPLOYMENT IMPACTS	Sales output loss	Sales output loss Income loss Job loss
	Income loss	
	Job Loss	
FISCAL IMPACTS	Sales tax loss	Property tax loss Sales tax loss Tourist-development tax loss
	Tourist-development tax loss	

APPENDIX B: KEY TERMS

1-YEAR TIDE
The highest annual tide, also referred to as the king tide.

10-YEAR STORM TIDE
A tide with a 10 percent chance of occurring in any given year. This event represents high-frequency conditions of temporarily elevated water levels due to coastal storms.

ADAPTATION
Strategies that anticipate and adjust human and natural systems to moderate the projected or actual impacts of climate change.

AVOIDED IMPACTS
This value represents the difference between the estimated impacts under the no-action scenario to the estimated impacts for the modeled adaptation scenario, essentially reflecting the amount of impact avoided as a result of investment in adaptation.

BEACH NOURISHMENT
The practice of adding sand or sediment to a beach to combat erosion, absorb wave energy, and prevent destructive waves from reaching upland development.

BENEFIT-COST RATIO (BCR)
The total present value of benefits conveyed by adaptation divided by the total present value of costs of adaptation. A ratio greater than one implies a return on investment.

BUILDING-LEVEL ADAPTATION
Structural modifications and improvements made to individual properties to protect against the threats of flooding. Examples include elevating structures and floodproofing.

CLIMATE-CHANGE MITIGATION
Strategies that focus on preventing the causes of climate change, specifically reducing or capturing anthropogenic emissions of greenhouse gases.

COASTAL HAZARDS
Physical risks related to coastal conditions, which have the potential to cause harm to humans, ecosystems, and property; the term encompasses different types of flooding, including storm surge, high tides, and sea-level rise.

COMMUNITY-WIDE ADAPTATION
A combination of soft and hard engineering investments made at the shoreline to minimize coastal hazard impacts and provide protection at the community scale. Examples include beach renourishment and seawall raising.

CUMULATIVE IMPACTS
The estimated impacts for each year in the period of analysis, which account for the likelihood of the modeled hazards occurring, are summed to develop an estimate of cumulative impacts. When calculating the benefit-cost ratio for this study, cumulative impacts were discounted to account for the time value of money.

JOB YEARS
Job years is equivalent to one year of work for one person; for example, a new construction job that lasts two years will equate to two job years.

MEAN HIGHER HIGH WATER (MHHW)
Average of the highest daily high tides occurring each day, also referred to as daily tidal inundation.

NET IMPACTS
The net impacts are calculated by subtracting the cumulative present value costs of adaptation from the cumulative present value of benefits (or impacts avoided) conveyed by investing in adaptation. A positive net impact generates a positive return on investment.

UNIFIED SEA-LEVEL RISE PROJECTIONS
Sea-level rise estimates produced by the Compact that are intended to assist decision-makers at the local and regional levels in Southeast Florida, and to ensure that major infrastructure projects have the same basis for design and construction relative to future sea level.

NOTES

This report summarizes the findings from a regional economic analysis conducted by AECOM. The full technical report can be accessed at: AECOM, *Business Case for Resilience in Southeast Florida*, August 2020.

QUICK FACTS & FIGURES

Disclaimer: this study represents a high-level regional analysis, leveraging readily available and regionally standardized physical and economic data, replicable analysis techniques, and generalized assumptions. Parcels impacted by daily tidal inundation are excluded from the 1- and 10-year tide damages. Results shown under the "What's at risk" findings are not adjusted to account for financial discounting. The 10-year storm tide results shown account for the impacts of one storm event and are not adjusted for probability of the storm event occurring. "What's at risk" findings were calculated assuming the superimposition of future physical conditions on the existing built environment and economy.

a. Data available at https://www.statista.com/statistics/183600/population-of-metropolitan-areas-in-the-us/.

b. 2018 American Community Survey 5-Year Estimates.

c. BEA Regional Data: 2018 Gross Domestic Product summary.

d. BEA Regional Data: 2018 Gross Domestic Product summary.

e. 2018 American Community Survey 5-Year Estimates.

f. Southeast Florida Regional Climate Change Compact Unified Sea Level Rise Projections (2019).

Rest of data obtained from AECOM, *Business Case for Resilience in Southeast Florida*, August 2020.

REPORT

1. According to 2018 American Community Survey 5-Year Estimates and BEA: Current-dollar gross domestic product (thousands of dollars)/Current-dollar gross domestic product (millions of current dollars) (https://www.bea.gov/).

2. Berm raising was not quantified in the study, although it is widely understood that the protection of beaches is a key element in supporting economic activity for the region outside of the Florida Keys.

3. The Real Deal, "Watch: Developers and Brokers Weigh In on Miami Sea-Level Rise," October 23, 2019, https://therealdeal.com/miami/2019/10/23/watch-developers-and-brokers-weigh-in-on-miami-sea-level-rise/.

4. Office of Economic and Demographic Research, "Demographic Overview and Population Trends," January 28, 2020 (http://edr.state.fl.us/Content/presentations/population-demographics/DemographicTrends_1-28-20.pdf).

5. According to Coastal Resilience, https://coastalresilience.org/project/southeast-florida-and-the-florida-keys/.

6. The Suddath Companies (global mobility company based in Florida) analyzed recent moving data to determine what was attracting Florida's new residents. "The findings show the state's robust job market is drawing in young talent from across the United States, with more than 30 percent of new Florida residents stating that it was a fresh opportunity provided by job transfers or new employment that made them want to call Florida home."

7. BEA Regional Data: 2018 Gross Domestic Product summary.

8. SmartAsset's interactive investing map: https://smartasset.com/investing/investment-calculator#florida/GDP.

9. See "Resilient305 Greater Miami and the Beaches" (http://www.mbrisingabove.com/wp-content/uploads/Resilient305_final.pdf).

10. Beacon Council economic overview (https://www.beaconcouncil.com/data/economic-overview/trade/).

11. Andres Viglucci, "Miami-Dade's Tale of Two Cities: 30 Billionaires and the Economic Inequalities of Colombia," *Miami Herald*, April 22, 2019.

12. S.A. McAlpine and J.R. Porter, "Estimating Recent Local Impacts of Sea-Level Rise on Current Real-Estate Losses: A Housing Market Case Study in Miami-Dade, Florida." *Population Research and Policy Review* 37 (2018): 871–95.

13. S.A. McAlpine and J.R. Porter, 871–95.

14. Global Resilience Institute, "Climate Gentrification: Why We Need to Consider Social Justice in Climate Change Planning," Northeastern University (https://globalresilience.northeastern.edu/climate-gentrification-why-we-need-to-consider-social-justice-in-climate-change-planning/).

15. One job year is one year of work for one person. For example, one construction job that will take five years is five job years.

TOURISM AND NATURAL RESOURCES IN THE REGION

a. Rockport Analytics, “Picking Up the Pace: Florida’s Tourism Performance Jumps into a Higher Gear” (https://www.visitflorida.org/media/30679/florida-visitor-economic-impact-study.pdf).

b. William B. Stronge, "The Economic Impact of the Beaches of Palm Beach County 2014," Nova Southeastern University (https://www.fsbpa.com/2016TechPresentations/Stronge.pdf).

c. National Park Service (https://www.nps.gov/bisc/learn/management/statistics.htm); National Park Service, “2019 National Park Visitor Spending Effects Report: Economic Contributions to Local Communities."

d. Rockport Analytics, "Picking up the Pace."

e. Florida Ocean Alliance, "Securing Florida’s Blue Economy: A Strategic Policy Plan for Florida’s Oceans and Coasts" (draft), 2020.

Urban Land Institute

Urban Land Institute
2001 L Street, NW
Suite 200
Washington, DC 20036-4948
uli.org

ULI Southeast Florida / Caribbean
500 West Cypress Creek Road
Suite 120
Fort Lauderdale, FL 33309
seflorida.uli.org