Financing Climate Resilience

Funding and Financing Models for Building Green and Resilient Infrastructure in Florida

HARVARD Kennedy School
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

April 2019

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Acknowledgements

We would like to thank the following people for their time and invaluable guidance and support:

Our Client—The Nature Conservancy, Florida Chapter
Janet Bowman, *Director of Legislative Policy & Strategies*
Rod Braun, *Manager, Climate Program*

Our Advisors
Professor Jesse Keenan, *Harvard Graduate School of Design*
Professor John Haigh, *Harvard Kennedy School*

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Jon Eichelberger, *Managing Director, Raymond James*
Jane Gilbert, *Chief Resilience Officer, City of Miami*
Amy Knowles, *Deputy Resiliency Officer, City of Miami Beach*
Michael Laas, *Founding Partner, Sustainable Futures Group*
Frank Leto*, Public Finance Associate, Raymond James*
Commissioner Janet Long*, Pinellas County*
Professor John Macomber, *Harvard Business School*
Jim Murley, *Chief Resilience Officer, Miami-Dade County*
Susanne Torriente, *Chief Resiliency Officer/Assistant City Manager, City of Miami Beach*

We would also like to thank the dozens of people who participated in our workshops on February 26, 2019, in Miami and on May 1, 2019, in Tampa. We hope that those events, coupled with this report, can play a small role in helping municipal governments address the climate-related challenges that they face.

Executive Summary

Florida is increasingly threatened by sea level rise, extreme heat, severe storms, and other climate stressors. Municipalities must invest in climate resilience, or the ability to anticipate, prepare for, respond to, and recover from significant climate-related threats. Paying for these investments is a significant challenge for local governments.

This report identifies and evaluates the following twelve creative funding and financing models that can help accelerate investment in infrastructure projects that incorporate resilient design features.

- **Green/climate bonds**
- **Tax increment financing**
- **Public private partnerships**
- **Collaborative revenue bonds**
- **Event-based insurance**
- **Regional resilience trust funds**
- **Carbon offset markets**
- **Mitigation banking**
- **Transfer of development rights**
- **Impact development fees**
- **Non-ad valorem special assessments**
- **Local infrastructure sales surtax**

Although many of these models can be successful in certain circumstances, the following four are most promising for municipalities in Florida aiming to scale up coastal resilience and green infrastructure projects.

I. **Impact development fees** are charges that can be levied on new development; they can fund capital-intensive infrastructure projects so long as the projects benefit the new development.
II. **Non-ad valorem special assessments** are charges that can be levied on properties in specified areas; they can be used to fund infrastructure projects with resilient design features that mitigate risks in those areas.
III. **Collaborative revenue bonds** allow multiple public authorities that benefit from a project to share the financial burden of financing the project; by each using cost savings to pay debt service costs, a diverse group of public entities can work together on projects with significant co-benefits.
IV. **Regional resilience trust funds** are funds, stewarded by political appointees, that can issue loans or grants to pay for infrastructure projects that mitigate climate risk; the funds can initially be capitalized with a real estate transfer tax or a surcharge on property and casualty insurance, but those mechanisms sunset once the fund becomes self-sustaining.

This report also outlines best practices for allocating financial resources. Local governments should employ a **total cost-benefit analysis** that considers the economic, social, and environmental impacts of a project over its lifecycle. This type of analysis will often reveal that nature-based and "green" infrastructure projects have higher benefit-to-cost ratios than traditionally understood. Building local capacity to incorporate these benefits and costs into the decision-making process is crucial to investing funds wisely.

I. Climate Change and Resilience in Florida

Climate change threatens all regions of the world, but Florida's geographic location and vast, low-lying coastline make it particularly vulnerable. As sea levels rise—14 to 34 inches by 2060—and coastal storms become more intense due to ocean temperatures rising, the state faces worsening beach erosion and shoreline recession, tidal and storm surge flooding, and saltwater intrusion.[1] Floridians will also continue to experience more extreme heat days and rainfall events.[2] Together, these impacts put coastal cities, their inhabitants, and their infrastructure at great risk.[3]

Flooding along the U.S. Gulf of Mexico alone, for instance, is estimated to cost between $134 and $177 billion by 2030.[4] As the effects of climate change, land subsidence, and concentration of assets in the coastal zone grow, annualized risk will more than double between 2030 and 2050. Local governments in coastal communities are increasingly understanding these risks and are beginning to plan to be more resilient.

Resilience or Adaptation?

Resilience is *the capacity of a system to anticipate, prepare for, respond to, and recover from significant threats*. Improving resilience reduces the recovery time and cost associated with returning to normal operations after a disruptive event. **Adaptation** is *the ability to adjust human and natural systems in response to expected climatic conditions*.

Resilience is short-term oriented, focusing on preserving normal operations, whereas adaptation entails transitioning to a different mode of operation that is more sustainable in the long-term. This report focuses primarily on resilience.

Infrastructure projects—both "grey" and "green"—with resilient design features can help mitigate these unfolding risks. Grey infrastructure projects are those that are traditionally engineered, and include seawalls, raised roads, and larger stormwater pipes. Green

[1] Southeast Florida Regional Climate Change Compact. "Unified Sea Level Rise Projections." October, 2015.
[2] "South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project." Parsons Brinckerhoff. April 15, 2015, (13).
[3] "What Climate Change Means for Florida." EPA. August 2016.
[4] Reguero BG, Beck MW, Bresch DN, Calil J, Meliane I. "Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States." 2018.

infrastructure options, on the other hand, refer to ecological solutions—natural or engineered—that mimic natural water cycles to manage stormwater.[5] They typically augment stormwater management systems. Other natural infrastructure projects, such as open space preservation, land conservation, and tree planting, can help reduce the impacts of extreme heat and flooding events. Green and natural infrastructure projects often generate indirect social and environmental benefits that are discussed in more detail in **Section IV: Evaluating Investment Opportunities**. In total, cost-effective adaptation measures (with benefit-to-cost ratios above 1) can prevent around half of the projected economic losses, between $57 and $101 billion, and nature-based adaptation options alone can cost-effectively avert more than $50 billion in economic impacts (Reguero). These options typically have high benefit-to-cost ratios and can provide other co-benefits.

Figure 1 details a four-step, iterative process that local governments can undertake to respond to unfolding climate risks through investments in resilient infrastructure. Each step is important and entails its own challenges, often stemming from of a lack of staff, time, and other resources and barriers to inter-agency coordination. Local governments identify paying for capital improvements as the biggest challenge they face in adapting to climate change.[6] Accordingly, this report focuses primarily on the third and fourth steps: (3) determining the best project alternatives so that municipalities can allocate their limited resources judiciously and (4) identifying creative funding and financing models that get projects off the ground.

Figure 1*: Pathway to a Resilient Infrastructure Program*

[5] "What is Green Infrastructure?" EPA.

[6] Moser, et. al. "Adaptation Finance Challenges: Characteristic Patterns Facing California Local Governments and Ways to Overcome Them." California Natural Resources Agency, (2).

Resilience Methods: Grey vs. Green Infrastructure

This section provides visual references for some of the project alternatives discussed throughout the report.

Grey Infrastructure[7]

Traditional, engineered systems that provide resilience benefits to water, drainage, or transportation systems through built structures.

Water Treatment Plants

Shoreline Levees

Sea Walls

Storm Drains and Sewers

Wave Attenuation Devices

Tidal Gates

Green Infrastructure

Projects that mimic natural water cycles to enhance stormwater management systems or provide other flood risk mitigation.

Living Shorelines

Tree Preservation/Planting

Green Roofs

[7] "Waste water." Sciencing.
SaultOnline.
Hard Armoring. CA Coastal Conservancy.
Precast.org.
North Carolina Coastal Federation.
Million Trees Miami. Miami-Dade County.
National Apartment Association.

Green Infrastructure Continued[8]

Rainwater Harvesting

Bioswales

Bio Retention Ponds

Other Nature-Based Resilience Methods

Open Space Preservation

Wetland Restoration

Coral Reef Restoration

Oyster Reef Restoration

Beach Re-Nourishment

Barrier Island Restoration

[8] "Rainwater Harvesting." Texas A&M.
Greater New Haven Water Pollution Control Authority.
"Bioretention Basins" Clean Site Prep.
"Open Space." Coastal Resilience.
"Florida's Oyster Reef Restoration." The Nature Conservancy.
"Dare County's Beach Restoration Recognized." Coastal Review Online.
Audubon

II. Funding and Financing Models

Governments pay for infrastructure projects through a combination of funding and financing models. Funding models are those that generate revenue that can directly pay for capital projects. Financing models are those that use some combination of debt and equity to acquire the capital necessary to pay for projects. In many instances, funding and financing models are used in tandem; the funding model raises revenue that pays the equity or debt service associated with the financing option.

Many governments struggle to acquire sufficient capital to fund large-scale capital projects with resilient design features through traditional funding and financing models. Through an extensive literature review and interviews with experts, we identified over 30 creative funding and financing models, that can be implemented by municipal, county, or regional jurisdictions in Florida to pay for infrastructure projects with resilient design features. The full list of these measures can be found in **Appendix 2: Other Policy Options**. The 12 creative models with the most potential based on a preliminary analysis are described in this section.

Traditional Models

The following traditional models are widely-known and used in Florida. Although the aim of this report is to identify and evaluate creative funding and financing and models, the traditional models are included to lay out a comprehensive list of options available and to ensure that the best options are ultimately selected, even if they are considered "traditional."

General Obligation (GO) Bonds

A municipal bond is debt issued by a municipality, typically as a means to finance capital projects, and GO bonds are one of the most common municipal bond structures. GO bonds are frequently used by municipalities in the United States and are backed by the full taxing authority of the government. Property taxes are the largest source of revenues for local governments in Florida and are the greatest source of funds to pay debt service on GO bonds.[9] Because municipalities in Florida are typically highly-rated by credit agencies, GO bonds give them access to a substantial amount of cheap capital.

[9] The Florida Legislature's Office of Economic and Demographic Research. "2018 Local Government Financial Information Handbook."

Opportunities

Municipalities in Florida are very familiar with GO bonds and issuing them is relatively easy. Cities and counties often issue large bonds. In 2004, for instance, the Building Better Communities Bond Program was approved in Miami-Dade County, approving $2.9 billion in bonds "to fund more than 300 neighborhood and regional capital projects to be completed over the next 15 years."[10]

Until recently, under the Government Accountability Standards Board (GASB) rules, no provisions existed for municipalities to issue bonds to pay for programs with distributed benefits, such as green infrastructure. A recent change to the GASB rules now allows local governments to book natural infrastructure programs as long-term assets, making them eligible for financing.[11] See **Appendix 3: Financing Natural Assets with Accounting Standards** for a more detailed discussion of this rule change.

Challenges

Local jurisdictions may not be able to issue additional debt at a reasonable rate if they have significant debt outstanding or a poor credit rating. Florida statute requires a referendum with a majority vote before a county, district, or municipality issues a bond, so only GO bonds that have popular support will be approved.[12] Although the bond must be approved by voters for a specific use, there is no mechanism that guarantees that the projects that are eventually financed will be align perfectly with climate resilience, or whatever was initially promised.

Revenue Bonds

Revenue bonds are also commonly used by city, county, and regional jurisdictions in the United States. They differ from GO bonds in that a specific revenue source, usually one that stems from the project being financed, is used to back the bond and pay the debt service. For instance, a highway can be financed with a revenue bond if tolls collected are earmarked for debt service.

Opportunities

As with GO bonds, revenue bonds can provide the capital required for substantial infrastructure investments and municipalities have substantial experience issuing this type of debt. A major benefit of these bonds is that they have no net revenue impact on the issuing jurisdiction; the debt service payments are offset by the new revenue stream.

Challenges

Local jurisdictions may not be able to issue additional debt at a reasonable rate if they have already issued a significant amount of debt or if they have a poor credit rating. And, because Florida statute requires a referendum with a majority vote before a county, district, or municipality issues a bond, only GO bonds that have popular support will be approved.[13] Although the bond must be approved by voters for a specific use, there is no mechanism that

[10] Miami-Dade Office of Management and Budget. "Building Better Communities."

[11] Earth Economics. "Go Green: Municipal Bond Financing for Consumer Rebates and other distributed water investments."

[12] Florida Statutes. 100.201

[13] *Ibid*.

guarantees that the projects that are eventually financed will be aligned with climate resilience. Finally, revenue bonds can only finance infrastructure projects that yield a revenue stream.

Federal Grants

There are many federal grants, a list of which is included in **Appendix 4**, that can be used for projects that improve climate resilience. The programs are either fully or partially funded by the federal government. For instance, the Federal Emergency Management Authority's (FEMA) *Hazard Mitigation Assistance* (HMA) grants can fund green infrastructure projects that mitigate hurricane impact risk. They are awarded based on the reduction in future losses that the project is estimated to yield. Local governments compete for these grants by demonstrating a need and plan for mitigating the hazards that they face from natural disasters. FEMA programs are awarded by the state and administered by the Florida Department of Environmental Protection.

Opportunities

Federal grants can provide 75 percent of project costs in most cases, potentially totaling millions of dollars in assistance. Local government staff are generally comfortable applying for grants. However, this may not be as easy for small governments with limited resources.

Challenges

Identifying and applying to federal grants often requires significant staffing resources and there is no guarantee that a jurisdiction will receive funding. Even when a jurisdiction wins a grant, receiving the funds can take a long period of time. Therefore, these grants are only an option for projects that are not time-sensitive.

State Grants

Similar to federal grants, state grants allow local governments to tap into state funds to pay for projects that would otherwise drain local resources. State grants that can support resiliency efforts include the Florida Communities Trust, Florida Forever funds, the Office of Resilience and Coastal Protection's resilience planning grants, and the Adaptation Action Initiative (AAI) grants.[14] Nearly 80 percent of all state revenues come from sales taxes.[15]

Opportunities

As with federal grants, state grants provide local governments an opportunity to invest in infrastructure projects and improvements without footing the entire bill. Counties and municipalities should apply for these grants to fund projects that are not competitive at the national grant level but may be at the state level.

Challenges

State grants restrict spending to certain projects. Furthermore, there is no guarantee that a jurisdiction will receive funding and once a grant is awarded it may take a long time to receive the funds from the state agency. Therefore, these grants are only an option for projects that are not time-sensitive.

[14] Florida Department of Environmental Protection. "Funding Opportunities."
[15] Florida Policy Institute. "A Citizen's Guide to the Budget."

Creative Financing Models

Green/Climate Bonds

Green/climate bonds are structurally similar to GO bonds. They are backed by the taxing authority of the municipality. Public authorities are typically only limited in the amount of debt they can issue by their debt ceiling and credit rating. A total of $389 billion in green bonds were issued in 2018.[16] The first green bond in Florida was a $924 million issuance by the Greater Orlando Aviation Authority in 2017.

KEY TAKEAWAYS

- High administrative burden without proven reduction in interest rates
- May be an attractive debt-based financing option in the future

Opportunities

Green/climate bonds have the potential to provide substantial revenue and the issuance of these bonds is relatively straightforward. They can be helpful for marketing projects to investors and the public as "green" initiatives, improving the city's image and reputation.

Challenges

Green bond issuance requires certification from a third-party rating agency, which adds to the cost of capital. The certification is essentially a marketing tool that helps sell the bond to those who are interested in green investments. To maintain the certification, the borrowers must update investors every year with details, which includes confirming that the value of the project remains at least as high as the amount of debt sold.

Theoretically, the green rating allows these bonds to be sold at a lower yield than traditional municipal bonds, but so far there is no indication that investors are willing to accept a lower yield.[17] This may change in the future as more international investors are required to invest a certain percentage of their funds in responsible investments, increasing the demand for green bonds.

The feasibility of this financing mechanism is largely project dependent. Because a referendum with a majority vote is required to approve the issuance of the bond, only issuances that will finance projects that have public support will be approved.

Ideal Uses

- A bundle of green infrastructure projects that together have wide popular support. Determine the project list the bond will fund before taking it to the ballot.

[16] Climate Bonds Initiative. "Bonds and Climate Change: The State of the Market 2018." September 2018, (3).
[17] Brian Chappatta. "Green-Bond Market Needs to Get Tough to Blossom." Bloomberg. July 18, 2018.

Tax Increment Financing (TIF)

TIF raises revenue by setting aside any property tax revenue increases within the geographic boundaries of the TIF district for a particular use or purpose. The TIF, or "land value capture," district can issue debt backed by projected increases in property values. Therefore, this is both a funding *and* financing model. The theory behind the model is that projects funded by TIF should increase property values in the district, raising property tax revenues, which, in turn, pay for the incurred debt service. TIF is generally used to channel funding toward improvements in distressed or underdeveloped areas where development would not otherwise occur.[18]

KEY TAKEAWAYS

- TIF earmarks incremental property tax revenues for reinvestment within a district
- TIF typically finances streetscaping projects, but could be used for projects that improve resilience

Opportunities

TIF programs are relatively east to implement, especially in already-existing business improvement districts. TIF is already widely used throughout Florida to fund streetscaping efforts but could also be used to finance capital projects, including stormwater management improvements that boost resilience in a specific district.

Challenges

TIF only works in areas where property values are rising or are likely to rise with infrastructure improvements, which may not be the case in many of the areas that are most vulnerable to climate change. Furthermore, the stream of generated revenues (i.e., increased property tax revenue) is uncertain because property values could fall, particularly in areas that are most vulnerable to climate change. Some residents may oppose the program because it may lead to higher property tax rates, which may make the model difficult to implement because it requires a vote. Finally, because TIF earmarks property tax revenue for a specific use, it diverts money from the jurisdiction's general fund.

TIF can lead to "climate gentrification," whereby long-time residents are pushed out of areas that become too expensive. Improvements in the district drive property values up, which may shift the demographic mix of the neighborhood over time. This is a particular problem in Florida, where TIF districts are often designed to attract wealthy, out-of-state residents. These districts must be designated carefully to ensure that benefits are realized for current residents without exacerbating housing unaffordability.

Ideal Uses

- Infrastructure that can directly improve property values, such as parks, bioswales, curb cuts, or seawalls.

[18] Council of Development Finance Agencies. "Tax Increment Finance Resource Center."

Public Private Partnerships (P3s)

A P3 is an agreement between a public and private entity in which the private entity agrees to renovate, construct, finance, operate, maintain, and/or manage a facility or system.[19] The core structural difference between a P3 and a traditional "design-bid-build" contract is the integration of the entities responsible for design and construction, known as a "design-build" model. A successful example of a P3 in Florida is the Port*Miami* Tunnel, a "design-build-finance-operate-maintain" (DBFOM) project completed in 2014.[20] This massive transportation initiative required a joint concessions agreement and cost share between the private sector, Florida Department of Transportation (FDOT), Miami-Dade County, and the City of Miami.

KEY TAKEAWAYS

- Private sector has a higher cost of capital than public authorities
- Contracts are difficult to design and negotiate

Opportunities

P3s shift risk to the private sector, which can often manage it more cost effectively, creating value for taxpayers by lowering long-term project costs, improving the quality of services, or both.[21] P3s can also reduce or eliminate the need for governments to provide upfront capital, which can make projects in cash-strapped jurisdictions possible. Furthermore, tasking one entity with both construction and operation yields efficiencies. Finally, P3s have demonstrated compelling on-time, on-budget deliveries and projects that are innovative or outside the core competency of the public authority's engineering capacity can benefit from specialized private expertise.

Challenges

Private entities may be willing to finance the project only if the project is able to generate a suitable revenue stream, which precludes many types of projects. Furthermore, the government typically has access to cheaper capital than does the private sector because it can issue tax-exempt bonds. Although, some projects will be eligible for tax-exempt private activity bonds. P3s require coordination between all the authorities whose boundaries the project crosses, which can be a barrier for large-scale projects. Finally, this financing model has a higher administrative cost since substantial know-how is necessary to negotiate a P3 contract. This may be difficult for local jurisdictions, particularly smaller ones, to navigate.[22]

Ideal Uses

- Infrastructure projects with substantial revenue streams, including water and sewer projects or raised roads with tolls.

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[19] The Associated General Contractors of America.

[20] Port of Miami Tunnel. "Project Overview."

[21] U.S. Treasury. "Expanding our Nation's Infrastructure through Innovative Financing."

[22] www.P3Guide.com is a tool that can help determine if a public-private partnership an appropriate model for a particular project. Developed by a principal shareholder at Greenberg Traurig, P.A., and researchers at the Harvard Kennedy School, the website provides information on P3 contract models and a decision tool that makes a recommendation based on a project's technical, financial, legislative, and political characteristics.

Collaborative Revenue Bonds (CRBs)

Collaborative revenue bonds finance resilience measures with capital from private investors who are paid back by stakeholders who benefit from the projects. Resilience measures often pay for themselves, but the benefits may be spread over a number of entities in the form of insurance premium savings, credit rating improvements, cost savings, revenue from user fees, etc. In this model, the public entities that benefit financially from the project pay for the debt service, though they may not be the entity that is legally allowed to construct the project.

KEY TAKEAWAYS

- CRBs set up a cost-sharing agreement across multiple entities that benefit from a project
- CRBs require economic, social, and environmental benefit valuation

In 2017, a "Forest Resilience Bond," an example of a CBR, was issued to improve forestry management in Tahoe National Forest.[23] Collaborators include the U.S. Forest Service (benefiting from a decreased risk of severe fire), electric utilities (benefitting from increased hydroelectricity generation, avoided sedimentation, and protected infrastructure), water utilities (benefitting from protected water quality, improved water volumes, and avoided infrastructure investments), and state and local governments (benefiting from avoided fire suppression costs, avoided carbon emissions, protected communities, and job creation). The structure of this bond is shown in **Figure 2** on the next page. The first image shows the structure of the financial transactions while the image below details the process for setting up a the CRB.

The financial structure has three main steps:

1. Measure benefits, called "co-benefits," conferred by the project
2. Create a contract that converts realized benefits into payments from beneficiaries
3. Structure the beneficiary payments into cash flows for investors

Opportunities

Resilience measures often pay for themselves, but the benefits may be spread over a number of entities. Resilience bonds allow projects to proceed so long as the total benefits outweigh the costs, even if the benefits to any one entity do not exceed the cost of the project.

Challenges

CRBs require collaboration between local governments, financiers, legal experts, and utility authorities, who may have little prior experience working together. The creation of a regional Resilience Bond Authority may help.

Ideal Uses

- Infrastructure projects that deliver benefits to a number of public entities.

[23] Blue Forest Conservation. "Fighting Fire with Finance: A Roadmap for Collective Action."

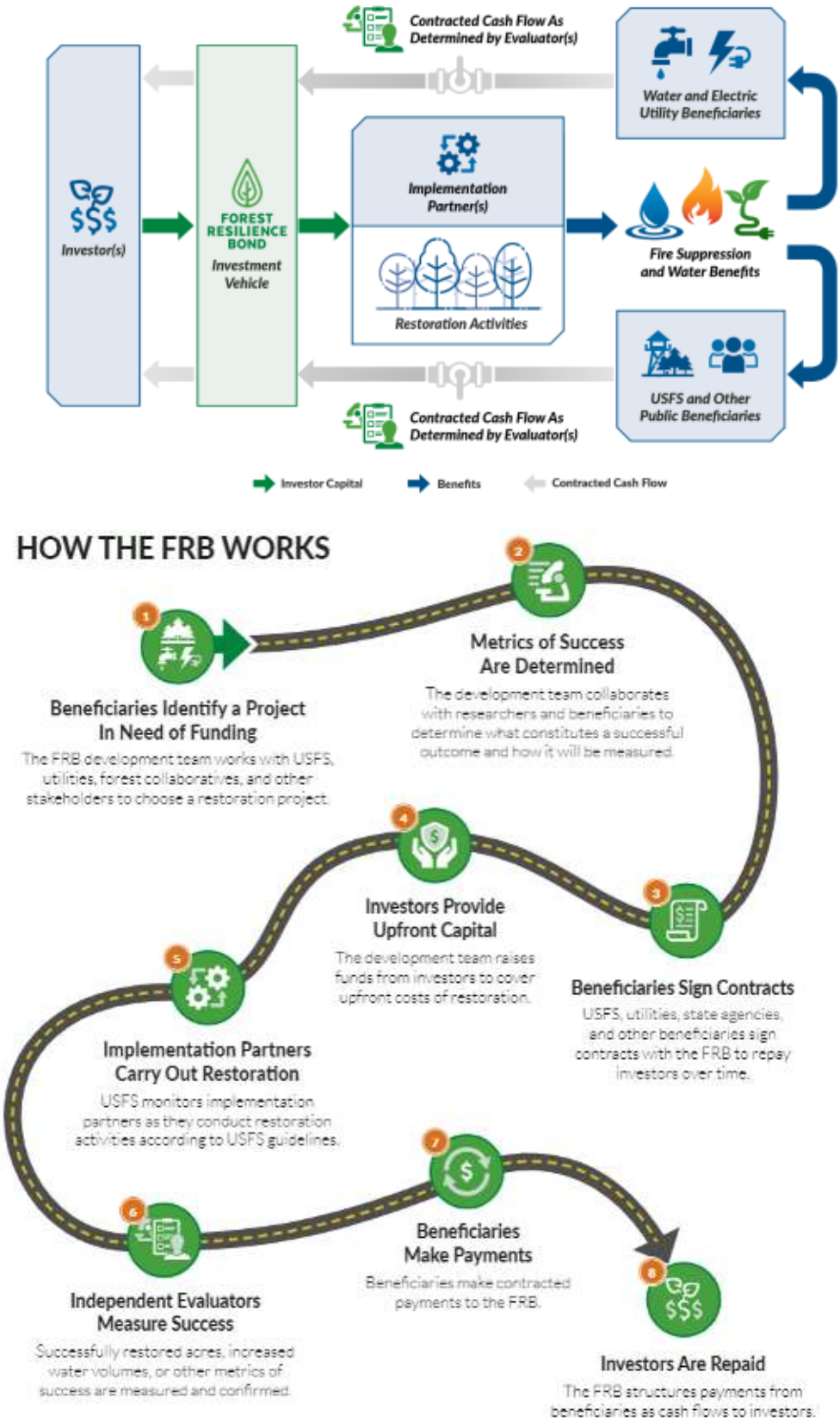

Figure 2. *Structure of the Forest Resilience Bond*, Source: Blue Forest Conservation

Event-Based Insurance

Parametric, or "event-based," insurance does not indemnify a specific asset as traditional insurance would; it insures against an event or an outcome, such as wind speed, wave height, barometric pressure, wildfire, etc.[24] The trigger point, or the event that needs to occur for the insurer to pay, is specified as the point that natural or infrastructural asset begins to break down.

KEY TAKEAWAYS

- Provides immediate and flexible recovery funds after a disruption event
- Must prove economic stake in the assets

An example of insuring natural assets using this concept is the Coastal Zone Management Trust, created by the Quintana Roo state government in Mexico in 2018 to insure coral reefs off the Yucatan Peninsula. The Nature Conservancy showed that coral reefs can absorb 97 percent of the impact of storm surges but will lose 20 to 60 percent of live coral after a Category 5 hurricane and require restoration to provide future protection for coastal structures.[25]

Opportunities

At the end of the day, local governments are concerned with the probability of an extreme weather event that compromises their infrastructure or decimates their barrier ecosystems. The benefit of event-based insurance is the immediacy and flexibility of the proceeds. Insuring against an event instead of insuring specific assets, such as buildings, allows the authority to use the payouts after an event where they are the most needed. Unlike traditional insurance, the insured party gets the money immediately without having to prove the value of its incurred losses. If affordability is a problem, a higher deductible or trigger point could be selected.

Challenges

Insuring natural assets is possible with parametric insurance, but the party paying for the insurance needs to have a vested interest in that natural asset. To create the governance structure around the policy, the risk and economic value must be assigned to one actor who benefits from the asset and, therefore, should pay for the insurance. For example, because coral reefs, barrier islands, and beaches are the lifeblood of Florida's tourist economy, Florida's government has billions of dollars of vested interest in these natural systems. The benefit valuation methodology for green infrastructure that is detailed in **Section IV: Evaluating Investment Options** is an important component of securing this financing method.

Ideal Uses

For an event to be insurable, it must have a known probability of occurring and occur randomly. Possible uses of event-based insurance in Florida include insuring against:

- Erosion / barrier island beach restoration
- Coral bleaching
- Mangrove restoration after storms
- Pollution and red tide

[24] Interview with Alex Kaplan, SVP Global Partnerships at Swiss Re.

[25] Hares, Sophia. "Mexican coral reef and beach get unique insurance policy against hurricane damage." Reuters, March 8, 2018.

Regional Resilience Trust Funds

Regional resilience trust funds are funds, stewarded by political appointees, that can issue loans or grants to pay for infrastructure projects that mitigate climate risk. They can be initially be capitalized with a real estate transfer tax, a surcharge on property and casualty insurance, or some other funding mechanism, but, over time, they become self-sustaining.[26] Those who steward the fund work to finance capital projects that benefit the region.

KEY TAKEAWAYS

- Provides self-sustaining source of capital for projects
- Allows for a regional approach to resiliency

A version of this idea, called the Florida Future Fund, has already been proposed in Florida.[27] It has been pitched as a state revolving loan fund that will provide capital for innovative energy, transportation, flood protection, and other neighborhood projects designed to reduce carbon emissions and withstand sea-level rise and more extreme weather. It could initially be funded by the state legislature through bonds, an appropriation, an expansion of stamp tax on real estate, or an electricity utility surcharge.

Opportunities

These funds are become self-sustaining so after the initial funding, no public dollars are necessary. They also can provide a substantial amount of capital for large infrastructure projects. Cities and other public authorities could then apply to the fund in a similar way that water management authorities can apply to the clean water revolving loan fund, also known as WIFIA. And, the fund could provide access to capital for distributed infrastructure. Property owners could apply to use to funds for first floor retrofits, home elevations, on-site water management practices, such as cisterns, rain gardens, or permeable surfaces, etc. Tying these projects to the property deed would allow the loan to transferred to a new owner, similar to a property-assessed resilience method tied to a mortgage.[28]

Challenges

This model requires establishing a regional entity, which may entail legal and governance challenges in Florida. The trust fund needs to be operated independently with a mandate authorized by participating jurisdictions. Substantial negotiation between interested governments may be necessary to get this option off the ground. There may also be a collective action problem because those who fund the trust are not guaranteed a proportionate benefit. The funds will be generated from all participating jurisdictions and may be used to improve resilience in some areas more than others, creating fairness concerns.

[26] Keenan, Jesse. "Climate Adaptation Finance and Investments in California."
[27] Cathlene Kelly and Miranda Peterson. "Florida Future Fund: Accelerating Investment in Resilient Infrastructure and Communities." Center for American Progress. April 12, 2018.
[28] Miami Beach Rising Above. "Miami-Beach ULI Panel Report."

Creative Funding Models

Carbon Offset Markets

A carbon offset represents one metric ton of avoided carbon dioxide emissions and can be purchased to offset an equivalent amount of greenhouse gas emissions elsewhere in the world. For instance, to offset some or all of its own emissions, a firm can purchase carbon offsets generated from, for example, a reforestation project that sequesters carbon.

KEY TAKEAWAY

- Revenue is likely insufficient to cover the cost of wetland restoration

There are two types of offset markets: compliance and voluntary. Compliance markets exist to help firms meet government-mandated emissions limits. In California, for instance, regulated entities can, as part of the Compliance Offset Program, purchase offsets to satisfy a portion of their emissions reduction obligations under the state's cap-and-trade program.[29] Compliance markets are governed by rules established by regulators about what types of offsets are permitted and with what rigor they must prove to be included in the market. In practice, compliance markets function like commodity markets: "there is little differentiation between products" and "trading occurs to favor the lowest price."[30] As a result, prices are generally predictable, but vary by market.[31]

Organizations that voluntary purchase carbon offset credits to meet internal climate goals, demonstrate corporate social responsibility, generate publicity, etc., do so through voluntary markets. There are no rules by which these markets must abide, though most "follow rules prescribed by one of a handful of voluntary standard bodies."[32] The price of offsets in voluntary markets is difficult to predict. The demand for offsets in these markets is inherently variable and uncertain and prices vary substantially based on the offset's perceived quality, value, and fit with buyer desire for project type, location, or other factors.[33] For instance, organizations often prefer to purchase offsets generated by nearby projects with "easily communicated social or environmental outcomes beyond carbon reductions."[34] Offsets with those characteristics can fetch a higher price.

Opportunities

[29] "The Role of Offsets in California's Cap-and-Trade Regulation: Frequently Asked Questions." Environmental Defense Fund. April 2002.
[30] Hamrick and Gallant. "Unlocking Potential: State of the Voluntary Carbon Markets 2017." Ecosystem Marketplace. May 2017, (8).
[31] "Carbon Market Opportunities for Louisiana's Coastal Wetlands." Tierra Resources and the Climate Trust. 2014, (25).
[32] Hamrick and Gallant. "Unlocking Potential: State of the Voluntary Carbon Markets 2017." Ecosystem Marketplace. May 2017, (1).
[33] "Carbon Market Opportunities for Louisiana's Coastal Wetlands." Tierra Resources and the Climate Trust. 2014, (20).
[34] Ibid., 25.

Florida's natural coastline and estuary system, salt marshes, seagrasses and mangroves, protect communities from storms, sea level rise, and erosion.[35] These ecosystems also capture and store carbon dioxide, often called "blue carbon" once sequestered. In fact, compared to other vegetation, mangroves store a large amount of carbon per acre and have a high market potential.[36] Connecting these benefits presents an opportunity: municipal and county governments can invest in restoration projects along the coast that both mitigate the impacts of climate change by restoring degraded barrier ecosystems and generate revenue through the sale of carbon offsets.

There is precedent for this type of arrangement. Projects have been proposed or completed in the Dominican Republic, Senegal, Madagascar, and Louisiana. The strategy is most common in developing countries under the Kyoto Protocol's Clean Development Mechanism, which cannot be used in Florida. However, projects like Apple's 30,000-acre mangrove restoration effort in Colombia could be replicated in Florida.[37]

Challenges

There are a number of financial challenges with this model. Offsets from coastal restoration projects are not yet allowed in any compliance markets, so municipalities would have to rely on revenues from voluntary markets, which are less lucrative and more unpredictable. As outlined in **Appendix 7: Estimating Carbon Offset Revenue for Mangrove Planting,** optimistically, revenue may reach $600 per acre of restored mangroves. If the project also protects existing mangroves, additional credits could be sold for the protected area for roughly $1,000 per acre.

Even if these generous assumptions hold, revenue from carbon markets would likely be insufficient to fund a substantial portion of current of future restoration projects. The cost of wetland restoration alone is between $20,000 and $150,000 per acre.[38] Municipalities would also be required to incur additional costs to (1) demonstrate that the emissions reductions are "additional," or that they would not have occurred absent the project, and (2) verify that the reductions materialize. According to the Carbon Market Opportunities for Louisiana's Coastal Wetlands report, the "costs of developing and reporting of a carbon project can be substantial, often in excess of $200,000 in initial development costs before offsets can be sold." Also, long-term monitoring in wetlands can be prohibitively expensive because wetland GHG emissions can vary greatly depending on the season and hydrologic site conditions. It is possible that the cost of monitoring alone exceeds the value of the carbon.

Ideal Uses

- Projects with substantial carbon sequestration potential, including mangrove planting and restoration, living shorelines, and wetland restoration

[35] Herr, et al. "Coastal 'blue' carbon. A revised guide to supporting coastal wetland programs and projects using climate finance and other financial mechanisms." IUCN. 2015, (12).
[36] Nick Davidson. "Achieving Carbon Offsets through Mangroves and Other Wetlands: November 2009 Expert Workshop Meeting Report" Danone Fund for Nature. 2010, (21).
[37] "A Critical Investment in 'Blue Carbon.'" Conservation International.
[38] "Carbon Market Opportunities for Louisiana's Coastal Wetlands." Tierra Resources and the Climate Trust. 2014, (27).

Mitigation Banking

Both the federal Clean Water Act and Florida state statute require that any adverse impacts to wetlands be offset through a process called "compensatory mitigation." The intent of the laws is to ensure that the degradation of "wetlands, streams or other aquatic resources" is offset by "the restoration, establishment, enhancement, or…preservation" of similar ecosystems elsewhere.[39]

KEY TAKEAWAYS

- Allows municipalities to receive compensation for investing in wetland restoration
- Financial and ecological challenges

Mitigation banking is a common form of compensatory mitigation. It entails developing a mitigation project (e.g., wetland restoration or enhancement) and setting it aside to compensate for future conversions of wetlands for development activities.[40] Following the completion of the project, credits are generated and then purchased by permittees to compensate for impacts associated with projects in the same watershed. Public, private, and non-profit organizations can participate in mitigation banking (Ibid) and projects can be sited on public or private lands.[41]

Opportunities

Local governments and water districts can invest in green infrastructure projects that provide, for instance, both stormwater management services and generate mitigation credits. The price of a credit is driven by the market and varies from one region of the state to another, but the revenue from these projects could be substantial. Today, credits are available in the Panhandle for roughly $30,000 to $60,000 and, in South Florida, for $100,000 to $130,000.

Challenges

A number of factors may prevent local governments from leveraging mitigation banking to develop substantial green infrastructure projects. First, Florida statue limits water management districts and local governments to selling credits only to single family homes, not larger developers, significantly reducing the size of the market. Secondly, projects on "sovereign" land—that which is owned by the state—are not eligible for credits. The state owns much of the land along the coast up to the mean high-water line;[42] therefore, local government mitigation banking is not allowed on much of the land where coastal resiliency projects (mangrove restoration, sea grass planting, etc.) would take place. Finally, credits are not a predictable source of revenue; credit demand, and therefore price, could drop drastically during economic downturns, as in 2008.

There are also ecological concerns. Wetlands provide ecosystem services; "banking facilitates the redistribution of [both] wetland resources from urban to rural areas" and "the important

[39] "Wetlands Compensatory Mitigation." Environmental Protection Agency. 2015, (1).
[40] Ibid., 2.
[41] 40 CFR Ch. I § 230.93(a)(3)
[42] "Sovereign Submerged Lands (SSL) - Proprietary Authority versus Regulatory Authority in Chapter 18-21, F.A.C." Florida Department of Environmental Protection.

ecosystem service values [that they provide] provide to human communities."[43] Similarly, because "wetlands within banks tend to be larger and...less diverse in type than the wetlands that are lost," some argue that mitigation banking does not offset aquatic degradation from development.[44] Finally, Florida's credit calculation methodology "does not consider ecosystem service impacts" (Ruhl). As a result, mitigation banking may result in a net loss of ecosystem services. Given these concerns, local governments and water districts may elect not to participate in the program.

Ideal Uses

- Wetland restoration and other green infrastructure projects that incorporate the establishment or restoration of wetland ecosystems

Transfer of Development Rights (TDR)

TDR programs encourage land preservation in one area and development in another. County and local governments typically use zoning ordinances to "establish the allowable uses on particular parcels of land and the intensity of those uses".[45] TDR, which is implemented at the county or local level, allows landowners in a designated location to sell the development rights associated with their property to landowners in another designated location. Those who sell their development rights are restricted from developing their land, usually by means of a conservation easement or restrictive covenant, while landowners who purchase the rights are allowed to develop their property more intensively than allowed by baseline zoning.[46]

KEY TAKEAWAYS

- TDR shifts development from one location to another
- These programs can be difficult to design and do not always result in substantial land preservation

The sending site is an area designated by the government for conservation. Those who own property in the site can become senders, or landowners who sell the right to build more densely or intensely to those who live in the government-designated "receiving area," where development is deemed desirable.

TDR programs are common in Florida. A 2014 study found that 20 counties in the state have a combined 31 programs.[47] For instance, "the City of Miami authorizes a TDR program for historic

[43] Ruhl and Salzman. "The Effects of Wetland Mitigation Banking on People." National Wetlands Newsletter, Volume 28, Number 2. March-April 2006, (1).
[44] Gordon Steinhoff. "Wetlands Mitigation Banking and the Problem of Consolidation." Electronic Green Journal, 1(27). 2008, (1).
[45] Walls and McConnell. "Transfer of Development Rights in U.S. Communities." Resources for the Future. September 2007, (8).
[46] Ibid.
[47] Linkous and Chapin. "TDR Program Performance in Florida." Journal of the American Planning Association, 80:3, (256).

preservation, and the City of Sunny Isles has a program established to enable the acquisition of park land."[48]

Opportunities

TDR programs have typically been used to shift development from one place to another as a means to protect "wildlife habitat, ecologically sensitive wetlands and stream buffers, forested areas, properties of historical significance, and farmland threatened by development" (ULI). But, TDR projects could also improve coastal resiliency, though "most jurisdictions are still exploring [the concept], and examples of programs with a track record are few" (ULI). A number of jurisdictions on the Atlantic coast, for instance, are considering implementing TDR to "enable managed retreat" from rising sea levels (Ibid, 1) and, in Florida, a TDR program was proposed at the University of Miami's and the Southeast Florida Regional Climate Change Compact's 2016 Resilient Redesign Workshop to encourage managed retreat and green flood mitigation infrastructure (Ibid, 2). In both cases, the proposal entails pushing development away from vulnerable areas where green infrastructure projects could then be deployed (Ibid, 1). Furthermore, TDR programs are often popular because they can operate without the need for public funding and because they are opt-in programs; no one is forced buy or sell development rights.

Challenges

The primary challenge with TDR programs is getting them to work well: they "sound relatively simple on paper…but in practice, they can be quite complicated" (Walls). In general, if local zoning rules have set density limits in receiving areas that reflect the current market demand, there may not be much demand for additional density and thus little demand for TDRs. At the same time, if sending areas have high potential values in development, few properties will be offered to the program even if TDR allocation rates are high, and little land will be preserved (Ibid).

Many of Florida's TDR programs have not been successful because demand for credits is weak. "In 2014, only 17 [of the state's TDR programs] reported transaction activity and just nine protected 1,000 acres or more" (Linkous). A number of factors, including "easier alternative ways for developers to increase density in new projects", are responsible for the weak demand (ULI). A well-designed program can avoid some of these pitfalls, but programs design and administration is difficult.[49] Both credit supply and demand must be sufficient, and the capacity to design a system in which they are balanced is technically challenging, costly, and may be outside of the capacity of a municipal government (Linkous).

Governments can establish a TDR bank to help with credit supply and demand issues. For instance, the TDR program in King County, Washington, one of the most successful to date, relies on a TDR bank, which helped it succeed. The bank is the program's most important feature and

[48] "Exploring Transfer of Development Rights as a Possible Climate Adaptation Strategy: Urban Land Institute Resilience Panel Focus Group with Miami-Dade County" Urban Land Institute, (3).

[49] "Planning Implementation Tools Transfer of Development Rights (TDR)." Center for Land Use Education. November 2005, (3).

allows the government or its delegate to purchase and sells TDR credits, acting as a middleman. It makes the program "more predictable and manageable."[50] Banks are endowed with an initial pot of money to purchase TDRs.[51] In King County, the bank was given an initial $1.5 million appropriation from the county to purchase TDRs. [52] It has since "directly purchased more than two-thirds of the 141,500 acres protected. Although these rights are then offered for sale to developers, the mostly public purchase of development rights demonstrates the limited role of private market transactions in program outcomes."[53]

It also could be the case, though, that the way in which municipalities have developed over time may preclude TDR programs from being successful, regardless of the use of a credit bank or other program designs. "Where considerable sprawl exists within the sending area, as in many waterfront communities, it may be too late for a TDR program to be successful."[54] In addition, "it has been difficult to force additional density into high-density residential areas." Although TDR programs often try to encourage growth in areas that are already dense, "no TDR program is consistently able to do this."[55]

TDR programs face a number of other challenges. They may experience some public opposition, often from those in receiving areas: "it may be difficult to find areas willing to accept higher density development (receiving areas), since it is often perceived that high density development decreases property values and quality of life."[56] At the same time, it may be the case that communities in sending areas experience an exodus. Therefore, local jurisdictions "must also establish policies to help facilitate relocating families in targeted areas to affordable housing, when needed."[57] In addition, the government must also "enforce the program, including overseeing the market, enforcing deed restrictions, and defending them in court."[58] Finally, if the program is across local governments, the program must "contend with tax-base transfer issues."[59]

Ideal Uses

- Projects that incorporate open space and stormwater retention systems

[50] "Planning Implementation Tools Transfer of Development Rights (TDR)." Center for Land Use Education. November 2005, (2).
[51] Linkous, Evangeline. "Transfer of development rights and urban land markets." Environment and Planning A, Vol. 49(5). 2017, (1125).
[52] "Exploring Transfer of Development Rights as a Possible Climate Adaptation Strategy: Urban Land Institute Resilience Panel Focus Group with Miami-Dade County" Urban Land Institute, (8).
[53] Linkous, Evangeline. "Transfer of development rights and urban land markets." Environment and Planning A, Vol. 49(5). 2017, (1125).
[54] "Transferable Development Rights and Density Transfers," (3).
[55] Walls and McConnell. "Transfer of Development Rights in U.S. Communities." Resources for the Future. September 2007, (15).
[56] "Transferable Development Rights and Density Transfers," (3).
[57] "Exploring Transfer of Development Rights as a Possible Climate Adaptation Strategy: Urban Land Institute Resilience Panel Focus Group with Miami-Dade County" Urban Land Institute, (9).
[58] "Transferable Development Rights and Density Transfers," (3).
[59] "Planning Implementation Tools Transfer of Development Rights (TDR)." Center for Land Use Education. November 2005, (3).

Impact Development Fees

Impact development fees are levied by municipal and country governments on new or expanded developments.[60] The revenue generated must be used to pay for capital projects necessitated by the growth.[61] For instance, new residential developments typically increase the number of students in a school district. Public school impact fees levied on new developments can be used to pay for capital projects that increase the capacity of schools in the district.

KEY TAKEAWAYS

- Must only fund projects necessitated by new development
- Internalize externalities by ensuring that investment decisions consider costs imposed on municipalities

These fees are a departure from the traditional local public financing model, "shift[ing] the burden of financing new infrastructure from the community at large to owners of developable land, developers, or buyers of new homes."[62] Across the United States, local and county governments have increasingly used impact fees to fund capital projects.[63] The rationale is that the new developments "not only impose a burden of higher costs but also they reap the benefits of growth," and should, therefore, pay their own way.[64]

Impact fees must pass the "dual rational nexus test," which requires that the fee (1) "offset reasonable needs that are sufficiently attributable to the new development" and (2) be "adequately earmarked for the acquisition of capital assets that will benefit the residents of the new development."[65] In other words, "the cost of new facilities should be borne by new users to the extent new use requires new facilities, but only to that extent."[66] If the capital project was, absent the new development, already required, paying for it through impact fees is prohibited.[67] Under this test, an over 55 adult community, for instance, cannot be assessed a public school impact fees because it imposes no costs on the school district.[68]

Municipalities have not always adhered to these standards, though; some have relied on impact fees to pay for capital projects that were not attributable to new development. For example, in 2007 transportation impact fees made up more than half of the entire city of Pasco's road budget—indicating a heavy reliance on impact fees to sustain basic construction and

[60] The Professional Staff of the Committee on Community Affairs. "The Florida Senate: Bill Analysis and Fiscal Impact Statement (SB 324)." December 1, 2017, (2).
[61] Ibid.
[62] Susan Opp. "Development Impact Fees as Planning Tools and Revenue Generators." Southeast Regional Environmental Finance Center and University of Louisville. 2007, (2).
[63] Ibid, 1.
[64] Ibid, 2.
[65] The Professional Staff of the Committee on Community Affairs. "The Florida Senate: Bill Analysis and Fiscal Impact Statement (SB 324)." December 1, 2017, (3).
[66] Contractors and Builders Association v. City of Dunedin, 329 So. 2d 314 (Fla. 1976).
[67] Nicholas, et al. "Impact Fees in Florida: Their Evolution, Methodology, Current Issues and Comparisons with Other States." September 19, 2005, (6).
[68] The Professional Staff of the Committee on Community Affairs. "The Florida Senate: Bill Analysis and Fiscal Impact Statement (SB 324)." December 1, 2017, (3).

maintenance costs.[69] Similarly, the city council of Zephyrhills, Florida discussed increasing its budget to offset the slowed pace of building in the city because building permit revenue and impact fees for new construction were down, indicating that impact fees were collecting more than just incremental costs.[70]

Opportunities

Impact fees can be used to fund infrastructure projects that mitigate the risks associated with climate change that face new developments. They may not be difficult to implement because Florida has a long history with impact fees; "Broward County assessed the first impact fee in the country in 1977."[71] Furthermore, Impact fees may be popular among current residents—those who vote today—because they "can enjoy the benefits from the construction of new public facilities without paying for them."[72]

Impact fees can raise a substantial amount of revenue. In 2017, 35 counties collected about $629 million in impact fees,[73] 194 cities collected $280 million,[74] and 28 school districts collected $330 million.[75] Between 2004 and 2007, a building boom in Florida, total impact revenues to municipalities, counties, and special districts surpassed $1 billion, and, at its peak, reached $1.4 billion, but dropped below $400 million for four straight years after 2008. In 2015, the average impact fee on a home in Florida was $7,660, down from $9,832 in 2008.[76]

Because impact fees impose costs on new development in proportion to the costs that those developments will impose on the municipality, they internalize a negative externality. As a result, present an opportunity to ensure that costs that would otherwise be socialized are factored into the decision-making process of those who invest in development. Ideally, municipalities would charge impact fees that represent the present value of the future resilience-related costs imposed on the municipality by the development.

Challenges

Although impact fees can raise substantial revenue, because of the dual rational nexus test, they cannot be used to fund infrastructure projects that are necessary irrespective of additional development. Instead, they can only be used to pay for a smaller subset of projects that are necessitated by development, including infrastructure armoring and flood-proofing.[77]

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[69] Susan Opp. "Development Impact Fees as Planning Tools and Revenue Generators." Southeast Regional Environmental Finance Center and University of Louisville. 2007, (7).
[70] Ibid.
[71] Ibid., 1.
[72] Ibid., 3.
[73] "County Revenues: LFY 1993-2017" spreadsheet. Office of Economic & Demographic Research. January 9, 2019.
[74] "Municipal Revenues: LFY 1993-2017" spreadsheet. Office of Economic & Demographic Research. January 9, 2019.
[75] "School District Revenues: SFY 1998-2017" spreadsheet. Office of Economic & Demographic Research. September 28, 2018.
[76] "Overview of Impact Fees and Affordable Housing." Florida Housing Finance Corporation, (2).
[77] "Adaptation Action Areas: Policy Options for Adaptive Planning For Rising Sea Levels." South Florida Regional Planning Council. November 6, 2013, (20).

Furthermore, many municipalities in Florida have reduced, limited, or entirely curtailed certain impact fees.[78]

Some argue that "impact fees constrain local economic development, serving as a de facto 'tax' on capital, stifling investment, and job growth."[79] In 2009, a bill in the Florida legislature to hold impact fees at their current rate for three years was only defeated narrowly.[80] Given this sentiment, some politicians may be opposed to assessing impact fees.

If impact fees are levied as a lump sum on each home or development, they are regressive because "they systematically overcharge purchasers in smaller, less expensive houses or apartments and undercharge others in the most valuable houses."[81] This can and has been addressed by many municipalities by varying impact fees on a number of factors, including the size of the building, number of bedrooms, etc.

Ideal Uses

- Infrastructure projects the mitigate the climate risks faced by new developments

Non-Ad Valorem Special Assessments

KEY TAKEAWAYS

- Special assessments are levied on property owners to fund investments that benefit those properties
- Can raise substantial revenue

Non-ad valorem special assessments are charges levied on property owners by local and county governments. These are "normally billed annually as a separate line item on the property tax bill," but are distinct from a property tax in two ways.[82] First, the revenue raised must be used to provide a benefit to the property, rather than a general benefit to the community. Second, the assessments must be levied not based on the value of the property but based on the benefit that the property receives.[83] Non-ad valorem special assessments include "fire and rescue, solid waste, navigable waterways, and stormwater utility collections."[84]

Chapter 170.201 of the Florida Statues "provide[s] broad authority to local governments to levy special assessments." The assessments have been used to fund stormwater, water supply and desalination, and sea wall construction and repair projects,[85] and in some projects that address

[78] Mullen and Nicholas. "Impact Fee Reductions and Development Activity: A Quantitative Analysis of Florida Counties." Presentation at the annual conference of the Growth and Infrastructure Consortium.
[79] Susan Opp. "Development Impact Fees as Planning Tools and Revenue Generators." Southeast Regional Environmental Finance Center and University of Louisville. 2007, (3).
[80] Clancy Mullen. "State Impact Fee Enabling Acts." www.impactfees.com. January, 3 2015, (16).
[81] "Overview of Impact Fees and Affordable Housing." Florida Housing Finance Corporation, (3).
[82] "Non-Ad Valorem Special Assessments for Funding Solid Waste Management Systems." SCS Engineers.
[83] Ibid.
[84] "Non-Ad Valorem & Special Assessment Districts." Sarasota County Property Appraiser.
[85] Corbett, Koslowe, and Lopez. "Sea level rise adaptation: Funding sources." The Reporter: The Environmental and Land Use Law Section, Vol. XXXIV, No. 8. June 2017, (11).

sea level rise specifically, including raising streets and bridges.[86] Just as with other states, local and county governments in Florida "must determine that the property upon which the assessment is levied receives an ascertainable 'special and peculiar benefit'" and the assessment that is levied must be "based upon fair and reasonable apportionment of the burden to pay."[87]

Opportunities

Non-ad valorem special assessments have the potential to fund large infrastructure projects because (1) "they are not subject to the millage limitations set forth in the Florida Constitution" so municipalities can raise substantial revenues from these assessments,[88] (2) collection rates are very high because the charges are included in property tax bills, and (3) the revenues from the program are stable so local governments can predict future revenues.[89]

A number of special benefits to properties have been recognized, including "actual and potential added use and enjoyment of the property" as well as "decreases in insurance premiums, increases in rental value, enhanced protection of public safety, and enhancement in the value of business property."[90] "Courts have held that the special benefits need not be either direct to the property or immediate."[91] Given these broad views, fees that fund investments that improve resiliency would likely be approved.

Often, a property's front-footage or surface area is used to calculate the charge.[92] In addressing sea level rise, "it may be that new ways of assessing property based on special benefits could be developed. For example, if a pumped drainage system benefits an entire area but has more benefit to the lowest-lying properties, it might be possible to incorporate elevation as one of the elements that helps apportion assessments among properties."[93]

Challenges

Non-ad valorem special assessments face a number of challenges as well. First, they must be voted for and will likely be perceived by the public as a tax. Another concern is climate gentrification. If high assessments are imposed in particular areas, they may cause those residents with fewer resources to leave the area. Finally, if the project fails to deliver the expected benefits, those who pay the assessment can question its legality.

Ideal Uses

- Any resilience measures that benefit properties in a special assessment district

[86] Ibid.
[87] Van Assenderp and Solis. "Dispelling the Myths: Florida's Non-Ad Valorem Special Assessments Law." Florida State University Law Review, Volume 20, Issue 4. Spring 1993, (853).
[88] Ruppert and Stewart. "Sea-Level Rise Adaptation Financing at the Local Level in Florida." Houston Endowment. October 2015, (10).
[89] "Non-Ad Valorem Special Assessments for Funding Solid Waste Management Systems." SCS Engineers.
[90] Van Assenderp and Solis. "Dispelling the Myths: Florida's Non-Ad Valorem Special Assessments Law." Florida State University Law Review, Volume 20, Issue 4. Spring 1993, (855).
[91] Ibid.
[92] Ruppert and Stewart. "Sea-Level Rise Adaptation Financing at the Local Level in Florida." Houston Endowment. October 2015, (10).
[93] Ibid.

Local Infrastructure Sales Surtax

State and local sales taxes on goods are common across the country. Forty-five states impose sales taxes and 33 states collect sales taxes at the local level.[94] The states with the highest combined taxes collect roughly nine or ten percent.[95]

KEY TAKEAWAYS

- A sales surtax can raise a substantial amount of revenue
- Requires a referendum

Florida has both a statewide sales tax and local sales taxes. Chapter 212.055 of the Florida Statues allows local governments to impose several "discretionary sales surtaxes," including up to a one percent regional transportation surtax and a half or one percent infrastructure surtax. The regional transportation tax must be voted on and can be used to pay for, among other things, roads and bridges. In 2018, Hillsborough County passed a one percent surtax to fund transportation infrastructure projects.

The infrastructure surtax must be enacted "pursuant to ordinance enacted by a majority of the members of the county governing authority and approved by a majority of the electors of the county voting in a referendum."[96] The funds can be used "to finance, plan, and construct infrastructure" and "to acquire any interest in land for public recreation, conservation, or protection of natural resources."[97]

Opportunities

Local governments can use infrastructure surtaxes to pay for resilient infrastructure projects. Surtaxes can raise a substantial amount of revenue because the base is broad: taxable sales in Florida topped $390 billion in 2018.[98]

Challenges

The major challenge with a surtax is receiving a sufficient number of votes to pass the measure.

Ideal Uses

- Large-scale infrastructure projects with resilient design features

[94] Walczak and Drenkard. "State and Local Sales Tax Rates 2018." The Tax Foundation. February 13, 2018.
[95] Ibid.
[96] F.S. 212.055 2(a)(1)
[97] F.S. 212.055 2(d)
[98] "Gross, Taxable, and State Sales & Use Tax Collections by County: SFY 1990-2018" spreadsheet. Office of Economic & Demographic Research. October 2, 2018.

III. Recommendations

This section uses four criteria to evaluate the 15 funding and financing models detailed in **Section II: Funding and Financing Models**, identifies the top four models, and provides ideal use case examples.

Evaluation of Funding and Financing Models

The funding and financing models are evaluated on four criteria: (1) the potential to generate revenue/attract capital, (2) feasibility, (3) fairness, and (4) equity. Each of these criteria is described below.

1. **Potential to generate revenue/attract capital:** Does the model raise sufficient revenue or attract sufficient capital to pay for large-scale investment projects? For those models that generate infrastructure projects through some mechanism other than revenue/capital, are those projects large or small?
2. **Feasibility**: How easily can the model be implemented? Are there technical challenges that could limit the model's feasibility? Is it difficult politically to implement the model?
3. **Fairness/Efficiency**: Does the funding or financing model ensure that those who benefit from investments also bear the associated costs? Are externalities internalized?
4. **Equity**: Does the cost burden reflect ability to pay? Do the resulting projects exacerbate inequalities?[99]

Each model is graded on these four criteria in **Table 1**. A more detailed comparison of the models is included in **Appendix 5: Evaluation of Funding and Financing Models**. Given the results of the comparison below, the following four following models stand out as most promising:

1. **Impact Development Fees**
2. **Non-ad Valorem Special Assessments**
3. **Collaborative Revenue Bonds**
4. **Regional Resilience Trust Fund**

Although these models have some particularly appealing characteristics, they are not appropriate for all infrastructure investments. A full suite of funding and financing options should be considered for any project and the right model selected based on its unique characteristics.

[99] Levy. "Financing Climate Resilience: Sustainable Solutions Lab Mobilizing Resources and Incentives to Protect Boston from Climate Risks." Sustainable Solutions Lab, University of Massachusetts Boston. April 2018.

Table 1. *Evaluation of Funding and Financing Alternatives Summary*

	Potential to Generate Revenue and Attract Capital	Technical and Political Feasibility	Fairness and Efficiency	Equity
GO Bonds	High	Medium	Low	Low
Revenue Bonds	High	Medium	High	Low
Federal Grants	Medium	Medium	Low	Medium
State Grants	Medium	Medium	Low	Low
Green/Climate Bonds	Medium	High	Low	Low
TIF	Medium	High	High	Low
P3s	High	Medium	High	Low
CRBs	High	Medium	High	High
Event-Based Insurance	Medium	Medium	Medium	Medium
Regional Resilience Trust Funds	High	Medium	Medium	High
Carbon Offset Markets	Low	Medium	Medium	High
Mitigation Banking	Low	Medium	High	High
TDR	Medium	Low	Medium	Medium
Impact Development Fees	High	Medium	High	Medium
Non-Ad Valorem Special Assessments	High	Medium	High	Medium
Local Infrastructure Sales Surtax	High	Medium	Low	Low

Combining Funding and Financing Models: Ideas for Best Practices

Funding and/or financing models can be combined in a number of ways. For instance, funding and financing models are often used in tandem; the funding model raises revenue that is used to pay the debt service associated with the financing model. In addition, two funding models, for instance, can be combined to fund an infrastructure project in a way their compliments their strengths and mitigates their weaknesses. The following "best practices" are examples of combinations of funding and/or financing models that work particularly well together.

Impact Development Fees and Non-Ad Valorem Special Assessments

Impact development fees collect costs imposed by new development and non-ad valorem special assessments can collect costs imposed by existing development. Together, these two funding models can provide capital for projects the mitigate the risks to all development, both new and existing. Leveraging these funding mechanisms would ensure that no development is overlooked. Projects funded by these two models should improve the resilience of the geographic areas that provide the funds. Road elevations, storm drain valves and other sewer retrofits, urban vegetation and green infrastructure, and sea walls or living shorelines could all be funded with these models.

A Regional Resilience Trust Fund and Collaborative Revenue Bonds

A Resilience Trust Fund can serve as a conduit for investments in projects that have substantial co-benefits. For instance, a collaborative revenue bond may finance the reconstruction of a stormwater management system, which would lower pollution clean-up costs for the city by reducing stormwater volume and improving water quality. The regional resilience trust fund could provide a portion of the capital for the project if operational savings that accrue to the water management authority and Department of Public Works alone are insufficient to cover the debt service.

GO bonds and Land Conservation

Local governments may also choose to employ a funding or financing mechanism that is not identified in this report as most promising. For example, GO bonds scored low on the fairness and equity criteria because, in general, they leverage property taxes and other broad-based, regressive sources of revenue. Nonetheless, GO Bonds could be used by a local authority in combination with grants to pay for land conservation initiatives. In some cases, the debt service from these bonds could be partially or fully paid for by the benefits of open space in urban areas, ecosystem services, or forestry opportunities, reducing fairness and equity concerns. Some examples of revenue streams that can be used to pay the debt service on bonds that back conservation or other ecosystem restoration projects can be found in **Table 2** below.[100]

[100] Mansfield duPont, Levitt, and Bilmes. "Green Bonds and Land Conservation: A New Investment Landscape?" Stanford Social Innovation Review, December 2, 2016.

Table 2, *Revenue streams for land conservation*, Source: Stanford Social Innovation Review.

REVENUE TYPE	DESCRIPTION	EXAMPLES
1) Sustainable Commodity Production	Commodities produced on the land that are sold	Agricultural products, timber, fisheries
2) Recreation and Ecotourism	Revenue generated from recreational users or tourists through entrance fees, permits, or concessions	Recreational fees, ecotourism concessions
3) Tax Revenues	Tax and regulatory frameworks that provide sustainable land use and conservation projects with quantifiable tax benefits	TIF, real estate transfer taxes, payments in lieu of taxes (PILOTs), linkage fees
4) Credits for Ecosystems Services	Value of environmental services or resources in markets where these services or resources have agreed-upon prices	Water credits, stormwater management credits, carbon credits, river quality credits
5) Risk Mitigation and Avoided Costs	Projects whose environmental benefits help the borrower avoid costs that would otherwise be incurred	Municipality or corporation weighing costs of green vs. grey infrastructure investment, e.g. riverside land conservation to reduce the need for downstream water treatment investment

IV. Evaluating Investment Options

This report focuses primarily on identifying funding and financing models that can help municipalities pay for infrastructure projects that mitigate climate-related risk, which is step 4 in **Figure 1**. But, interviews with experts uncovered another need: better understanding how to select projects, or step 3 in **Figure 1**. This section of the report aims to partially fill that need by proposing a **total cost-benefit analysis** methodology that can help with project selection.

Figure 1*: Pathway to a Resilient Infrastructure Program*

Local governments should select projects that maximize return on investment but, in doing that calculation, should consider all economic, social, and environmental costs and benefits. This section outlines how local governments can quantify these values using a total cost-benefit analysis. The analysis entails a lifecycle cost analysis and a benefits valuation. A total cost-benefit analysis is similar to typical cost-benefit analysis but attempts to monetize typically unquantified social and environmental costs and benefits. In addition, it estimates costs and benefits over the lifetime of an asset rather than over a specified time period that captures only a portion of an asset's lifecycle.

Lifecycle Cost Analysis

Methods for estimating capital project costs are well established. But, estimating on-going costs, including operation, maintenance, and repair costs, as well as the scrap value of the asset at the end of its life, though just as important, is less common. Ultimately, the local government will typically pay all costs associated with a project, so all costs should be considered in any analysis.

Both grey and green infrastructure often require regular maintenance. In fact, many benefits of green infrastructure projects are contingent on regular maintenance; without it, they will not materialize. For example, vegetated green infrastructure, including green rooves and tree plantings, will only sequester carbon if properly maintained. Other more capital-intensive green infrastructure may require operational maintenance (e.g., regularly cleaning permeable pavement for optimal performance) and repair to extend the life of the asset and to ensure that the associated benefits are realized.[101]

Benefit Valuation

Infrastructure projects that mitigate the risk of climate change will likely deliver a stream of expected benefits, often in the form of cost-savings. But, many infrastructure projects—particularly those that are green—also generate positive social and/or environmental externalities. For instance, mangrove restoration projects can mitigate climate change. Incorporating these benefits into the total cost-benefit analysis is crucial to selecting the project with the highest overall return on investment.

The "Green Infrastructure Benefits" box lists some of the benefits that green infrastructure projects may provide. A more detailed list along with information on how to monetize benefits is included in **Appendix 6: Economic Benefits of Nature-Based Infrastructure.**

Not all of these benefits will be relevant in every case; rather, some benefits are applicable in only some cases. For example, urban tree preservation and planting yields the following benefits: a reduction in flood risk, water treatment and grey infrastructure needs, the heat island effect, and energy use, and improved water quality, groundwater recharge, and carbon sequestration.

Determining the value of some of these benefits can be difficult for municipalities.[102] As a result, decision-making around infrastructure investments has not typically considered the social and environmental benefits that green infrastructure provides and, as a result, has implicitly favored single-purpose grey infrastructure projects. However, including the benefits associated with green infrastructure and

GREEN INFRASTRUCTURE BENEFITS

- Reduced flood risks and resulting property damage or economic disruption
- Increased water supply
- Reduced stormwater management and water treatment costs
- Avoided infrastructure investment
- Energy savings due to reduced need for heating and cooling
- Reduced greenhouse gas emissions & increased carbon sequestration
- Avoided health costs due to improved air quality and heat mitigation
- Habitat creation
- Water quality & aquatic habitat improvement
- Recreation
- Groundwater recharge

[101] Center for Neighborhood Technology. "The Value of Green Infrastructure."
[102] *Ibid*.

other nature-based alternatives to flood mitigation is critical to selecting projects that have the greatest return on investment.

Benefit to Cost Ratios Comparison Studies

Total cost-benefit analyses often reveal that projects with green infrastructure components provide higher returns on investments than traditional grey infrastructure alone.[103] The selection of studies below highlights this finding.

Orange County, Florida: Orange County undertook an initiative to plant vegetation in its stormwater retention ponds to improve the ponds' absorption rates and reduce water treatment costs. Vegetating the ponds helps filter stormwater before it drains into soils or storm drains. The county reports that, if considering only avoided maintenance costs, the projected yielded positive benefits in 86 percent of ponds. But an analysis that also includes environmental benefits found that the benefit-to-cost ratio is greater than one for 99 percent of ponds that were vegetated.[104]

De Groot, *et al* (2013) Study: A group of researchers scrutinized over 200 peer-reviewed, scientific papers from which they identified 94 restoration case studies.[105] They determined that the benefit-to-cost ratios of restoring nine non-urban ecosystem types ranged from 0.5 to 35, with the bulk falling between 5 and 20, showing highly positive economic benefits.

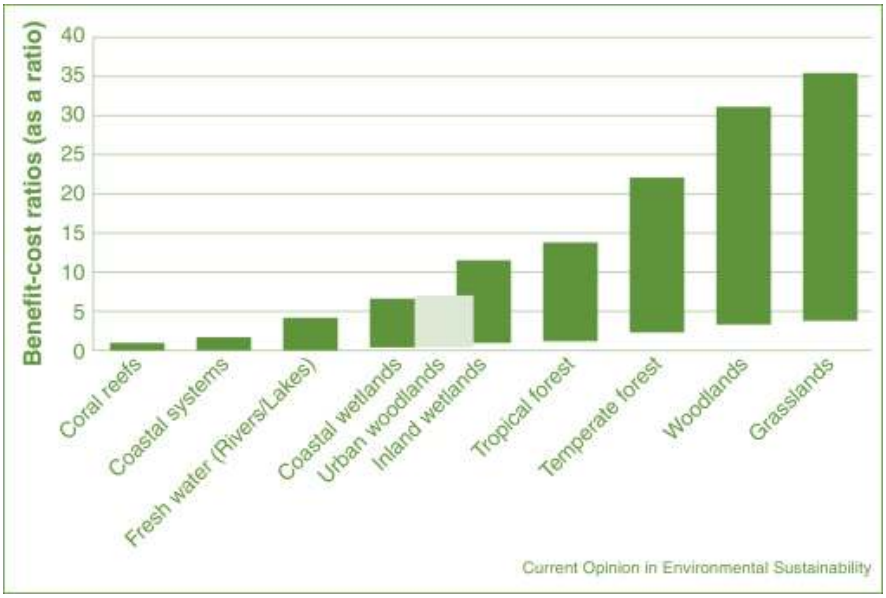

Figure 4*: Benefit–cost ratios of restoring urban woodlands (grey) in relation to ratios calculated for nine different ecosystem types*

[103] T, Elmquist; H, Setälä; SN, Handel; S, van der Ploeg; J, Aronson; JN, Blignaut; E, Gómez-Baggethun; DJ, Nowak; J, Kronenberg; R, de Groot. "Benefits of restoring ecosystem services in urban areas." Current Opinion in Environmental Sustainability, Volume 14, June 2015, Pages 101-108.

[104] Balmoral Group. Presentation for Southeast Stormwater Association Conference.

[105] R.S. De Groot, J. Blignaut, S. Van Der Ploeg, J. Aronson, T. Elmqvist, J. Farley "Benefits of investing in ecosystem restoration". Conserv Biol, 27 (2013), pp. 1286-1293

Gulf Coast of the United States: A comprehensive study undertaken by researchers at the University of California, Santa Cruz, the Nature Conservancy, and the Swiss Federal Institute of Technology determined the costs and benefits of several adaptation methods along the Gulf Coast of the United States.[106] The study area included coastal counties from Texas, Louisiana, Mississippi, Alabama, and Florida as shown in **Figure 5**. The values in **Figure 5** represent net present values associated with a number of infrastructure projects. The findings, summarized in **Figure 6**, indicate that the most cost-effective adaptation methods are (1) laying sandbags around buildings, (2) restoring coastal wetlands, and (3) restoring barrier reefs, while the least cost-effective measure is shoreline levees. While shoreline levees avert the most damages, they are expensive to construction and upkeep, making them less cost-effective than strategic wetland restoration.

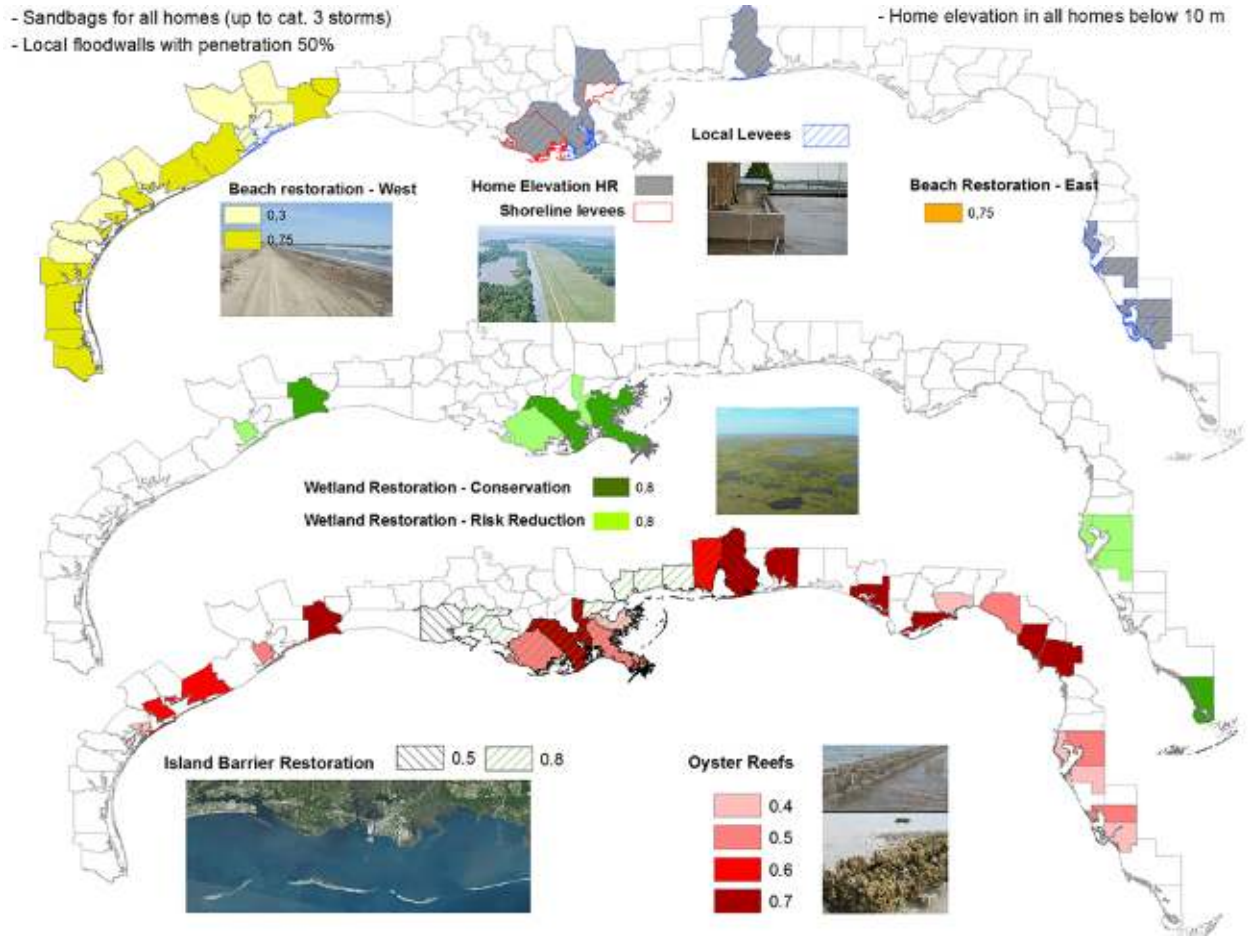

Figure 5*: Spatial Portfolio of Adaptation Measures* (Reguero, Beck, Bresch, Calil)

[106] Reguero BG, Beck MW, Bresch DN, Calil J, Meliane I (2018) "Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States."

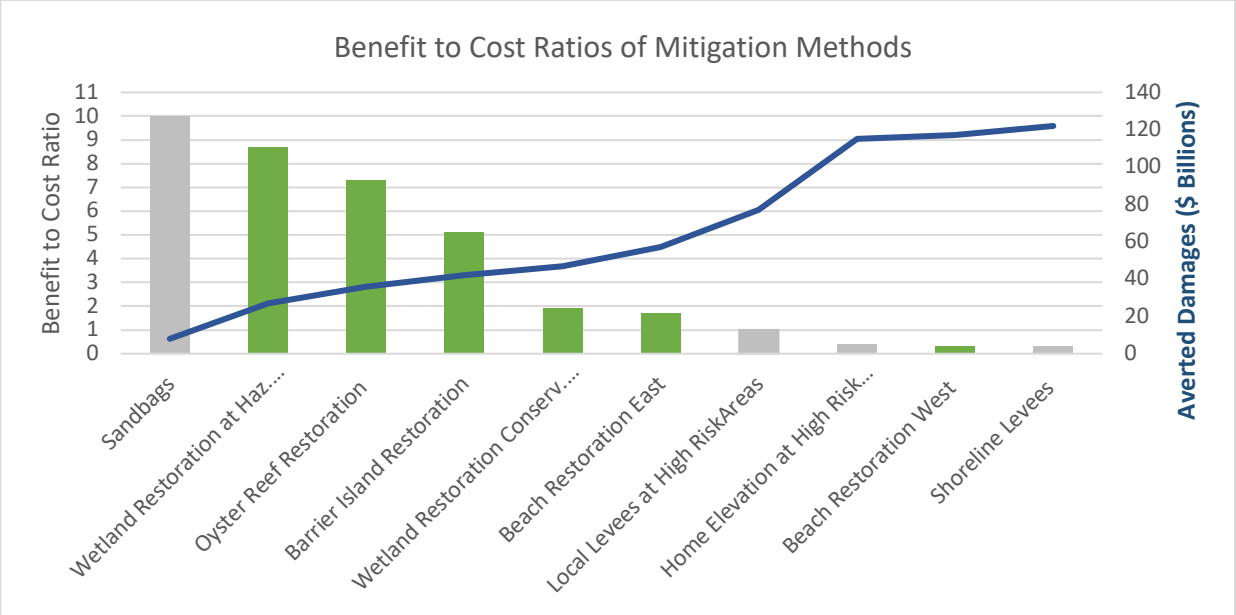

Figure 6. *Comparison of the Cost of Adaptation Measures along the U.S. Gulf Coast* (Reguero, Beck, Bresch, Calil)

Milwaukee, Wisconsin: To reduce the occurrence of combined sewer overflows and the stress on aging grey infrastructure, the Milwaukee Metropolitan Sewerage District (MMSD) created a program called GreenSeams, which allows the district to purchase land upstream along streams, shorelines, and wetlands. The intent of the program is to conserve these resources in an effort to retain infiltration and riparian services.

MMSD estimates that, in total, the program's acreage holds over 1.3 billion gallons of stormwater at a cost of $0.017 per gallon. In contrast, one of its flood management facilities holds only 315 million gallons at a cost of $0.31 per gallon (MMSD 2010). While the comparison is not direct, Milwaukee has found that managing stormwater upstream through conservation and the use of green infrastructure is cheaper than employing traditional grey infrastructure projects.

Figure 7. *Milwaukee River,* Source: visitmilwaukee.org

V. Conclusion

Immediate action is imperative for local governments that face climate threats. Floridians rely on water, transportation, energy, and building systems that are vulnerable to failure. Adapting these systems to withstand projected climate conditions is vital to reducing that risk that coastal communities face and maintaining economic viability.

No perfect funding or financing solution exists that can help local governments pay for crucial infrastructure improvements. But, the creative funding and financing models identified in this report are important options to consider when selecting funding and/or financing models for a portfolio of climate adaptation projects.

It is equally important for local governments to select the best projects. This process entails creating a long-term community vision, prioritizing the most vulnerable assets, and identifying the projects that have the highest return on investment. This analysis should consider all economic, social, and environmental project costs and benefits over the lifetime of each asset.

Responding to climate change haphazardly or only during crises and immediate infrastructure failures will be too costly for local governments to bear. By starting the long-term capital planning process today, utilizing a total cost-benefit methodology, and selecting appropriate funding and financing models, local governments in Florida can create a brighter future for their communities.

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Appendix 2: Other Policy Options

The following policy options were considered for use in funding or financing resilience but were not analyzed in detail because they (1) are not creative or (2) were determined to be suboptimal choices early on in the assessment process.

Policy Option	Description
Ad Valorem Property Taxes	Taxes levied on real or personal property by local government (e.g., counties, municipalities, school districts, and special taxing districts); expressed as a percentage, or millage rate, of a property's sale price or assessed value.
Carbon Tax	A tax on carbon emissions; likely would entail adding to the state gas tax and to gas and electric utility bills; revenue could be earmarked for programs related to climate adaptation.
Catastrophe Bonds	A weather or event-based derivative whereby an authority can effectively insure against extreme weather. Investors purchase the bond, receiving a high (usually 10-20%) yield rate, unless the weather event occurs, in which case they pay the local authority for their weather-based losses up to a specified threshold.
Congestion Pricing	Transportation authorities charge higher tolls or fees for thoroughfares at the busiest times.
Cruise Ticket Surcharge	A tax on cruise ship passengers; there were nearly 1 million passengers at Port Tampa Bay public berths in 2017.
Energy Service Corporations	ESCOs develop, design, build, and fund projects that save energy, reduce energy costs, and decrease operations and maintenance costs at their customers' facilities through a long-term contract.
Environmental Impact Bonds	Provide public entities up-front capital for environmental projects; bond investors are repaid based on project success
Foreign Purchaser Tax on Real Estate	If the property buyer is not a U.S. Citizen, they pay an additional fee to own the real estate asset within the state.
Gas Tax	Requires state or federal action. Indexing the gas tax to inflation would solve long-term underfunding issues in the transportation sector.
General Taxes	Expressed as a line item in the budget and would be paid for out of general revenue sources.
Hotel Assessment	A fee levied on each room rental at all hospitality facilities within a district.
Increased Parking Fees	Cities generate additional revenues from parking fees in downtown areas.
Pension Fund Investment	If the project can generate returns, the project manager may partner with a pension fund which can provide upfront capital for projects with long time horizons.
Positive Incentive/ ESG-linked Loans	Loans with rates linked to performance on environmental, social, and governance criteria.

Real Estate Transfer Tax	Raising this tax, which may be imposed by states, counties, or municipalities, on real property transfers within the jurisdiction.
Rideshare Fee	Fees levied on transportation network companies in proportion to the externalities that they impose.
Stormwater Retention Credit Trading Program	Projects develop and sell credits for green infrastructure that accommodates stormwater runoff, reducing the need for expensive stormwater drain upgrades
Tax Deductions for Donated Conservation Easement	Property owners who devote their land to conservation can receive tax deductions for the value of that property.
Tax/Fee on Rental Cars	The Florida Rental Car Surcharge could be increased above the current rate, which is $2 per day for the first 30 days of a rental.
Toll Increase	Expressways that are currently tolled could raise rates to cover the expenditures of necessary road adaptions.
Tourist Development Tax	Counties can impose taxes on short-term rentals, including hotels and timeshares; revenues can be spent on beach and shoreline maintenance.
Vehicle Registration Fees	New Florida drivers pay a one-time $225 “new wheels on the road” fee, $2 per lien, plus registration fees depending on the weight of the vehicle that ranges from $46.15 to $72.40

Appendix 3: Financing Natural Assets with New Accounting Standards

Accounting standards, which are not covered in **Section II: Funding and Financing Models** are an additional tool that can help finance resilient infrastructure. Given that green infrastructure can have high economic returns, it is often in the public's interest to finance these projects. To date, public authorities have found it challenging to invest in natural assets because accounting standards required distributed, green infrastructure programs to booked as annual expenses, meaning they compete with other items on the budget for yearly funding. Accounting rules can support utility investment via tax-exempt municipal bonds in distributed and green infrastructure at the scale required to achieve meaningful improvements in water management.

Government Accountability Standards Board (GASB) Statement No. 62 provides guidance on "Regulated Operations." **GASB 62 was updated in 2018 to allow green and distributed infrastructure assets to be accounted for as long-term investments, and therefore eligible for bond financing**.[107] This is a clear-cut accounting convention that allows public agencies and utilities to book certain "business type activities" as assets that would normally be treated as annual expenses. To qualify, the public authority has to (1) have the ability to set rates and (2) promise to have rates in place to pay for the costs of a program or project over future years.

Case Studies

King County, Washington

King County is using GASB 62 to treat $4 million in pollution remediation obligations as regulatory assets to allow for cost recovery through future rate increase.

- $4 million spend on pollution clean-up; amortized over 30 years

Los Angeles Department of Water and Power

LA Water & Power finances a variety of conservation-focused distributed infrastructure programs as regulatory assets. Its programs include:

- Rebates for water efficient installations, amortized over five to 20 years
- Funding for large-scale green stormwater projects owned by other agencies that improve groundwater recharge and quality, amortized over 30 years
- Green street installations and open space preservation
- Over $140 million in natural assets on its balance sheet

[107] "Go Green: Municipal Bond Financing for Consumer Rebates and other distributed water investments." Earth Economics.

Appendix 4: Summary of Federal Grants Available for Resilience

Post-Disaster, Disaster Risk Reduction, and Resilience

Federal Emergency Management Agency Hazard Mitigation Grants*
Federal Emergency Management Agency Pre-Disaster Mitigation Program*
Federal Emergency Management Agency Flood Mitigation Program
Department of Homeland Security Regional Resilience Assessment Program
Community Development Block Grant Disaster Recovery Program

*As of 2016, FEMA allows projects related to land conservation in floodplains, open space, acquisition of parcels with flood-prone structures and conversion to open space, aquifer storage and recovery, active restoration of green infrastructure on open parcels to provide flood storage, and other conservation measures to be eligible for funding from these two grant programs. All FEMA grants require 25% matching funds from their recipients.

Natural Infrastructure (Coastal, Watershed, Habitat, and Wetlands Projects)

National Oceanographic and Atmospheric Agency Coastal Resilience Grants
National Oceanographic and Atmospheric Agency Office of Coastal Management Grants
United States Department of Agriculture Conservation Easement Program
United States Fish and Wildlife Service Grants

Agriculture and Working Lands

United States Department of Agriculture Natural Resources Conservation Service
United States Department of Agriculture Risk Management Agency Crop Insurance

Housing, Community Development, and Public Space

Department of Energy Property Assessed Clean Energy Program
Environmental Protection Agency Smart Growth Grants
Federal Historic Preservation Tax Incentives
United States Department of Housing and Urban Development Community Development Block Grants

Fire and Forest Management

United States Forest Service Grants

Water Management (Flood Risk Reduction, Water Supply, and Drought Resistance)

Bureau of Reclamation WaterSMART Water and Energy Efficiency Grants
Environmental Protection Agency Water Infrastructure and Resilience Finance Center
Other United States Environmental Protection Agency Grants
United States Army Corps of Engineers Continuing Authorities Program
United States Army Corps of Engineers Planning Studies
Clean Water State Revolving Fund

Transportation

United States Department of Transportation Build America Bureau
United States Department of Transportation Better Utilizing Investments to Leverage Development Grants
Federal Transit Administration Grants

Public Health

Centers for Disease Control and Prevention Climate Ready States and Cities Initiative

Adapted from Climate Adaptation Finance and Investment in California (Keenan, 2018)

Appendix 5: Evaluation of Funding and Financing Models

Traditional Models

	Potential to Generate Revenue/ Attract Capital	Technical/Political Feasibility	Fairness/Efficiency	Equity
GO Bonds	**High** Revenue raised can be substantial	**Medium** Moderate political feasibility: requires voter approval; technically feasible: often used by local governments	**Low** No direct link between the particular people who pay and the particular people who benefit	**Low** Likely backed by property, sales, or some other regressive tax
Revenue Bonds	**High** Revenue raised can be substantial	**Medium** Moderate political feasibility: requires voter approval; technically feasible: often used by local governments	**High** Infrastructure is paid for by those who it benefits	**Low** Often results in user fees, which are not equitable because the same charge applies to all regardless of ability to pay
Federal Grants	**Medium** Can provide a substantial portion of project funding but are awarded competitively	**Medium** Politically feasible: federal grants are "free;" moderately technically feasible: application requires substantial resources and time without a guarantee	**Low** No direct link between the particular people who pay and the particular people who benefit	**Medium** Federal taxes are not considered too regressive or progressive
State Grants	**Medium** Can provide a substantial portion of project funding but are awarded competitively	**Medium** Politically feasible: federal grants are "free;" moderately technically feasible: application requires substantial resources and time without a guarantee	**Low** No direct link between the particular people who pay and the particular people who benefit	**Low** Florida has the third most regressive tax structure in the country

Creative Financing Models

	Potential to Generate Revenue/ Attract Capital	Technical/Political Feasibility	Fairness/Efficiency	Equity
Green/Climate Bonds	**Medium** Revenue can be raised, but at higher cost than for GO bonds	**High** Politically feasible: may be easier to get voter approval; technically feasible: local governments often use similar structure	**Low** No direct link between people who pay and people who benefit	**Low** Likely backed by property, sales, or some other regressive tax
TIF	**Medium** Can raise substantial revenue so long as property values in the area increase, which may not be the case in the most vulnerable areas	**High** TIF is widely used in Florida already	**High** Infrastructure is paid for by the district that benefits	**Low** Fixed assessments are likely regressive; can lead to unaffordability and gentrification
P3s	**High** Attract private capital because there is potential for high ROI	**Medium** Politically feasible for most projects; designing contract is technically challenging	**High** Likely paid for with user fees by those who benefit from project	**Low** User fees are not equitable; the same fee is imposed regardless of ability to pay
CRBs	**High** Large potential for new projects with co-benefits	**Medium** Moderate political feasibility; moderate technical feasibility: no prior experience with this financial contract	**High** Infrastructure is paid for proportionally by the authorities that benefit	**High** No authority disproportionally bears costs
Event-Based Insurance	**Medium** Generates substantial recovery funds after event; may not be applicable to all assets	**Medium** Politically feasible: line item in budget with funds obtained when needed; Moderately technically feasible: need to prove economic stake	**Medium** Funded by general revenues, at relatively low cost, unknown who claims funds will benefit from within tax base	**Medium** Funded by general revenues, which may be slightly regressive
Regional Resilience Trust Fund	**High** Self-sustaining, provides substantial funds for capital projects	**Medium** Low political feasibility: coordinate between authorities; moderate technical feasibility: dependent on trust fund structure	**Medium** Infrastructure is paid for by property owners, whose value will be protected; unclear how funds would be geographically apportioned	**High** Funded by property surcharge over a region, relatively progressive

Creative Funding Models

	Potential to Generate Revenue/Attract Capital	Technical/Political Feasibility	Fairness/Efficiency	Equity
Carbon Offset Markets	**Low** Program costs likely far exceed potential revenue	**Medium** Politically feasible: no public funds required; technically challenging: may be difficult to verify, monitor, and sell offsets	**Medium** Not publicly funded so no costs are socialized but no externalities are internalized	**High** No public funds required so no group disproportionately bears costs
Mitigation Banking	**Low** Projects limited by location (allowed only on non-sovereign land) and credit market (sold only to single-family homes)	**Medium** Politically feasible: no public funds required; technically feasible: program has a long history in Florida	**Medium** Those who impact wetlands pay to mitigate that damage, but ecosystem services may not be replicated	**High** No public funds required so no group disproportionately bears costs
TDR	**Medium** Proper program design & TDR bank can yield substantial conservation, but current development patterns cap potential	**Low** Moderate political feasibility: public funds necessary for a bank; potential opposition from receiving areas; technically challenging: difficult to successfully design and monitor	**Medium** Not publicly funded so no costs are socialized but no externalities are internalized; ecosystem services may not be replicated	**Medium** No public funds required so no group disproportionately bears costs; program may impact affordability & cause dislocation for some residents
Impact Development Fees	**High** Revenue raised can be substantial if fees are sufficiently large	**Medium** Moderate political feasibility: requires voter approval but costs imposed on future residents, so voters may favor the policy, though some may oppose any new "tax;" technically feasible: these fees have a long history in Florida	**High** Infrastructure is paid for by those who it benefits	**Medium** Fixed fees are likely regressive; assessments based on property characteristics (e.g., building size) can partially mitigate inequity
Non-Ad Valorem Special Assessments	**High** Revenue raised can be substantial if assessments are sufficiently large	**Medium** Moderate political feasibility: requires voter approval and some may oppose a new "tax;" technically	**High** Infrastructure is paid for by those who it benefits	**Medium** Fixed assessments are likely regressive; assessments based on certain property

		feasible: these assessments have a long history in Florida		characteristics (e.g., building size) can partially mitigate inequity
Local Infrastructure Sales Surtax	**High** Revenue raised can be substantial	**Medium** Moderate political feasibility: requires voter approval and some may oppose a new "tax;" technically feasible: these surtaxes have a long history in Florida	**Low** No direct link between the particular people who pay and the particular people who benefit	**Low** Sales taxes are regressive

Appendix 6: Economic Benefits of Nature-Based Infrastructure

This guide attempts to quantify the benefits of green and other nature-based components of infrastructure program alternatives. All of these may not be quantifiable for each project, even if applicable, due to data limitations in an area. If the data cannot be determined to estimate a value, the magnitude or other qualitative measures of the benefit should still be included in the cost benefit analysis used internally to determine the best project alternative. If this is just being used for internal decision-making purposes, it is more important to include the magnitude (i.e. $10,000 vs. $100,000) of the benefits than to have precise numbers backed up by local data.

This guide breaks the co-benefits up by what party is receiving the benefits. This is helpful to quantify the social, environmental, and economic benefits separately, if so desired. These co-benefits could also be estimated on an aggregated level if data is limited.

Households

Recreational Value

Green infrastructure can provide additional recreational opportunities for individuals, such as walking the dog, jogging, or even fishing. This can be measured by willingness to pay for access to nature, or the days of recreation residents and visitors may enjoy resulting from the project. Willingness to pay for nature could be quantified by recreational user fees such as entrance fees, hunting permits, fishing permits, or kayak rental fees that this project could generate, and associated values.

A study from Philadelphia in 2009 found that each additional vegetated acre would provide 1,340 user days per year, each of which had a present value of $0.71 over a 40-year project life. This translates to a recreational benefit of $950 per vegetated acre per year.

A 2013 ESM study found that recreational benefits of urban woodlands are $6,325 per hectare on average annually.

Another example: a proposal for the Miami Baywalk project that includes a living shoreline and walking path along the waterfront adds $200,000 of tourism and healthy lifestyle benefits per year.

Impact on Public Health

Avoided medical costs and premature mortality. Air quality, improved mental health, avoided heat stroke victims, and reduced injuries during severe weather events could be some of the health benefits from green and resilient infrastructure.

An ESM study found that positive health effects of urban woodlands are $18,870 per hectare per year.

- **Air quality improvement:** Trees, bio retention ponds, and green roofs reduce nitrogen dioxide, sulfur dioxide, ozone, and particulate matter in the nearby air. Asthma risk will be reduced in the area, as well as other health benefit. See the source from the Center for Neighborhood Development for estimates of the pollutant quantities taken out of the air by projects. A 2013 ESM study found that annual energy savings benefits of urban woodlands are $647 per hectare on average.
- Urban vegetation greatly **reduces the heat island effect**. Days on which the low temperature does not drop below 80 degrees are a condition that the human body cannot thrive in, as the

body cannot shut down to sleep. Ambient temperature can be reduced by 3-4°C for 10% increase in tree canopy.

- **Healthy lifestyle benefits**: If the project provides greenspace for exercising that encourages previously inactive individuals to walk or exercise more regularly, it can dramatically improve their health and reduce their medical expenses. In a 2000 study, researchers found that when previously inactive adults regularly incorporated moderate physical activity into their routines, annual mean medical expenditures were reduced by $865 per individual (Pratt et al. 2000).
- **Improved mental health**: People are much happier if their street has trees on it. a 'green view' from a window increases job satisfaction and reduces job stress. Researchers at the University of Chicago found that "having 10 more trees in a city block, on average, improves health perception in ways comparable to an increase in annual personal income of $10,000 and moving to a neighborhood with $10,000 higher median income or being 7 years younger".
- **Toxic exposure**: If floodwaters could contain dangerous pollutants, such as in Houston in 2017, the costs of reducing the risk of exposure to these toxic floodwaters should be included.
- **Lack of access to flushing toilets and clean water** can occur during extreme weather events that compromise water treatment facilities and has serious health risks. If water and sewer systems have climate risk, quantify the value of the probability that this project mitigates that risk.
- **Access to healthcare:** if the project helps protect a hospital or other health facility so it can remain open during a storm event, these benefits can be quantified by the operating revenues saved at each facility by avoiding a shutdown event, which will usually be a few days to a few weeks for a severe storm event after a facility has been flooded.

Effect on Insurance Premiums for Households

Projects that protect against wind damage to homes or businesses will impact Property & Casualty insurance rates. Flood insurance premiums and discounts are determined by the City's ranking within the Community Rating System, which is part of the National Flood Insurance Program. It is very unlikely a single barrier wall or small project could move a community up a class in CRS to receive more discounts. Moving down CRS classes is a process that currently takes several years even if the projects are large enough to successfully qualify the city for enough points to move down. Each class moved down in the CRS system brings an additional 5% discount rate to

Impact on Property Values

Determine the number of households likely to be less affected by flooding, heat, or SLR because of this project, and their property values. Multiply that value by the reduction in property damage caused by a 10-year event, and multiply by 0.10 to obtain the annual average benefit. Studies have found that homes inside flood prone areas are typically discounted 2-5% compared with homes with less flood risk. Thus, one could assume the value of homes in the project area could increase by 2-5% if the project perfectly protects against flood risk and may increase by a proportional amount if the project reduces a portion of the flood risk.

For example, in Monroe County, 25% of homes were damaged beyond repair by Hurricane Irma so the following valuation could apply for a beach restoration project in this area that reduces the expected damages by 5% (to 20% from 25% of the homes) during a 10-year storm event.

$$\boldsymbol{Annualized\ average\ benefit} = total\ property\ value\ of\ homes\ in\ impact\ area\ (\$)\ x\ probability\ of\ catastrophic\ event\ (0.10)\ x\ impact\ reduction\ factor\ (0.05)$$

Reduced Economic Costs to Households of Non-Performance

Economic costs of natural disasters have been widely studied in the past and generally includes avoided travel, home repair, auto damage, and other costs to the public. Use an economic costs reduction factor assumed for the project (ex. 5%), which is the percentage by which these costs are reduced during a failure event (for example, a 10-year storm event) as a result of the project. It is important to define the project area that is impacted by the resilience measure.

$$\boldsymbol{Annual\ cost\ savings} = cost\ reduction\ during\ an\ event\ inside\ the\ area\ (0.05)$$
$$x\ expected\ economic\ disruption\ value\ in\ the\ area\ x\ annual\ probability\ of\ occurrence\ (0.10)$$

The expected economic disruption value in the formula above could be estimated as the economic costs of the most recent large storm event, such as Hurricane Irma, for the localized area. This data should be publicly available from insurance companies like Swiss Re or Munich Re. If data is only available for a larger geographic area than that which the project impacts, the proportion of property values inside the project impact area out of the total property values in the region could be used to scale down the data.

Energy Savings

Green roofs increase the insulation of a roof, which has an impact on the building energy use. A study found that a 5,000 square foot green roof in Chicago saves around $100 in electricity costs per year. Tree canopy in neighborhoods and on sidewalks can also reduce energy use of buildings by providing shade and reducing wind speeds. A study in the Midwest found that electricity savings per urban tree planted range from 48 kWh to 136 kWh, or $6 to $16 per year, depending on the size of the tree planted. The energy savings from urban trees planted in Florida will likely be higher.

A 2013 ESM study found that energy savings benefits of urban woodlands are $1,412 per hectare annually on average.

Water Use Savings

Can be measured by the cost to residences of water that is saved by the green infrastructure project.

$$\boldsymbol{Savings\ value} = marginal\ cost\ of\ water\ purchased\ x\ annual\ gallons\ saved$$

Impact on Social Service Delivery

Does the project help maintain access to emergency services, health care, municipal offices, airports, or other structures with public good? How much are services worth to citizens? Willingness to pay*reduction in risk of inability to provide services*probability of critical event

Commerce

Jobs Creation

This is typically included in economic impact analyses. Use the wages multiplied by the number of jobs created by the construction, operation, and maintenance involved with the project over its lifetime to anticipate some of the returns to local workers.

Insurance Premiums for Businesses

Is the flood insurance lowered by CRS class improvement? Does the project reduce expected wind damage to homes from storms or other factors relevant in P&C insurance? If so, multiply number of households impacted by individual savings estimates.

Reduced Economic Costs to Commerce of Non-Performance

Businesses lose revenue when they are closed, may have shipping routes interfered, port/airport impacts, other industries may be affected. This value may be included in the value entered for the household section. Often the data/estimate will only be provided as an overall economic impact to the area after an event. You could break apart the data by % of property values or tax revenue from commerce versus residences.

Environment

Ecosystems Service Impacts

Mangroves serve as natural barriers for shoreline protection; they attenuate destructive wave energy and reduce the impact of storm surges. The intricate root system of mangroves also makes these forests attractive to fish and other organisms seeking food and shelter from predators. Along the southeast Florida coast, mangroves provide critical nursery and foraging habitat for marine aquatic and water bird species. Mangroves have also been found to filter nitrogen, phosphorous, and heavy metals - all commonly found in wastewater and stormwater. Both mangroves and cordgrasses have the provisioning service to sequester carbon. Trees and other vegetation in natural infrastructure have similar benefits as mentioned for mangroves.

Greenhouse Gas Emissions Reduction or Increase

Both sequestration for green infrastructure and embodied carbon in grey infrastructure should be considered. Carbon sequestration can be valued by the content of carbon stored per year in the natural assets created or conserved multiplied by carbon's market value. Mangrove forests store an average of 1.5 – 2.0 metric tons of CO2/acre in around the Gulf of Mexico. Trees around the world have been found to store carbon exponentially with age. The older the tree is (especially if more than 70 years) the more carbon it locks up each year as it grows outwards. See the Center for Neighborhood Development resource for more information on carbon sequestered by different types of plantings.

Carbon offset credit value ranges from $3 to $7 per metric ton of CO2. You could use the social cost of carbon instead, which will be around $42 ($51 2019 USD) per metric ton of CO2, according to a 2013 OMB estimate.

Concrete is currently the material that embodies the greatest amount of carbon in the world. The average carbon content in concrete is 100 kg (0.1 metric ton) of CO2 per metric ton of concrete (1.0 metric ton of carbon is equivalent to 3.67 metric tons of carbon dioxide). The carbon embodied by concrete should be considered a social cost.

Water Quality and Aquatic Habitat Improvements

This can be measured based on household willingness to pay, acres of wetlands improved or created, and associated value of wetland services. It has been estimated as approximately $125 per acre of mangroves forests per year in south Florida.

For example, a hedonic pricing study of the St. Mary's River Watershed in the Chesapeake Bay estimated home price impacts of water quality changes not merely for waterfront properties but for the entire watershed. It found marginal implicit prices for changes of one milligram per liter in total suspended solids (TSS) concentration of $1,086 and in dissolved inorganic nitrogen (DIN) concentration of $17,642 for each home in the watershed. This type of benefit could also be accounted for under "Impact to Property Values".

Value of Habitat Creation or Destruction

This can be measured by the cost to restore wetlands or other wildlife habitats elsewhere. The cost of wetland restoration can run from $20,000 to $150,000 per acre, but an average of $100,000 per acre (one time value creation) could be assumed for internal analysis.

Other Infrastructure Providers/Authorities

Energy Savings

Does the project save operating expenses or energy costs for other public authorities? Use the same formula for quantifying it as above, with an average cost per kWh of $0.10.

Reduced Stormwater Management and Water Treatment Costs

Stormwater volume may be reduced as well as be partially treated by green infrastructure, reducing costs for the authority responsible for managing and treating wastewater. Green infrastructure allows the underground aquifer to recharge, which helps avoid costly land subsidence and inland infiltration of the saltwater envelope in the aquifer, which both are exacerbated by over drawing from the groundwater.

> **Value of Water Retention**: Determine the number of gallons of rain water than is retained or diverted from storm drains. You can calculate this from the average annual inches of rainfall for the site, square footage of the green infrastructure feature, and the percentage of precipitation the feature can retain.

$$\boldsymbol{Annual\ gallons\ diverted} = annual\ precipitation\ (feet)\ x\ GI\ area\ (SF)\ x\ \%\ retained\ (gal/CF)$$
$$\boldsymbol{Reduced\ Treatment\ Costs} = gallons\ diverted\ x\ marginal\ cost\ of\ treatment/gal\text{lon}$$

For example, The Metropolitan Water Reclamation District of Greater Chicago has a marginal cost of treating its wastewater and stormwater of $0.0000919 per gallon (CNT 2009). If a 5,000 SF green roof provided a runoff reduction of 71,100 gallons, the annual avoided cost for water treatment associated with this site becomes: 71,100 gallons * $0.0000919/gallon = $6.53 in annual avoided treatment costs.

A 2013 ESM study found that stormwater reduction benefits of urban woodlands were $922 per hectare annually on average.

Avoided Grey Infrastructure Investment

Would the city have had to install expensive pumps or enlarge pipes or build larger levees to mitigate the same risk green infrastructure is mitigating? This is money saved by the taxpayers.

$$\boldsymbol{Avoided\ Grey\ Investment, Cost\ Savings} =$$
$$marginal\ costs\ of\ treating\ runoff\ from\ conventional\ feature\ (\$/SF)\ \ x\ size\ of\ feature\ (SF) x\ \%\ retained$$

For example, in Portland, Oregon a 5,000 SF conventional roof would have a one-time expenditure of $13,550. However, by utilizing a green roof, which a study has shown to retain 56 percent of runoff, Portland can expect an avoided cost savings of $7,588: $2.71/SF x 5000SF x 0.58 = $7,588

In addition, there may be more cost savings since hydraulic design criteria for expected flow volumes of traditionally engineered stormwater systems in south Florida will have to increase by a factor of 1.2 to 1.8, corresponding to an increase in rain intensity of 20-80%, depending on the return period during projected lifetime of new water management assets.

Reduced Emergency Shelter Costs

Cost savings for a household whose risk is significantly mitigated for a ten-year flooding event vary but have been estimated to be around $1,000 on average. For example, the project reduces the risk of 36 households on average over a 40 year life.

$$Annualized\ cost\ savings\ =\ \$1000\ x36\ households\ x\ 0.10\ probability\ =\ \$3{,}600\ per\ year$$

Adjusting Over Time

Note that many of the benefits will not be constant over the lifetime of the project. Some disaster mitigation benefits may depreciate to near zero by the end of the lifetime of the asset (ie the wall would be overtopped). Other benefits may appreciate in value (for example, grey infrastructure maintenance cost savings where costs typically rise each year). Many benefits of green infrastructure will increase over time as plantings and ecosystems mature.

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Appendix 7: Estimating Carbon Offset Revenue from Mangrove Planting

The amount of revenue generated by a mangrove planting program depends on (1) the amount of carbon that is sequestered and (2) the value of the resulting carbon offsets. Net revenue depends on the cost of the program, which includes planting and verification and monitoring. The calculations below very roughly estimate the revenue that municipalities can expect raise per acre of mangrove planting if they elect to sell the associated carbon offsets.

Carbon Dioxide Sequestration

The incremental carbon that mangrove plantings sequester is the difference between the carbon sequestered in the environment with planted mangroves and the carbon sequestered in that same environment absent the plantings (i.e., the baseline carbon sequestration). The "Carbon Market Opportunities for Louisiana's Coastal Wetlands" report reviews of number of studies and estimates that incremental carbon sequestration is between 0.9 and 2.2 metric tons of carbon per acre per year ($mtCO_2e/ac/yr$), with an average of 2.0 $mtCO_2e/ac/yr$.

Despite those averages, a number of factors could push actual sequestration above or below those values. First, average incremental carbon sequestration masks significant variation by site: "the amount of carbon sequestered is highly dependent on the health and productivity of the wetland."[108] For instance, a study of mangroves in South Florida found an average sequestration rate of 98 grams of carbon per square meter per year ($g\text{-}C/m^2/year$), but a range of 47 to 162 $g\text{-}C/m^2/year$ across sites.[109] Therefore, it is difficult to make broad claims about the sequestration potential of mangroves even within South Florida. Site-specific analysis is necessary.

A second consideration is the protection of exiting mangroves. Mangrove planting can be a "long-term restoration technique" that "to reduce[s] wetland loss and prevent[s] further erosion of shorelines due to relative sea-level rise."[110] If additional wetlands are saved as a result of mangrove plantings, the carbon that remains sequestered in those wetlands can be counted as carbon offsets. More research is necessary, but a range of 51.6 to 154.7 $mtCO_2e/ac$ with a mean of 103.2 $mtCO_2e/ac$, were used in the "Carbon Market Opportunities for Louisiana's Coastal Wetlands" report.[111]

Finally, it is important to note that wetlands also *emit* greenhouse gases. Additional research is needed, but it may be the case that greenhouse gas emissions from restored wetlands may be

[108] "Carbon Market Opportunities for Louisiana's Coastal Wetlands." Tierra Resources and the Climate Trust. 2014, (48).
[109] Marchio, Savarese, Bovard, and Mitsch. "Carbon Sequestration and Sedimentation in Mangrove Swamps Influenced by Hydrogeomorphic Conditions and Urbanization in Southwest Florida." Forests 2016, 7, 116. May 30, 2016, (8).
[110] "Carbon Market Opportunities for Louisiana's Coastal Wetlands." Tierra Resources and the Climate Trust. 2014, (57).
[111] Ibid.

greater than baseline emissions. If so, those incremental emissions should be debited from the total number of offset credits that the project yields. Further investigation in necessary.[112]

Carbon Market Revenues

The first step in calculating revenues is determining how many credits will be available to sell. Verification organizations have different crediting period requirements. For instance, the ACR has a 40-year period for wetland restoration projects while the ARB has a 25-year period.[113] The crediting period is important not only in calculating credits, but in determining how long monitoring activities will need to continue.[114] Secondly, not all carbon offsets from a project can be sold. A certain percentage must be set aside in a "reserve buffer pool" to "guard against risk of reversal."[115] The amount set aside varies by project risk, from 10% to more than 50%.[116]

Today, mangrove and other coastal resiliency projects do not qualify for the California compliance market. As a result, in the near term, credits must be sold into voluntary markets. Some verification organizations support these projects. For instance, Verra established rules regarding how to "calculate, report, and verify greenhouse gas reductions for tidal wetland restoration projects," including "removing tidal barriers, improving water quality to increase seagrass habitat, beneficial use of dredged material, and re-introducing native plant communities."[117]

The price of a carbon offset credit in voluntary markets in 2016 ranged from $0.50 to $50.[118] The average price was roughly $3, and the mode was less than $1 because, "in general, prices were lower on higher volumes traded."[119] That said, projects that are most similar to mangrove restoration—afforestation/reforestation and grassland/rangeland management—averaged $8.1 and $6.9 respectively.[120]

Selling these credits is not an easy process because "there is no single marketplace for voluntary offsets."[121] "Some project developers develop their own marketing and advertising teams to identify and promote their project directly to end buyers. Others prefer to sell their offsets to intermediaries like a broker or a retailer, who takes responsibility for marketing those offsets to end buyers."[122] And, it's a buyer's market—"almost as many offsets remain unsold as sold."[123]

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[112] Ibid, 13.
[113] Ibid., 18.
[114] Ibid., 63.
[115] Ibid., 17.
[116] Ibid.
[117] Simpson, Stefanie. "Seagrass Restoration Methodology." Blue Forests Project. November 24, 2015.
[118] Hamrick and Gallant. "Unlocking Potential: State of the Voluntary Carbon Markets 2017." Ecosystem Marketplace. May 2017, (8).
[119] Ibid., 3.
[120] Ibid., 11.
[121] Ibid., 2.
[122] Ibid.
[123] Ibid., 4.

The tables below show pessimistic, average, and optimistic cases. The sequestration estimates come from the "Carbon Market Opportunities for Louisiana's Coastal Wetlands" report. Although these tables create a range of potential revenues, actual revenues could deviate from these calculated revenues for a number of reasons, including site-specific characteristics, protection of existing mangroves, wetland greenhouse gas emissions, etc.

For mangrove planting:

Case	CO_2 sequestered (per acre year)	Percentage of credits in reserve buffer pool	Credits to be sold (given 40-year life)	Credit value	$/acre
Pessimistic	0.9	50%	18	$1	$18
Average	2.0	20%	64	$3	$192
Optimistic	2.2	10%	79	$8	$633

For mangrove preservation:

Case	CO_2 sequestered (per acre)	Percentage of credits in reserve buffer pool	Credits to be sold	Credit value	$/acre
Pessimistic	51.6	50%	26	$1	$26
Average	103.2	20%	83	$3	$248
Optimistic	154.7	10%	139	$8	$1,114