



Socio-Economic Metrics to Measure Impacts from DOI Hurricane Sandy Coastal Resiliency Projects and Programs

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Report Available at:

https://www.doi.gov/sites/doi.gov/files/uploads/Socio_Economic_Metrics_Final_Report_11DEC2015_0.pdf

Overview



1. Introduction and terminology
2. Describe DOI Sandy resilience efforts
3. Overview of socio-economic framework and metric
4. Example of metric application
5. Next steps
6. Questions

Natural Infrastructure Metrics



- **Metric defined: *a measure or suite of measures (index) that can be used to detect change***
 - ... No clear measures of change in resilience
- **We know natural infrastructure provides services to ecosystems and communities**
 - ... But we do not have a handle on what these are
- **Decision makers and engineers need to know what will work**

Key Definitions



- **Resilience:**

The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions (Executive Order 13653).

- **Natural Infrastructure**

Includes green infrastructure, natural and nature-based features, living shorelines, etc. for the purpose of building resilience in ecosystems and communities

- **Performance Metric:**

A qualitative or quantitative measurement or suite of measurements (index) that can be used to detect and assess a change in DOI coastal resilience objectives.

- **Core Performance Metrics:**

A subset of performance metrics that are applied to multiple projects and at the full range of temporal and spatial scales to detect a change in resilience in one or more coastal features.

DOI Overview



- Department of Interior (DOI) allocated \$340 million for projects that promote improvements in community and ecological resilience
- Over 160 projects
- Evaluate project success and establish metrics that quantify change in resilience resulting from project actions
- Goals: reduce impacts of coastal flood hazards, strengthen ecosystems, better understand storm impacts and advance resilience tools



DOI Ecological Metrics



- Metrics Expert Group (MEG) convened July 2014
- Report at:
<https://www.doi.gov/sites/doi.gov/files/migrated/news/upload/Hurricane-Sandy-project-metrics-report.pdf>
- Goals: Recommend metrics for DOI resilience assessment; determine data and information gaps; and recommend core metrics

Process:

Organized metrics around 6 coastal features

Identify core metrics (Abiotic, Biotic, Structural)

Peer review

Benefits: project comparisons and regional resilience assessments

Table 1. Recommended ecological core performance metrics by coastal feature for Department of the Interior Resilience projects funded through the Disaster Relief Recovery Act of 2013.

| Natural and Artificial Coastal Features | Primary Objectives and Ecosystem Services | Recommended Core Performance Metrics |
|--|--|---|
| Beach System: Beach, Barrier Island, and Dunes (for back bay areas, see Estuaries and Ponds) | <p><u>Beaches and Dunes:</u></p> <ol style="list-style-type: none"> 1) Restore or improve beach habitat to enhance resilience of fish, wildlife, and plants, and their habitats (e.g., spawning, migration stopovers, critical habitats) 2) Restore/improve dune habitat to enhance resilience of coastal infrastructure by reducing flooding extent and attenuating wave energy 3) Improve/sustain beach/barrier island ecological system and community resilience to storm surge events 4) Enhance understanding of natural system dynamics including immediate storm responses, natural recovery from disturbance events, and natural adaptation capacities and tendencies. 5) Improve recreation/aesthetics <p><u>Breaches:</u></p> <ol style="list-style-type: none"> 1) Manage breach occurrences to maximize ecosystem function and reduce risks to built infrastructure, human health, and human safety. | <p><u>Beaches and Dunes:</u></p> <p>Biotic</p> <ul style="list-style-type: none"> • Vegetation cover of dunes pre and post event • Fish and wildlife population/ recruitment/ overwintering/stopover weight/health relative to other mitigating factors (e.g. other threats throughout range: site and species specific) <p>Abiotic</p> <ul style="list-style-type: none"> • Post-storm volume of sand in the active shoreface • Recovery rates of beach and dunes <p>Structural/Engineering</p> <ul style="list-style-type: none"> • Beach width, elevation, volume, shoreline position (post-event) • Dune characterization (height, width, length, texture, substrate) <p><u>Breaches:</u></p> <p>Biotic</p> <ul style="list-style-type: none"> • Fish and wildlife population/ recruitment/ overwintering/ stopover weight/health changes relative to other mitigating factors (e.g. other threats throughout its range: site and species specific) <p>Abiotic</p> <ul style="list-style-type: none"> • Volumes of material in flood and ebb shoals • Water flow and current dynamics • Water quality: temperature, salinity, pH, dissolved oxygen, turbidity, nutrients, contaminants • Water level changes, especially in back bays <p>Structural/Engineering</p> <ul style="list-style-type: none"> • monitoring of breach morphologic changes |

DOI Socio-Economic Metrics



- Objective: Develop socio-economic metrics and assign to each project
- Classify 167 projects (project activity, project outcome)
- Develop framework to organize and assign metrics
- Identify methodologies and data for measures

**Iterative Information Collection
(classification, lit review, interview)**

**4 Resilience Output Categories
(and 16 resilience goals)**

**Link Project Activities to
Outcomes and then Outcomes to
Resilience Goals (e.g. *causal
chains*)**

Project Categorization



- Record information from proposals and project summaries (habitat, project activities, monitoring, budget)
- Iterative approach: pull every key word and roll up to categories
- Project activity emerged as critical characteristic to inform metric development

| Activities | Project Count Total |
|--|---------------------|
| Community Resilience Planning | 19 |
| Contaminant Assessment or Remediation | 4 |
| Critical Infrastructure Assessment or Protection | 3 |
| Data, Mapping, and Modeling | 60 |
| Ecological Resilience Planning | 13 |
| Green Infrastructure Planning and Implementation (living shorelines) | 33 |
| Grey Infrastructure (dams, culverts, berms) | 26 |
| Habitat Restoration | 49 |
| Impact or Vulnerability Assessments | 24 |
| Public Access | 5 |
| Sand Resource Identification or Assessment | 13 |
| Multiple | 63 |

Metric Development – Example of Sources



Resilience Outcome: Change in number of households exposed to risk of injury, casualty, or other health effects

| | |
|---|--|
| 1. Review of Projects | Reusing Dredged Material to Restore Salt Marshes and Protect Communities (NFWF) discusses the importance of restoration projects to protect communities from flood risk |
| 2. Interview with project leads and experts | Develop Breach Management Plans for Coastal National Seashores to Maximize Plans Ecological Benefits interviewee mentioned the importance of the project in protecting communities from risk |
| 3. Literature Review | USACE 2015; Cutter 2010; NIST 2015; NOAA; and Norris 2007 mention the importance of change in risk to households as related to ecological restoration projects and discuss the importance of measurements of community vulnerability and environmental justice |

Socio-Economic Impact Categories



Project Types:

- Restoration Projects
- Community Planning



Resilience Categories

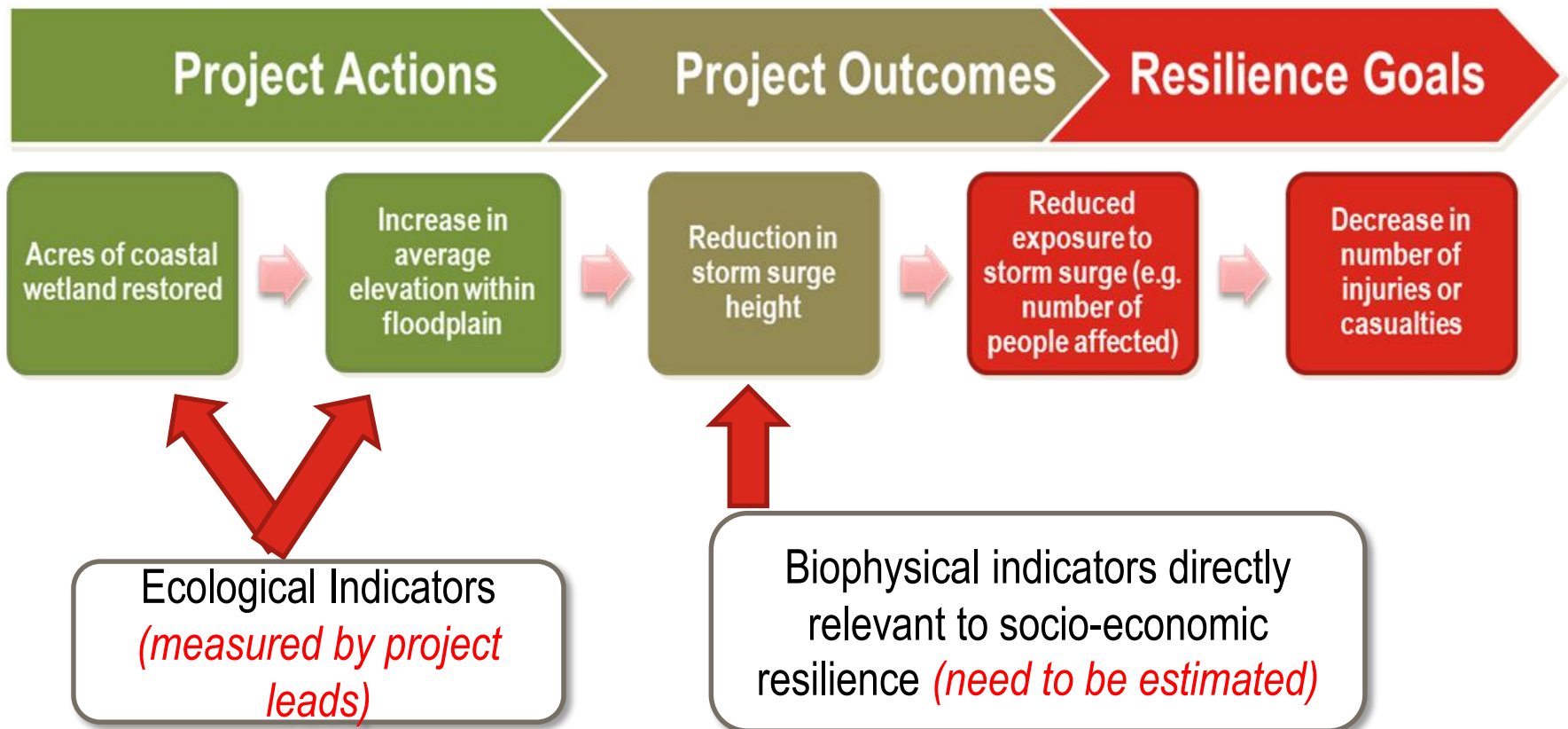
- Human Health and Safety
- Physical Infrastructures
- Economic Resilience
- Community Competence and Empowerment



Metric Development



- Causal Chain for Wetland Restoration



Metrics Methodology



■ Main Methodological Components

1. Translating core ecological metrics into biophysical changes relevant to socio-economic resilience
 - Reduce exposure to flood hazard and damaging inundation; Enhanced environmental quality
2. Estimating affected populations or properties and infrastructure components
3. Constructing socio-economic resilience metrics
 - Metrics calculation options range from simple counts to and narratives to complex environmental modeling

Metric Products



Exhibit 5. Metrics for Property and Infrastructure Protection

| Metrics for Property and Infrastructure Protection | | Resilience Goals | | | |
|--|--|--|---|--|--|
| | | Reduction in number of residential, commercial, cultural, and heritage properties at risk to potentially damaging inundation | Reduction in miles of roads, highways, and rail lines at risk to potentially damaging inundation | Reduction in number of critical service facilities at risk to potentially damaging inundation | Reduction in number of critical service facilities at risk to potentially damaging inundation |
| | | Metrics ^a | | | |
| Biophysical and Ecological Outcomes | Reduced extent of damaging inundation from major storm and flood events ^b | 1. Reduction in number of properties exposed to flood event with the project as compared to without | 1. Reduction in miles of transportation infrastructure exposed to a flood event, leading to a decrease in accessibility, with the project as compared to without. | 1. Reduction in number of critical service utility facilities exposed to a flood event with the project as compared to without | 1. Reduction in number of critical service utility facilities exposed to a flood event with the project as compared to without |
| | Reduced hazard of nuisance flooding ^c | 2. Reduction in percentage of total residential and commercial property value expected to be damaged in floods with the project as compared to without | 2. Reduction in number of users potentially affected due to exposed transportation infrastructure | 2. Reduction in number of users or customers potentially affected due to disruption of critical service utilities | 2. Reduction in number of users or customers potentially affected due to disruption of critical service utilities |
| | | 3. Property value of residential and commercial properties exposed to a flood event with and without project | 3. Avoided repair/replacement cost to transportation infrastructure exposed to a flood event | 3. Avoided days of closure or disruption of critical service utilities | 3. Avoided days of closure or disruption of critical service utilities |
| | | 4. Reduction in flood insurance premiums or change in the Community Rating System (CRS) rating of the National Flood Insurance Program (NFIP) as the result of project | 4. Avoided days of closure of transportation infrastructure | 4. Avoided loss of critical service utilities | 4. Avoided loss of critical service utilities |
| | | 5. Tax base increase attributed to residential and commercial properties exposed to a flood event with and without project | 5. Avoided losses from closures or delays | | |
| | | 6. Reduction in expected damages to properties from floods with the project as compared to without | | | |

- Metrics are numbered in order of increasing level of detail and potential difficulty in measuring relative to each individual list.
- Critical service facilities include power, fuel/gas/electricity, water, and sewer utilities, emergency services, health services, communication services, food supply, National Guard bases, and transportation hubs.
- Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.
- Nuisance flooding is defined as flood events that occur at least every year.

Exhibit 12. Methodologies for Property and Infrastructure Protection and Enhancement, mapped to resilience goals, project outcomes, and core metrics.

| Socio-Economic Resilience Goals | Project Outcomes | Performance Metrics | Possible Methodologies ^a |
|--|--|---|--|
| Reduction in number of residential, commercial, cultural, and heritage properties at risk to potentially damaging inundation | Reduced extent of damaging inundation from major storm and flood events ^b and reduced hazard of nuisance flooding ^c | Reduction in number of properties exposed, reduction in percentage of total residential and commercial property value exposed, increase in property value, increase in tax base attributed to properties, reduction in expected damages | <ul style="list-style-type: none"> Low: Use changes in a community's ranking or participation in the NFIP's CRS program as a proxy to indicate improved protection of infrastructure. Medium: Demonstrate the link between the project actions and increased protection to infrastructure functionality by using one of the methods described for estimating biophysical change. High: Model the effects of the project using a spatial overlay of the extent and depth of inundation with property and infrastructure components with and without the project using Hazus-MH. |
| Reduction in miles of roads, highways, and rail lines at risk to potentially damaging inundation | | Reduction in number of miles exposed, reduction in number of users affected, avoided damage cost, avoided days of closure or disruption | |
| Reduction of critical service facilities at risk to potentially damaging inundation | | Reduction in number of critical service and utility facilities exposed, reduced in number of users or customers affected, avoided loss of critical service and utility facilities, avoided days of closure or disruption | |
| Property enhancement from improved amenities | Improved water and soil quality, reduced soil contamination, restored beaches, dunes, improved fish and shellfish habitat; increased fish and shellfish abundance and diversity, improved vegetative cover, and improved amenities | Number of residential, commercial, cultural, and heritage properties benefiting, property value of residential and commercial properties, tax base attributed to residential and commercial properties benefiting, increase in property value of residential and commercial properties benefiting | <ul style="list-style-type: none"> Low: Spatial overlay with the estimated of affected area and properties Medium: Demonstrate the link between the project actions and increased protection to infrastructure functionality by using one of the methods described for estimating biophysical change. High: Actual changes in property values resulting from environmental quality improvements can be estimated based on an original hedonic valuation study. |

a. Methodology options: **Green** – low level of effort; **Blue** – medium level of effort; **Red** – high level of effort

b. Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.

c. Nuisance flooding is defined as flood events that occur at least every year.

Example: Human Health and Safety



Ecological Outcomes

- Changes in floodplain area
- Changes in the maximum height of water from a particular flood
- Improved water quality
- Reduced soil contamination
- Increase in % native vegetation
- Improved water management and fire control

Socio-economic Metrics

Reduction in # of households exposed to flood hazard



Reduction in # people exposed to contaminated water, soil, mosquito-borne disease, and wildfire

Metrics - Human Health and Safety



| Metrics for Human Health and Safety | | Resilience Goals | |
|-------------------------------------|---|---|---|
| | | Reduction in number of people at risk for injury, casualty, or other health effects from a particular flood event | Reduction in number of people at risk for negative effects from contaminated water, soil, mosquito-borne disease, and wildfire |
| | | Metrics ^a | |
| Biophysical and Ecological Outcomes | Reduced extent of damaging inundation from major storm and flood events ^b | 1. Number of households in the area potentially affected by a project 2. Reduction in number of households exposed with the project as compared to without | |
| | Reduced hazard of nuisance flooding ^c | | 1. Number of households in the area potentially affected by a project 2. Reduction in number of households exposed with the project as compared to without |
| | Improved water quality | | 1. Reduction in number of households exposed to water-borne disease with the project as compared to without |
| | Improved water management and fire control | | 1. Reduction in number of households exposed to smoke and particulate matter with the project as compared to without |
| | Reduced soil contamination | | 1. Reduction in number of households exposed to a toxic pollutant with the project as compared to without |
| | Increased % native vegetation | | 1. Increase in number of households benefiting from reduced likelihood of West Nile Virus transmission |
| | Improved fish and shellfish habitat, increased fish and shellfish abundance and diversity | | 1. Increase in number of households with improved access to seafood |

a. Metrics are numbered in order of increasing level of detail and potential difficulty in measuring

b. Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.

b. Nuisance flooding is defined as flood events that occur at least every year or more.

Example – Human Health



USFWS Project: Increasing Water Management Capability at Great Dismal Swamp NWR to Enhance its Resiliency for Wildlife and People

Project Action

Project Outcome

Resilience Goal

Metric

**Increase in
water level in
the Great
Dismal Swamp**

**Reduced number
of wildfires**

**Reduced number of
individuals exposed to
particulate matter**

**Reduced medical
cost or reduced
work days lost**

Methodologies – Human Health



| | |
|--|---|
| Simple counts and narratives | Use existing literature to discuss potential changes in human health based on reduced exposure to smoke and particulate matter |
| Basic quantitative and GIS analysis | Assemble geospatial data of satellite images of smoke plumes on areas historically affected by wildfire smoke and overlay plume boundaries with the U.S. decennial census data. |
| Complex analysis | Determine the avoided incidence of adverse human health effects associated with reduced exposure to particulate matter in the areas affected by smoke from wildfire using EPA's BenMAP-CE |

Effects on Vulnerable Populations – Human Health



| Project Name | Total Number of Affected Households | Total Number of Affected Vulnerable Households |
|--|---|---|
| Increasing Water Management Capability at Great Dismal Swamp NWR to Enhance its Resiliency for Wildlife and People | Total number of affected households would be provided by the spatial overlay using the smoke plume and the U.S. decennial census data | Total number of affected vulnerable households would be provided by the spatial overlay using the smoke plume and the American Community Survey |

Vulnerable Households are defined as low income households and those with retirees, children below the age of five, and individuals with low English proficiency (Jepson and Colburn 2013)

Metrics - Property and Infrastructure Protection



| Metrics for Property and Infrastructure Protection | | Resilience Goals | | |
|--|--|--|--|---|
| | | Reduction in number of residential, commercial, cultural, and heritage properties at risk to potentially damaging inundation | Reduction in miles of roads, highways, and rail lines at risk to potentially damaging inundation | Reduction in number of critical service facilities ^a at risk to potentially damaging inundation |
| | | Metrics ^a | | |
| Biophysical and Ecological Outcomes | Reduced extent of damaging inundation from major storm and flood events ^b | <ol style="list-style-type: none"> 1. Reduction in number of properties exposed to flood event with the project as compared to without 2. Reduction in percentage of total residential and commercial property value expected to be damaged in floods with the project as compared to without | <ol style="list-style-type: none"> 1. Reduction in miles of transportation infrastructure exposed to a flood event, leading to a decrease in accessibility, with the project as compared to without. 2. Reduction in number of users potentially affected due to exposed transportation infrastructure | <ol style="list-style-type: none"> 1. Reduction in number of critical service and utility facilities exposed to a flood event with the project as compared to without 2. Reduction in number of users or customers potentially affected due to disruption of critical services or utilities |
| | Reduced hazard of nuisance flooding ^c | <ol style="list-style-type: none"> 3. Property value of residential and commercial properties exposed to a flood event with and without project 4. Reduction in flood insurance premiums or change in the Community Rating System (CRS) rating of the National Flood Insurance Program (NFIP) as the result of project 5. Tax base increase attributed to residential and commercial properties exposed to a flood event with and without project 6. Reduction in expected damages to properties from floods with the project as compared to without | <ol style="list-style-type: none"> 3. Avoided repair/replacement cost to transportation infrastructure exposed to a flood event 4. Avoided days of closure of transportation infrastructure 5. Avoided losses from closures or delays | <ol style="list-style-type: none"> 3. Avoided days of closure or disruption of critical services or utilities 4. Avoided losses from closures or delays |

- Metrics are numbered in order of increasing level of detail and potential difficulty in measuring relative to each individual list.
- Critical service facilities include power, fuel/gas/energy, water, and sewer utilities, emergency services, health services, communication services, food supply, National Guard bases, and transportation hubs.
- Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.
- Nuisance flooding is defined as flood events that occur at least every year.

Metrics - Property Enhancement



| Metrics for Property and Infrastructure Protection | | Resilience Goals |
|--|---|--|
| | | Enhancement of property and infrastructure components from improved natural amenities |
| | | Metrics ^a |
| Biophysical and Ecological Outcomes | Improved water quality | <ol style="list-style-type: none"> 1. Number of residential, commercial, cultural, and heritage properties benefiting from improvement 2. Property value of residential and commercial properties benefiting from improvement 3. Tax base attributed to residential and commercial properties benefiting from improvement 4. Increase in property value of residential and commercial properties benefiting from improvement (benefit transfer approach or original study) |
| | Reduced soil contamination | |
| | Reduced beach erosion; increased beach width; restored dunes | |
| | Improved vegetation cover; increase in vegetated area | |
| | Improved fish and shellfish habitat, increased fish and shellfish abundance and diversity | |
| | Improved natural amenities | |

a. Metrics are numbered in order of increasing level of detail and potential difficulty in measuring

Metrics - Economic Resilience

(*Exposure to Flood Hazard*)




| Metrics for Economic Resilience and Reduction to Exposure to Inundation | | Resilience Goals | | | |
|---|--|--|---|--|--|
| | | Reduction in quantity of tourism and recreational infrastructure at risk to flood hazard | Reduction in quantity of commercial fishing, shellfishing, and aquaculture infrastructure at risk to flood hazard | Reduction in the share of agricultural land and output at risk to flood hazard | Reduction in share of local and regional economic output at risk to flood hazard |
| | | Metrics ^a | | | |
| Biophysical and Ecological Outcomes | Reduced extent of damaging inundation from major storm and flood events ^b | 1. Reduction in number of buildings (e.g., hotels and summer rentals), recreational facilities, and amenities exposed to flood hazard | 1. Reduction in number of boat launches, warehouses, fishing vessels, and aquaculture leased bottom exposed to damage or disruption | 1. Reduction in number of acres exposed to flood hazard or increased salinity | 1. Reduction in number of businesses affected by a flood event |
| | Reduced hazard of nuisance flooding ^c | 2. Reduction of number of visitors affected 3. Avoided user days lost 4. Avoided replacement cost 5. Avoided economic losses (lost revenue) | 2. Reduction of number of potentially jobs affected by flood event 3. Avoided work days lost 4. Avoided replacement cost 5. Avoided economic losses (lost revenue) | 2. Avoided economic losses (lost revenue) | 2. Reduction of percent of local economic output potentially exposed to damage or disruption 3. Reduction of number of jobs potentially affected by a flood event 4. Avoided economic losses (total value and % of local output) |

- Metrics are numbered in order of increasing level of detail and potential difficulty in measuring
- Major storm and flood events are defined as FEMA's 0.2%, 1%, 2%, or 5% flood events.
- Nuisance flooding is defined as flood events that occur at least every year or more.

Metrics - Economic Resilience

(Natural Amenities Enhancement)



| Metrics for Economic Resilience and Natural Amenities Enhancement | | Resilience Goals | | |
|---|---|---|---|---|
| | | Enhancement of tourism and recreational | Enhancement of fishing, shellfishing, and aquaculture business | Enhancement of local and regional ^a economic output |
| | | Metrics ^a | | |
| Biophysical and Ecological Outcomes | Improved fish/shellfish habitat; increased fish abundance and diversity; improved water quality | <ol style="list-style-type: none"> 1. Number of recreational fishing/shellfishing sites and areas in project's vicinity 2. Number of anglers/users visiting the affected sites; number of fishing permits 3. Increase in fish/shellfish abundance and harvest or catch rates | <ol style="list-style-type: none"> 1. Area of aquaculture leased bottom in project's vicinity 2. Number of commercial fishing/shellfishing permits holders affected by project 3. Increases in commercial fishing/shellfishing revenues 4. Avoided number of days of shellfish bed of closures (acres/days) 5. Increases in commercial species harvest | <ol style="list-style-type: none"> 1. Number of related businesses affected 2. Percent of local economic output affected  |

a. Metrics are numbered in order of increasing level of detail and potential difficulty in measuring

Metrics - Community Competence and Empowerment



| Metrics for Institutional and Community Resilience for Planning, Tools, and Science Outcomes | | Resilience Goals | | |
|--|--|---|--|--|
| | | Increased institutional capacity | Enhanced knowledge | Increased community competence and engagement for projects other than restoration |
| | | Metrics* | | |
| Project Outcomes | Improved community comprehensive planning, mapping, and zoning efforts | 1. Increase in participation or ranking of NFIP's CRS program | 1. Increase in number of partnerships across institutions, governments, and community groups | 1. Increase in number of repeat volunteers at events |
| | Improved communication plans, including emergency communication plans and communication tools for mitigation, risks, and hazards | 2. Number of stakeholder/lead user groups involved in development and implementation of project | 2. Increase in number of regional partnerships | 2. Increase in number of households participating in public planning sessions or project run events |
| | Improved hazard mitigation planning, actions, or capital expenditures | 3. Increase in number of communities with comprehensive plans, hazard planning, and emergency communication plans that meet minimum or best practice standards | 3. Creation of improved best practices for planning and mitigation for other regions, projects, institutions | 3. Increase in number of households making changes to own property (e.g. people storm proofing/or fitting houses to meet Federal |
| | | 4. Responsiveness to stakeholders/lead user groups involved in development and implementation (i.e., engagement with stakeholders through meetings, responses to comments, incorporation in to decision making process, etc.) | 4. Increase in number of planning and mitigation plans for the transfer and communications of best practices | |
| | | 5. Uptake of best practices for planning and mitigation by other organizations | 5. Increased regional actions and lasting planning coordination as the result of project | |
| | | 6. Increased speed of delivery of services and improvement of quality of services because of information provided by project | 6. Increased regional actions and lasting planning coordination as the result of project | |
| | | 7. Reduced cost or savings to implementing new | 7. Increased speed of delivery of services and improvement of quality of services because of information provided by project | |
| | | | 8. Reduced cost or savings to implementing new | |

■ Projects with Planning, Tools, and Science Outcomes

| | | | | |
|------------------|---|---|---|--|
| Project Outcomes | Increased quality and diversity of data acquisition, including datasets, maps, and models | 1. Increase in number of communities and other institutions accessing project products or tools | 1. Increase in number of tailored or gap-filling plans, datasets, maps, or models for specific communities | 1. Increase in number of households making changes to own property (e.g. people storm proofing/or fitting houses to meet FEMA BFE; people raising elevation/increasing freeboard of buildings) |
| | Increased quality and diversity of data analysis, including datasets, maps, and models | 2. Provision of technical assistance training to communities or stakeholders as part of the project | 2. Increase in number of partnerships across institutions, governments, and community groups | 2. Increase in number of households aware of risk reduction tools like early warning systems, evacuation routes, etc. |
| | Increased quality and diversity of data delivery for datasets, maps, and models (i.e. portals, visualization, etc.) | 3. Number of stakeholder/lead user groups involved in development and implementation of project | 3. Creation of improved best practices for other projects, institutions | |
| | | 4. Number of communities | 4. Creation of science or tools that can be used by other organizations and leveraged for additional research goals | |
| | | | 5. Increase in number of | |

Metrics - Community Competence and Empowerment

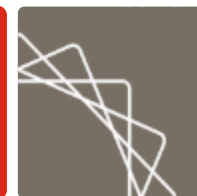


Projects with Biophysical or Ecological Outcomes

| Metrics for Institutional and Community Resilience for Biophysical or Ecological Outcomes | | Resilience Goals | |
|---|--|--|--|
| | | Increased community engagement and well-being resulting from restoration projects | Enhanced knowledge |
| | | Metrics ^a | |
| Biophysical and Ecological Outcomes | Improved fish/shellfish habitat; increased fish abundance and diversity; improved water quality | 1. Number of educational, outreach, and volunteer events held by the project | 1. Increase in number of partnerships across institutions, governments, and community groups |
| | Improved amenities—presence of observation platforms, boardwalks, etc.; changes to amenity accessibility | 2. Number of sites with enhanced activities (i.e. educational programs, recreational programs, etc.) | 2. Creation of improved best practices for other projects, institutions |
| | Improved vegetation cover; increase in vegetated area | 3. Number of researchers, volunteers, and students engaged in project | 3. Creation of science or tools that can be used by other organizations and leveraged for additional research goals |
| | Improved avian and terrestrial species habitat and biodiversity | 4. Number of community groups involved in project | 4. Increase in number of planning and mitigation plans for the transfer and communications of best practices Uptake of best practices by other organizations |
| | Reduced beach erosion; increased beach width; restored dunes | 5. Increase in number and percentage of schools with access to natural resources | 5. Use of science or tools by other organizations or stakeholders and analyzed by user type (public, decision makers, researchers, etc.) |
| | Improved fish/shellfish habitat; increased fish abundance and diversity; improved water quality | 6. Increase in number and percentage of local residents spending time outdoors due to project | 6. Reduced cost or savings to implementing new projects elsewhere because of information provided by project |

a. Metrics are numbered in order of increasing level of detail and potential difficulty in measuring relative to each individual list

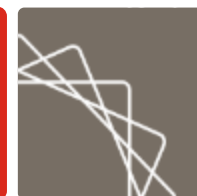
Metric Assignment



| | A | F | G | H | I | J |
|----|--|--|--|--|--|--|
| 1 | Resilience Categories→ | Property and Infrastructure Protection and Enhancement | | Economic Resilience | | |
| 2 | Resilience Goals→ | P3) Reduction of critical service facilities at risk to potentially damaging inundation | P4) Enhancement of property and infrastructure components from improved amenities | E1) Reduction in quantity of tourism and recreational infrastructure at risk to flood hazard | E2) Reduction in quantity of commercial fishing, shellfishing, and aquaculture infrastructure at risk to flood hazard | E3) Reduction in shoreline agriculture land at risk to flood hazard |
| 4 | Project Outcomes↓ | | | | | |
| 16 | 12) Reduced extent of damaging inundation from major storm and flood events | 1. Reduction in number of critical service and utility facilities exposed to a flood event with the project as compared to | | 1. Reduction in number of buildings (e.g., hotels and summer rentals), recreational facilities, and amenities exposed to | 1. Reduction in number of boat launches, warehouses, fishing vessels, and aquaculture leased bottom exposed to | 1. Reduction in number of acres exposed to flood hazard or increased salinity 2. Avoided economic |

| | | | | |
|----|---|--|---------------------------------------|--|
| 17 | 13) Reduced hazard from flooding | If a project includes: | HHS metrics categories | PI metric categories |
| | | Community Resilience Planning | | |
| | | Contaminant Assessment or Remediation | H2.15; H2.10 | P4.14; P4.10 |
| | | Critical Infrastructure Assessment or Protection | | P2.12; P3.12; P2.13; P3.13 |
| | | Data, Mapping, and Modeling | | |
| | | Ecological Resilience Planning | | |
| | | Green Infrastructure Planning and Implementation (livable) | H1.12; H2.13; H2.10; H2.8; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.10; P4.11; P4.8; P4.5 |
| | | Grey Infrastructure (dams, culverts, berms) | H1.12; H2.13; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.11 |
| | | Habitat Restoration | H1.12; H2.13; H2.10; H2.9; H2.8; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.10; P4.11; P4.8; P4.5 |
| | | Impact or Vulnerability Assessments | | |
| | | Public Access | | P4.5 |
| | | Sand Resource Identification or Assessment | | |

Metric Assignment



| | A | F | G | H | I | J |
|---|------------------------|--|--|---|--|--|
| 1 | Resilience Categories→ | Property and Infrastructure Protection and Enhancement | | Economic Resilience | | |
| | Resilience Goals→ | P3) Reduction of critical service facilities at risk to potentially damaging | P4) Enhancement of property and infrastructure | E1) Reduction in quantity of tourism and recreational | E2) Reduction in quantity of commercial fishing, shellfishing, and | E3) Reduction in share of agriculture land at risk from flood hazard |

H2.14.1

H2

Resilience Category (H) and Resilience Goal (#2)

Human Health & Safety (H) and Reduction of people at risk for negative effects from contaminated water... (#2)

14

Project Outcome (#14)

Reduced soil contamination

1

Metric (#1)


Reduction in the number of households exposed to toxic pollutants

| | | | |
|----|---|---------------------------------------|--|
| 17 | Data, Mapping, and Modeling | | |
| | Ecological Resilience Planning | | |
| | Green Infrastructure Planning and Implementation (livestock, agriculture, etc.) | H1.12; H2.13; H2.10; H2.8; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.10; P4.11; P4.8; P4.5 |
| | Grey Infrastructure (dams, culverts, berms) | H1.12; H2.13; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.11 |
| | Habitat Restoration | H1.12; H2.13; H2.10; H2.9; H2.8; H2.3 | P2.12; P3.12; P2.13; P3.13; P4.10; P4.11; P4.8; P4.5 |
| | Impact or Vulnerability Assessments | | |
| | Public Access | | P4.5 |
| | Sand Resource Identification or Assessment | | |

Metric Assignment Testing



USFWS- 32 Resilience of the Tidal Marsh Bird Community to Hurricane Sandy and Assessment of Restoration Effects

| Resilience Goal | Metrics ^a assigned through <u>activity</u> categories | Metrics ^a assigned through <u>individual</u> review |
|---|--|--|
| Increased institutional capacity | <ol style="list-style-type: none"> 1. Increase in participation or ranking of NFIP's CRS program 2. Increase in number of partnerships across institutions, governments, and community groups 3. Increase in number of communities with comprehensive plans, hazard planning, and emergency communication plans that meet minimum or best practice standards, including for green infrastructure 4. Increase in number of tailored or gap-filling plans, datasets, maps, or models for specific communities | <ol style="list-style-type: none"> 2. Increase in number of partnerships across institutions, governments, and community groups 3. Increase in number of communities with comprehensive plans, hazard planning, and emergency communication plans that meet minimum or best practice standards, including for green infrastructure 4. Increase in number of tailored or gap-filling plans, datasets, maps, or models for specific communities |
| Increased community competence and engagement for projects other than restoration | <ol style="list-style-type: none"> 1. Increase in number of repeat volunteers at events 2. Increase in number of households participating in public planning sessions or project run events 3. Increase in number of households making changes to own property (e.g. people storm proofing/or fitting houses to meet FEMA BFE; people raising elevation/increasing freeboard of buildings) 4. Increase in number of households aware of risk reduction tools like early warning systems, evacuation routes, etc. | <ol style="list-style-type: none"> 1. Increase in number of repeat volunteers at events  |

Products



- Report
- Metrics Matrix
- User Guide
- Literature Review

| Summary of literature review to support Socio-Economic metric development | | | | | | | | | | | |
|---|--|------|--|---------------------|--|---|---|--------------------|--|--|--|
| Author(s) | Title | Year | Source | Document | Full Citation | Key words | Annotation | Key | | | |
| Alberini, A. & Guignet, D. | Preliminary stated-preference research on the impact of LUST sites on property values: focus group results | 2010 | National Center for Environmental Economics | Government Report | Alberini, A. & Guignet, D. (2010). Preliminary stated-preference research on the impact of LUST sites on property values: focus group results (No. 201009). National Center for Environmental Economics. | soil contamination; stated preference | This stated preference study was used for developing soil contamination value estimates. There were a couple of survey groups, with the response range due to different assumptions about level of risk, and different | Metric Methodology | | | |
| Allan, B.F. et al. | Ecological correlates of risk and incidence of West Nile virus in the United States | 2008 | Oecologia | Journal Publication | Allan, B.F. et al. (2008). Ecological Correlates of Risk and Incidence of West Nile Virus in the United States. Oecologia 158:693-708. | methodology; West Nile Virus; avian diversity | This study provides evidence of reducing the risk of transmission of the West Nile Virus resulting from increased avian diversity in the area, and the effect of the diversity is represented by the change in the per capita human | Metric Methodology | | | |
| Artell, J. | Lots of Value? A spatial hedonic approach to water quality valuation | 2014 | Journal of Environmental Planning and Management | Journal Publication | Artell, J. (2014). Lots of Value? A spatial hedonic approach to water quality valuation. Journal of Environmental Planning and Management 57(6): 862-882. | property values; methodology | This paper was referenced in the "property and infrastructure protection and enhancement" metric methodology. Information from this source can be used to estimate changes in property | Metric Methodology | | | |
| Atlantic Coast Cooperative | Data Collection and | | Atlantic Coast Cooperative Statistics Program's | | "Data Collection and Reporting." ACCSP. The Atlantic Coastal Cooperative Statistics Program (ACCSP) is the Principal Source of Dependable and Timely Marine Fisheries Statistics for Atlantic Coast | methodology | This source was used in the "economic resilience" metrics methodology discussion. Data necessary to estimate the extent | Metric | | | |

2. Project Categorization

Our effort to develop socio-economic metrics began with a screening level review of the 162 DOI Hurricane Sandy Coastal Resiliency program's subprojects (resilience projects). The goal of this initial review was to identify critical project characteristics that could be used to categorize projects. In turn, being able to categorize the projects was critical for establishing representative subsets of projects that would undergo a more in-depth review through interviews to help develop and review potential metrics. We ultimately categorized the reviewed proposals according to the location, budget, primary activities (e.g., Community Resilience Planning, Habitat Restoration, Grey Infrastructure), and environmental feature (e.g., beach, nearshore, etc.).

In particular, a project's primary activity quickly emerged as a critical characteristic that could be used to distinguish and thus categorize Resilience Projects. Characterizing and categorizing

Project activity refers to the primary actions of a project, as described in its grant/proposal.

Project outcome refers to the final impact or intended impact of a project on its location. It roughly corresponds to ecosystem services.

SOCIO-ECONOMIC METRICS USER GUIDE

User Guide

[This user guide should be used with the "Metrics Matrix and Project Analysis" Excel workbook. The workbook includes a "File" tab with definitions and descriptions of each worksheet; a "Project Analysis" tab which includes the 162 DOI Hurricane Sandy resilience projects reviewed with descriptive information; a "Metrics for Project Activities" tab which recommends suites of metrics for Project Activity categories; and a "Metrics" tab which includes all the metrics presented as a matrix of Project Outcome and Resilience Goals.

Recall that the metrics process was first informed and organized by Resilience Categories. In particular, four Resilience Categories were identified: Human Health and Safety; Property and Infrastructure Protection and Enhancement; Economic Resilience; and Community Competence and Empowerment. The purpose of organizing by Resilience Category is to ensure that each metric is tied to a socio-economic benefit and to provide a framework for understanding the value of each metric in evaluating community resilience. The first three Resilience Categories (Human Health and Safety; Property and Infrastructure Protection and Enhancement; and Economic Resilience) collectively address projects with direct ecological or biophysical outcomes. The Community Competence and Empowerment Resilience Category provides metrics for projects that consist of planning, outreach, or research with the primary objective of indirect efforts to advance community competence and resilience (or ultimate and final services that will advance community competence and resilience). Each metric is mapped to the Project Outcomes and then grouped under Resilience Categories and Resilience Goals.

The metric design developed for this study is purposely flexible and provides for three approaches to identify metrics and methodologies. These three approaches are based on how one will enter or begin the metric's consideration process, and include:

- The Project Activity(s) assigned to each project.
- The Project Outcomes (e.g., a project lead may know or design a project to result in a particular outcome).
- The specific Resilience Goal.

"Project Analysis" tab includes information for all 162 DOI Hurricane Sandy Resilience projects:

- Project identification number
- Funding organization or agency
- Project name
- Brief description of the project
- State where the project is located
- Grant amount awarded to the project
- Habitat where the project occurs
- Record of socio-economic measures if they are currently being measured
- Number of Project Activities assigned to the project
- Specific Project Activities assigned to the project
- Any self-reported measurements done by the project

"Metrics" tab includes a matrix of all the metrics with the Resilience Goals as columns and the Project Outcomes as rows. The matrix is coded with reference letters and numbers to help identify each metric.

"Metrics for Project Activities" tab includes reference codes for each suite of metrics assigned to the Project Activity broken out by the four Resilience Categories.

Next Steps



- **Path forward:** merging and refining of ecological and socio-economic metrics, advance best practices, prioritize/standard set of measures
- **Integrate** with other metric efforts
- **Evaluation:** Conduct evaluation of DOI resilience portfolio
- **Download report:**
<https://www.doi.gov/hurricanesandy/doi-news-socio-economic-metrics-report-0>
- Questions, email Susan_Taylor@abtassoc.com