

COASTAL VULNERABILITY INDEX FOR THE UAE



Photo: Paul Quinn

GREGG VERUTES
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CVI PROJECT TEAM



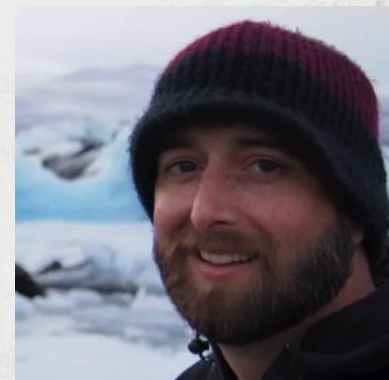
GREGG
VERUTES



LAURETTA
BURKE



MELISSA
ROSA



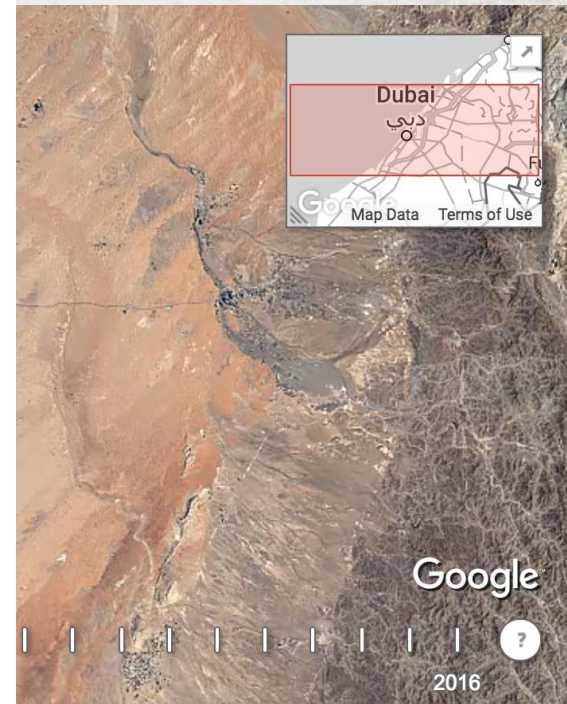
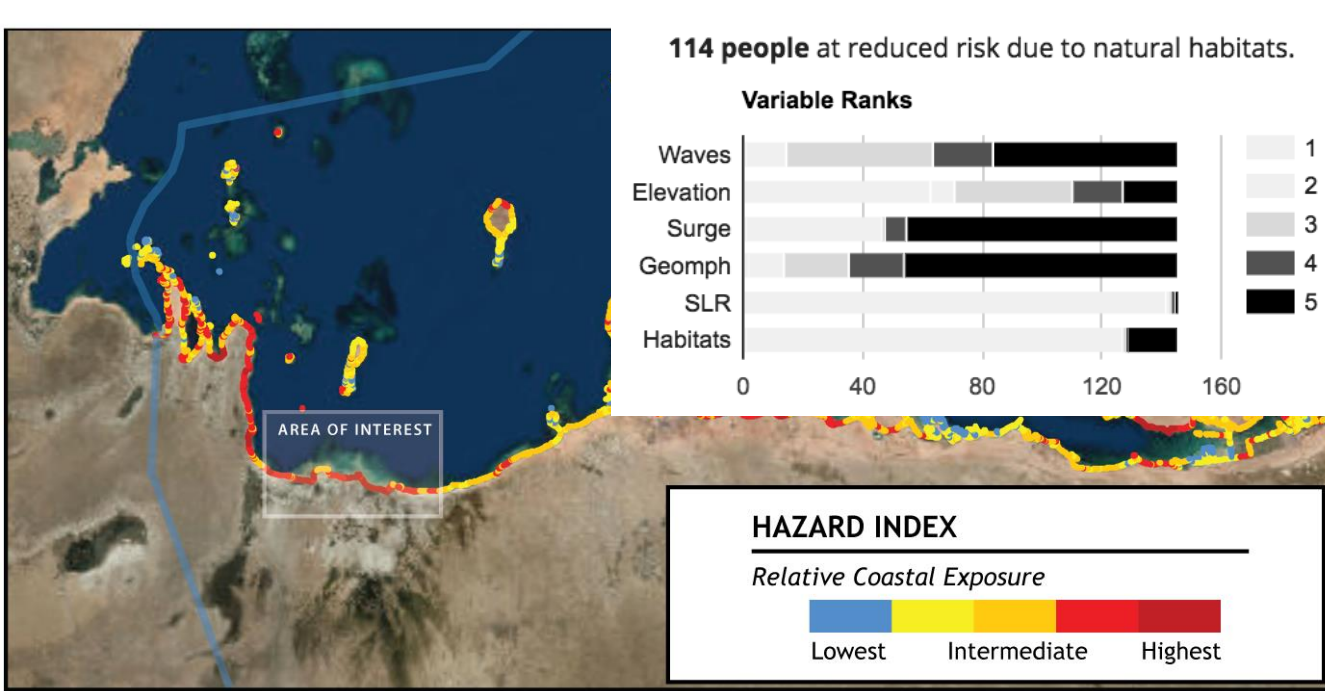
CHRISTOPHER
REED

COLLABORATORS & DATA PROVIDERS

- Jane Glavan, William Dougherty, Robert Arthur, John Burt, Raymond Grizzle
- AGEDI, MOCCE, UPC, EAD, EWS-WWF, NYU, and many others!

MOTIVATIONS & GOALS

Faced with growing intensity of human activities and climate change... coastal communities seek a better understanding of how modifications to the biological and physical environment can affect their exposure to storm-induced erosion and flooding



OBSERVED EROSION & ACCRETION

DUBAI EXAMPLE



PALM JUMEIRAH

THE WORLD ISLANDS / JUMEIRAH BEACH





Food,
fuel, fiber



Tourism

Climate
regulation



Coastal
protection



Clean
water

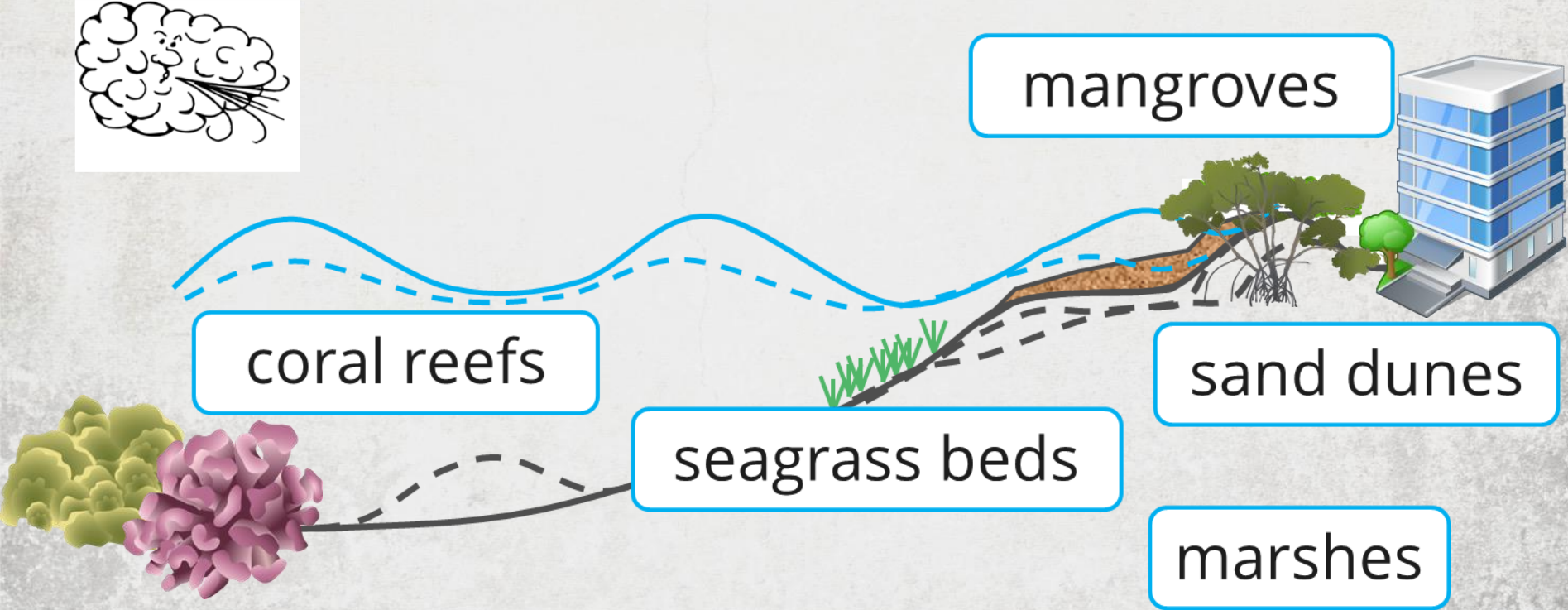


Spiritual
Fulfillment



COASTAL PROTECTION

“NATURE’S SHIELD”



Guannel et al., 2015.

Coastal Hazard Risk

High Risk Areas:

Coastal development with no habitat can increase risk.



Habitat Loss and Risk:

Loss of habitat erodes the coast and increases wave energy.



Reducing Risk with Habitat Restoration:

Marshes and oysters gather sediment and reduce wave energy.



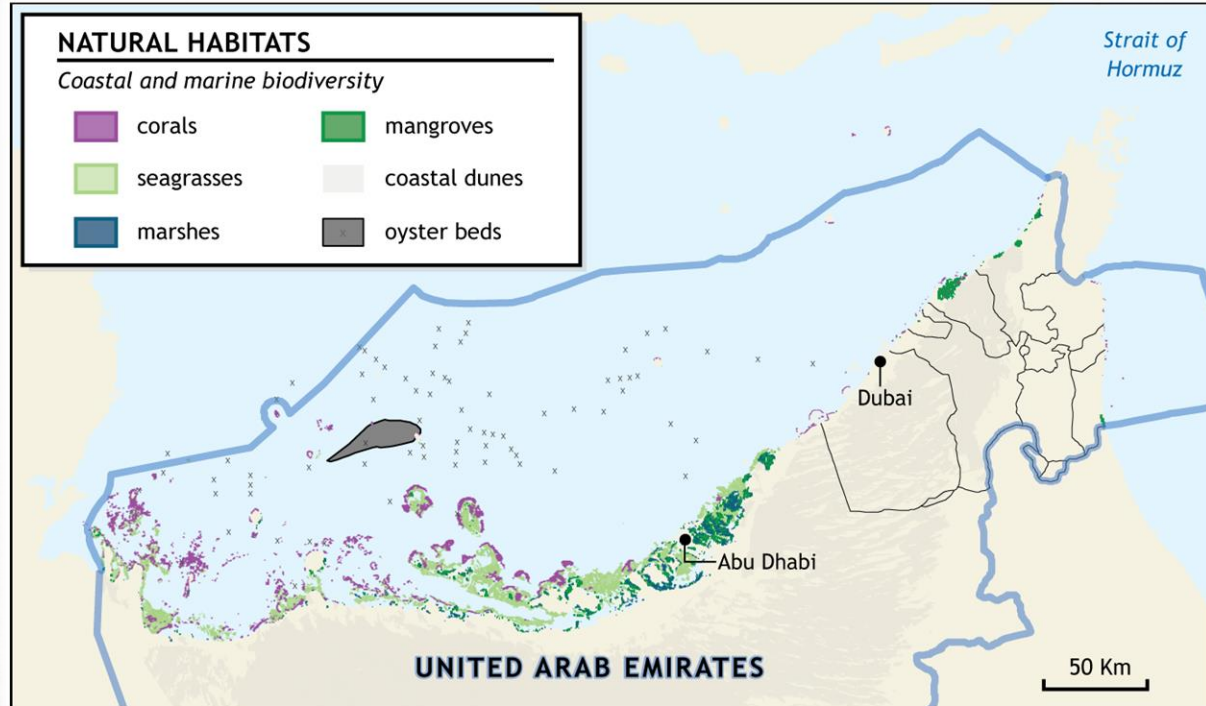
NATURE-BASED STRATEGIES

Arkema *et al.* 2013; The Nature Conservancy, 2013

SPATIAL SCOPE

Current distribution of **six natural habitats** along UAE's seven coastal emirates:

1. coral reefs
2. seagrass beds
3. salt marshes
4. mangrove forests
5. coastal sand dunes
6. oyster beds



COASTAL VULNERABILITY INDEX

IN THE CONTEXT OF CLIMATE CHANGE



Common barriers

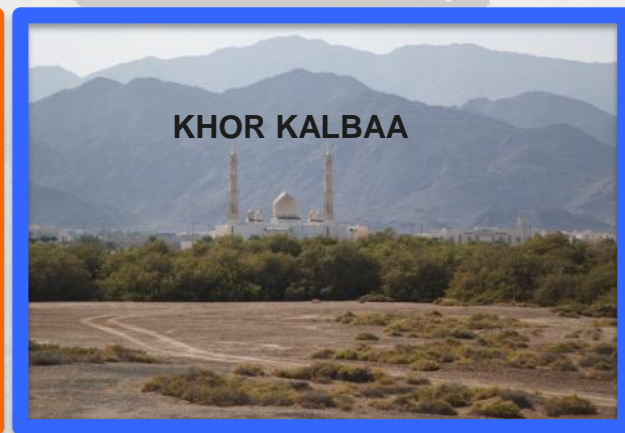
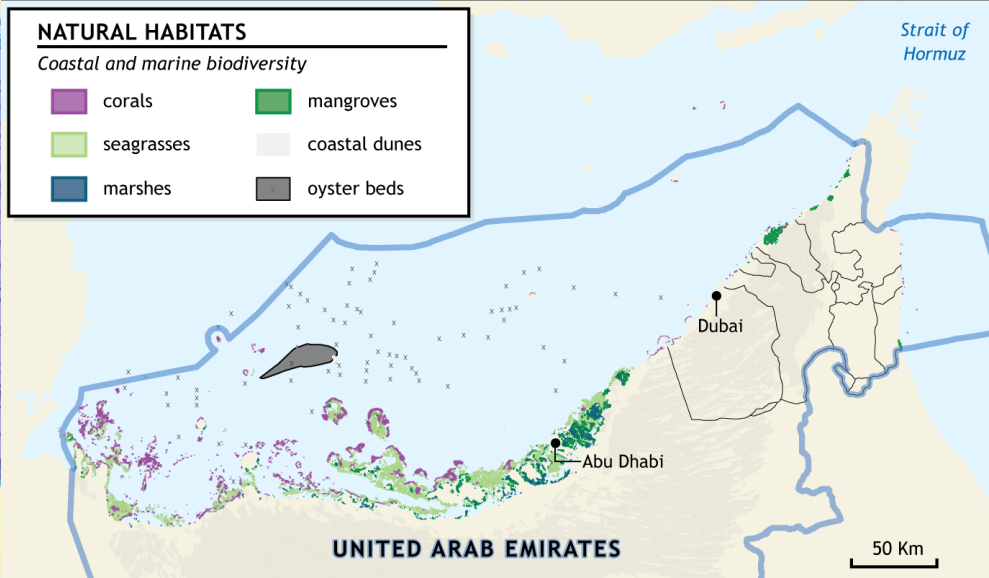
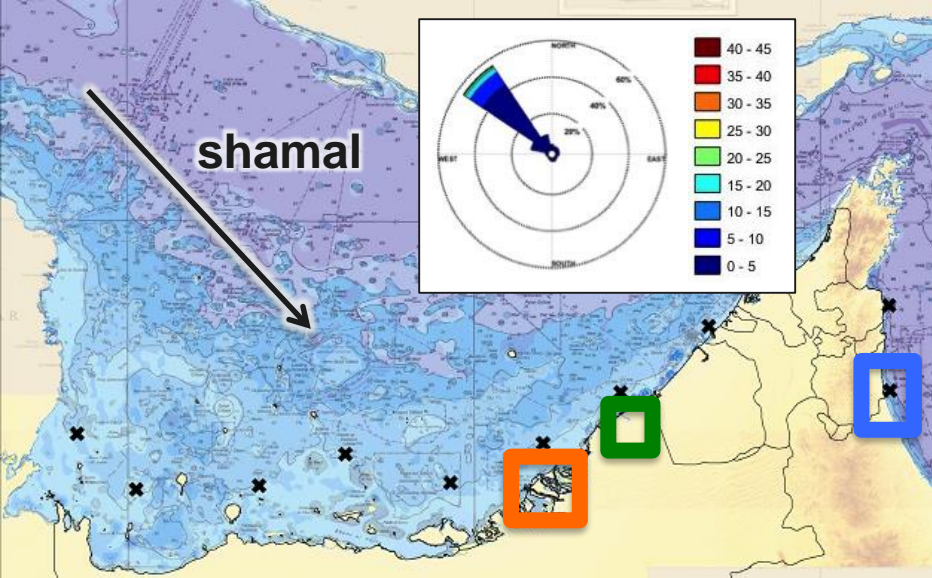
- Dearth of data describing the health of the coastal zone
- Limited technical capacity
- Complicated legal and political landscapes

Verutes et al. in press, IJBESM

CVI CONSULTATIONS & SITE VISITS

MAY 2016





Sandy Beach



Mangroves



The COMET Program



1



Rocky Coast

2



3

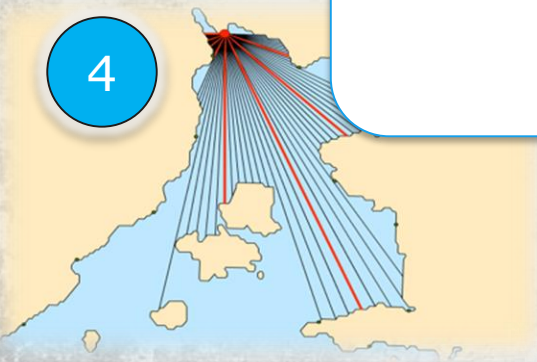


INPUT VARIABLES

GEOMORPHOL

ENTIAL

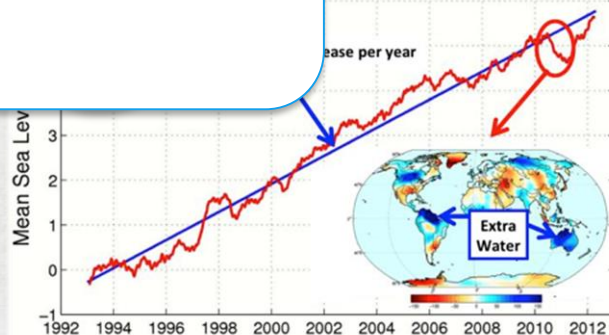
4



WAVE EXPOSURE



ELEVATION



SEA LEVEL CHANGE

Arkema et al. Nature Climate Change 2013

1. Which sections of the UAE coastline are **most exposed to hazards** from climate change and other factors?
2. Can we rely on **natural habitats** (coastal-marine biodiversity) to **reduce the impacts of coastal hazards** under future scenarios?
3. How can these findings inform future planning and management including conservation and restoration of **natural habitats that protect coastal populations, infrastructure and other assets**?



CONCLUSIONS



CVI DRIVERS ASSETS RESOURCES

COASTAL VULNERABILITY INDEX ?

Scale
 National

Zoom map to selected scale: no yes

Sea level rise ?
 2020 2050 2100

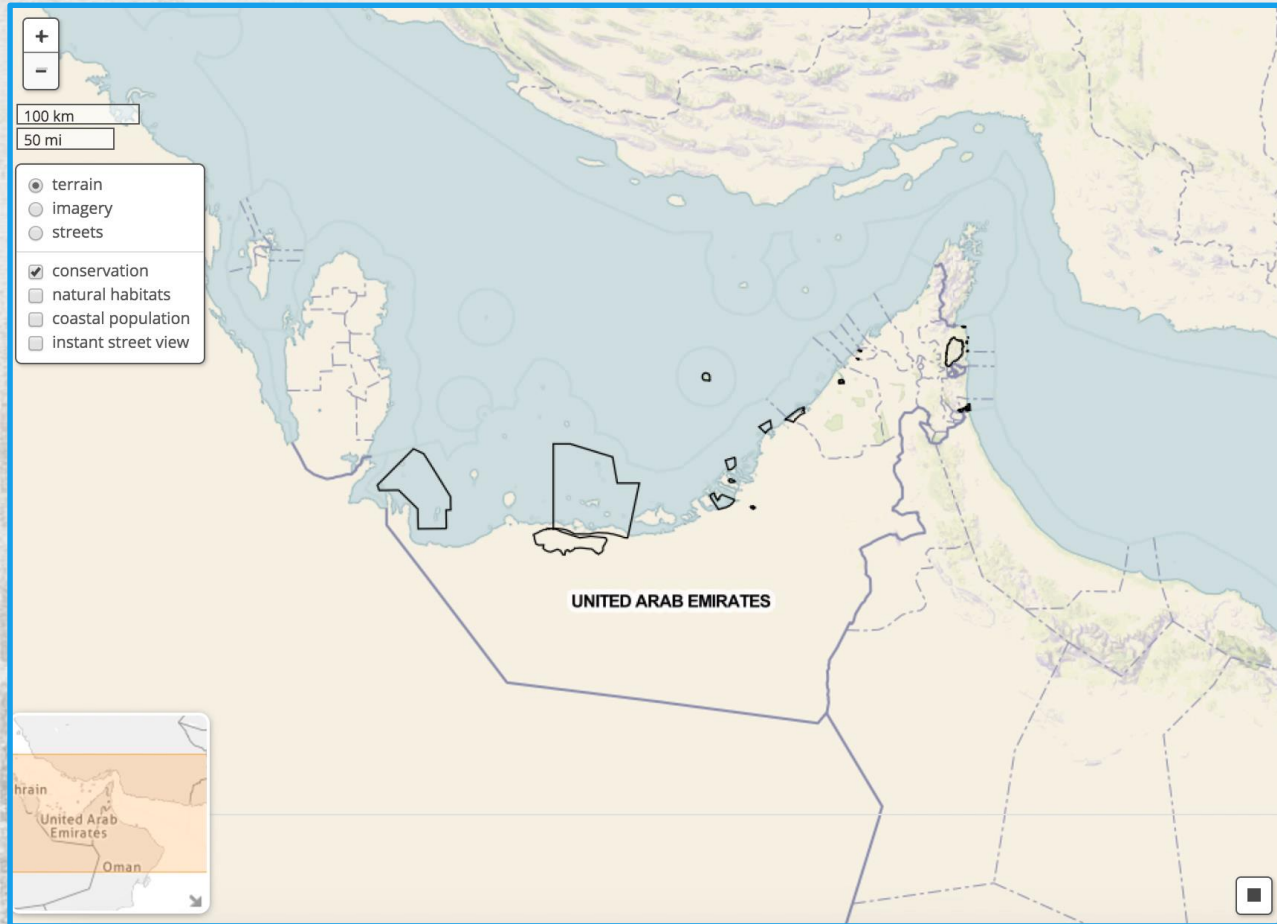
SHOW ME...
 Relative exposure to coastal hazards with current habitats
 Where habitats currently reduce risk to coastal communities
 Priority conservation areas where mangroves likely reduce risk

SHOW CLEAR

LEGEND

HABITAT ROLE
Reducing risk to coastal communities

Limited Moderate Highest



CVI DRIVERS ASSETS RESOURCES

COASTAL VULNERABILITY INDEX ?

Scale

Zoom map to selected scale: no yes

Sea level rise ?
 2020 2050 2100

SHOW ME...
 Relative exposure to coastal hazards current habitats
 Where habitats currently reduce risk to coastal communities
 Priority conservation areas where likely reduce risk

NATURAL HABITATS

Coastal and marine biodiversity

<input type="checkbox"/> corals	<input type="checkbox"/> mangroves
<input type="checkbox"/> seagrasses	<input type="checkbox"/> coastal dunes
<input type="checkbox"/> marshes	<input type="checkbox"/> oyster beds

RECOMMENDATIONS & NEXT STEPS

Can we rely on **natural habitats** to reduce the impacts of coastal hazards?



Where to prioritize conservation and restoration to

reduce risk to coastal communities?



MAPPING LOCALLY-RELEVANT METRICS: SOCIAL & ECOLOGICAL VULNERABILITY

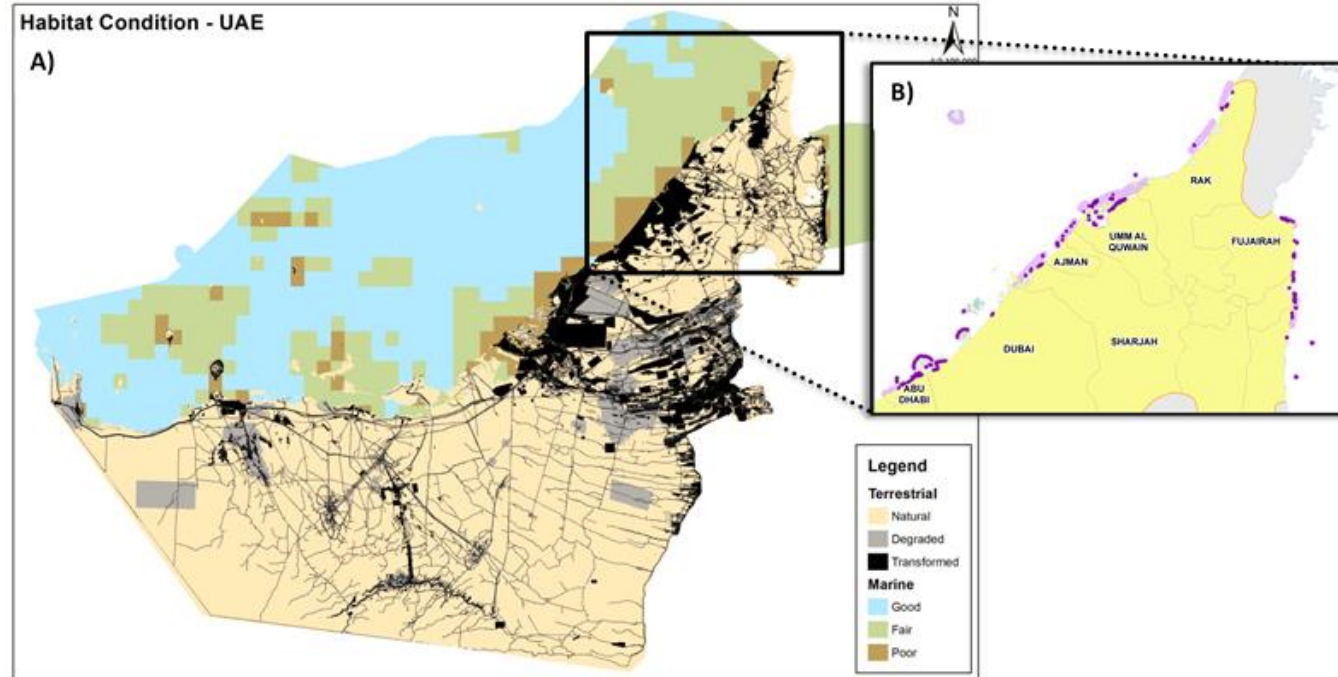
- **Ocean benefits:** tourism/recreation, blue carbon, f
- **Coastal communities:** total population, youth, el
- **Infrastructure** and other **coastal assets**
 - Access points, emergency services, ecologically-important roads, energy, cultural heritage, ...

SPATIAL PRIORITIZATION

TWO APPLICABLE FRAMEWORKS



Scenario-based planning?



ECOSYSTEM SERVICES

ECONOMIC

BIOPHYSICAL UNITS



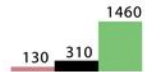
Belize Integrated Coastal Zone Management Plan 2016

“Promoting the Wise, Planned Use of Belize’s Coastal Resources.”

FUNCTIONAL HABITAT (km²)

- CORALS
- MANGROVES
- SEAGRASSES

YEAR: 2010
CURRENT



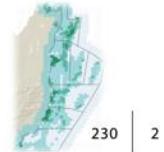
LOBSTER FISHERIES

LOW HIGH



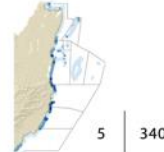
TOURISM

LOW HIGH



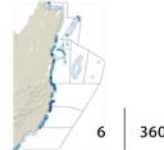
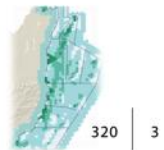
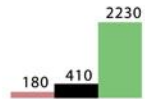
COASTAL PROTECTION

LOW HIGH

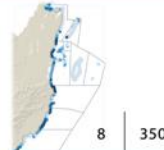
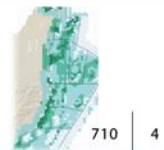
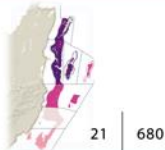
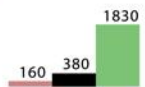


YEAR: 2025

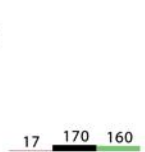
CONSERVATION



INFORMED MANAGEMENT



DEVELOPMENT



Verutes *et al.* in press
Arkema *et al.* 2015 PNAS



Coastal Zone Management Authority & Institute
Ministry of Agriculture, Forestry, Fisheries, the Environment & Sustainable Development

CHALLENGES & OPPORTUNITIES

- **Index-based approach**
 - Screening tool with relative ranks (lowest – intermediate – highest)
- **Multiscaled decision-support tool**
 - National >> Emirate >> Local?
- **Linkages to socioeconomic requires more spatial detail**
- **Potential for scenario-based planning and policy-**



NEXT STEPS

BUILDING UPON NATIONAL CVI

1. Model validation

- Observed (empirical) data; spatially-explicit

2. Scenario planning

- Localized habitat risk assessment (UPC: Plan Maritime)
- Ecosystem services (MOCCA: natural capital mapping)

3. Science-policy connections for nature-based strategies

- Restoration projects that meet least legal / political resistance
- Examples of successful implementation



CVI FOR LAND USE PLANNING

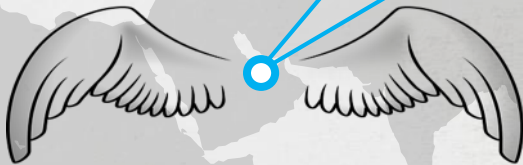
CALIFORNIA

SLS
Stanford Law School

CENTER FOR
OCEAN
SOLUTIONS

**UNITED ARAB
EMIRATES**

**THE
BAHAMAS**



IDB

Inter-American
Development Bank

natural
capital
PROJECT

EXTRAS

KNOWLEDGE CO-DEVELOPMENT

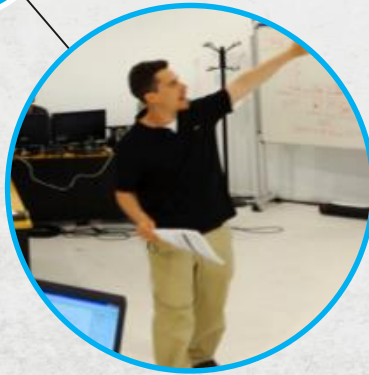
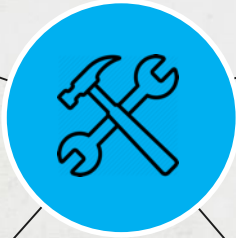
STAKEHOLDER ENGAGEMENT CAN...

- Improve the quality of decisions¹
- Increase perceptions that decisions are legitimate²
- Strengthen stakeholder knowledge and social capital³

¹Reed 2008

²Cash et al. 2003

³Chess & Purcell 1999, Blackstock et al. 2012



ASSESSING COASTAL VULNERABILITY

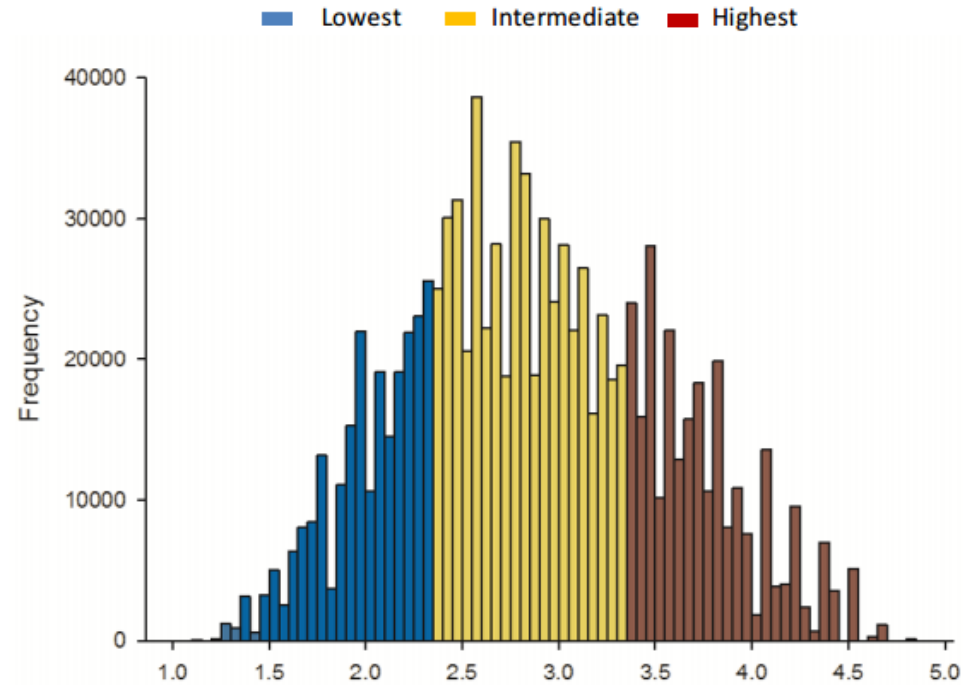
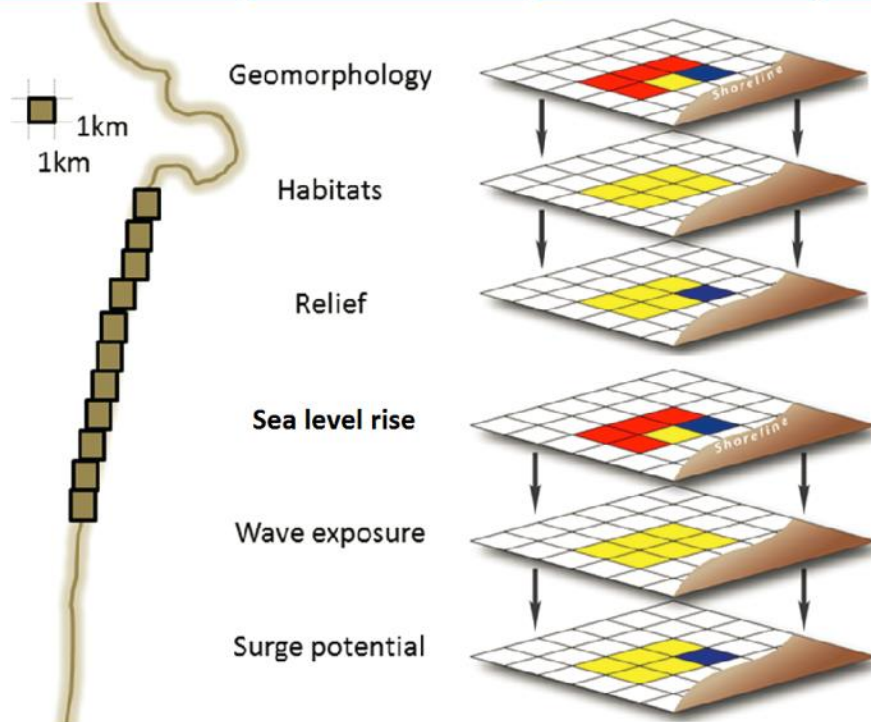
Factors affecting spatial distribution of vulnerability to hazards along the coastline:

Grid coast

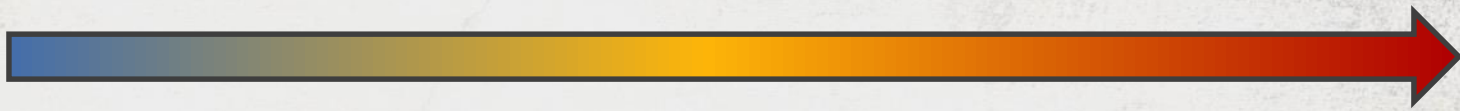
Input data

Variable ranks

Exposure index

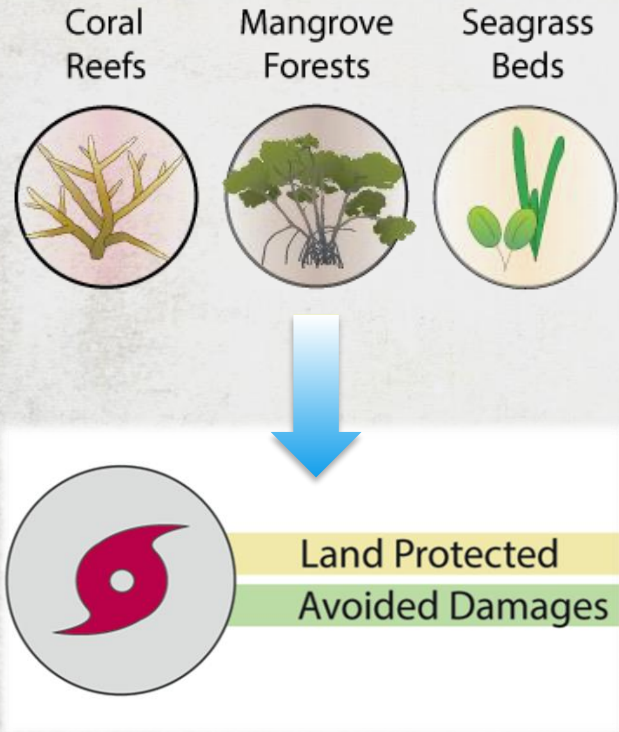


$$\text{Exposure Index} = (R_{\text{Habitats}} R_{\text{Sea level rise}} R_{\text{Geomorphology}} R_{\text{Relief}} R_{\text{Wave}} R_{\text{Surge Potential}})^{\frac{1}{6}}$$

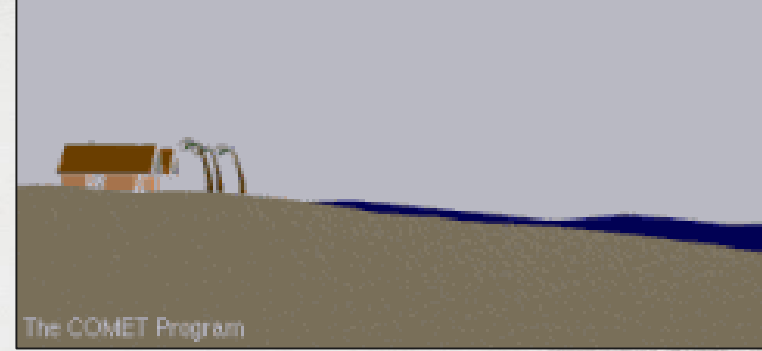


VARIABLE	Very Low Exposure Rank (1)	Low Exposure Rank (2)	Moderate Exposure Rank (3)	High Exposure Rank (4)	Very High Exposure Rank (5)
Geomorphology	Rocky; high cliffs; seawalls	Medium cliff; bulkheads and small seawalls	Low cliff; alluvial plain; revetments; rip-rap walls	Cobble beach; estuary; lagoon; bluff	Barrier beach; sand beach; mud flat; delta
Elevation (meters)	14.1 - 290 (<small>< 20th percentile</small>)	11.3 - 14.1 (<small>20th to 40th percentile</small>)	9.9 - 11.3 (<small>40th to 60th percentile</small>)	8.5 - 9.9 (<small>60th to 80th percentile</small>)	8.5 - 0 (<small>>80th percentile</small>)
Habitats	Coral reef; mangrove	Marsh	Coastal dune; oyster bed	Seagrass	No habitat
Sea Level Change (year)	Near term (2020)	Mid term (2050)	Long term (Arabian Sea: 2100)	Long term (Arabian Gulf: 2100)	-
Wave Exposure (kW/m)	< 0.001 (<small>< 20th percentile</small>)	0.001 - 0.007 (<small>20th to 40th percentile</small>)	0.007- 0.025 (<small>40th to 60th percentile</small>)	0.025 - 0.200 (<small>60th to 80th percentile</small>)	0.200 - 22.35 (<small>>80th percentile</small>)
Storm Surge Height (meters)	-	1.79 - 2.13 (<small>< 25th percentile</small>)	2.13 - 2.15 (<small>25th to 50th percentile</small>)	2.15 - 2.37 (<small>50th to 75th percentile</small>)	2.37 - 2.63 (<small>>75th percentile</small>)

DATA GAPS



Ruckelshaus *et al.* 2016, Coastal Management



MANY factors affecting flooding and erosion damages:

- Wave height and period
- *Net sea level change (long-term tide gauges)
- Land and *water depths
- Substrate type
- Natural habitats (*condition, *function)
- *Storm wind speeds & duration