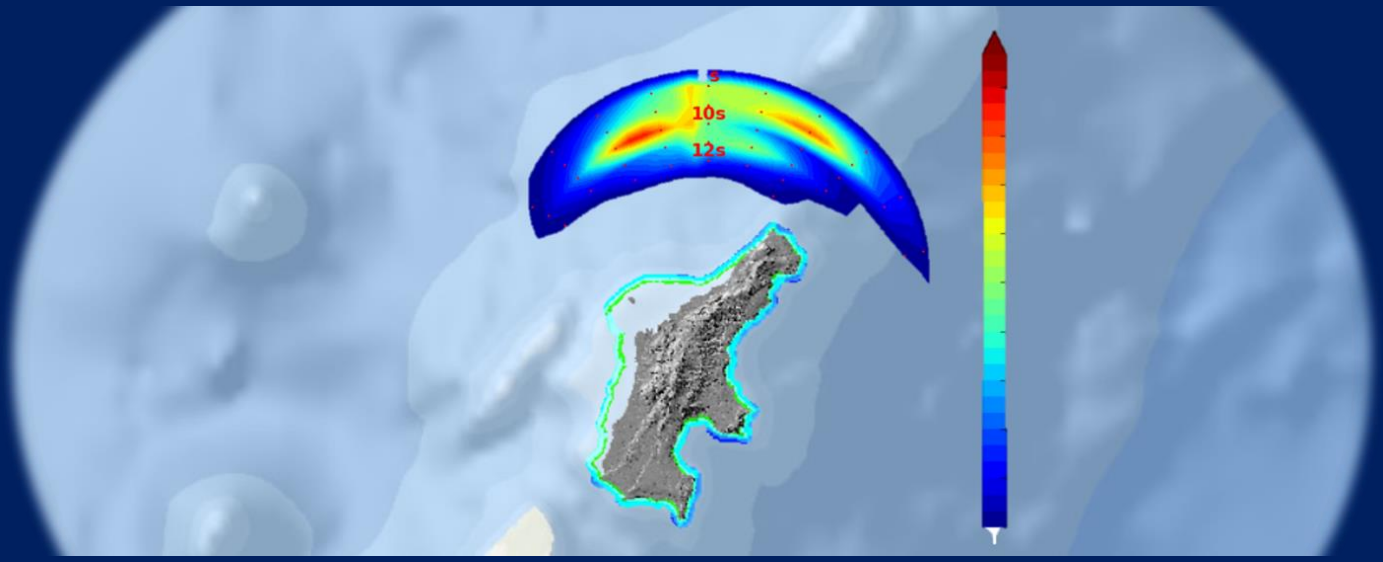
Shoreline Vulnerability Along The Saipan Lagoon:

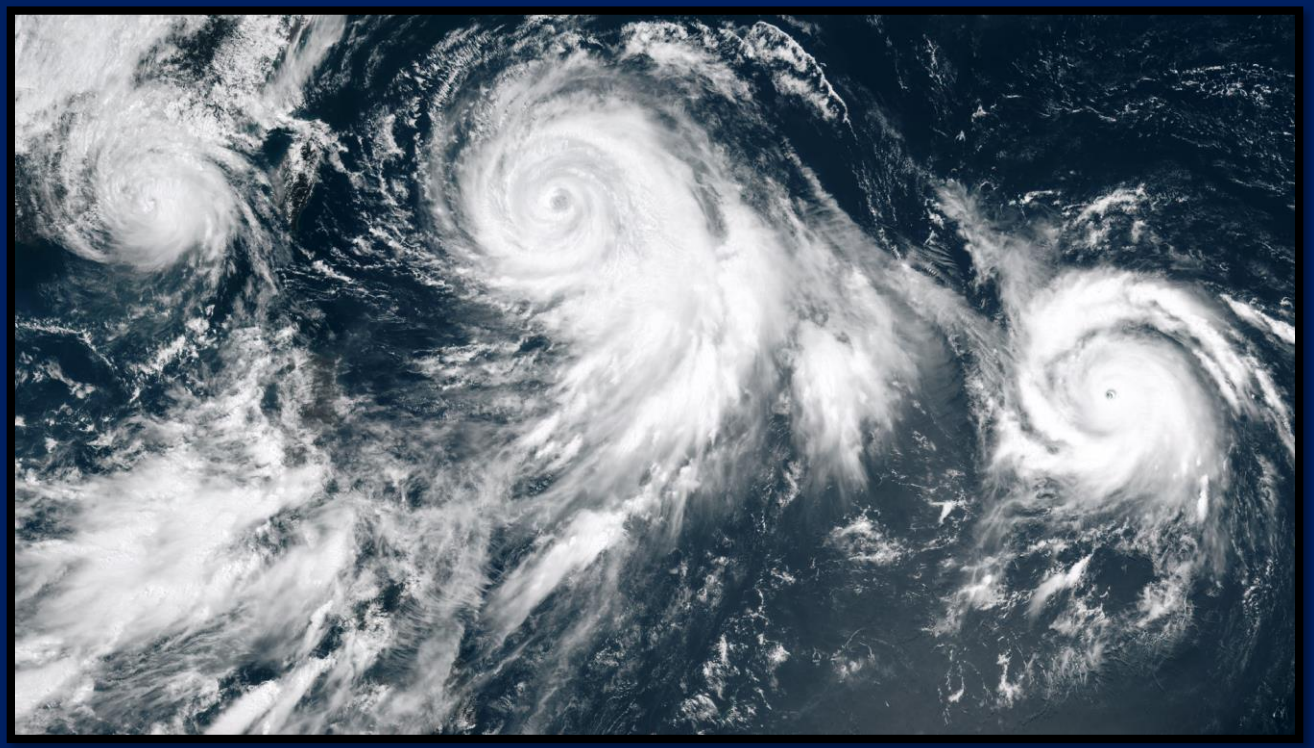
Measuring exposure in our lower watersheds



Rodney Camacho, BECQ

Robbie Greene, NOAA (affiliate)

What's the big deal?



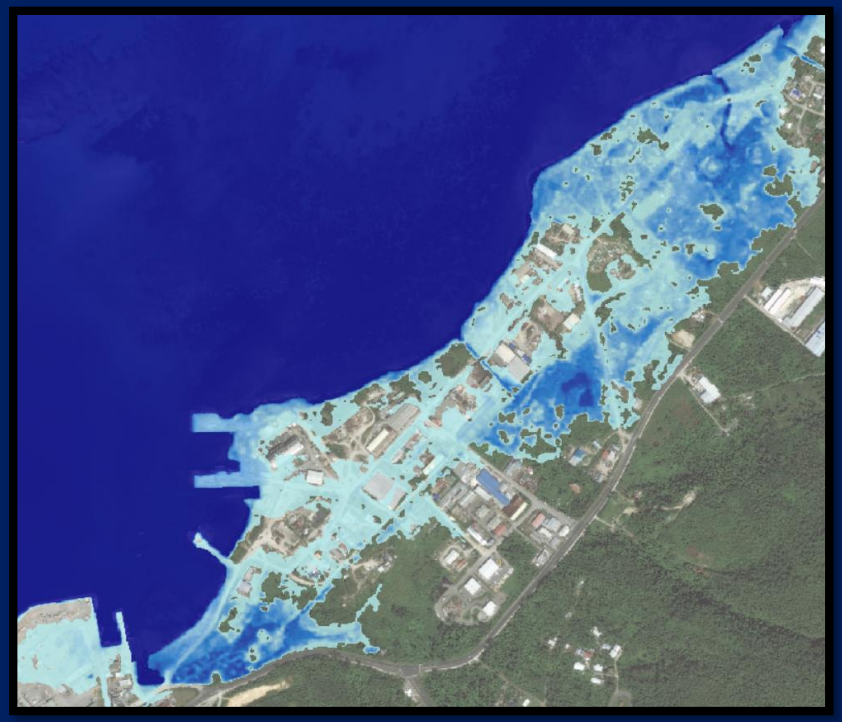
Were we lucky during Soudelor? How about the last 10 years?

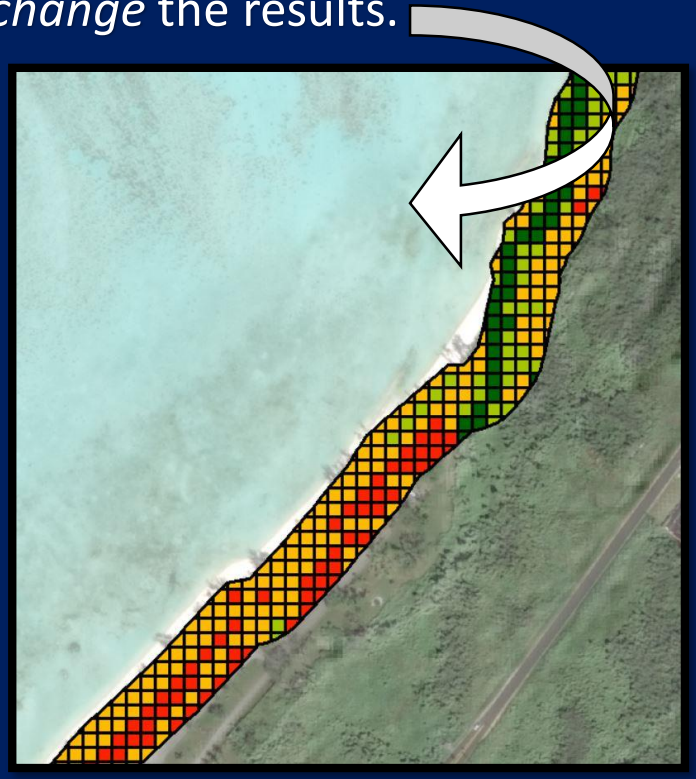
What is the reach *AND* magnitude of impact?

"Exposure vs. Sensitivity"

Relevance

- *"All models are wrong, but some are useful"*
  - *AST siting process; DCRM Regs,…?*
- Unlike the inundation model, we can *change* the results.





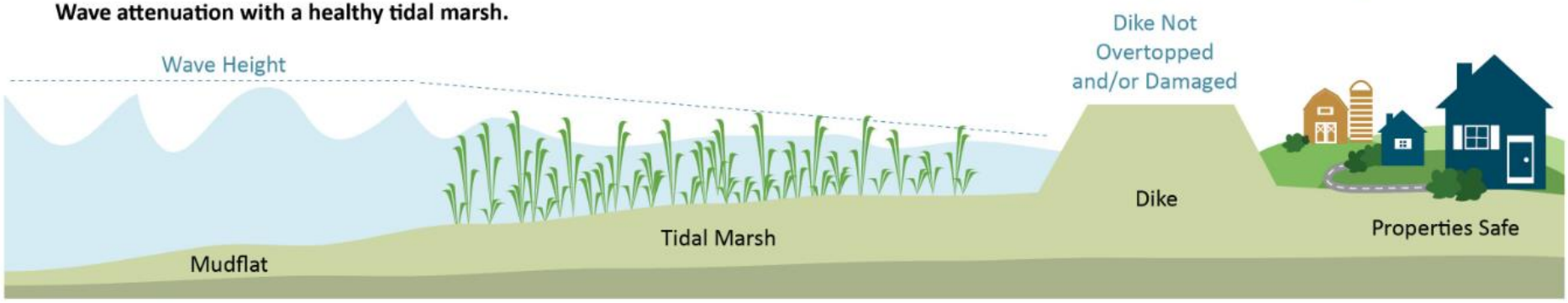
Intuition (and management activities) suggest overlap among lower watershed issues & vulnerable coastline

Approach:
InVEST Model/Coastal Defense App Overview

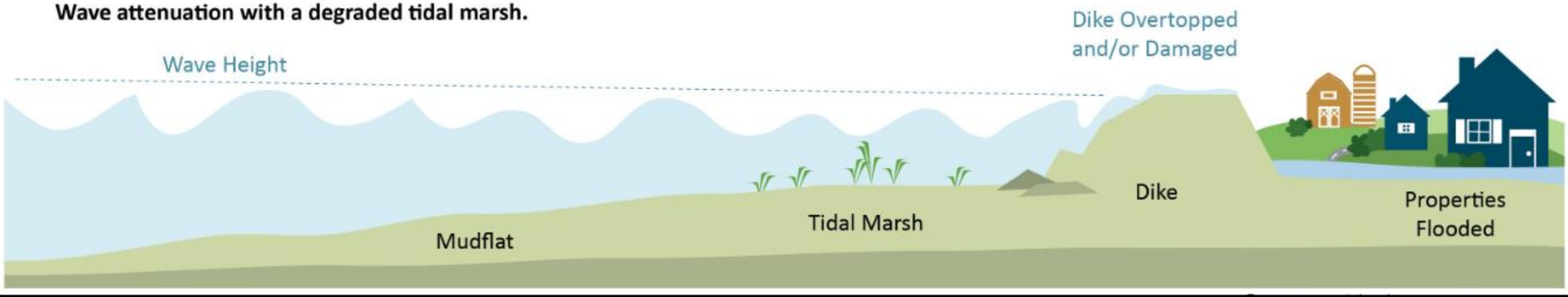
Coastal Defense quantifies how natural habitats (oyster reefs, tidal marshes, seagrass ...) protect coastal areas by reducing wave-induced erosion and inundation. It uses standard engineering techniques to help you estimate how and where to restore or conserve critical habitat, and increase the resilience of your coastal community and infrastructure.

esri RESILIENCY APP WINNER

Wave attenuation with a healthy tidal marsh.



Wave attenuation with a degraded tidal marsh.



Approach: InVEST Variables & Formula

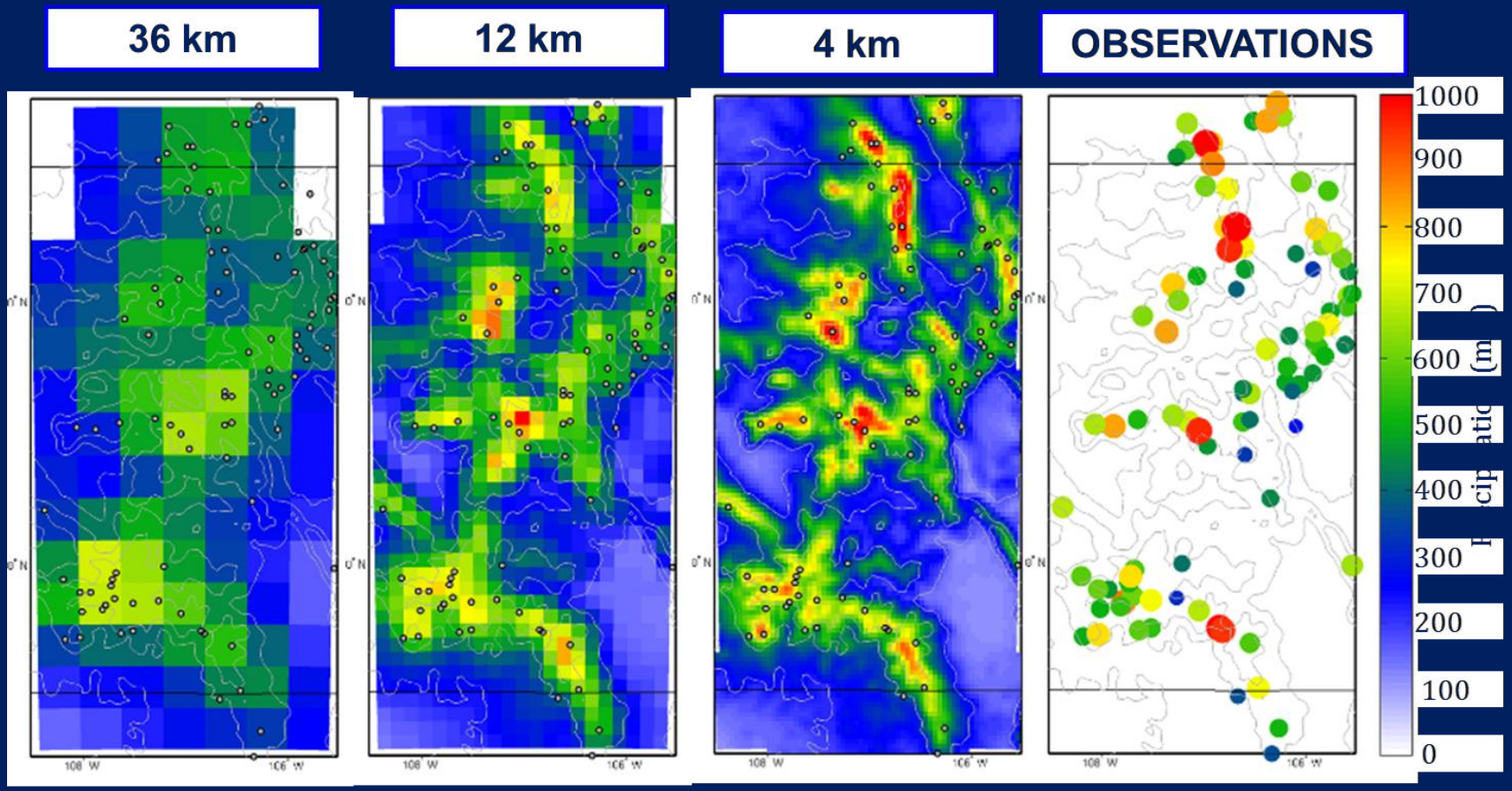
$$EI = (R_{Geomorphology} R_{Relief} R_{Habitats} R_{SLR} R_{WindExposure} R_{WaveExposure} R_{Surge})^{1/7}$$

$$ErI = (R_{Geomorphology} R_{Habitats} R_{WaveExposure})^{1/3}$$

"...index provides an example for how users can similarly create their own index by defining a unique combination of these rankings."

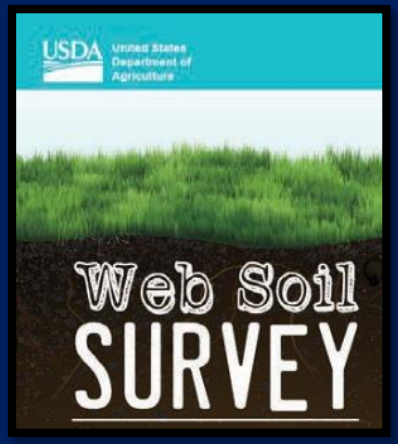
Rank	Very Low	Low	Moderate	High	Very High
Variable	**1**	**2**	**3**	**4**	**5**
Geomorphology	Rocky; high cliffs; fjord; fiard, seawalls	Medium cliff; indented coast, bulkheads and small seawalls	Low cliff; glacial drift; alluvial plain, revetments, rip-rap walls	Cobble beach; estuary; lagoon; bluff	Barrier beach; sand beach; mud flat; delta
Relief	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Natural Habitats	Coral reef; mangrove; coastal forest	High dune; marsh	Low dune	Seagrass; kelp	No habitat
Sea Level Change	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Wave Exposure	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile
Surge Potential	0 to 20 Percentile	21 to 40 Percentile	41 to 60 Percentile	61 to 80 Percentile	81 to 100 Percentile

Limitations on CNMI Application Of the InVEST Tool & Input



Using what we have, at a scale that's useful

$$R_{Geomorphology} R_{Relief} R_{Habitats} R_{SLR}$$



USDA

NOAA's Coastal Change Analysis Program (C-CAP)

BECQ-DCRM, 2017

The Abbreviated Work Flow…

AOI 1: Full Lagoon Polygon (Kendall et al. corresponding with Rasters)

AOI 2: Shoreline + 150 ft. buffer

Exposure Index (EI) = (Geomorph + Relief + Habitat + Inundation potential)/4

Attenuation Index (AI) = (Wave Exposure + Surge)/2

Vulnerability (V) = (Lagoon AI x Shoreline EI)/2

Inputs (all in 10X10 meter fishnet)

Shoreline EI (In Shoreline AOI)

- Geomorphology: USDA NRCS Soils class & slope bin
- Relief: Classified by Avg. slope in 150 ft. buffer
- Inundation potential: Extent of Inundation based on (a) Typhoon Skewed OND 100-year extreme (Scenario OND_TY) & Inundation Potential *with* 50 years SLR
- Habitat: LC/LU, re-classed

Lagoon AI (In Lagoon AOI)

- Surge Potential (SP): Benthic re-classed based on energy reduction + Bathymetry re-classed based on energy reduction + Rugosity re-classed based on energy reduction
    - 1 = least amount of wave/current energy; 5 = greatest wave energy (least attenuation)

- AI = Surge Potential (SP, above), combined with "distance to shoreline raster"(DS), where AI = SP + DS. This will result in areas with identical benthic habitat having greater WE the farther they are from the shoreline (trying to capture wave attenuation over distance here).

Combined Shore Vulnerability:

- (Lagoon AI value in fishnet polygons adjacent to shoreline X adjacent Shoreline EI)/2

Remaining Question: How do we integrate wave exposure/intensity along coastline into the Lagoon AOI?

Processing Steps:

Shoreline AOI – same as shoreline APC, but cut at N and S end of lagoon

1) **Create G variable:**
    a) Clip USDA NRCS Soils Poly to AOI
    b) Add Integer Field for Soil class as Geomorphology proxy
    c) Reclass based on soil composition and slope classification.
    d) Dissolve soil polygons based on re-classed values
    e) Spatial join to the 10x10 index fishnet

[Screenshot Attribute Table]

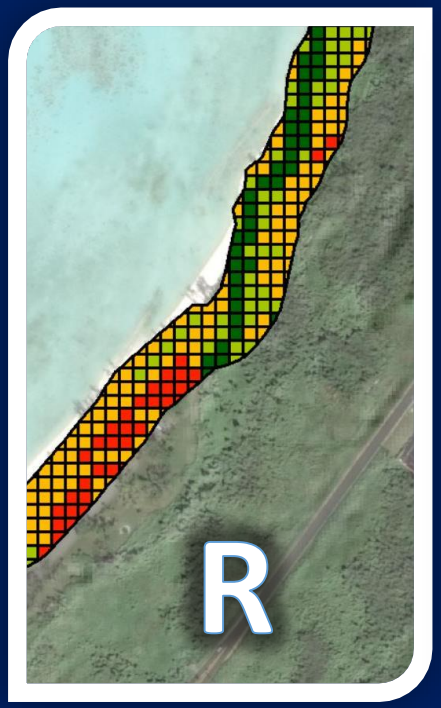
2) **Create R variable**
    a) Clip lidar-derived slope to AOI
        i) Output: Slope_AOI
    b) Add new field "avg_slope" in the fishnet for mean slope (field type "short integer")
    c) Spatial statistics -> Zonal Stats -> Mean
        i) Input fishnet features as zonal definition, and specify "FID" (or some other unique identifier for each polygon) as zone field
        ii) Input 'Slope_AOI' as raster values, run tool with "mean" selected
        iii) Output: Zone_avgSlope
    d) Reclass raster: Natural Breaks 5 classes; highest slope class = lowest vulnerability score (capturing cliff and harder geology/soils as high slope)
    e) Convert raster to polygon
    f) Dissolve polygons based on value
    g) Spatial join to fishnet target
3) **Create H variable**
    a) Clip C-CAP to Shoreline AOI
    b) Class & Re-class to 1-5
    c) Convert raster to feature
    d) Dissolve features, dissolve field 'H_val'
    e) Spatial Join H polygon layer to Fishnet, with H_Val field merge rule being mode (highest frequency of H value in the fishnet polygon, if multiple are present.

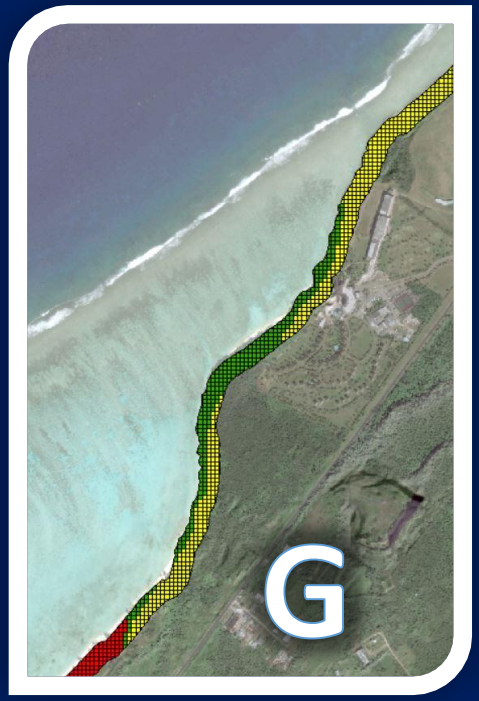
4) **Create IP variable**
    a) Input both OND_TY inundation polygon *and* OND_TY_50. Repeat all processing of OND_TY with OND_TY_50 to have a second IP variable, allowing index calculations with and without climate change considerations.
    b) Clip OND_TY to Fishnet/AOI
    c) Use Analysis Toolbox -> Overlay -> Intersect
        i) Input: Fishnet polygons and clipped Inundation extent (e.g. 'OND_TY_AOI')
        ii) Rank: Fishnet = 1, Inundation Extent = 2
        iii) Output: OND_TY_Intersect
        iv) Create new field "flood_area", type double. Field Calculator: Calculate Geometry – Area in meters.
    d) Spatial Join OND_TY_Intersect to Fishnet, joining only the field 'Flood_Area', which is the extent of flood within a given fishnet polygon.
        i) Output: 'Shoreline_G_R_H_IP'
    e) Add new field to 'Shoreline_G_R_H_IP', field type double, name "Prct_Fld" (for percent of fishnet cell flooded)
        i) Field Calculator: ([flood_area]/[Area_Shape]) * 100
    f) Re-class Prct_Fld field based on 5 classes

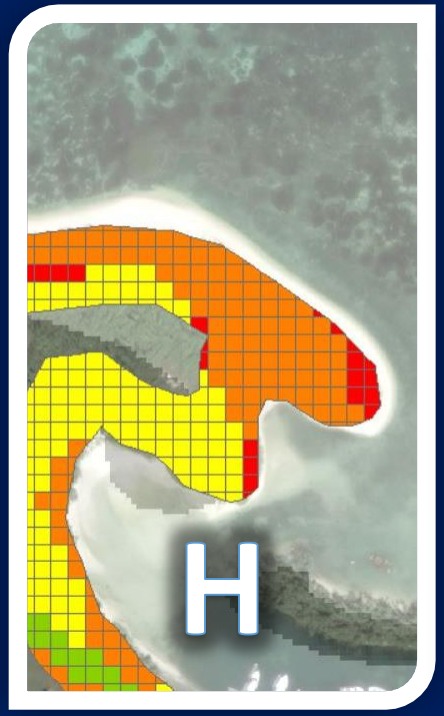
5) **Create Shoreline AOI Index**
    a) New field in fishnet: Index
        i) Field Calculator: ('G_Val'+'H_Val'+'R_Val'+'IP_Val')/4
    b) New field in fishnet: Index_CC
        i) Same as above, but substitute in 'IP_Val_SLC'

Geoprocessing Steps
(prepping the variables, generalized)

Bringing it All Together:







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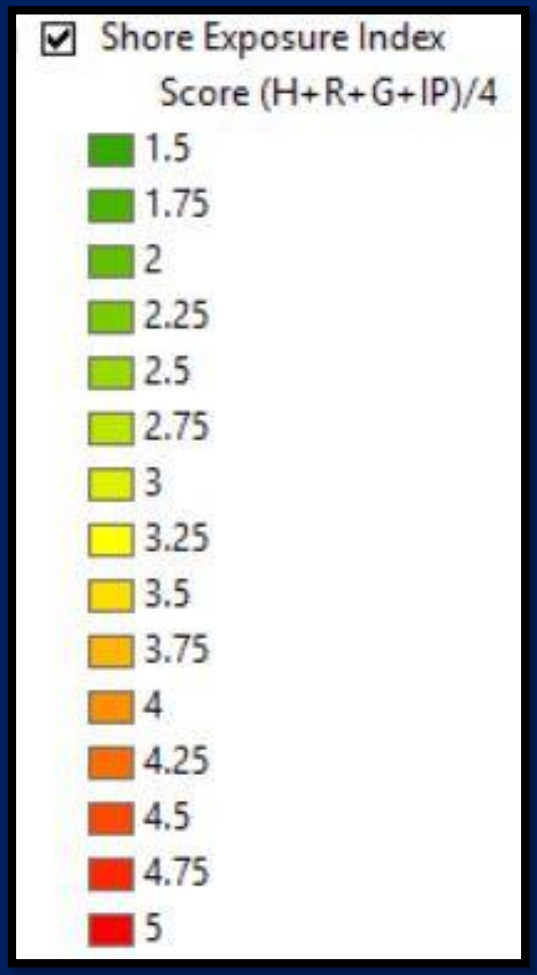
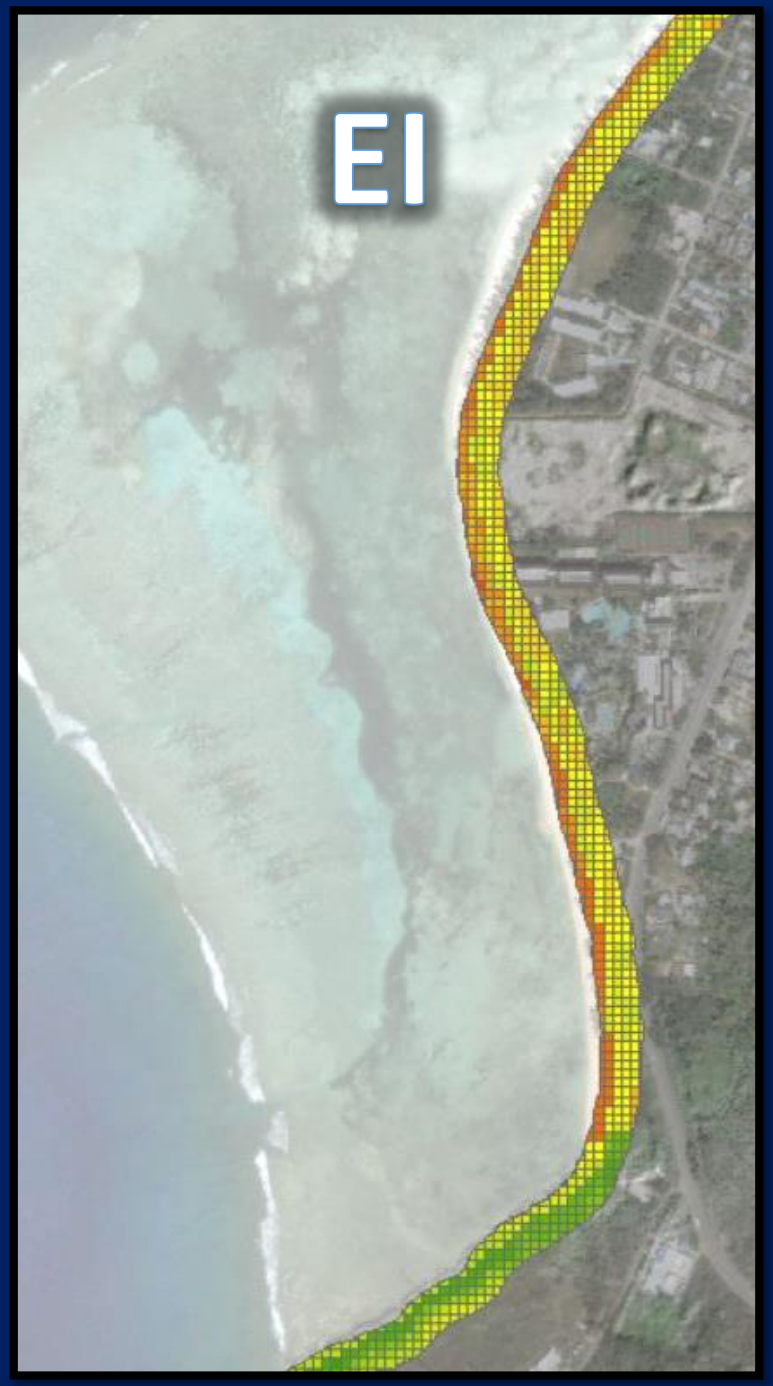
Index Results

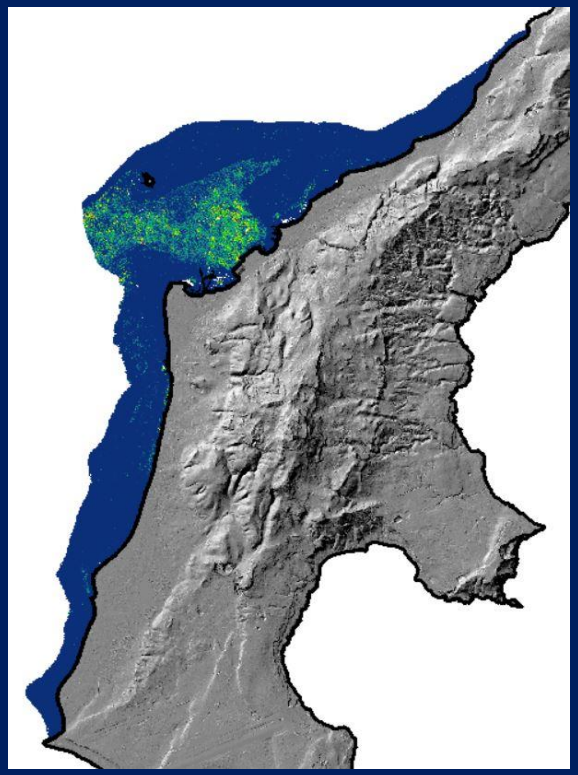


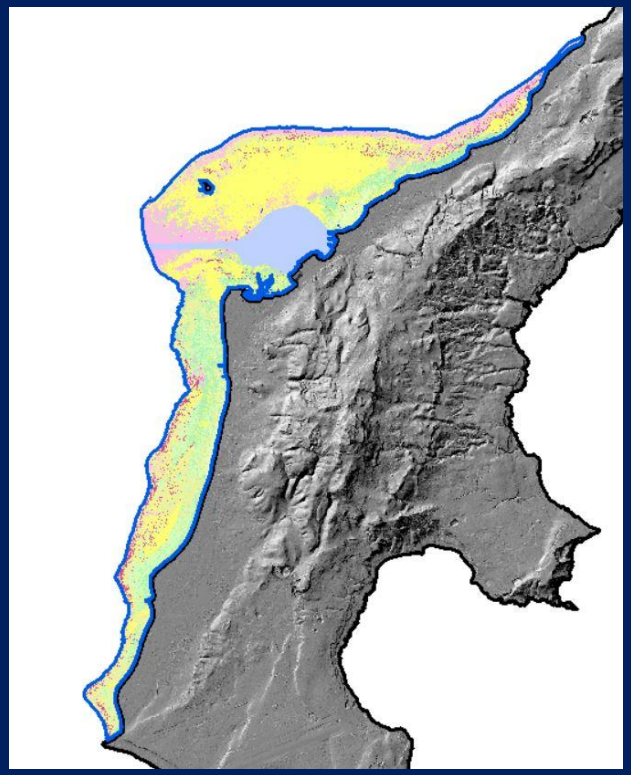

EI

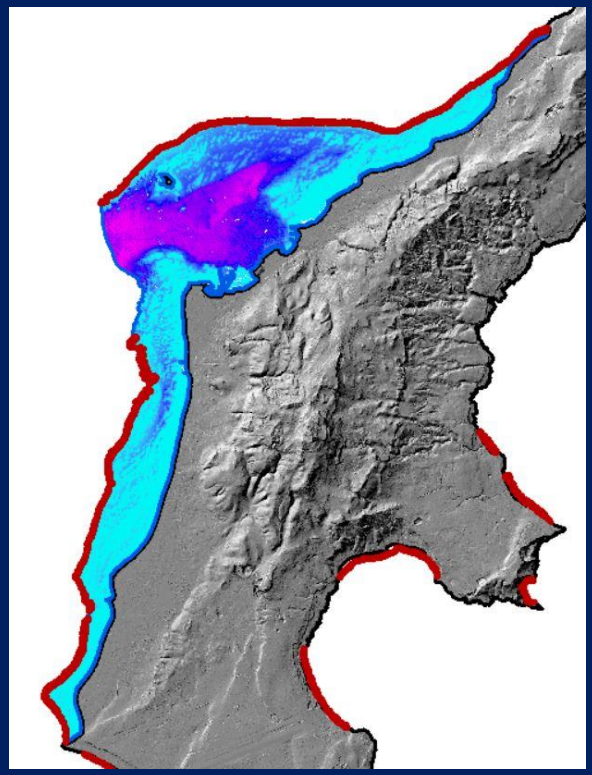

EI-CC

Next Steps!

1. Those other letters in the equation
2. Tools? Management? (it does align with a DCRM APC…)

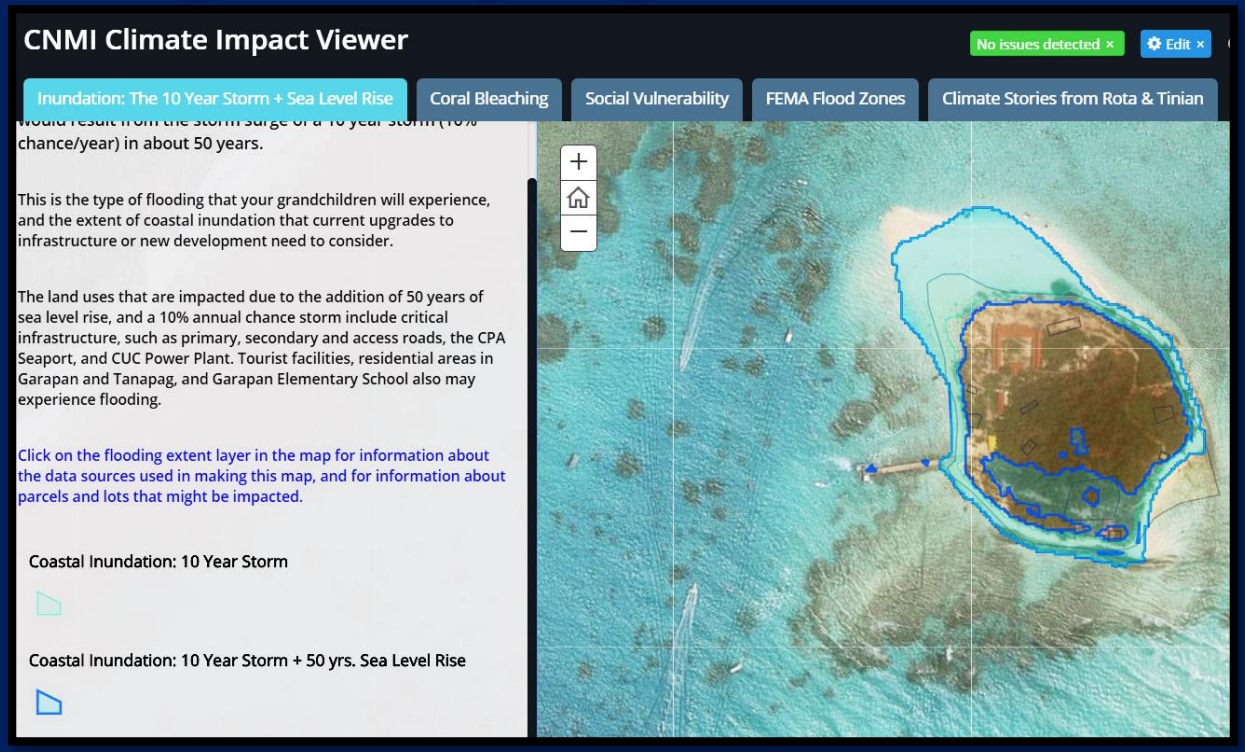






Take-Homes:

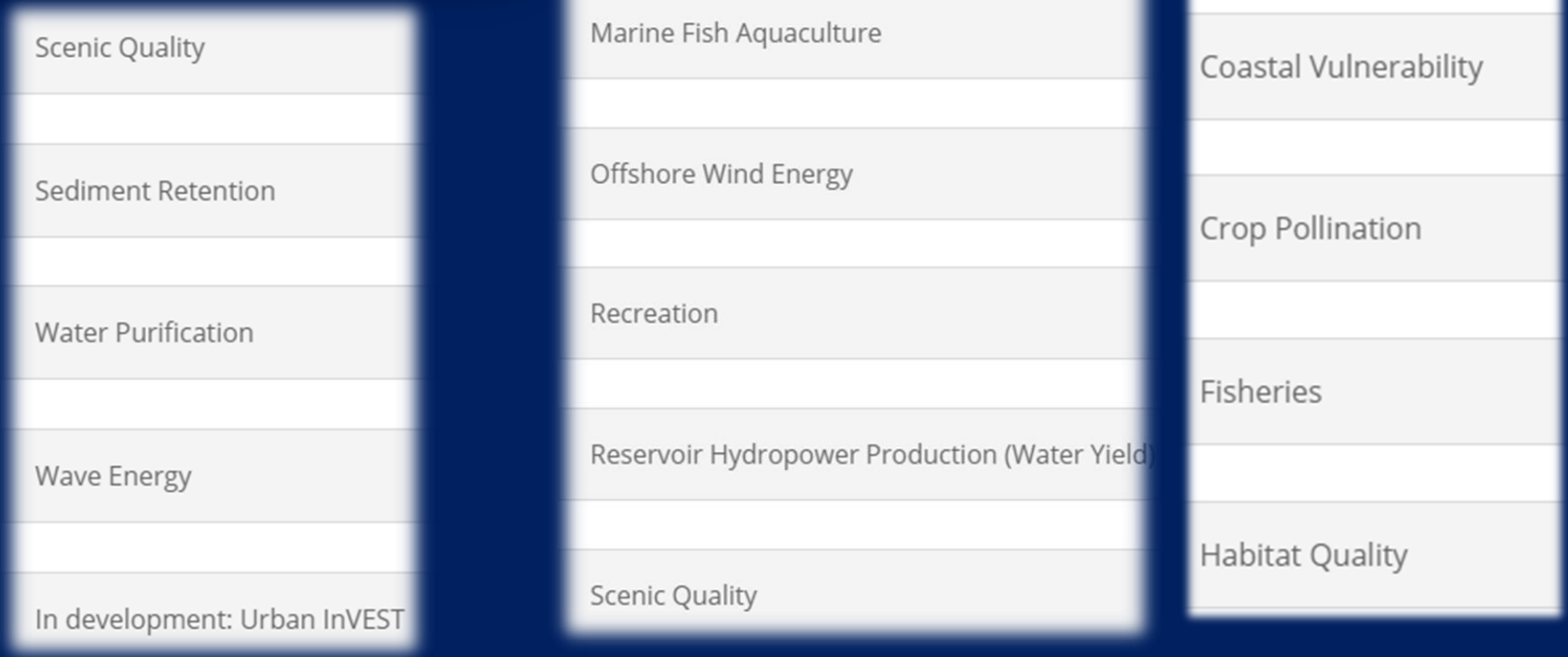
- Replicable under different conditions
  - We can change output over time with good management!
- Conditions that increase EI match those that encourage development
- How can you use this?
- Visualization is important! Check the hazards viewer later this week
  - http://dcrm.maps.arcgis.com/home/index.html



InVEST

integrated valuation of ecosystem services and tradeoffs

"InVEST is a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfill human life."



Up Next:

LiDAR – it's coming for us, so we need to know how to deal with it