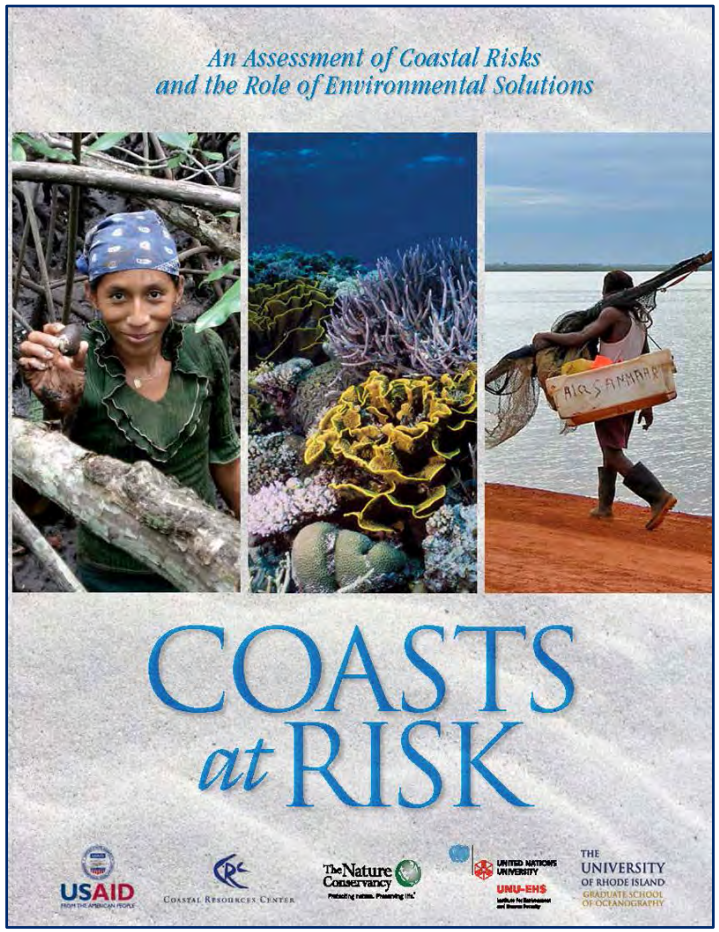
Coasts at Risk:

An Assessment of Coastal Risks and the Role of Environmental Solutions



Report at -
http://www.crc.uri.edu/download/SUC09_CoastsatRisk.pdf

Interactive Maps at -
www.maps.coastalresilience.org\global

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United Nations University UNU-EHS Institute for Environment and Human Security
The University of Rhode Island Graduate School of Oceanography

TNC, Arlington, VA // July 30, 2014

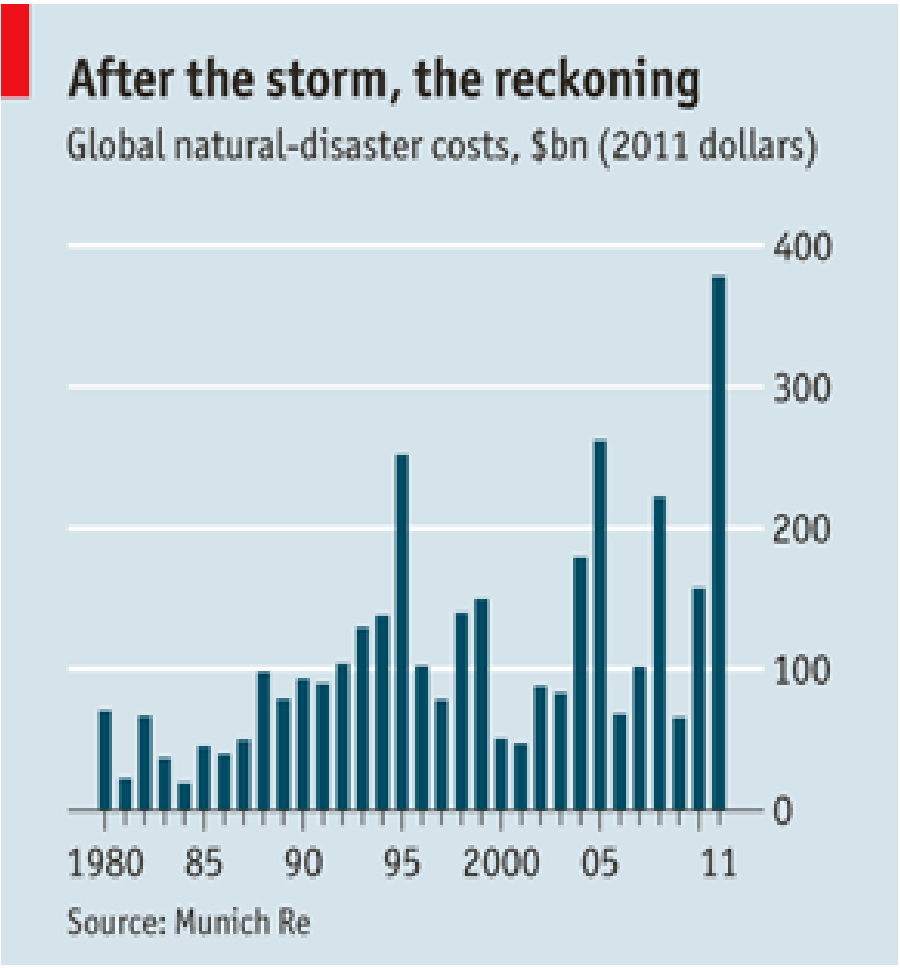
Aims

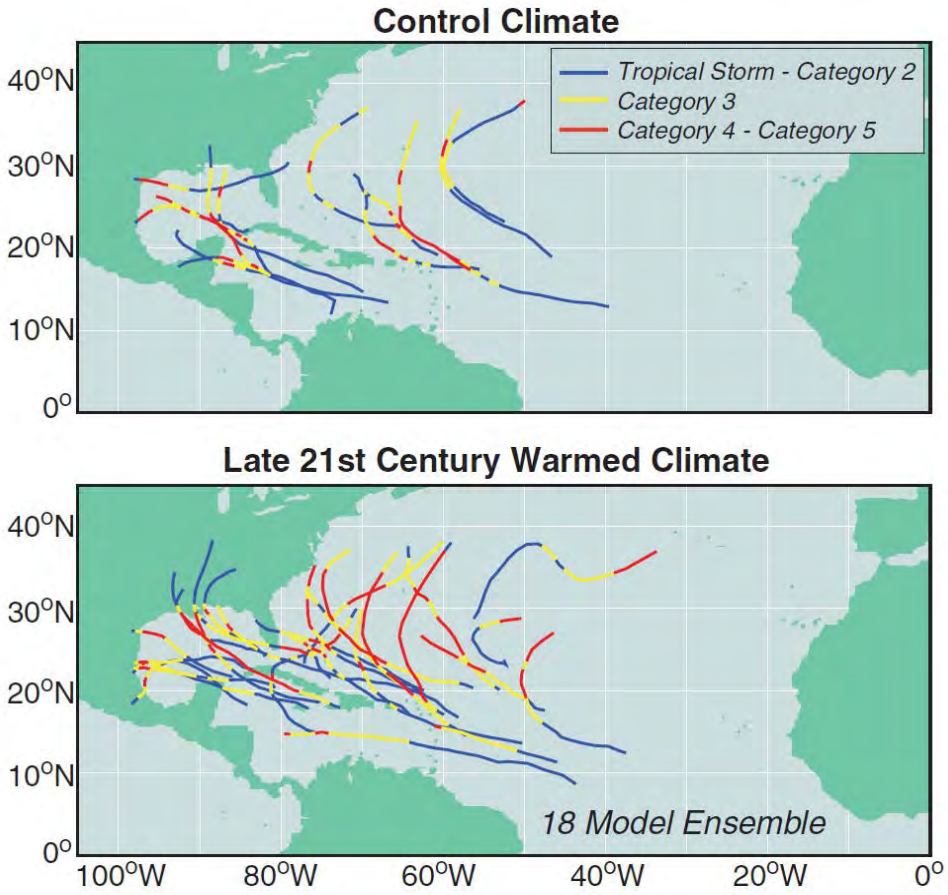
- To examine risks that nations face from vulnerability & exposure to coastal hazards;
- To identify where environmental degradation contributes to these risks; and
- To explore where environmental solutions can contribute to risk reduction.

Storm Hazards Are Real Now & Rising

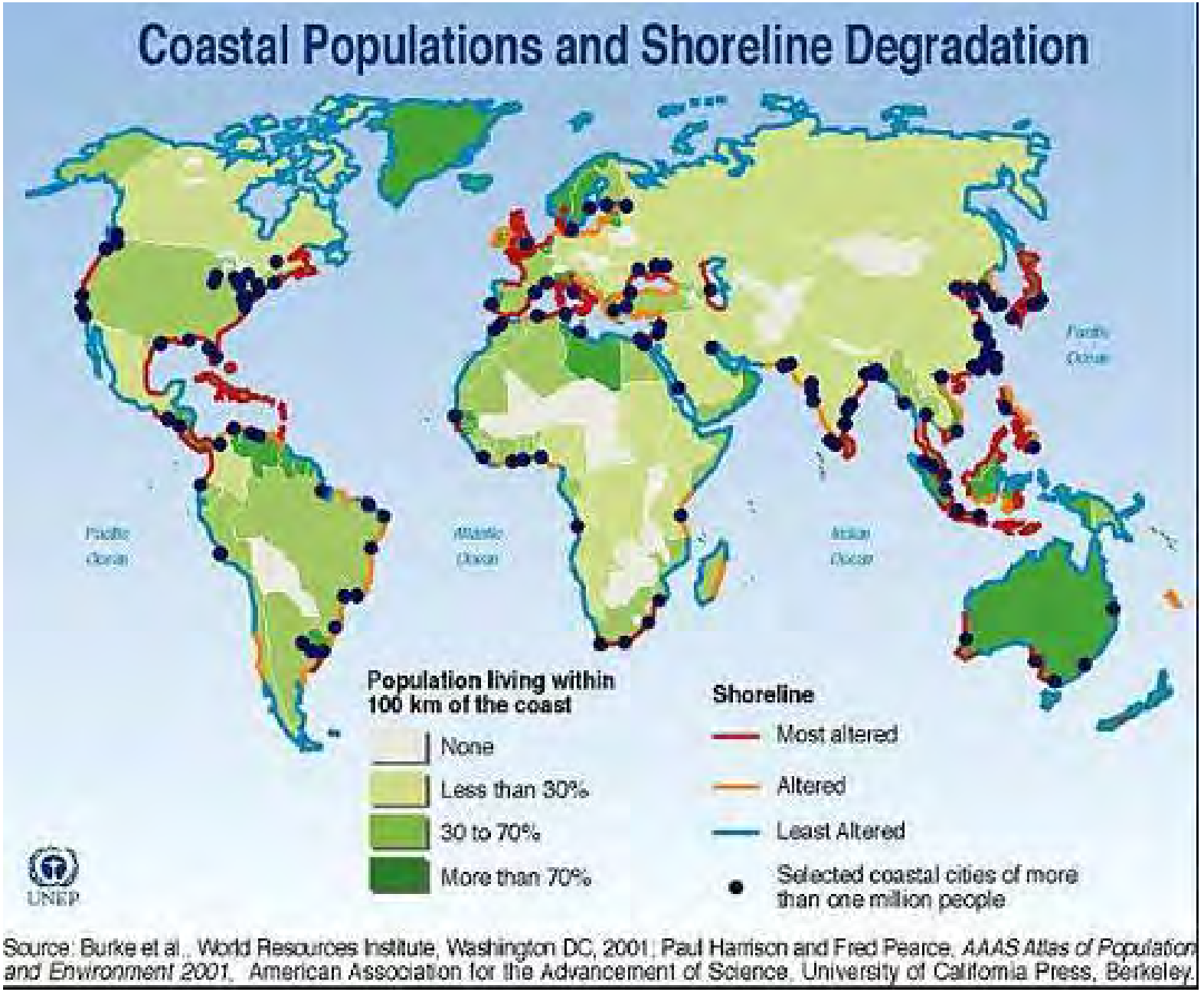
Coasts at Risk: *An Assessment of Coastal Risks and the Role of Environmental Solutions*

Storm Hazards Are Real Now & Rising





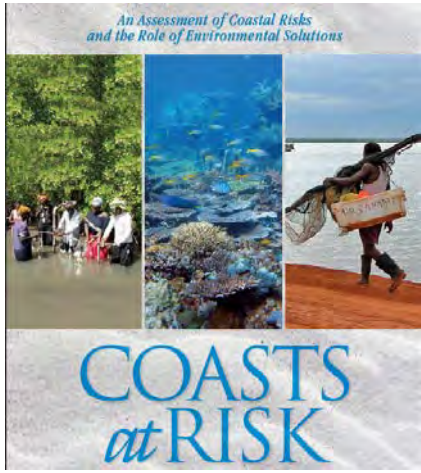
Bender et al 2010, Science


Coastal Populations and Shoreline Degradation
Pacific Ocean
Atlantic Ocean
Indian Ocean
Pacific Ocean
Population living within 100 km of the coast
None
Less than 30%
30 to 70%
More than 70%
Shoreline
Most altered
Altered
Least Altered
Selected coastal cities of more than one million people
UNEP
Source: Burke et al., World Resources Institute, Washington DC, 2001; Paul Harrison and Fred Pearce, AAAS Atlas of Population and Environment 2001, American Association for the Advancement of Science, University of California Press, Berkeley.

Coastal Habitats and Risk Reduction
Green(er) vs Gray Infrastructure

Builds on World Risk Report

- WorldRiskIndex is our base index;
- 2012 report & index identifies that coastal nations face the greatest risk
- Identifies the need to better assess connections between environment & risk
- We have added more coastal nations and new environmental indicators, included fisheries, and focused on integration



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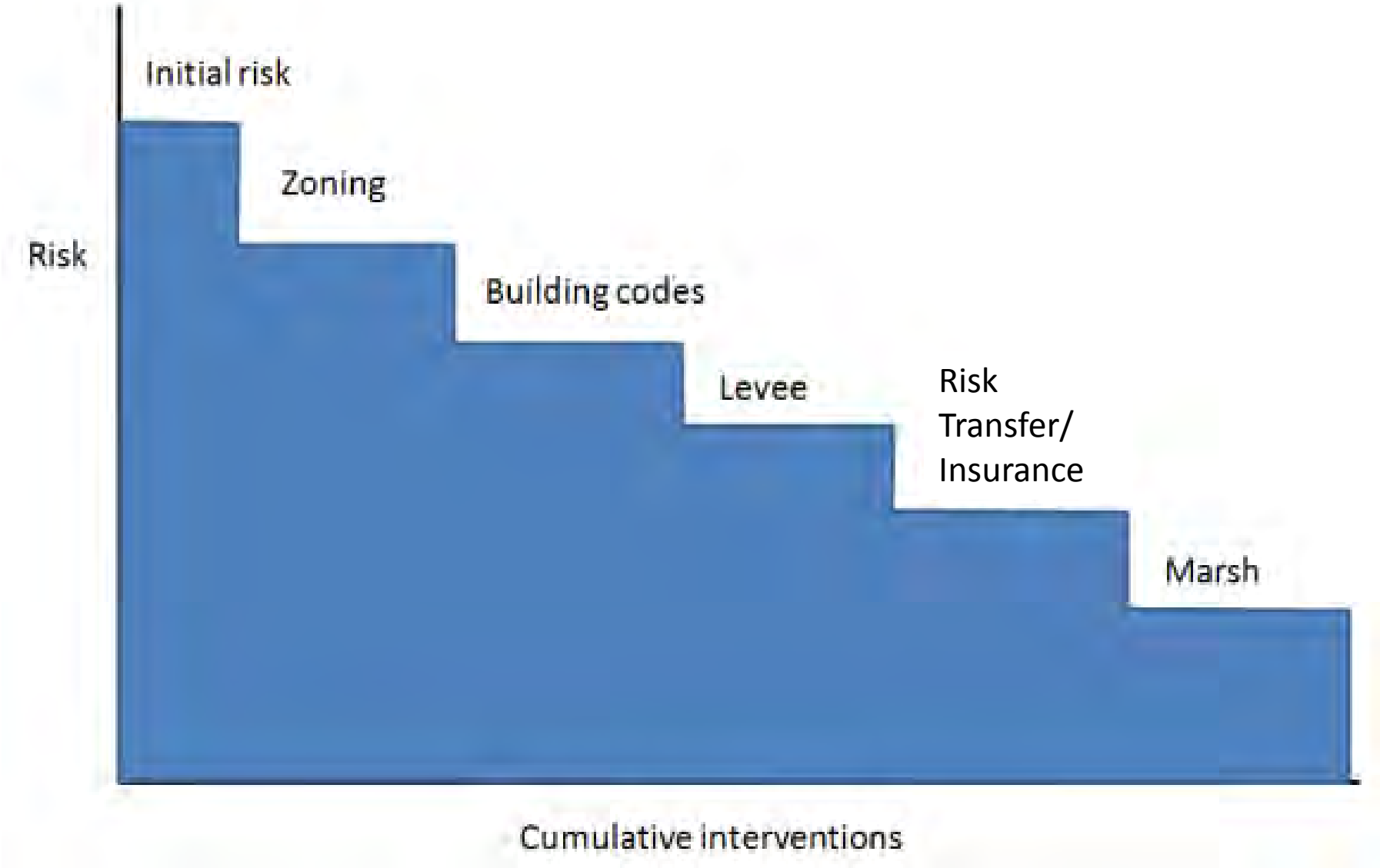
Risk Reduction- Many Steps



Coasts at Risk: *An Assessment of Coastal Risks and the Role of Environmental Solutions*

Aims

- To examine risks that nations face from vulnerability & exposure to coastal hazards;
- To identify where environmental degradation contributes to these risks; and
- To explore where environmental solutions can contribute to risk reduction.

Coasts at Risk

An Assessment of Coastal Risks and the Role of Environmental Solutions

The Coast at Risk Index

Torsten Welle, PhD (UNU-EHS)
Michael W. Beck. PhD (TNC)
Joern Birkmann, PhD (UNU-EHS)

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WHY

- Results from the WorldRiskReport 2012 show that all of the Top 15 high risk countries are coastal countries and eight are located in the tropics with large coastal zones – some facing severe environmental degradation (e.g. Philippines; [R: 3]).
- 1.2 billion people (23% of the world's population) live within 100 km of the coast and 50% are likely to do so by 2030 (Adger et al., 2005).
- Communication tool of risk in the context of natural hazards and climate change
- Identification of countries that show high risk to coastal related hazards
- Determination of risk factors, analyse the relationship between environmental indicators and vulnerability
- clarify the need for a longterm and comprehensive approach for disaster risk reduction to the public and stakeholders
- Suggestion for activities regarding disaster risk reduction for several stakeholders (NGO's, authorities)

Source: Alliance Development works (2012) http://www.worldriskreport.com/

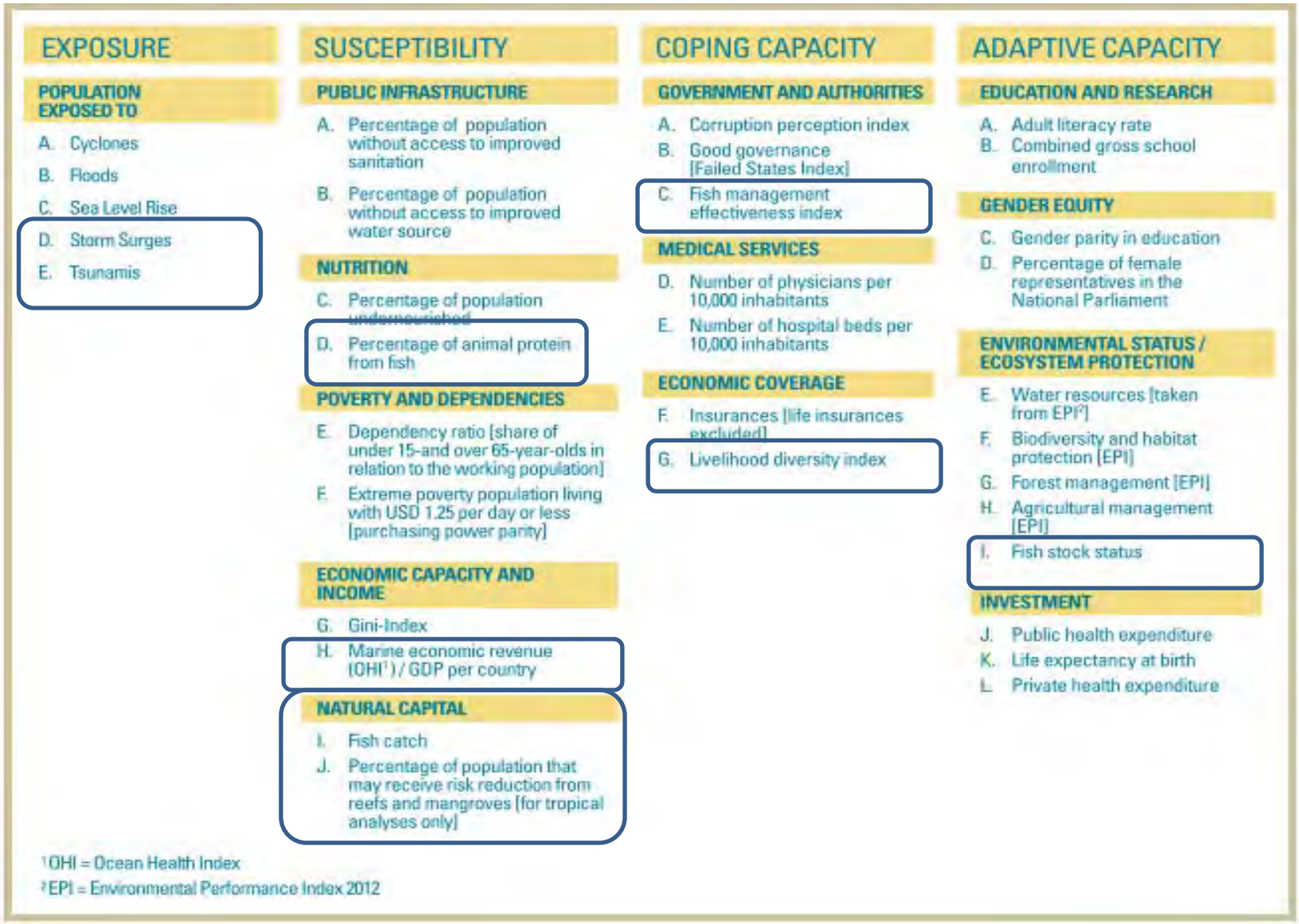
HOW

RISK:

"The probability of harmful consequences or expected loss of lives, people injured, property and livelihoods, economic activity disrupted or environment damage resulting from interactions between natural or human induced hazards and vulnerable conditions"

(UN/ISDR 2002)

Indicators



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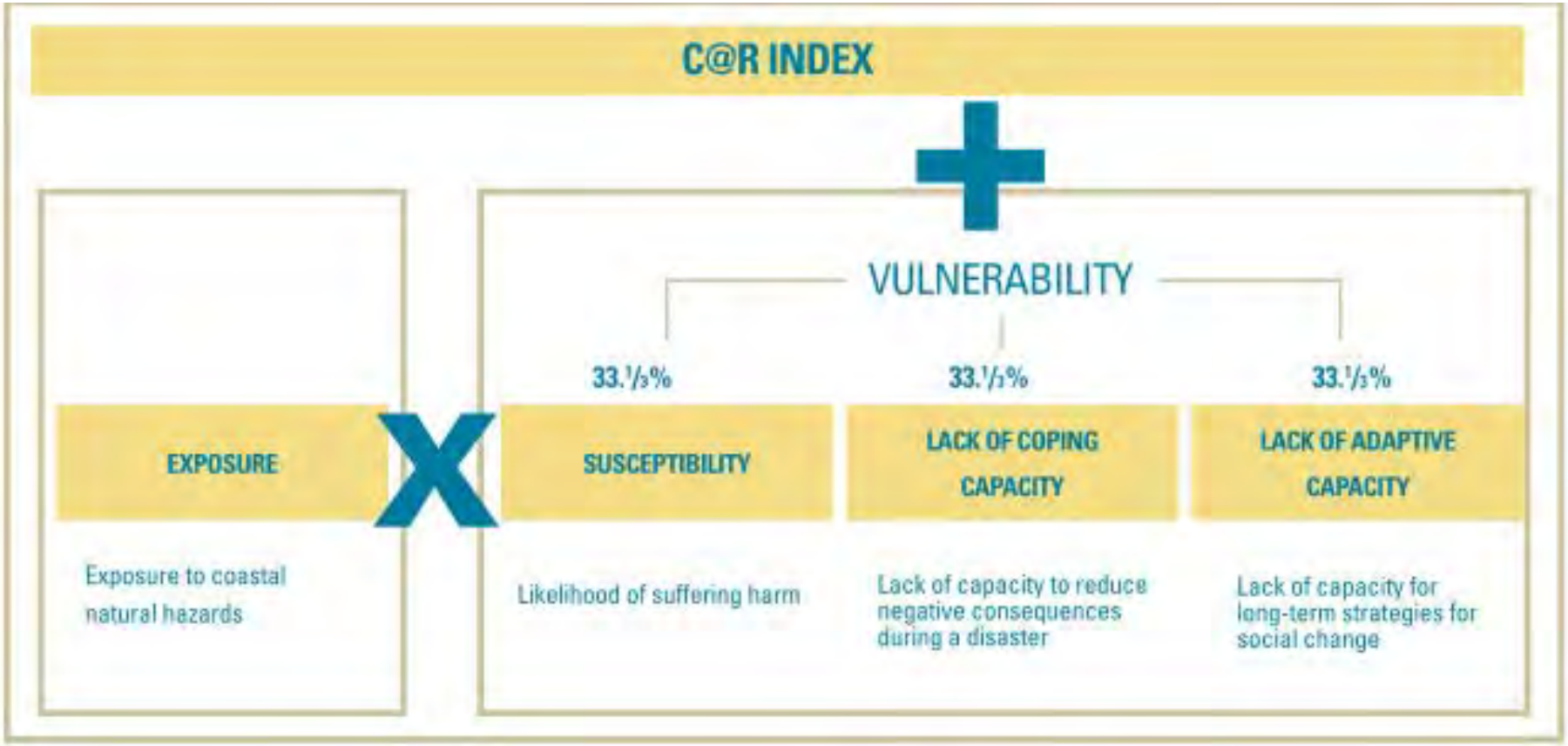
Aggregation



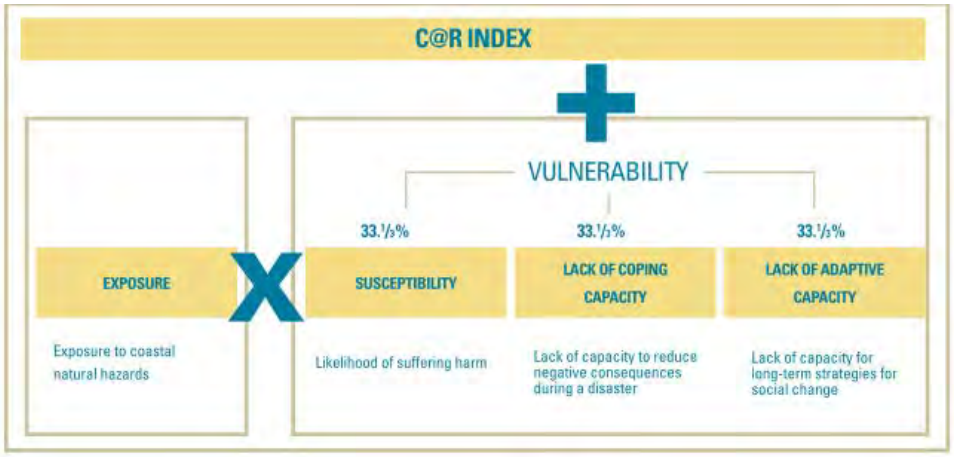
Reliability analysis and factor analysis

- reliability analysis describes the degree of accuracy of an existing model structure and Cronbachs Alpha is a measure for the internal consistency.

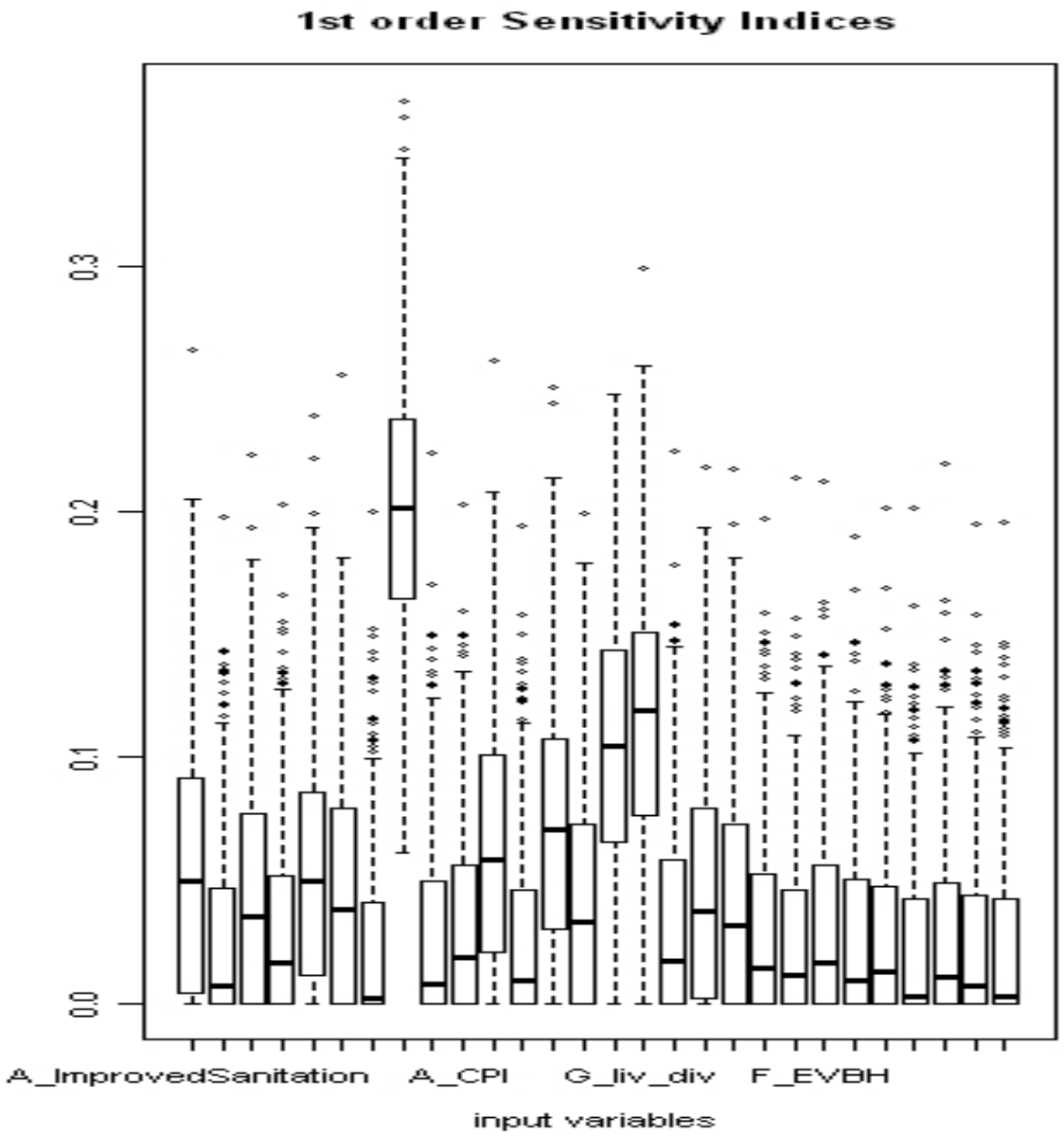
  Cronbachs Alpha: 0.889

- factor analysis was done in order to validate the aggregation formula of the Coast at Risk Index

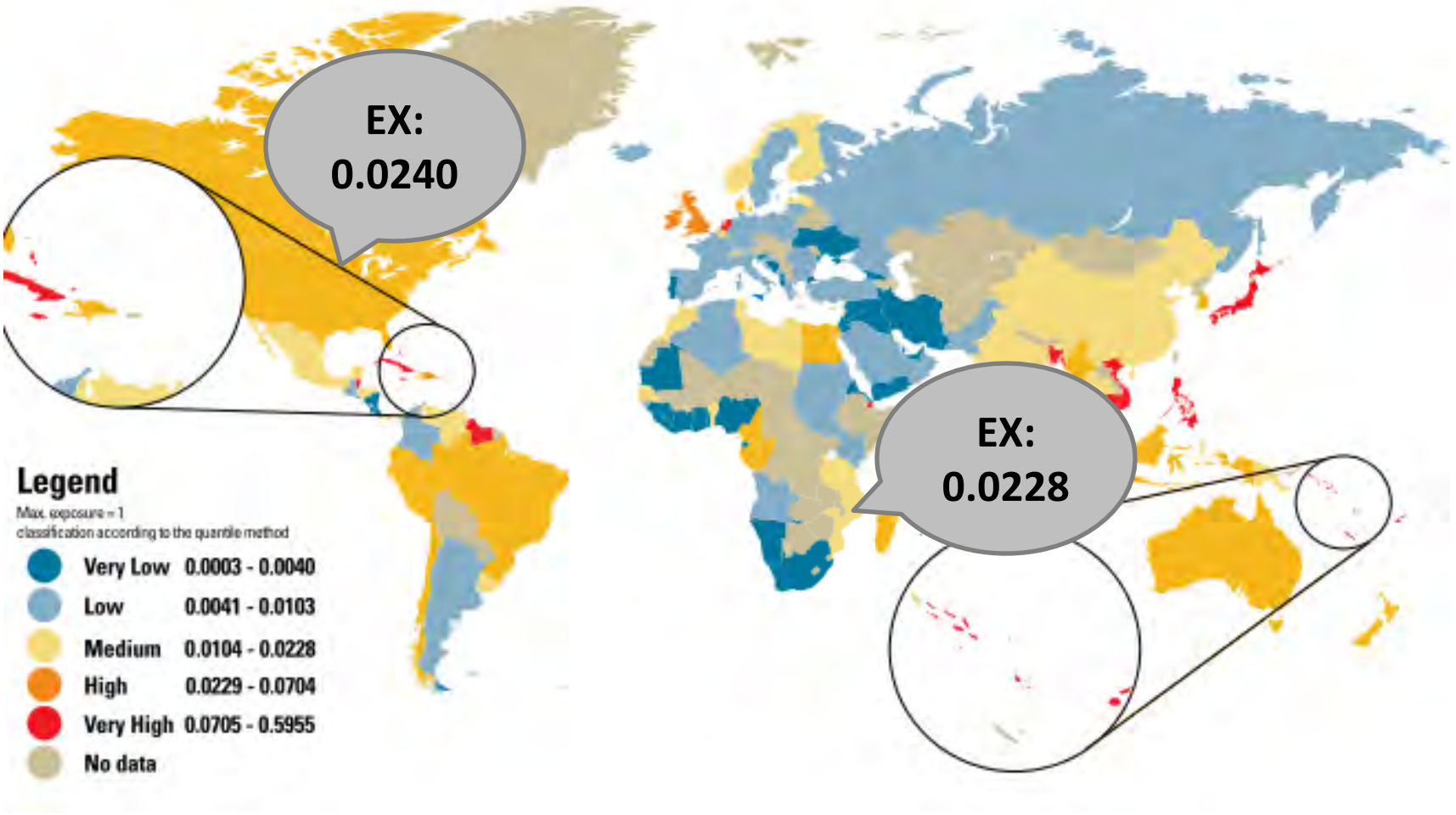
  Kaiser-Meyer-Olkin (KMO): 0.903 [1.0=best result]



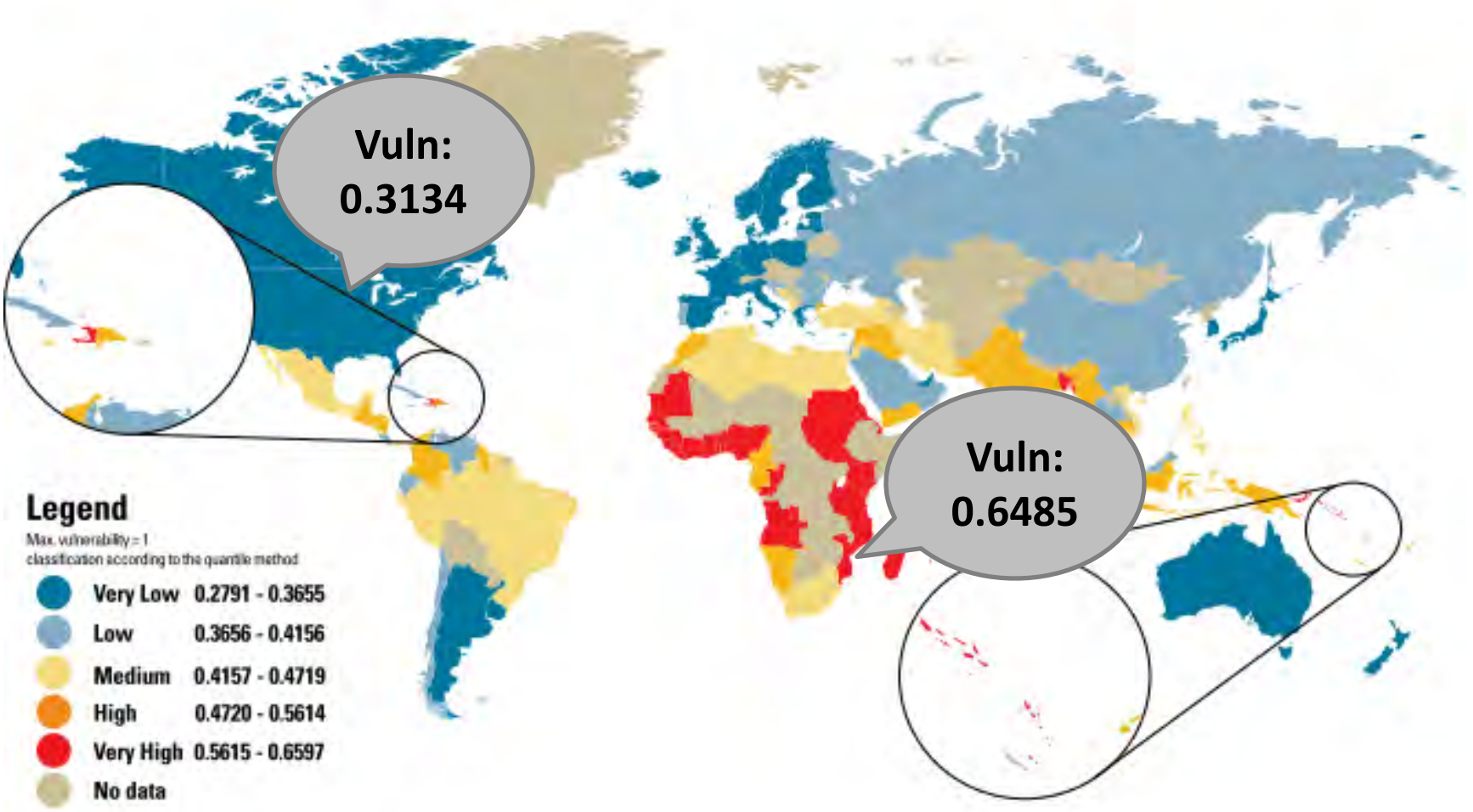
Sensitivity analysis



Results – Exposure



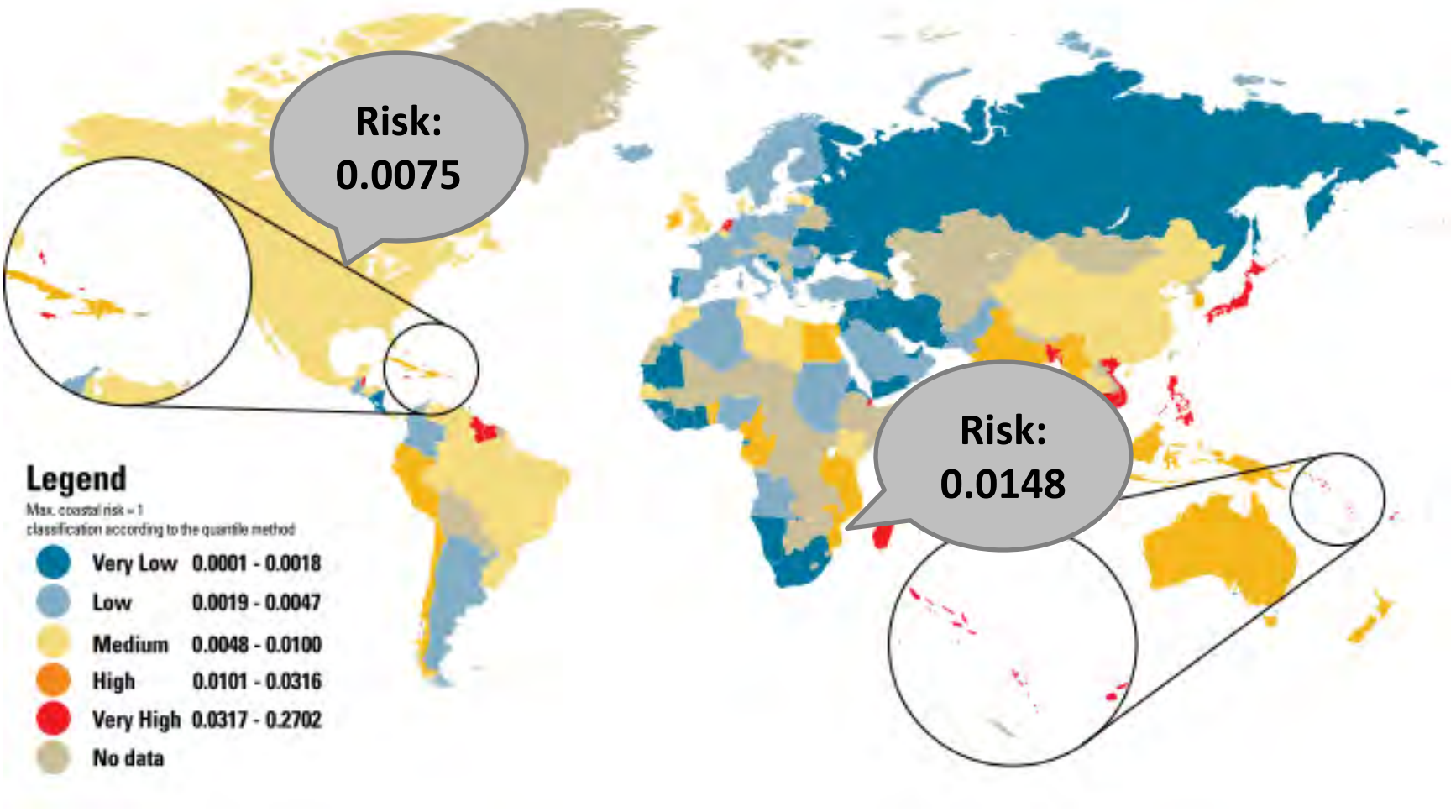
Results – Vulnerability



Vulnerability

Factors	United States	Mozambique
Percentage of animal protein from fish	6.01 %	23.98 %
Extreme poverty population living with USD 1.25 per day or less [purchasing power parity]	Approx. 2 % (dummy variable)	More than 59.6% of the population lives below the poverty line
Fish catch	5.14 bn t	116.478 t
Governance	Corruption 7.3 [Scala 1-10; 1 highest corruption value]; Failed State Index 34.8 [120 worst value]	Corruption 3.1 Failed State Index 82.4

Results – Coast at Risk



Coasts at Risk: *An Assessment of Coastal Risks and the Role of Environmental Solutions*

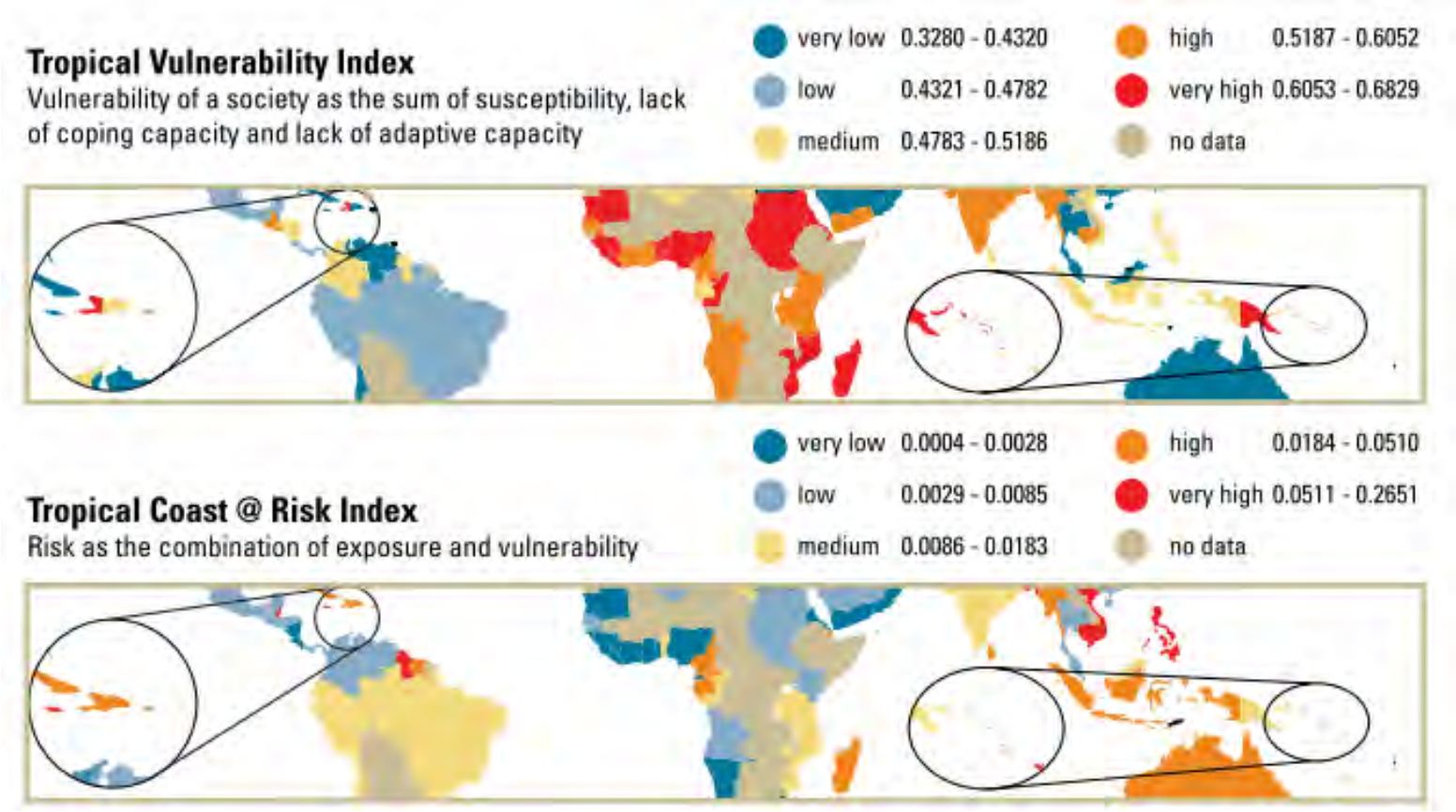
Results – Coast at Risk

NAME	Rankings (C@R)	COAST at RISK	Exposure	Vulnerabililty	Susceptibility	Lack of Coping Capacity	Lack of Adaptice Capacity
Mozambique	47	0,0148	0,0228	0,6485	0,4837	0,8577	0,6041
United States	68	0,0075	0,0240	0,3134	0,1320	0,4825	0,3257

NAME	Rankings (C@R)	COAST at RISK	Exposure	Vulnerabililty	Susceptibility	Lack of Coping Capacity	Lack of Adaptice Capacity
Antigua and Barbuda	1	0,2702	0,5893	0,4584	0,3304	0,6052	0,4398
Tonga	2	0,2482	0,5108	0,4859	0,2823	0,7256	0,4497
Saint Kitts and Nevis	3	0,2366	0,5955	0,3973	0,2211	0,5854	0,3853
Vanuatu	4	0,1508	0,2392	0,6306	0,5053	0,8251	0,5613
Fiji	5	0,1254	0,2568	0,4884	0,2568	0,7470	0,4615
Brunei Darussalam	6	0,1093	0,2818	0,3878	0,1919	0,6011	0,3704
Bangladesh	7	0,1056	0,1878	0,5626	0,2706	0,7792	0,6381
Philippines	8	0,1003	0,2095	0,4786	0,2630	0,7298	0,4431
Seychelles	9	0,0851	0,1776	0,4791	0,3738	0,6113	0,4522
Kiribati	10	0,0830	0,1558	0,5329	0,4264	0,6713	0,5010
Belize	11	0,0779	0,1685	0,4622	0,2375	0,6624	0,4866
Cambodia	12	0,0737	0,1333	0,5533	0,3037	0,8178	0,5385
Bahamas	13	0,0701	0,1717	0,4080	0,2298	0,5720	0,4221
Japan	14	0,0694	0,2080	0,3337	0,1674	0,4767	0,3569
Viet Nam	15	0,0677	0,1445	0,4686	0,2035	0,7309	0,4714
Samoa	16	0,0665	0,1409	0,4719	0,2414	0,6999	0,4743
Mauritius	17	0,0658	0,1548	0,4251	0,2180	0,6204	0,4368
Guyana	18	0,0642	0,1352	0,4752	0,2408	0,7243	0,4607
Netherlands	19	0,0634	0,2036	0,3112	0,1339	0,4892	0,3106
Jamaica	20	0,0522	0,1135	0,4599	0,2562	0,6846	0,4389

Results – tropical Coast at Risk

- Most at risk nations are tropical
- Analysis of the effects of natural capital on overall risk was done because of data availability on tropical coastal habitats



Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions

Summary

- Global hot spots of coastal risk :the Caribbean,South Pacific Islands and South East Asia
- Exposure is the most important driver of risk, though vulnerability may be more readily improved to reduce risk
- Tropical analysis showed that through adding „benefits from reefs and mangroves“ vulnerability could be reduced in some countries
- Vulnerability in coastal countries is correlated with environmental status
- Indices just show a theoretical concept and it never reflects reality

Thank you for your attention!

welle@ehs.unu.edu

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Marine Fisheries, Social Vulnerability and Risk

Vera Agostini, PhD
Shawn Margles
Global Marine Team, The Nature Conservancy


Photo: M. Ajo


Photo: M. Ajo

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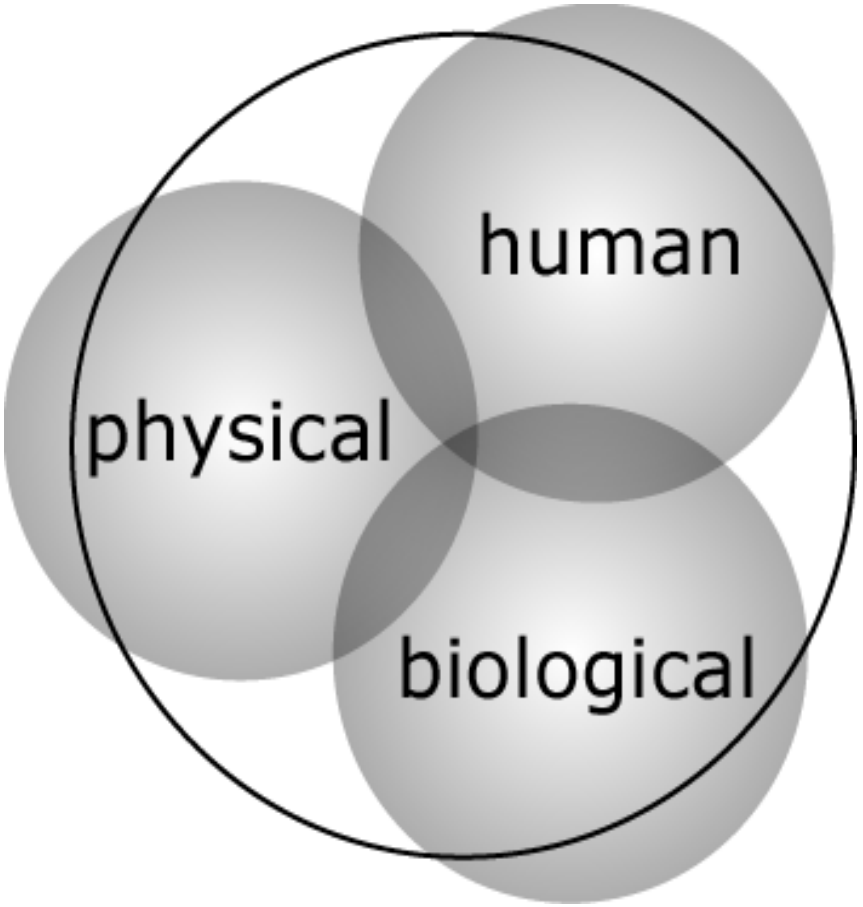

human
physical
biological

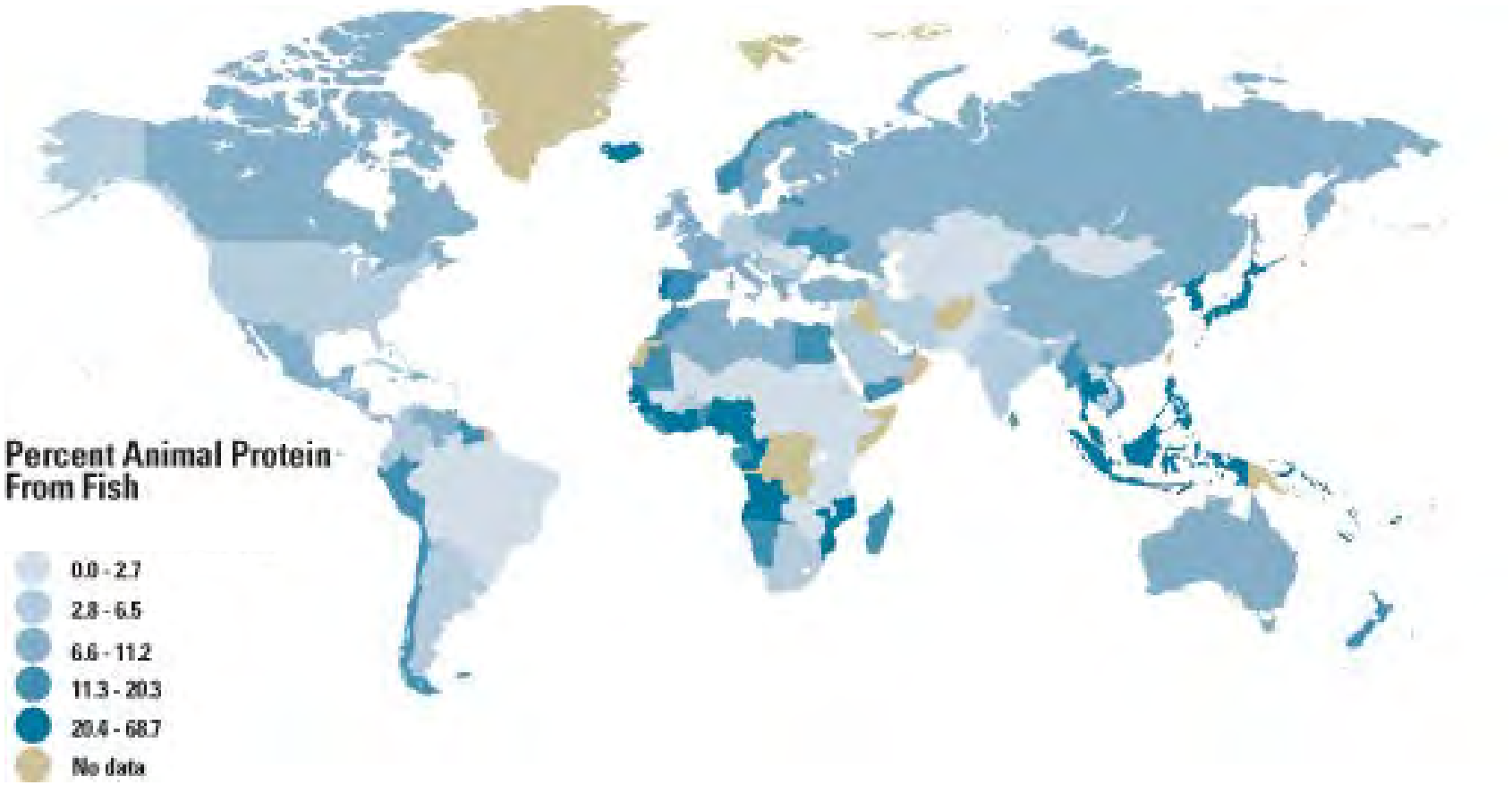

Why
Food
3 billion people
Photo: M. Ajo


Why
Livelihood
660-820 million people
Photo: M. Ajo

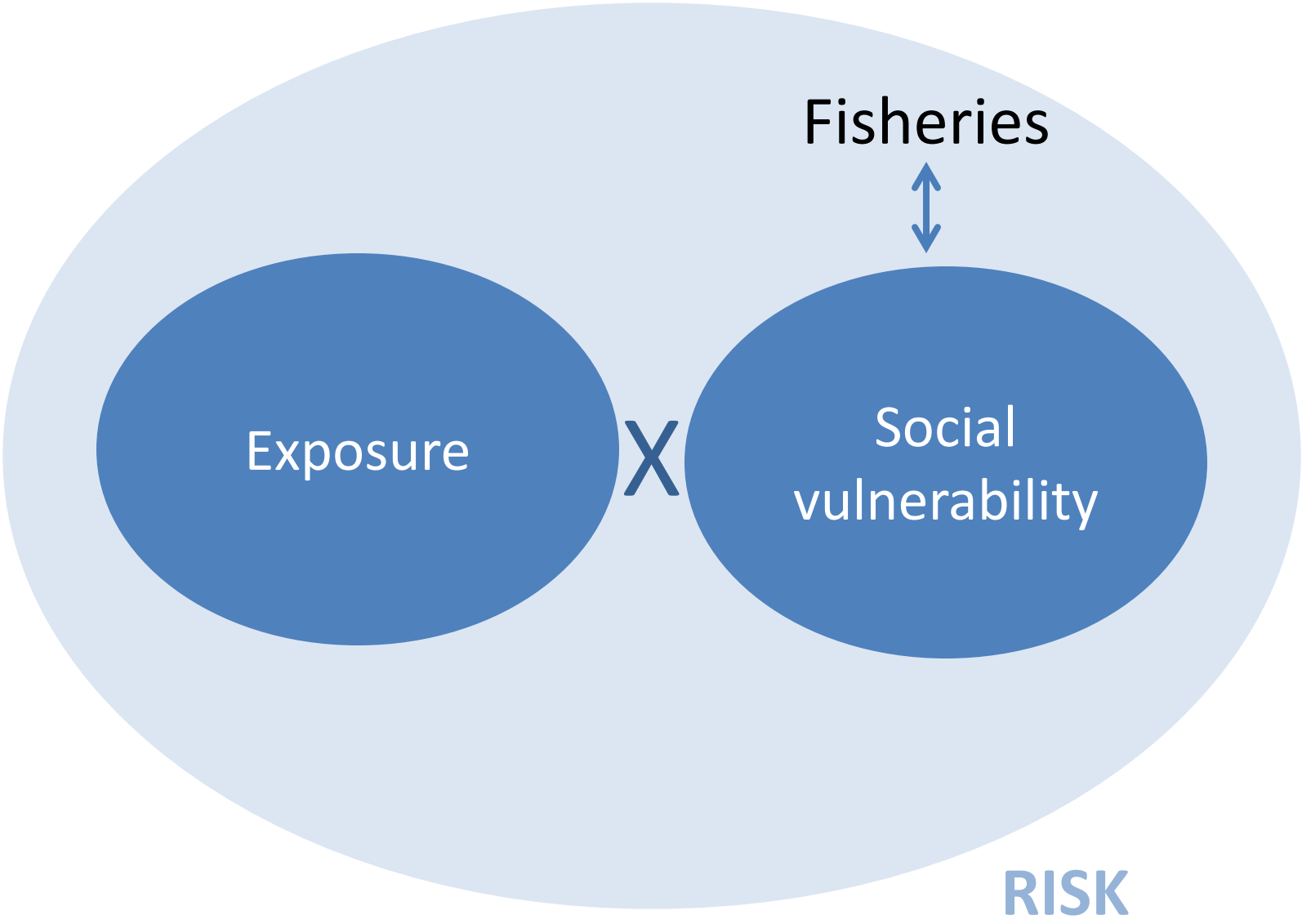
Why

Trade: 37 percent by volume of world production

Photo: M. Ajo

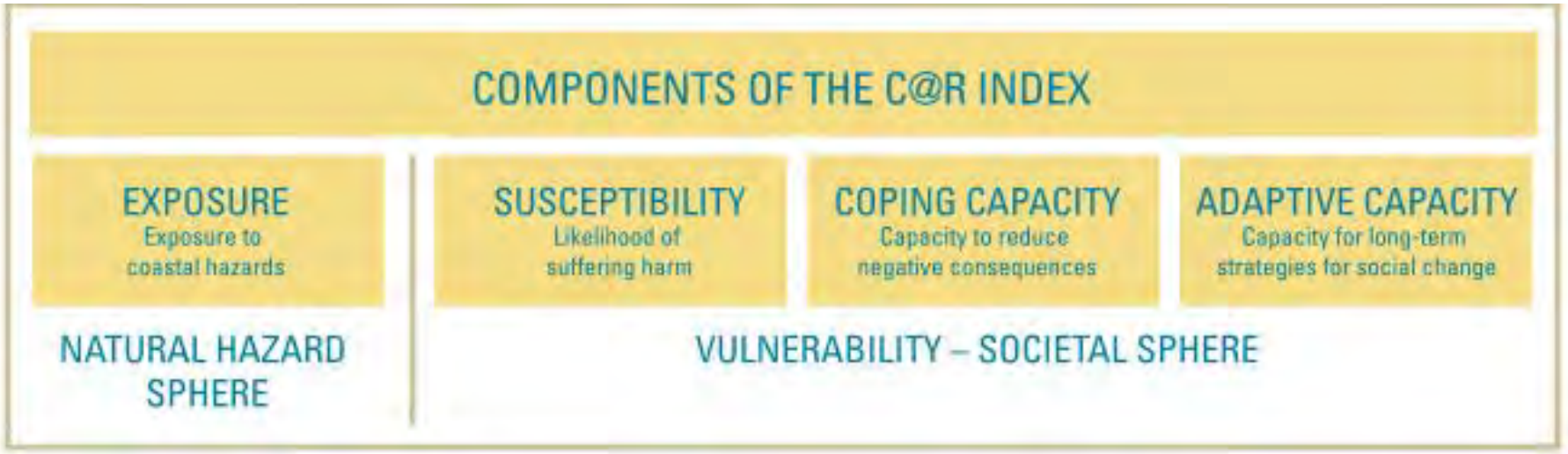

Percent Animal Protein From Fish
0.0 - 2.7
2.8 - 6.5
6.6 - 11.2
11.3 - 20.3
20.4 - 68.7
No data

Data:FAO



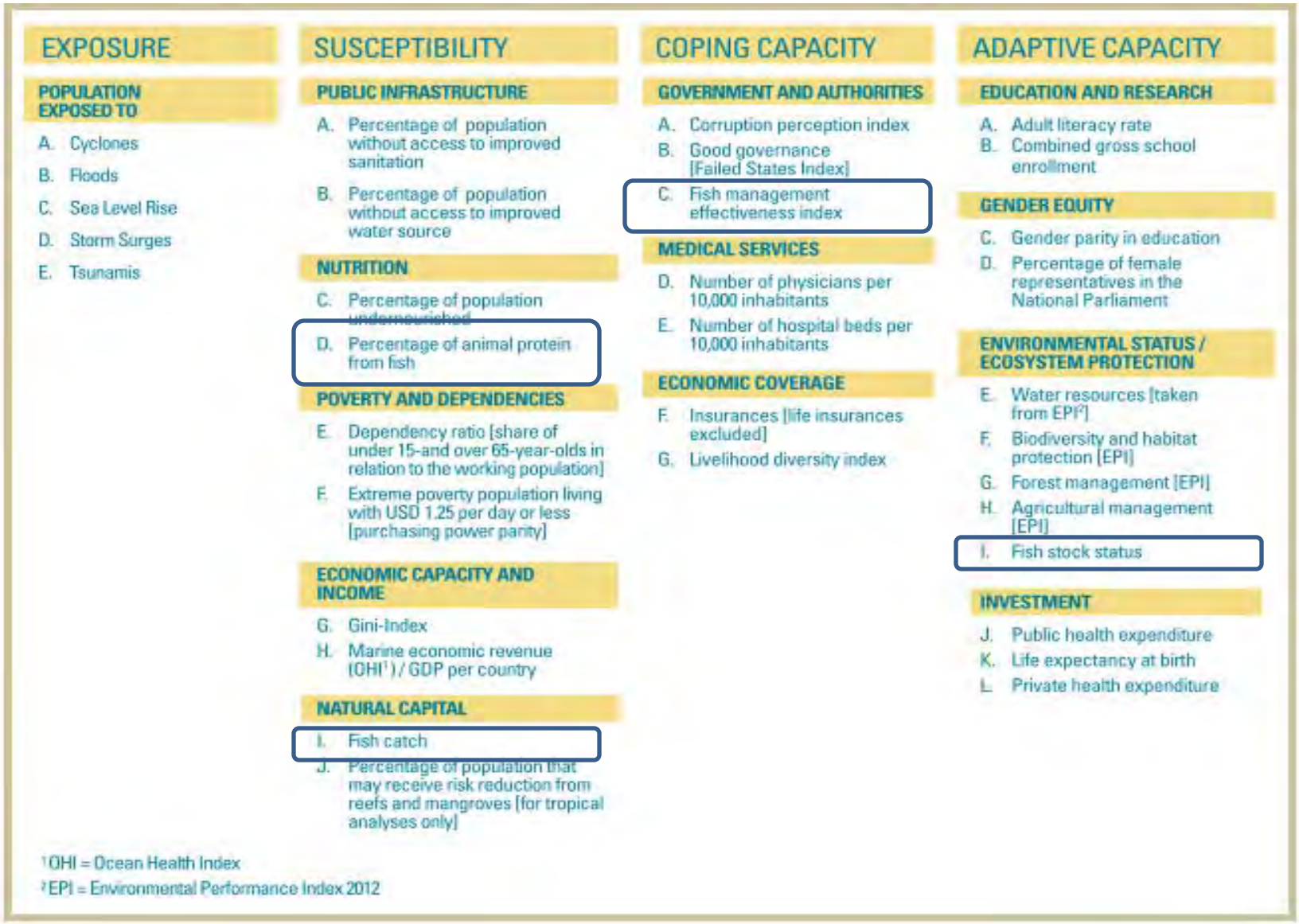
Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions

How



Fisheries indicators

Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions



Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions

How

Susceptibility - nutrition and natural capital

- Percentage of animal protein from fish
- Fish catch

How

Susceptibility - nutrition and natural capital

- Percentage of animal protein from fish
- Fish catch

Coping – government and authorities

- Fish management effectiveness

How

Susceptibility - nutrition and natural capital

- Percentage of animal protein from fish
- Fish catch

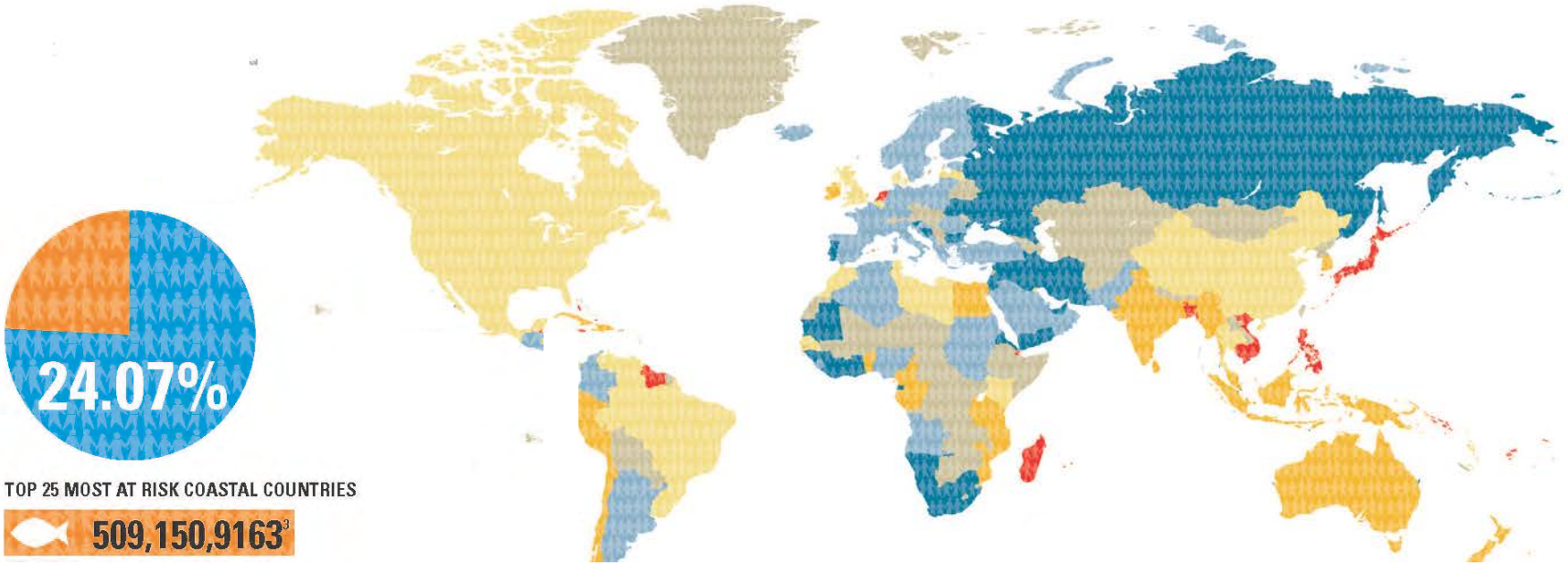
Coping – government and authorities

- Fish management effectiveness

Adaptive capacity – Ecosystem vitality

- Fish stock status

Fisheries and risk



Data:FAO and c@risk

Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions

Fisheries and risk

Country	Total 2012 Population	Number of Fishing Jobs	C@R Index Rank
China	1,350,695,000	2,570,274	medium
Indonesia	246,864,191	1,640,705	high
India	1,236,686,732	1,011,471	high
Viet Nam	88,775,500	944,788	very high
Burma	52,797,319	513,879	high
Brazil	198,656,019	497,819	medium
Taiwan	23,315,000	406,475	not included in C@R
Philippines	96,706,764	365,141	very high
Nigeria	168,833,776	294,558	low

Data:WB and FAO

Coasts at Risk: An Assessment of Coastal Risks and the Role of Environmental Solutions

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Photo: J. Castano


Photo: S.Margles

Summary

- Fisheries are central to **food, livelihood and economies** of coastal communities
- Fisheries are a critical component of **managing risks to coastal hazards**
- Fisheries and disaster risk management need to be **better integrated**

Photo: M. Ajo

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THANK YOU

vagostini@tnc.org

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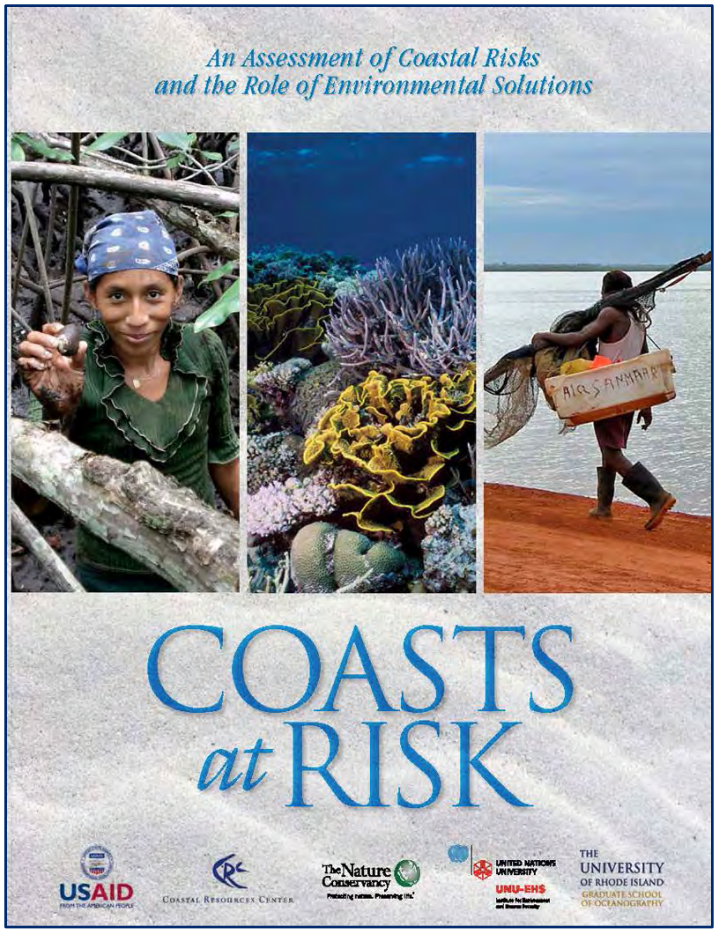
Coasts at Risk

An Assessment of Coastal Risks and the Role of Environmental Solutions



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Coastal Habitats

Do mangroves attenuate wind waves?

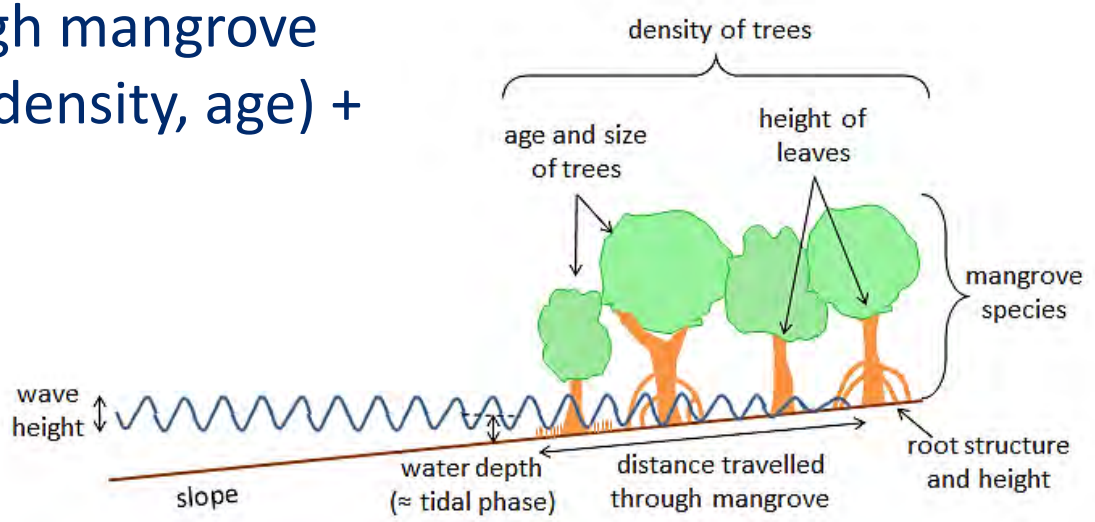
Location	Species	Wate attenuation / transmission	Source
Cocoa Creek, Australia	*Rhizophora stylosa*	Wave transmission factor 0 to 0.7	Brinkman *et al.* 1997
Iriomote Island, Japan	*Bruguiera* sp.	Wave transmission factor 0.2 to 0.8	Brinkman *et al.* 1997
Tong King Delta, Vietnam	*Kandelia candel*	Waves attenuated 20% per 100m	Mazda *et al.* 1997
Vinh Quang coast, northern Vietnam	*Sonneratia* sp.	45% / 100m when water 0.2m deep, 26% per 100m when water 0.6m deep	Mazda *et al.* 2006 ***(typhoon conditions)***
Red River Delta, Vietnam	*Kandelia candel*	0.002 to 0.011/m	Quartel *et al.* 2007
Nang Hai, Can Gio Mangrove Forest, Vietnam	*Avicenia* sp. and *Rhizophora* sp.	50-70% in first 20m (coinciding with 2m scarp)	Vo-Luong & Massel 2006, 2008
Red River Delta and Can Gio forest, Vietnam	as above	mean 0.0043/m over 80m of forest	Bao, 2011

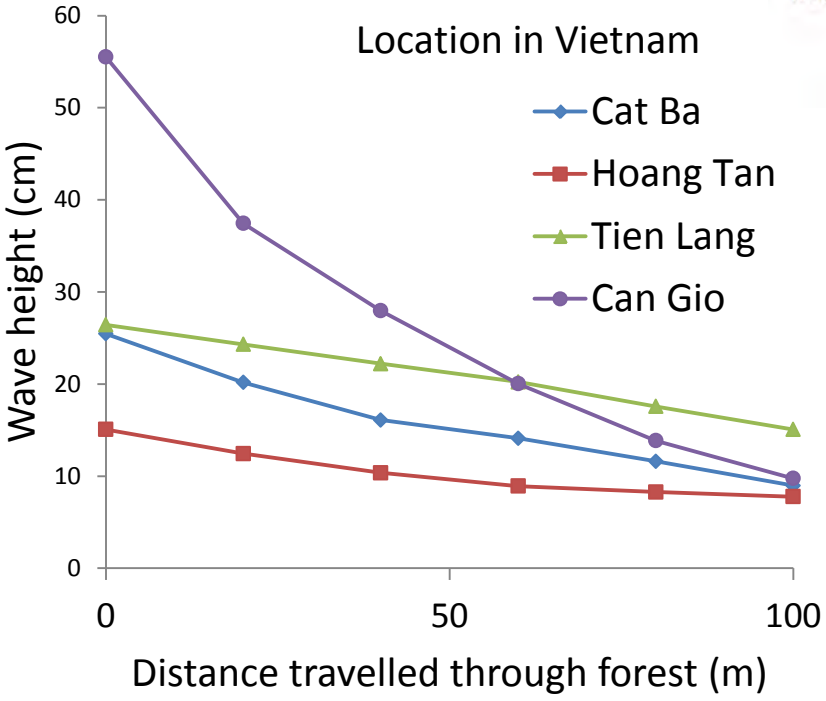
Yes, all studies so far have shown that mangroves are capable of attenuating waves (i.e. reducing wave energy and height).

A 100m wide mangrove belt can reduce wave height by 13 to 66%.

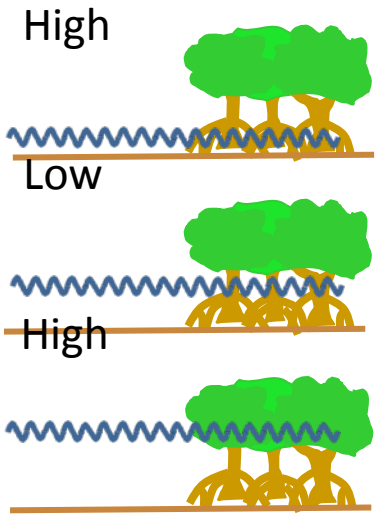
Factors affecting wave attenuation

a) Distance travelled through mangrove
b) Projected area (species, density, age) + water depth/tidal phase
c) Wave height
d) Topography





Data from Bao (2011), Oceanologia, 53: 807-818.



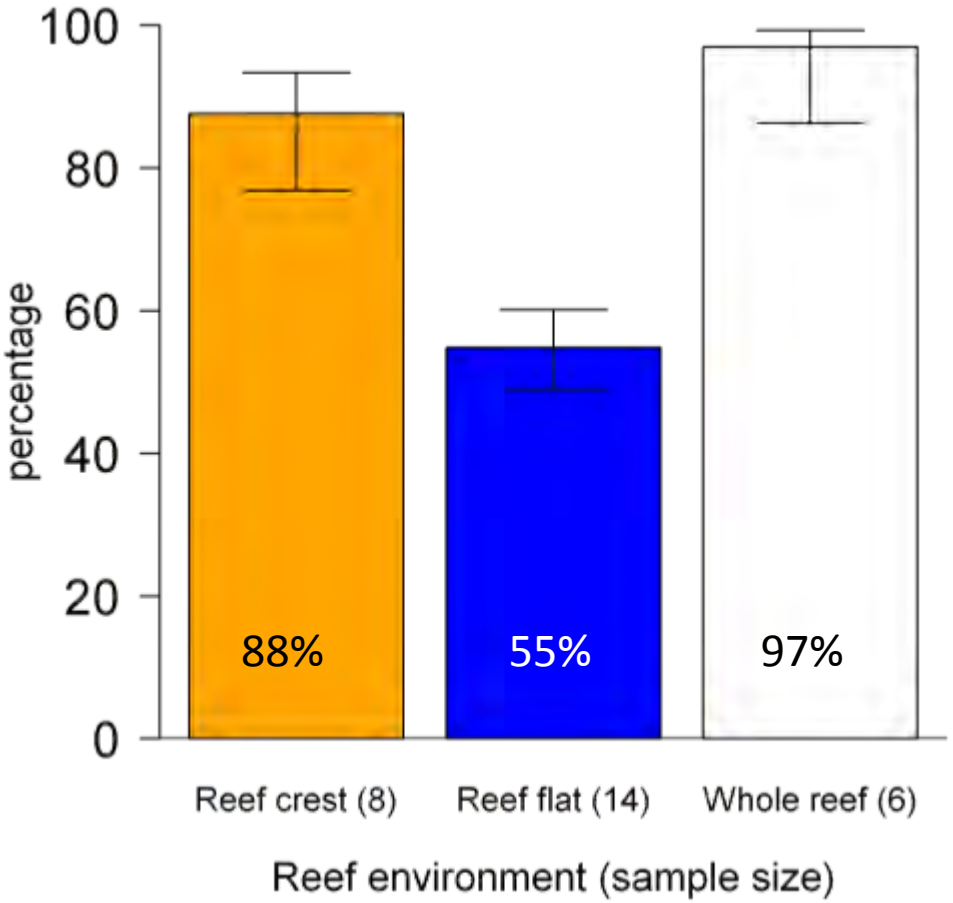
Do mangroves reduce storm surges?

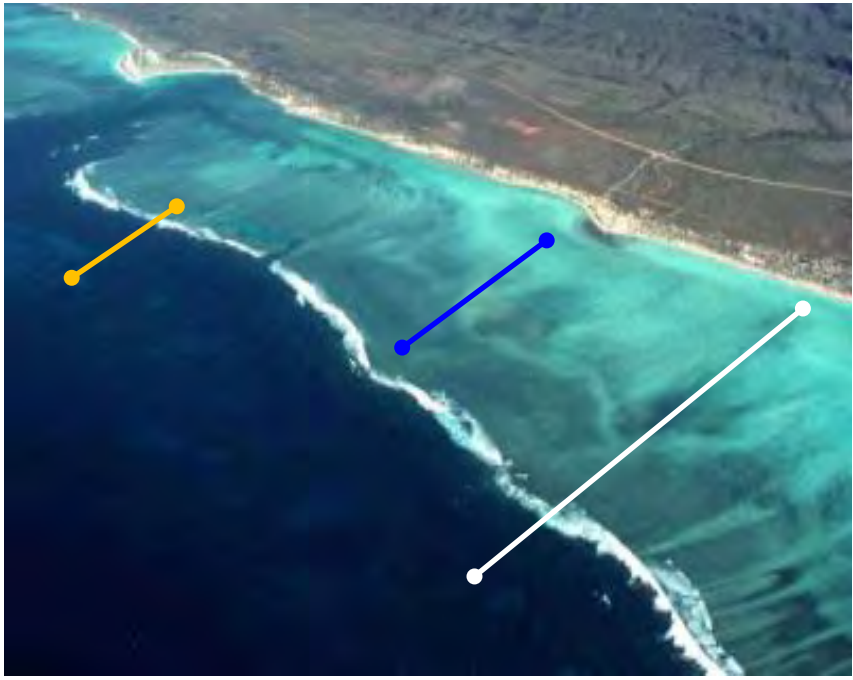
Limited data available on water levels and inundation; validated numerical models are more useful.

Location	Storm surge	Water level height reduction
Ten Thousand Islands NWR, FL USA	**Hurricane Charley**, 13 August 2004, max winds 240 km/hr, peak water level travelled at 0.4 km/hr	**9.4 cm/km** across whole area (15.8 cm/km in mangrove area)
Shark River (Everglades), FL, USA	**Hurricane Wilma**, 24 October 2005,	**4.2 cm/km**
Gulf Coast, Florida, from Sanibel West to Key West, USA	**Hurricane Wilma**	**Models suggest 23 to 48 cm/km**

Mangroves attenuate storm surges by a small amount per km. **Therefore wide bands of mangroves needed to reduce storm surges.**

Wave Energy Reduction By Coral Reefs





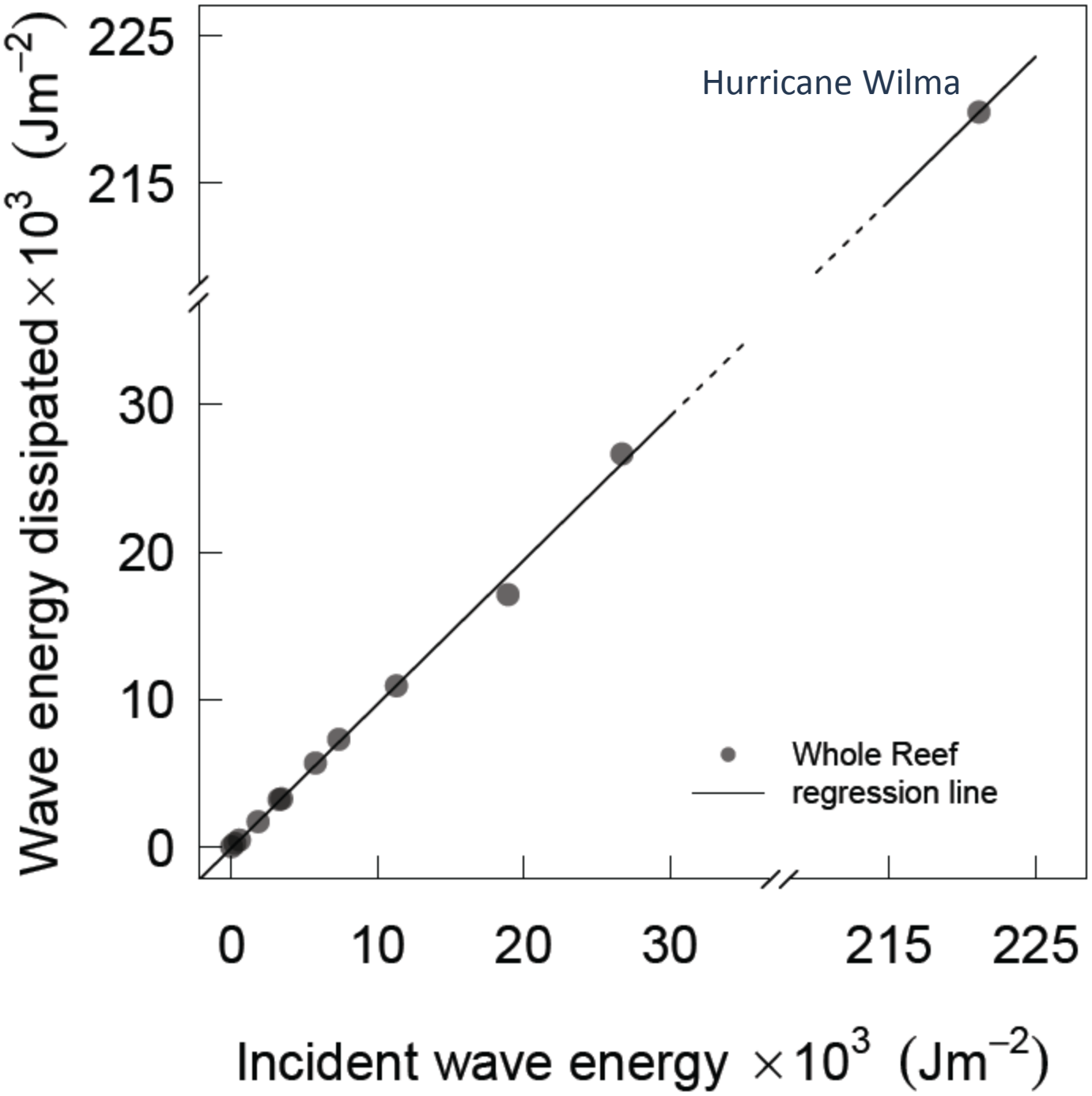

Hurricane Wilma
Wave energy dissipated ×10³ (Jm⁻²)
225
215
30
20
10
0
Whole Reef
regression line
0
10
20
30
215
225
Incident wave energy ×10³ (Jm⁻²)

Table 1 | Costs of construction or significant maintenance intervention for tropical breakwaters.

Location	Source (refs)	Length (*m*)	Year	Original cost ($)	Cost* 2012 ($)	2012 Unit cost ($ m^{-1})
Sri Lanka	64	16,000†	1994‡	13,400,000	20,759,511	1,297
Maldives	16	1§	1997‡	10,000	14,305	14,305
Haleiwa, Hawaii	65	58	1975	150,000	640,132	11,037
Hilo, Hawaii	65	3,073	1946	1,500,000	17,661,077	5,747
Kalaupapa, Hawaii	65	35	1967	95,000	653,037	18,658
Kawaihae, Hawaii	65	808	1973	6,000,000	31,026,216	38,399
Manele, Hawaii	65	143	1965	742,850	5,414,410	37,863
Nawiliwili, Hawaii	65	152	1959	1,000,000	7,889,828	51,907
Pohoiki, Hawaii	65	27	1979	335,500	1,061,003	39,296
Auasi, Samoa	65	206	1981	1,166,300	2,945,825	14,300
Aunuu, Samoa	65	27	1981	2,018,400	5,098,048	188
Tau, Samoa	65	88	1981	2,020,400	5,103,099	
Agana, Guam	65	221	1977	1,220,550	4,624,273	
Sungai, Malaysia	66	1§	2008	428	456	
Korea	67	3,000	2010	124,000,000	130,561	,520
Nakhon Si Thammarat, Thailand	68	40	2012	180950	18	4524

Median/m = $20,924

Table 2 | Costs of coral reef restoration projects.

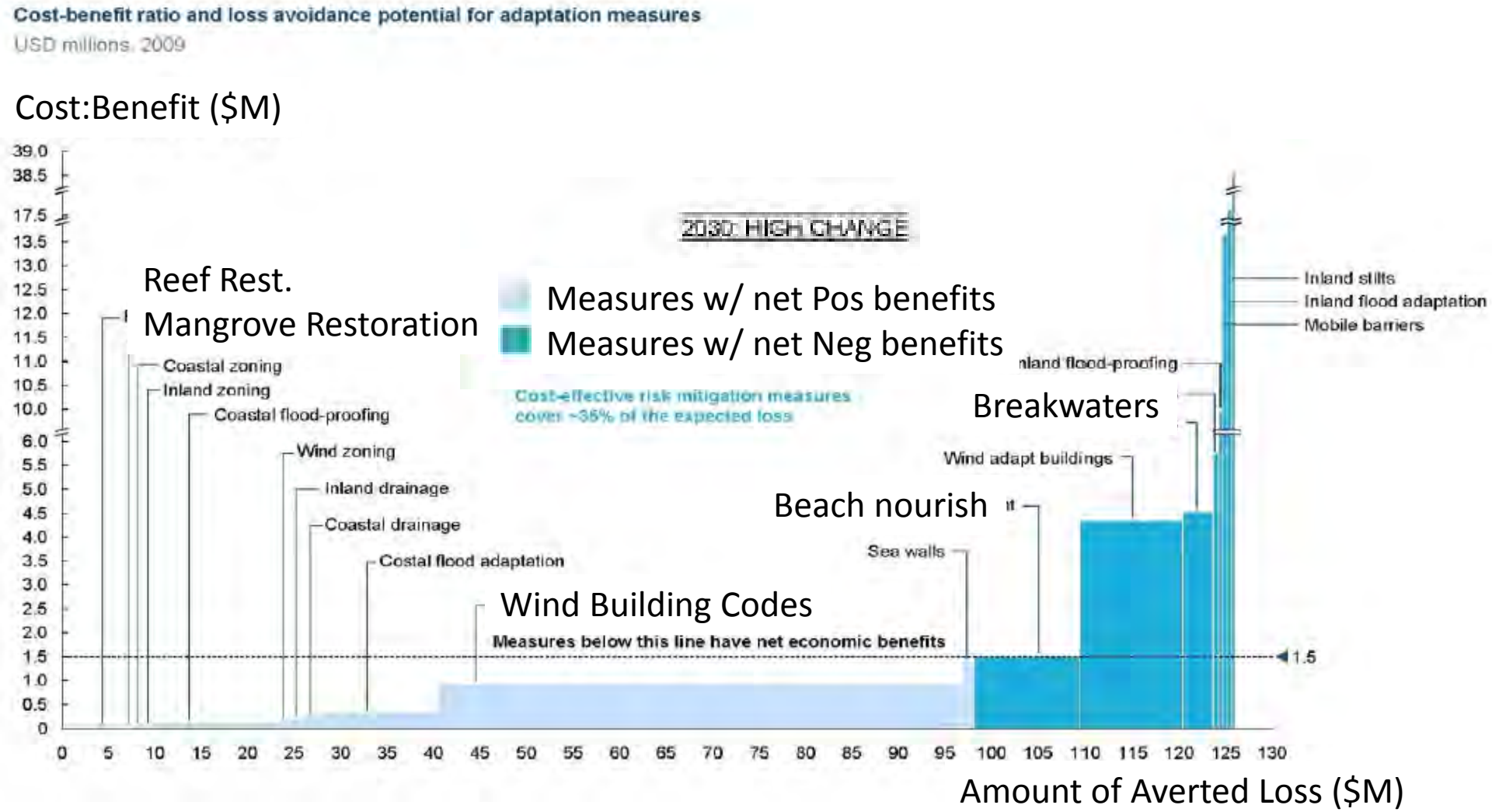
Restoration technique	Location	Source (refs)	Year	Original cost ($ m^{-2})	2012 Unit cost* ($ m^{-2})	2012 Linear unit cost† ($ m^{-1})
Paving slabs + chain-link fencing	Maldives	62	1994	40	62	620
Armorflex	Maldives	62	1994	103	159	1,590
Armorflex + coral transplantation	Maldives	62	1994	151	233	2,330
Concrete Blocks	Maldives	62	1994	328	508	5,080
Concrete structures + coral transplantation	Florida	69	1991	550	927	927
Concrete structures + coral transplantation	Florida	69	1994	10,000	15,500‡	155,000
Rock stabilization	Indonesia	70	2005	5	6	60
Reef Ball	Various	70	2005	40	47	
EcoReef	Various	70	2005	70	82	
Biorock	Various	61	2005	1.6-110	2-129	

Median/m = $1,290

Ferrario, Beck et al. 2014. *Nature Communications* .

Barbados

Examining Costs:Benefits of Coastal Adaptation Approaches

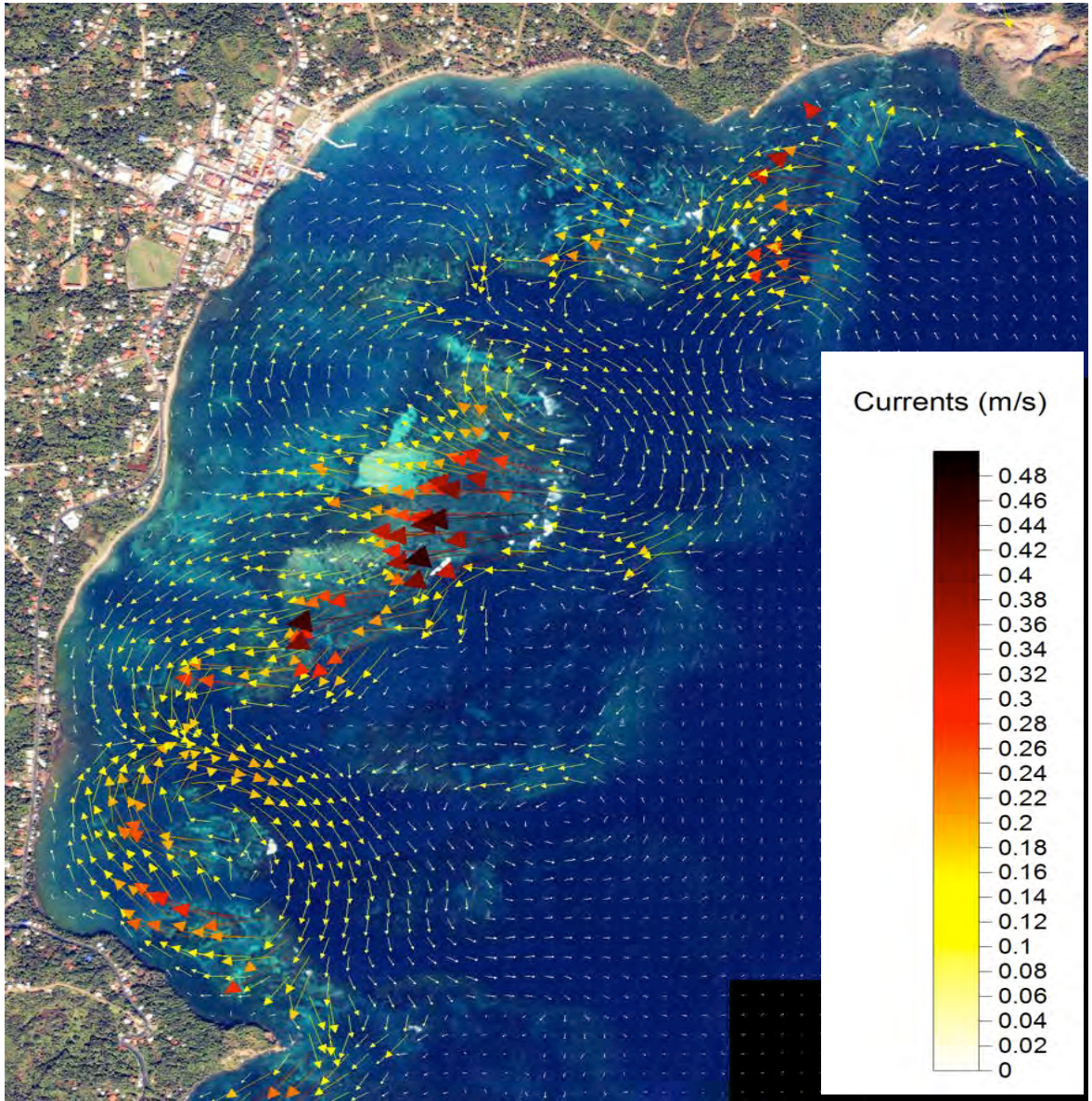


Based on work by Economics of Climate Adaptation working group- Swiss Re climada model

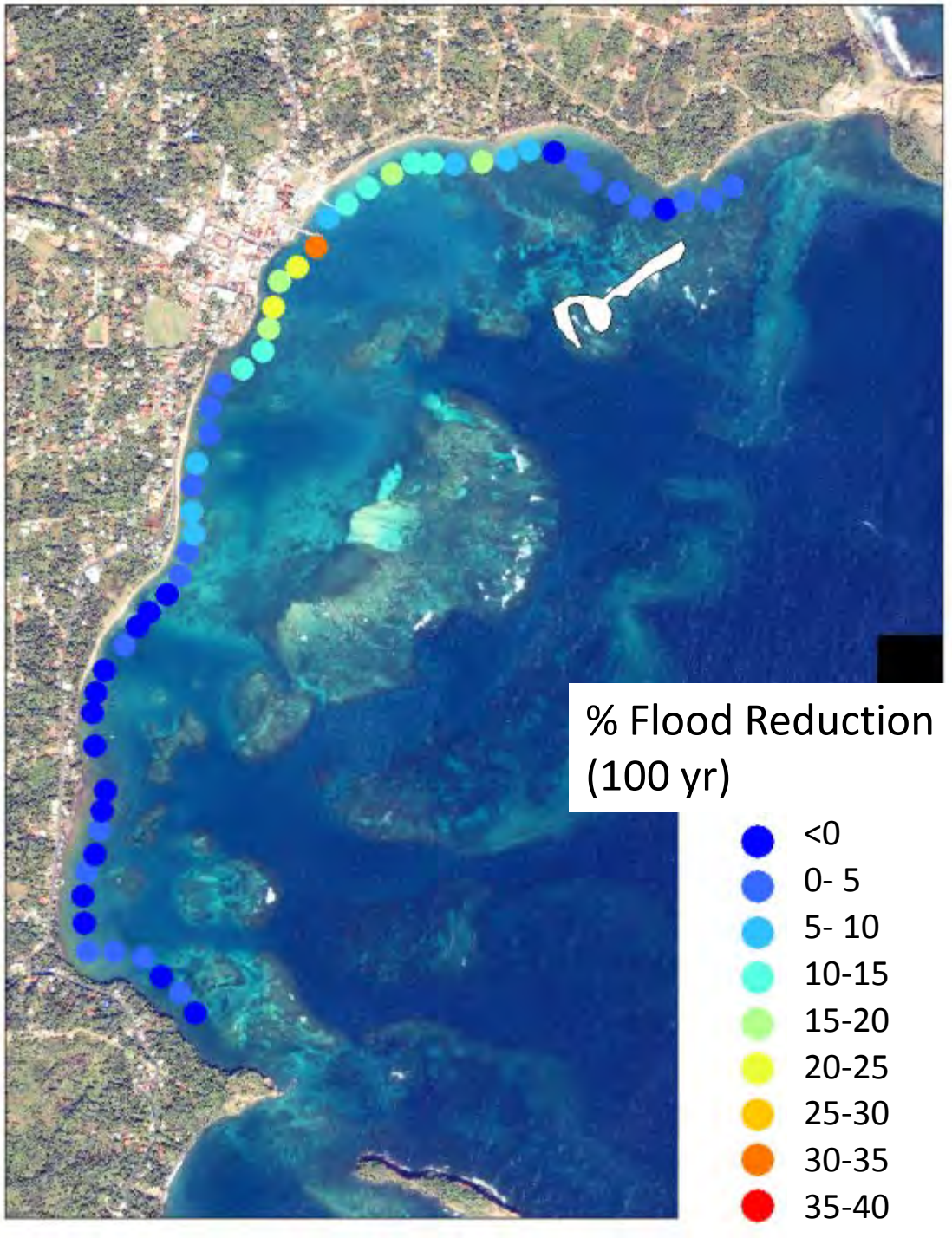
Grenville, Grenada Reef Restoration

Detailed Nearshore Hydrodynamics Analysis

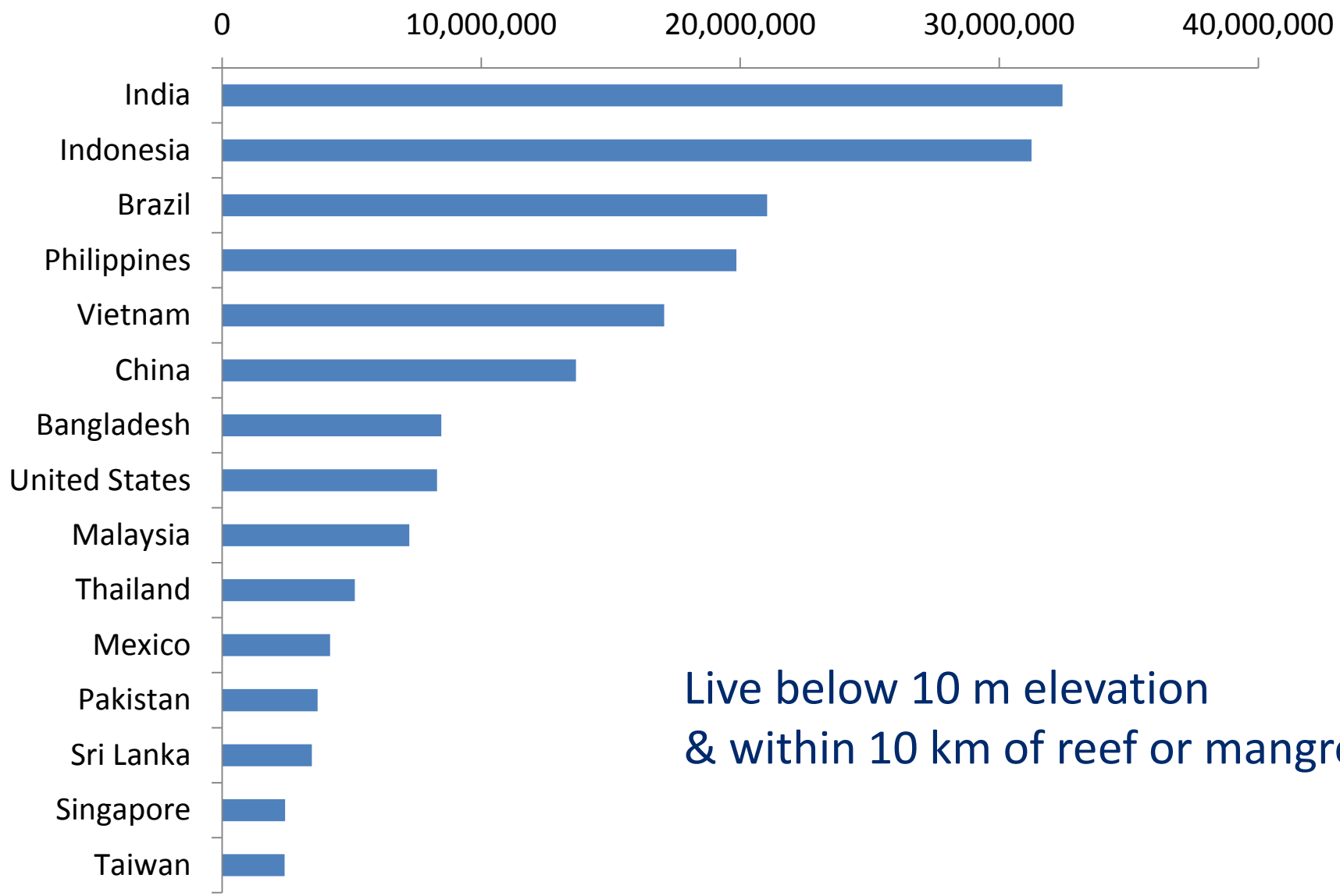
Currents



Flood Reduction: Reef Restoration vs Current Situation

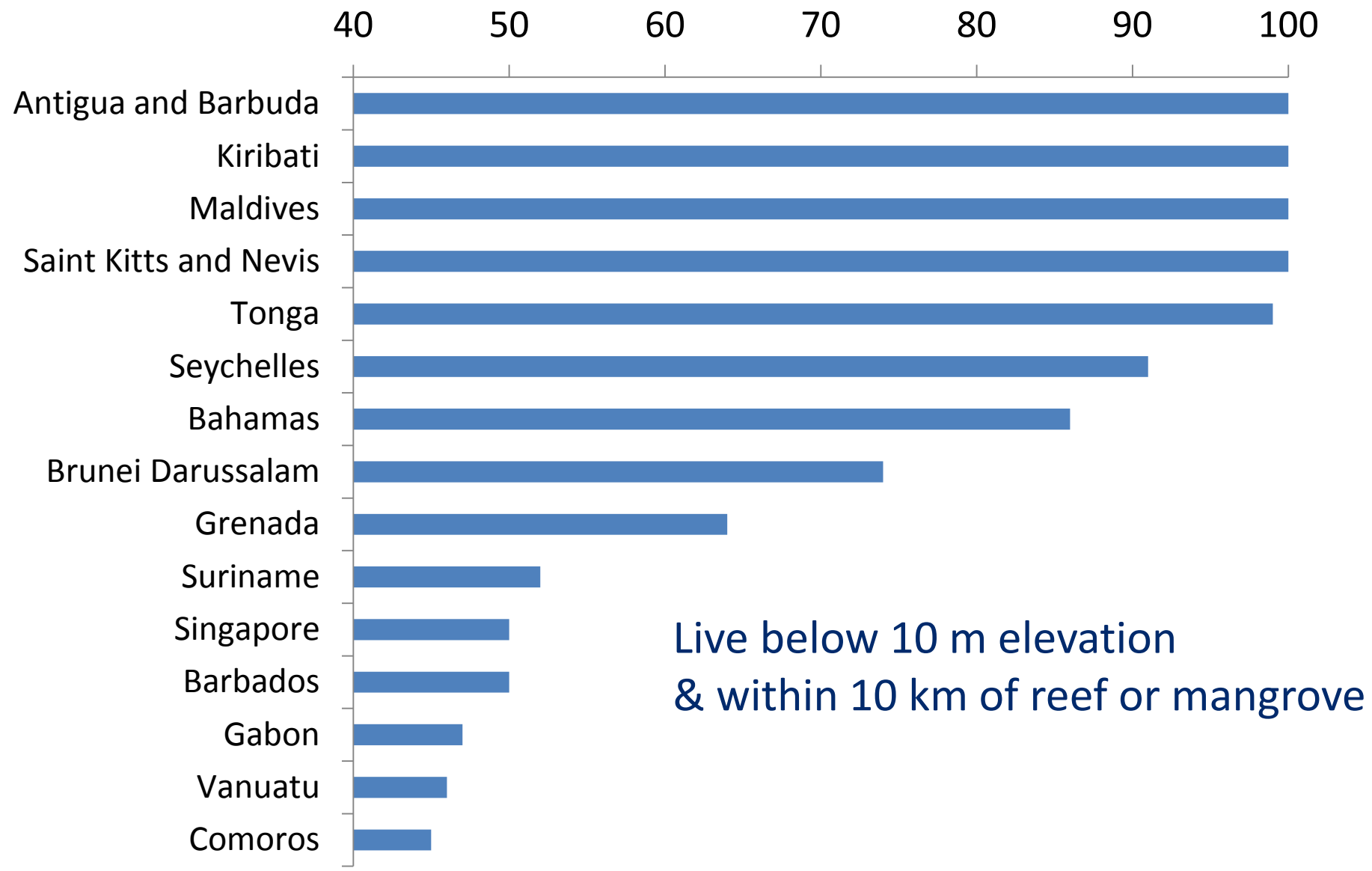


People Who May Benefit from Reefs & Mangroves

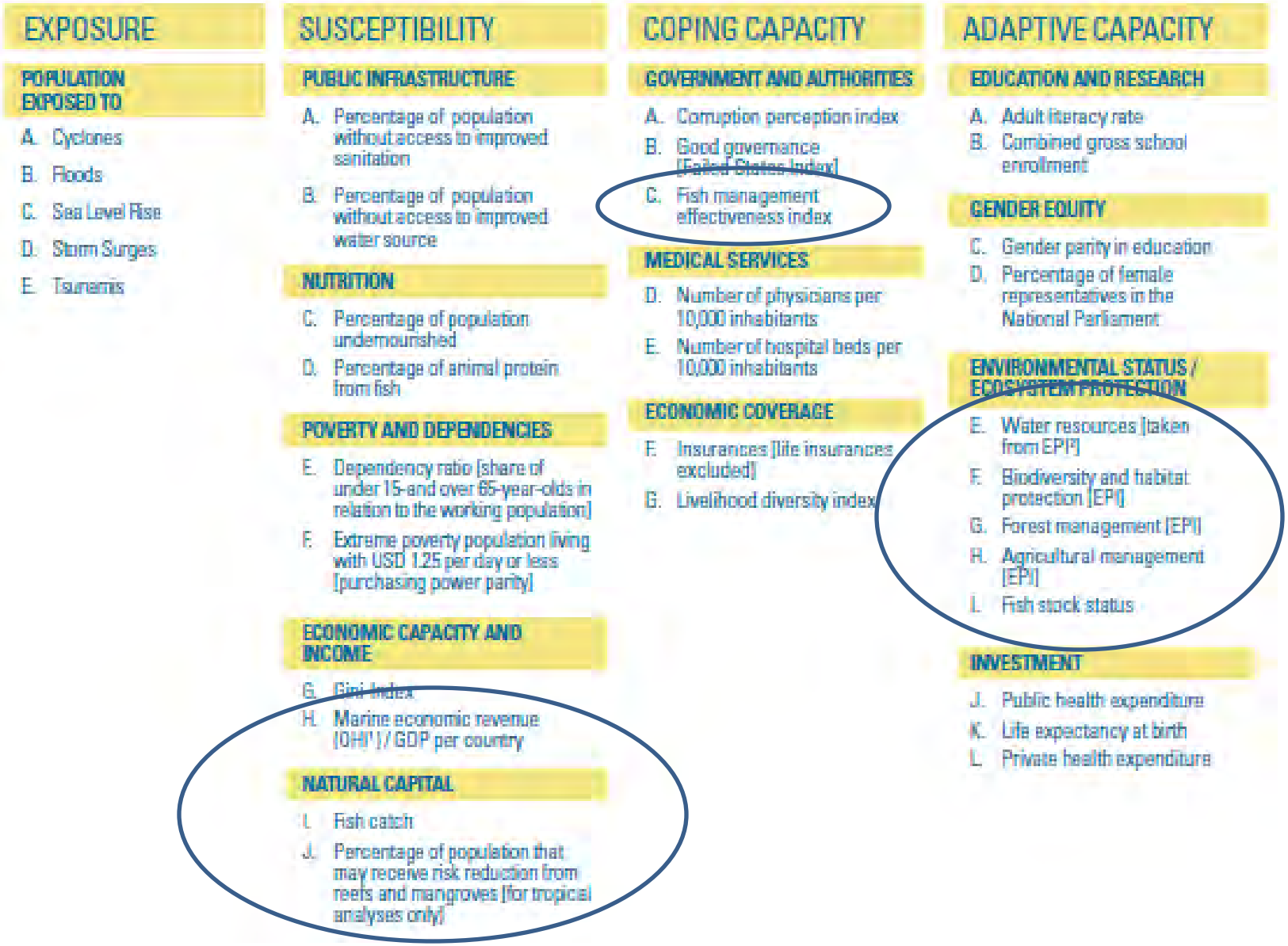


Live below 10 m elevation
& within 10 km of reef or mangrove

People Who May Benefit from Reefs & Mangroves

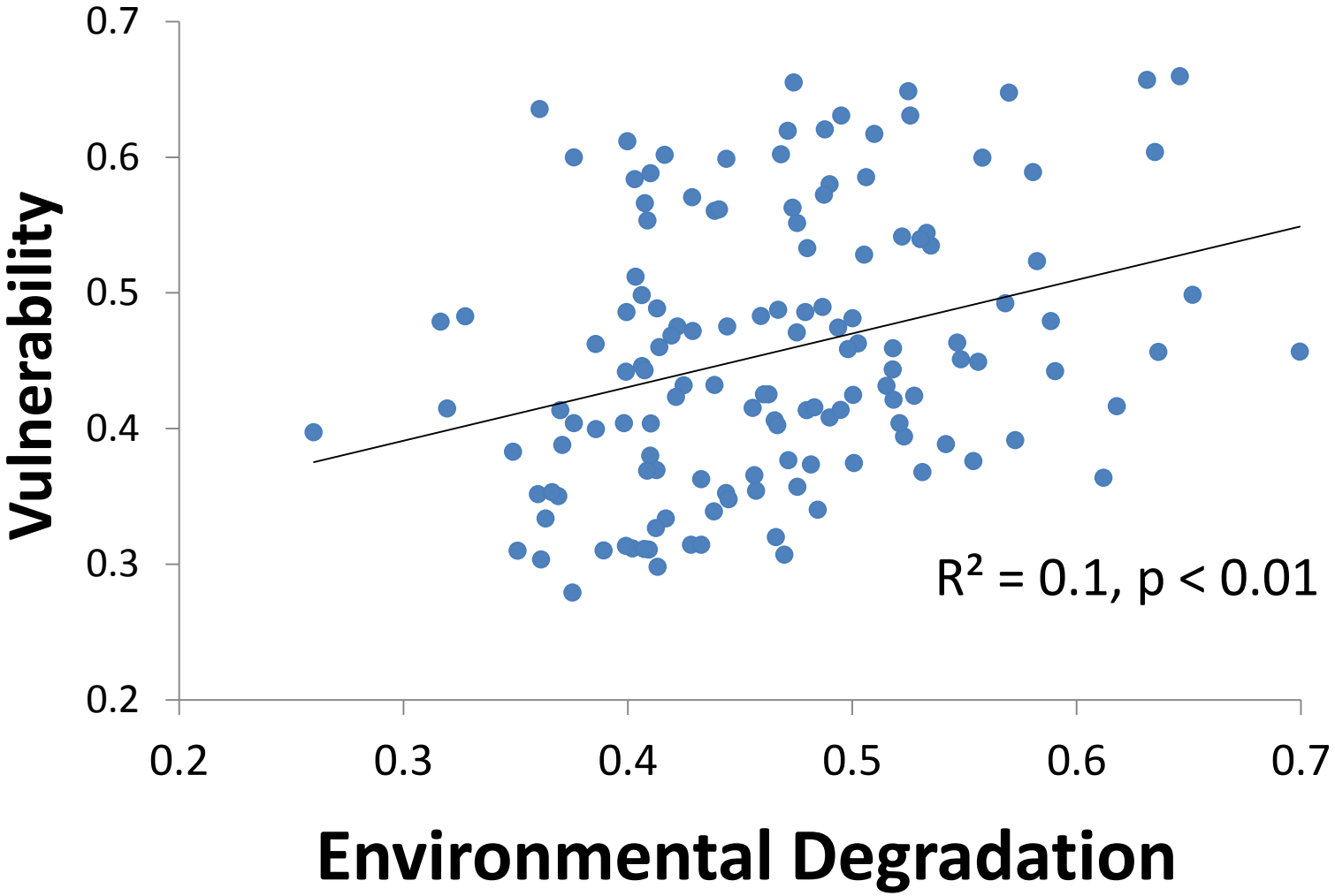


Environmental Indicators in C@R



Coasts at Risk: *An Assessment of Coastal Risks and the Role of Environmental Solutions*

Environment & Social Vulnerability



Recommendations

There is a need to increase risk prevention measures and opportunities for better post-disaster development choices

- Post-disaster choices could support risk reduction & conservation
- Govt's and multinational funders should be more cautious about rebuilding in highest risk, low-lying areas.

Habitat restoration can contribute to risk reduction and opportunities exist to focus these restoration efforts

- Coral reef and mangrove restoration offer cost-effective options

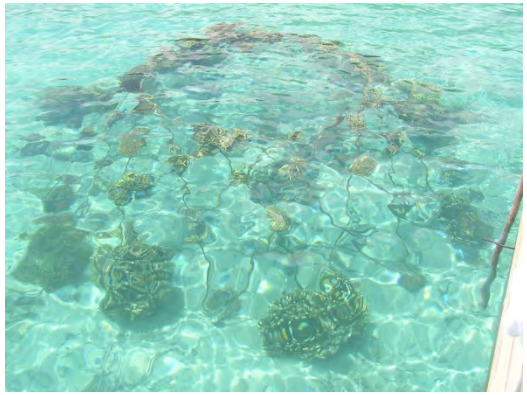
Recommendations

Targeted research is needed on environmental risk reduction services to create better opportunities for investment

Govt's & multinational funders need integrated risk assessments that account for drivers of risk, e.g., env. degradation

Leaders need to demand more cost-effective solutions thus creating investment opportunities in natural infrastructure

- Adaptation and development funders should encourage better mainstreaming of cost-effective solutions
- Habitat restoration creates opportunity for business



Recommendations

Fisheries management and research need to be better linked to disaster risk reduction and climate adaptation

- Creating opportunities to improve fisheries and reduce social vulnerability

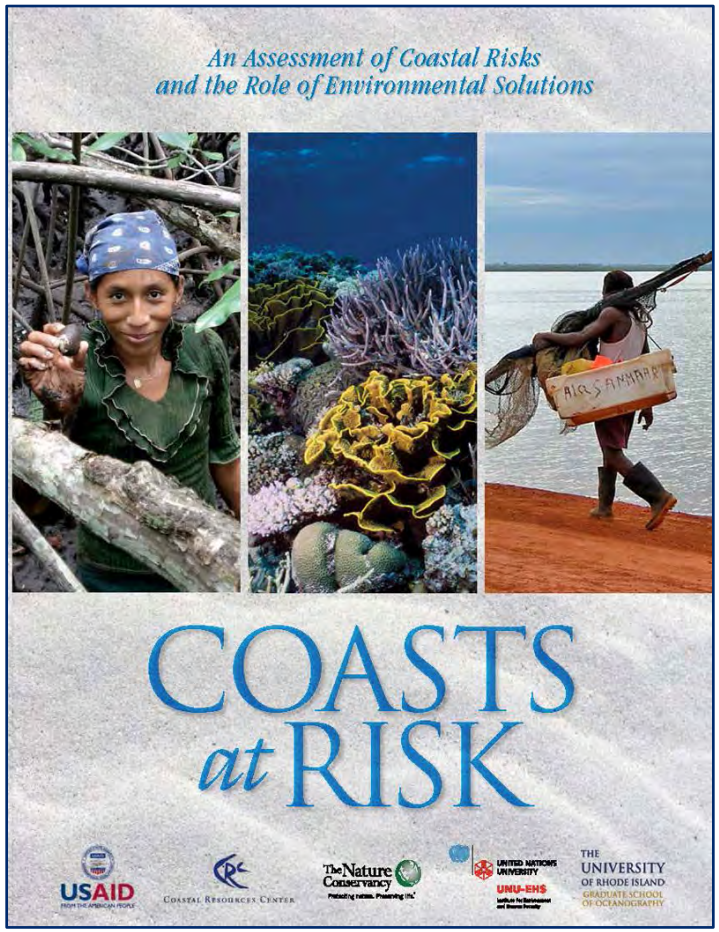
Coasts at Risk

An Assessment of Coastal Risks and the Role of Environmental Solutions

Thank You

Coasts at Risk:

An Assessment of Coastal Risks and the Role of Environmental Solutions



Report at -
http://www.crc.uri.edu/download/SUC09_CoastsatRisk.pdf

Interactive Maps at -
www.maps.coastalresilience.org\global

USAID FROM THE AMERICAN PEOPLE
Coastal Resources Center
The Nature Conservancy Protecting nature. Preserving life.
United Nations University UNU-EHS Institute for Environment and Human Security
The University of Rhode Island Graduate School of Oceanography

TNC, Arlington, VA // July 30, 2014