

Assessing the Vulnerability Level in Coastal Communities in the Caribbean: A Case Study of San Pedro, Belize

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*Managing for Development in Caribbean Economies Addressing the
Challenges for Poverty and Inequality*

Presented by

Sherry Ann Ganase and Dr. Sandra Sookram

Outline

- ➔ Introduction
- ➔ Who are most vulnerable?- Focus on SIDS
- ➔ Literature Review
- ➔ Methodology
- ➔ Case Study and Data Collection
- ➔ Empirical Results:
 - ⊗ Vulnerability Index
 - ⊗ Structural Equation Model
- ➔ Conclusions

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INTRODUCTION

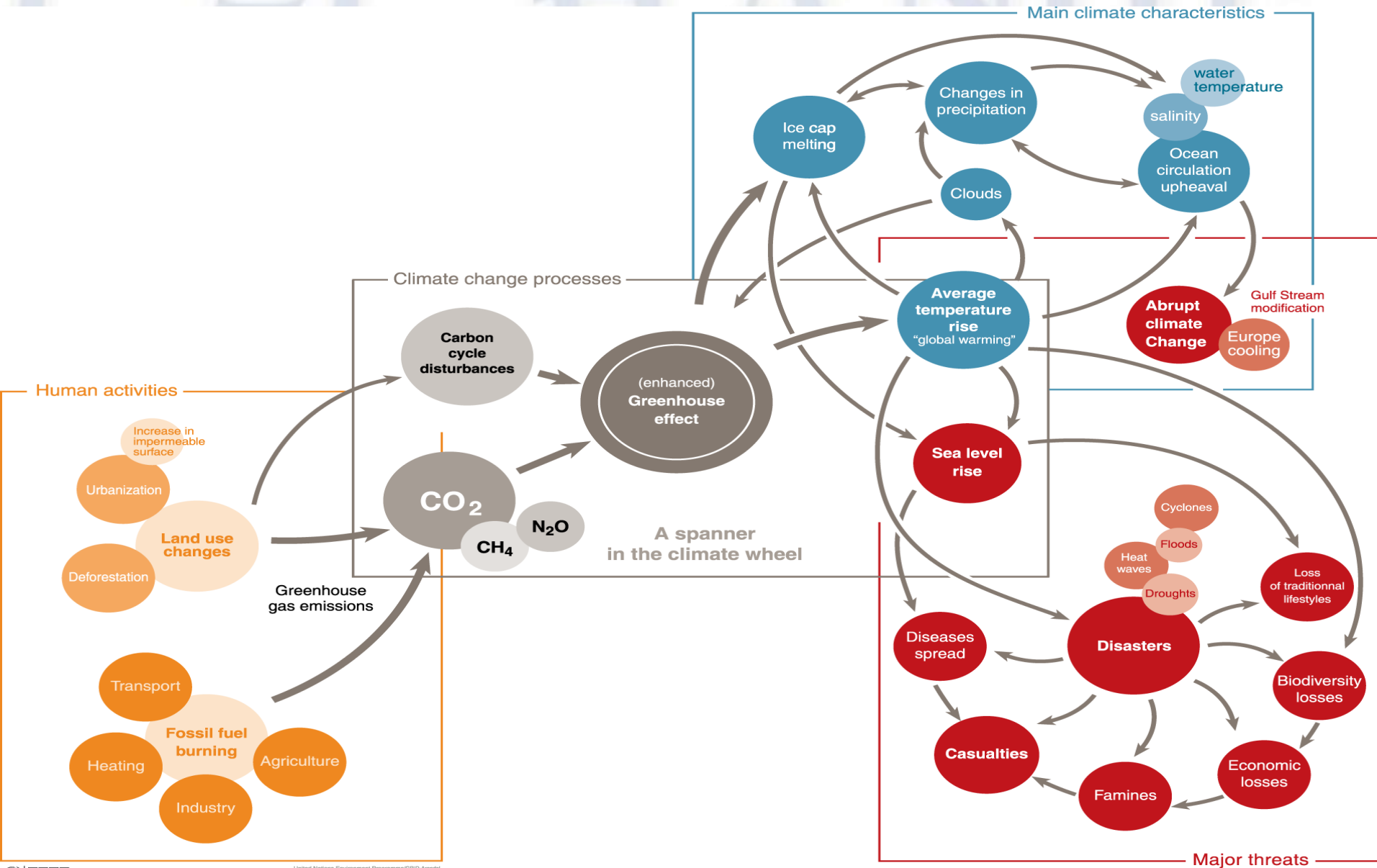
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Coastal Climate Adaptation Strategies

Climate Change

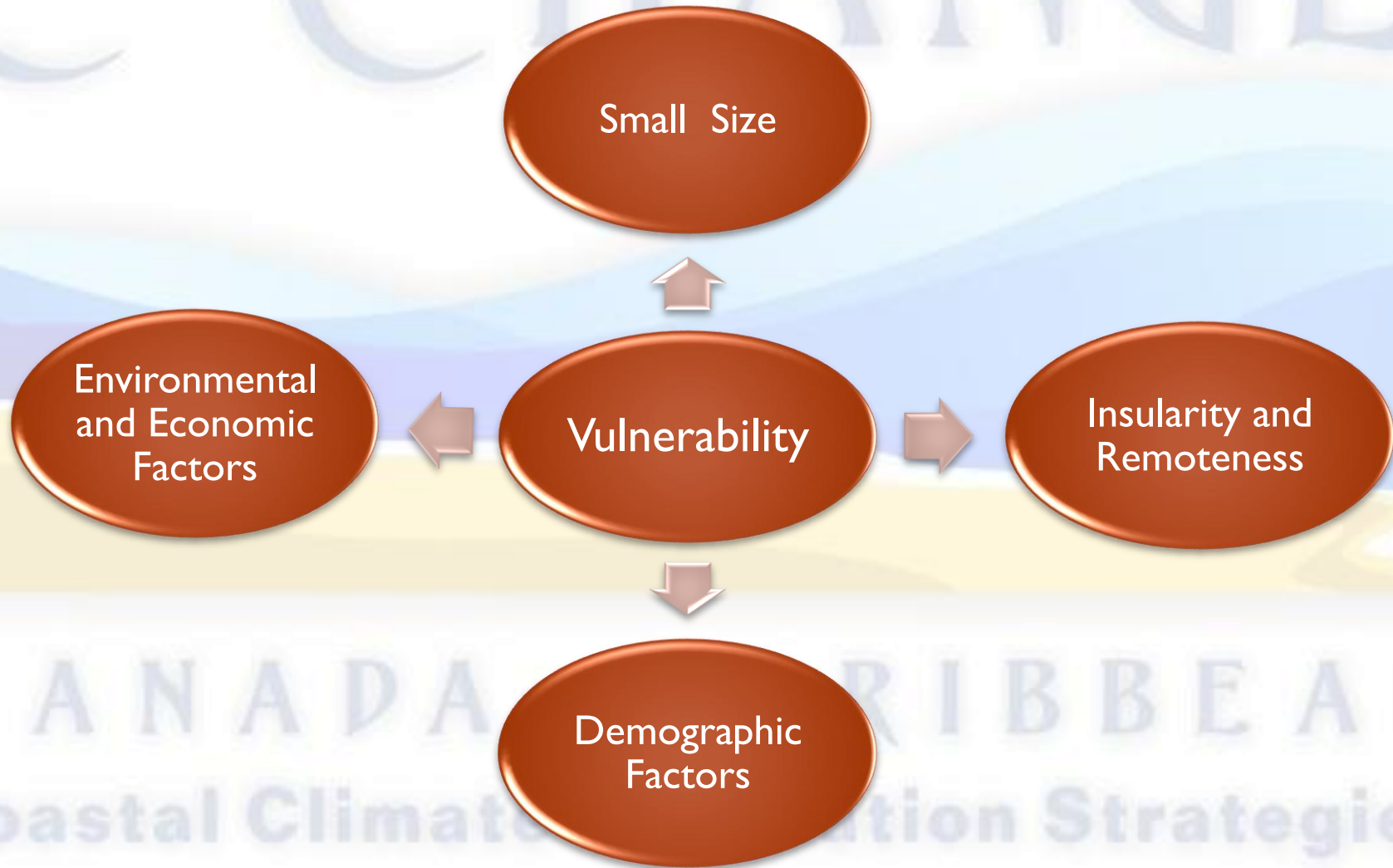


- Refers to “*any changes over climate over time, whether due to natural variability or as a result of human activity*” (IPCC 2007).
- Increasingly being accepted as the single major threat facing the socio-ecological systems in the 21st century

Climate Change Processes



Who are Most Vulnerable? A Focus on SIDS



Cost and Action?

- Actions cannot be delayed as annual cost of inaction for the Caribbean is **USD\$22 billion annually by 2050** and USD\$46 billion by 2100 (Bueno et al., 2008)
- Very little SIDS can do to reduce GHGs
- Benefits of developing Vulnerability Index:
 - ⊕ Offers a reference point for evaluating framework for development
 - ⊕ Provides information for developing adaptation and mitigation measures
 - ⊕ Allows for the allocation of resources
 - ⊕ Allows for spatial and temporal comparison

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LITERATURE REVIEW

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Some Recent Measures of Vulnerability

Reference	Geographic Focus	Vulnerability Index/ Focus	Scale	Categories Chosen	Type of Data
Skondras et al (2011)	Greece	Environmental Vulnerability	Country	Hazards, resistance, and damage	Secondary data
Hahn et al (2009)	Mozambique	Livelihood Vulnerability	Community	Socio-demographic, profile, livelihood strategies, health, food, water, and natural disasters	Primary data-survey
St Bernard (2007)	The Caribbean	Social Vulnerability	Country	Education, health, security, social order and governance, resource allocation, and communication architecture	Primary and Secondary data
SOPAC (2004)	SIDS	Environmental	Country	Hazards, resistance, and damage	Secondary data
Vincent (2004)	Africa	Social Vulnerability	Country	Economic well being and stability, demographic structure, global interconnectivity, natural resource dependence	Secondary data
Briguglio and Galea (2003)	SIDS	Economic Vulnerability	Country	Economic openness, export concentration, peripherality, and dependence on strategic imports	Secondary data
Gowrie (2003)	Tobago	Environmental	Country	Environmental risk, Intrinsic Resilience, and Environmental degradation	Secondary data

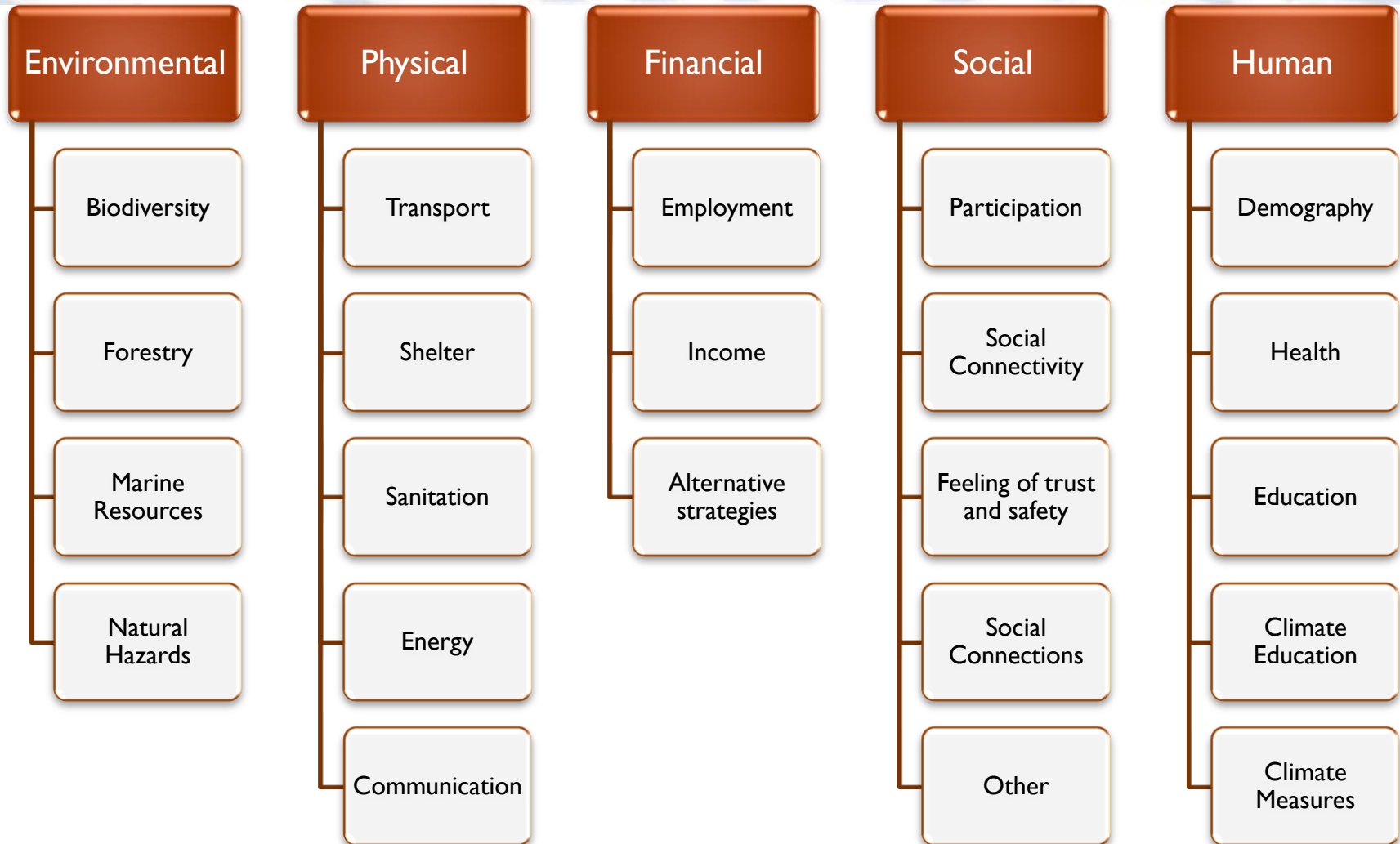
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METHODOLOGY

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Methodology: Developing the Index

VULNERABILITY INDEX



Calculating the Index

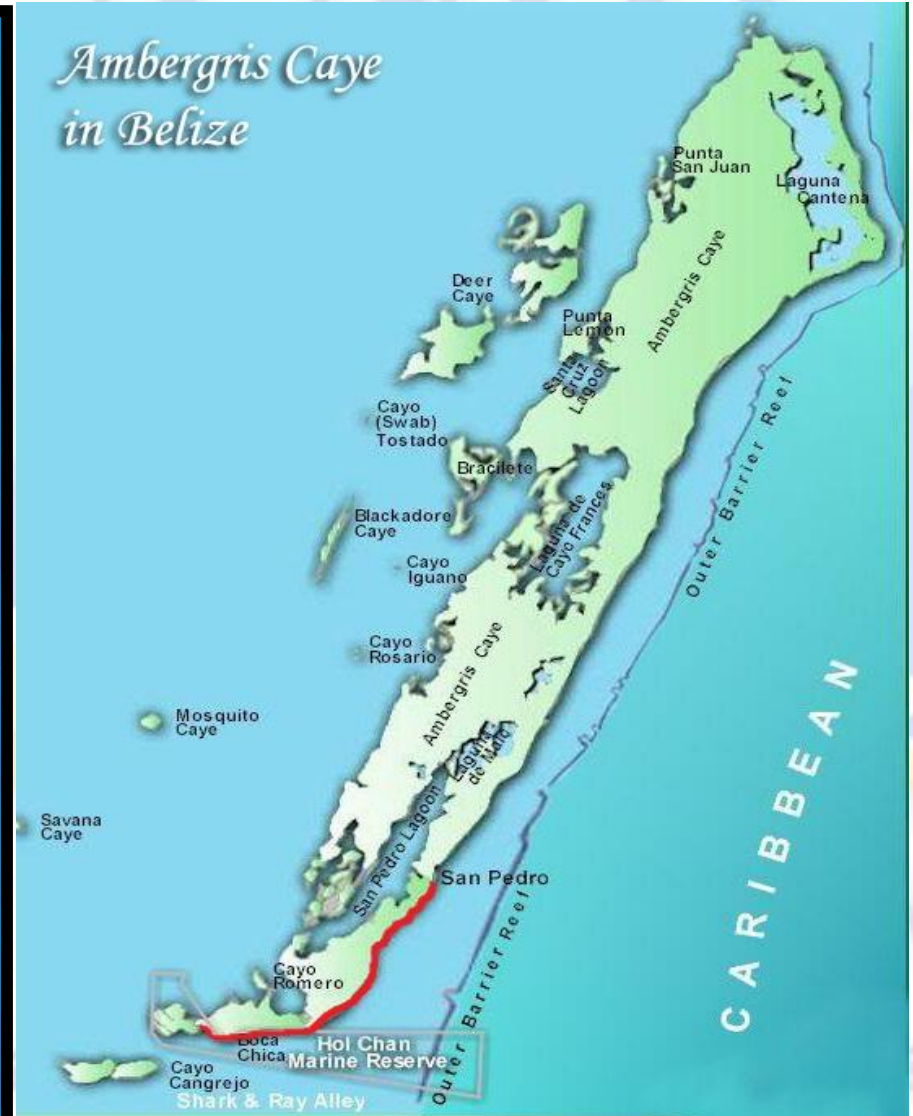
- Standardisation = $\text{Value} - \text{Minimum} / \text{Maximum} - \text{Minimum}$
- $M_c = \sum_{i=1}^n \text{index } s_{ci} / n$
- Where M_c is one of the major 22 components, s_{ci} is the sub component
- $VI = \sum_{i=1}^{22} w_{Mi} M_{ci} / \sum_{i=1}^{22} w_{mi}$
- Scores assumes standard format with Minimum of 0 and Maximum of 1 (least and most vulnerable respectively)

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CASE STUDY AND DATA COLLECTION

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Case Study: San Pedro, Belize



Some Basic Facts on San Pedro, Belize

- Small urban town located on the southern part of Ambergris Caye
- Second largest town in the Belie district and largest in the Belize Rural South Constituency
- Approximately 4000 residents of Mexican descent who speaks both Spanish and English
- 2nd largest reef in the world: Belize Barrier Reef - Rich source of biodiversity and ecosystem
- Environmental degradation: erosion of mangroves and ecosystems, land reclamation, ribbon development, urbanization, intensity of extreme events, climate change
- Projections by CARIBSAVE (2012):
 - ⊕ Increase in average atmospheric temperature
 - ⊕ Reduction in average annual rainfall
 - ⊕ Increase in sea surface temperature
 - ⊕ Increase in intensity of tropical storms
 - ⊕ Sea level rise -Total loss of beach area with 3m SLR

Data Collection

- **Primary Data: community survey**

- ⊕ 10 districts surveyed

- Required information was grouped into Pillars:
Environmental, Social, Human, Financial and
Physical

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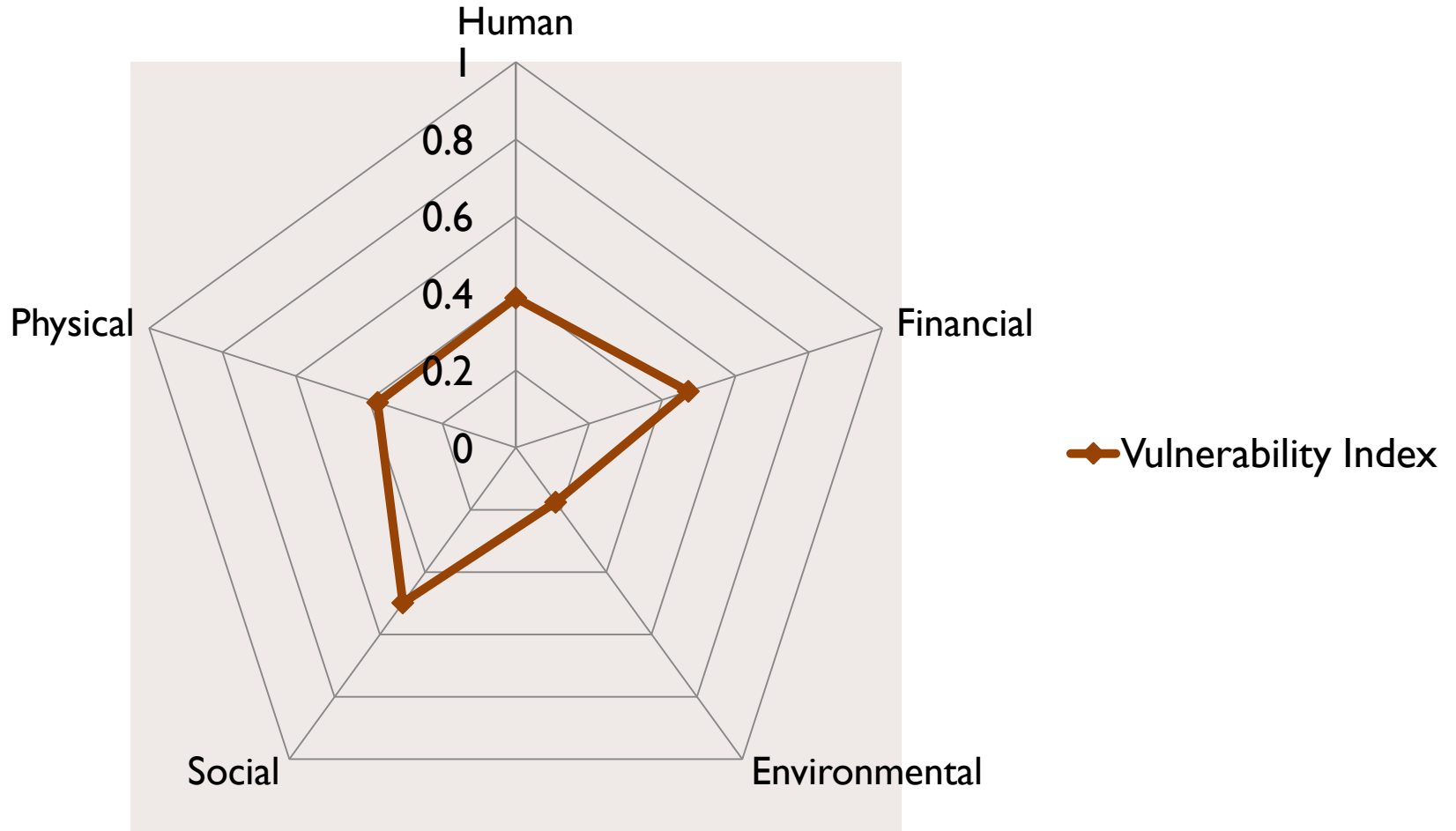
EMPIRICAL RESULTS

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Vulnerability Index Results

Pillars	Major Component values for San Pedro
Social	0.499
Financial	0.471
Human	0.388
Physical	0.377
Environmental	0.176
VULNERABILITY INDEX	0.382

Spider Diagram showing Vulnerability Index



Example Calculation: Financial Pillar

Indicator	Sub-components for Physical	Sub-component values	Maximum	Minimum	Index value	Sub-Component value	Component Value
Employment	Average number of persons employed	1.233	5	1	0.233	0.396	0.4710
	•	•	•	•	•		
	•	•	•	•	•		
	Average number of persons working in immediate community	1.527	5	1	0.527		
Income	Average number of households deriving income from tourism	1.131	2	1	0.131	0.419	
	•	•	•	•	•		
	•	•	•	•	•		
Alternative Strategies	Average number of households that would be interested in creation of small bar	3.086	5	1	0.522	0.548	
	•	•	•	•	•		
	•	•	•	•	•		

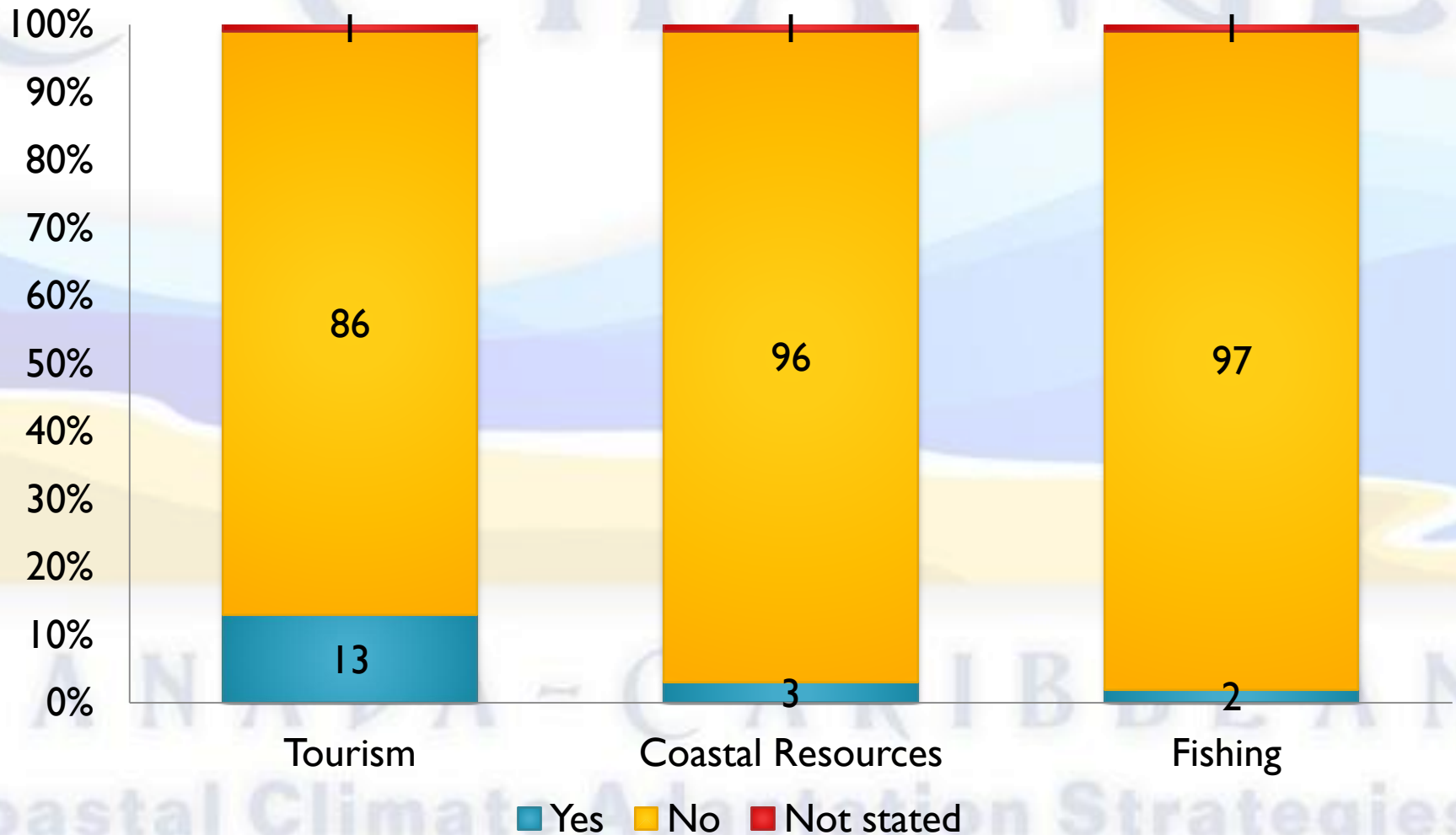
Results: Indicators and Sub-indicators

Pillar	Indicator	Indicator Value	Total Indicator Value	Number of Indicators	Index Value
Social	Participation	0.847	2.498	5	0.499
	Social Connectivity	0.528			
	Feeling of trust & safety	0.347			
	Social Connections	0.519			
	Other	0.257			
Financial	Employment	0.396	1.413	3	0.471
	Income	0.469			
	Alternative Strategies	0.548			
Human	Demography	0.184	1.939	5	0.388
	Health	0.197			
	Non-climate education	0.362			
	Climate education	0.570			
	Climate Measures	0.626			
Physical	Transport	0.425	2.26	6	0.3766
	Shelter	0.524			
	Sanitation	0.193			
	Energy	0.363			
	Communication	0.629			
	Asset ownership	0.126			
Environmental	Biodiversity	0.426	0.88	5	0.176
	Forestry	0.029			
	Marine Resources	0.006			
	Tourism	0.021			
	Natural Hazards	0.398			

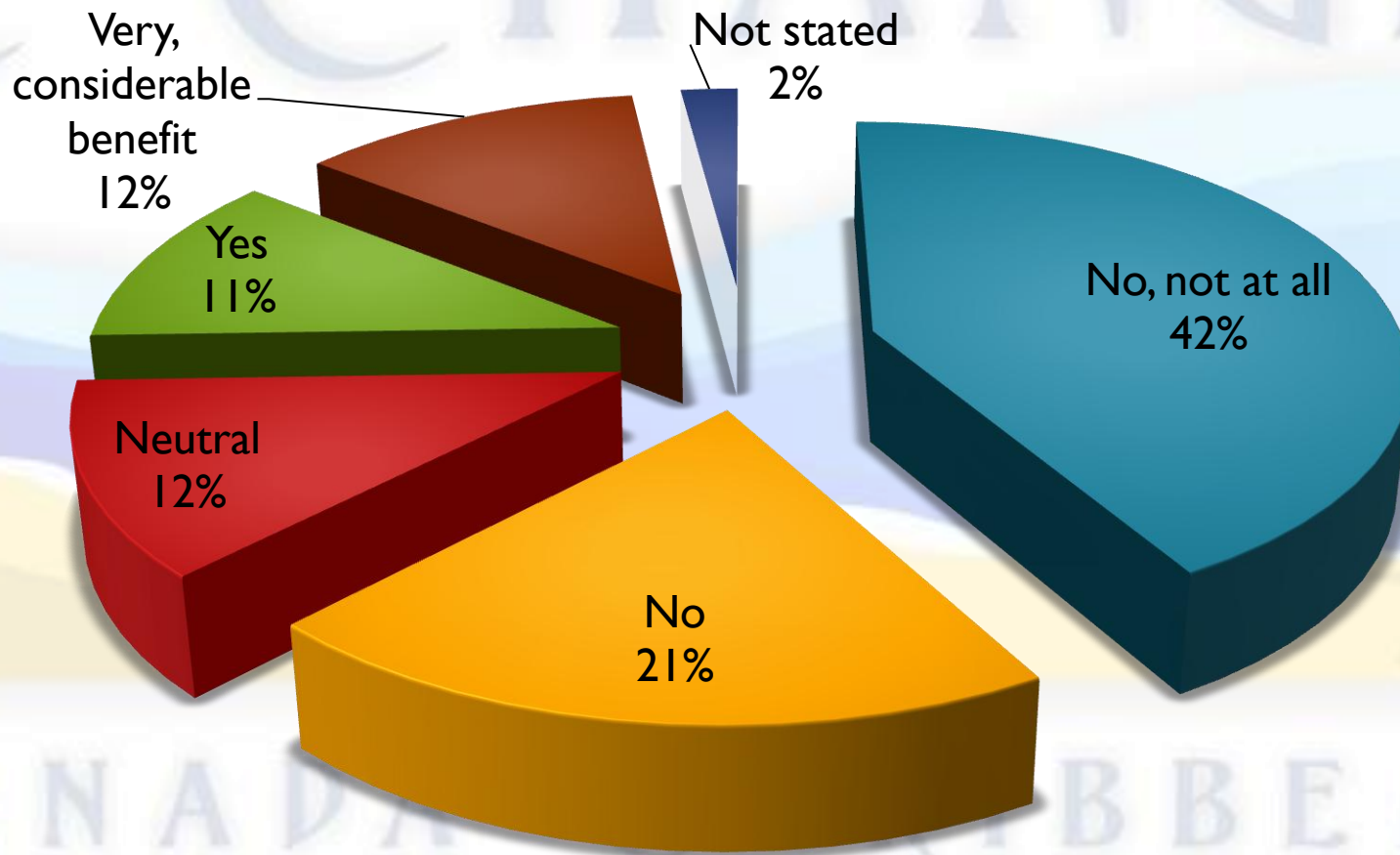
Financial Pillar

Indicator	Sub-indicator	Sub-indicator Value	Index Value
Income	Tourism	0.419	0.469
	Coastal Resources	0.540	
	Fishing	0.426	

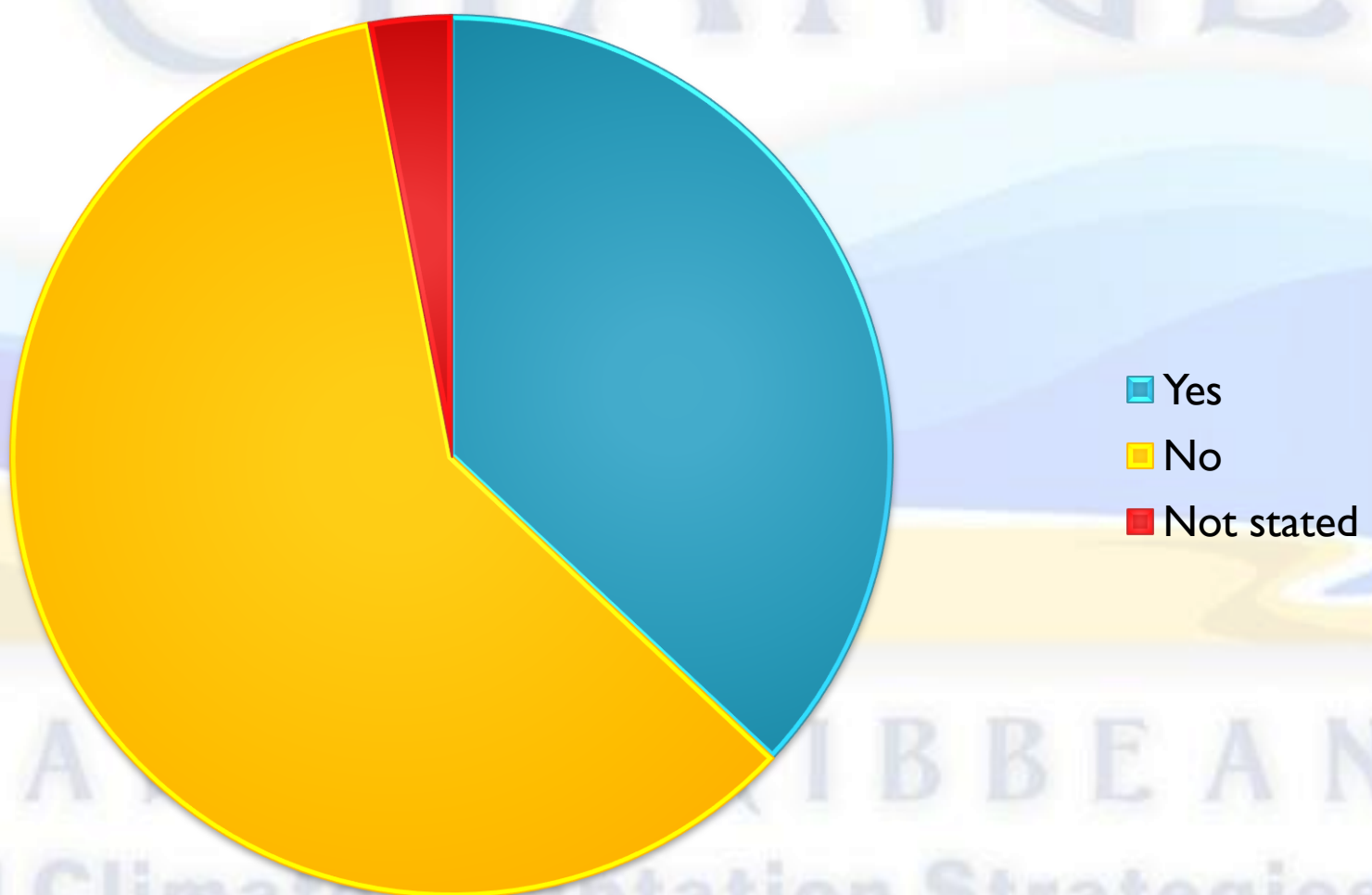
Income Derived from Activities



Benefit from Nature



Alternative Income Available?



Alternative Sources of Income

Alternative	No		Neutral		Yes, most definitely
Craft making	16	58	81	105	112
Cottage industry	31	66	60	94	80
Other public sector	28	88	99	97	27
Other private sector	23	59	96	108	85
Self-employed in agriculture	44	70	92	93	65
Self-employed (other than agriculture)	46	52	73	100	100
Life off savings	192	81	36	32	21
Depend on other household members	179	66	53	46	18
Depend on Government	234	63	28	23	11

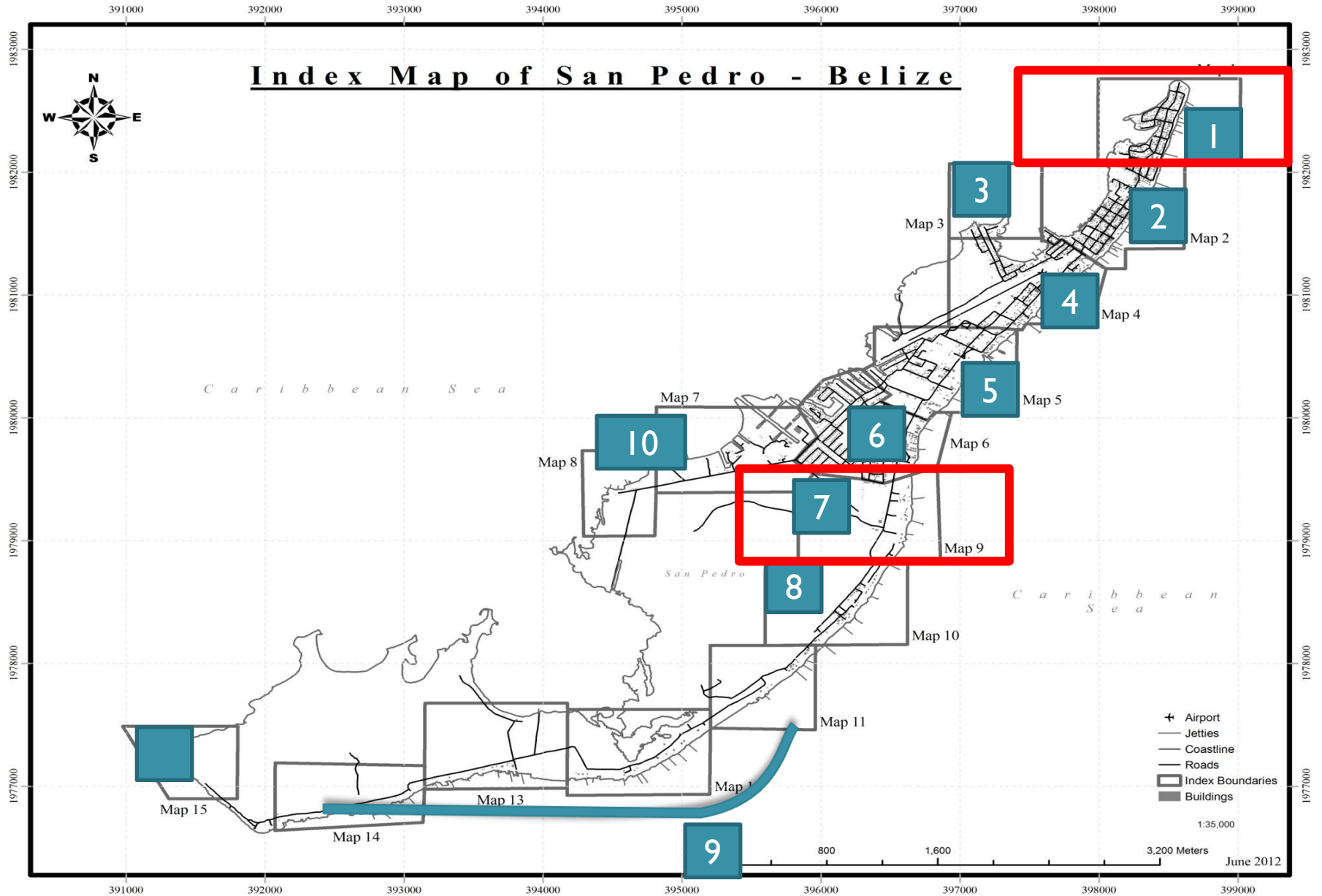
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**VULNERABILITY INDEX:
SAN PEDRO DISTRICTS**

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Vulnerability Index- Districts

Districts	Vulnerability Index Value	Rank
1	0.431	1st
2	0.367	6 th
3	0.378	5 th
4	0.353	7 th
5	0.366	8 th
6	0.388	4 th
7	0.307	10th
8	0.396	2 nd
9	0.356	9 th
10	0.389	3 rd



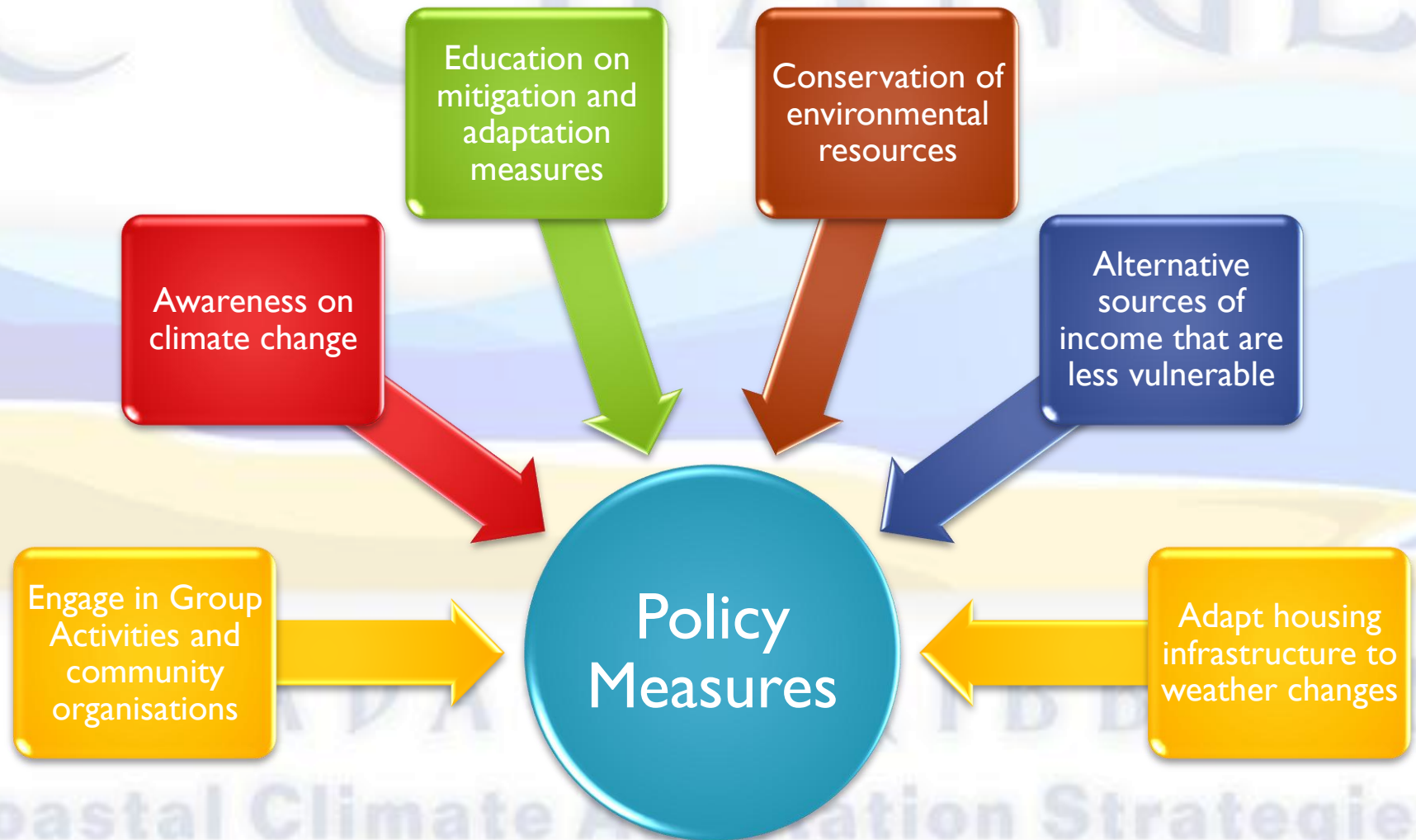
Vulnerability Indices by Pillars for Districts

Pillar	District 1	District 2	District 3	District 4	District 5	District 6	District 7	District 8	District 9	District 10
Social	0.483	0.490	0.514	0.450	0.489	0.498	0.471	0.536	0.507	0.540
Financial	0.499	0.435	0.465	0.449	0.419	0.498	0.309	0.484	0.311	0.448
Physical	0.373	0.370	0.375	0.297	0.343	0.397	0.374	0.417	0.391	0.411
Human	0.634	0.377	0.383	0.388	0.391	0.387	0.185	0.369	0.402	0.373
Natural	0.168	0.165	0.153	0.182	0.189	0.164	0.195	0.172	0.166	0.174

Results for Indicators and Sub-indicators

Pillar	Indicator	1	2	3	4	5	6	7	8	9	10
Social	Participation	0.841	0.841	0.856	0.810	0.819	0.854	0.841	0.893	0.861	0.866
	Social Connectivity	0.571	0.499	0.550	0.504	0.533	0.539	0.493	0.561	0.557	0.532
	Feeling of Trust and Safety	0.328	0.335	0.356	0.318	0.355	0.310	0.222	0.371	0.348	0.426
	Social Connections	0.510	0.523	0.521	0.418	0.525	0.545	0.546	0.560	0.508	0.552
	Other	0.218	0.251	0.287	0.198	0.212	0.240	0.255	0.293	0.272	0.327
Financial	Employment	0.471	0.412	0.392	0.422	0.369	0.439	0.367	0.342	0.392	0.331
	Income	0.426	0.400	0.484	0.462	0.434	0.467	0.105	0.515	0.044	0.484
	Alternative Strategies	0.599	0.494	0.520	0.463	0.455	0.587	0.454	0.594	0.496	0.529
Human	Demography	0.183	0.140	0.154	0.203	0.198	0.159	0.167	0.148	0.157	0.186
	Health	0.191	0.240	0.231	0.220	0.187	0.205	-0.869	0.163	0.249	0.130
	Non-climate Education	0.451	0.332	0.318	0.387	0.398	0.380	0.457	0.328	0.337	0.324
	Climate Education	0.598	0.550	0.577	0.535	0.569	0.569	0.546	0.579	0.604	0.580
	Climate Measures	1.745	0.624	0.633	0.593	0.603	0.620	0.624	0.629	0.665	0.643
Physical	Transport	0.399	0.424	0.422	0.268	0.373	0.450	0.419	0.521	0.453	0.527
	Shelter	0.537	0.556	0.573	0.389	0.437	0.576	0.453	0.545	0.553	0.501
	Sanitation	0.175	0.163	0.181	0.164	0.207	0.221	0.216	0.202	0.187	0.227
	Energy	0.361	0.357	0.351	0.297	0.362	0.380	0.382	0.387	0.375	0.373
	Communication	0.639	0.595	0.605	0.547	0.573	0.640	0.641	0.722	0.676	0.692
	Asset Ownership	0.126	0.125	0.116	0.117	0.108	0.114	0.131	0.129	0.102	0.146
Environmental	Biodiversity	0.428	0.431	0.350	0.389	0.434	0.392	0.475	0.429	0.393	0.442
	Forestry	0.019	0.019	0.036	0.042	0.032	0.031	0.017	0.029	0.080	0.013
	Marine Resources	0.004	0.005	0.009	0.009	0.011	0.005	0.005	0.005	-0.005	0.010
	Tourism	0.024	0.025	0.024	0.019	0.022	0.027	0.031	0.020	0.021	0.021
	Natural Hazards	0.364	0.345	0.348	0.451	0.449	0.362	0.446	0.378	0.343	0.383

Policy Prescription



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**EXAMINATION OF CORRELATION
BETWEEN OBSERVED
ENVIRONMENTAL CHANGES AND
THE QUALITY OF LIFE**

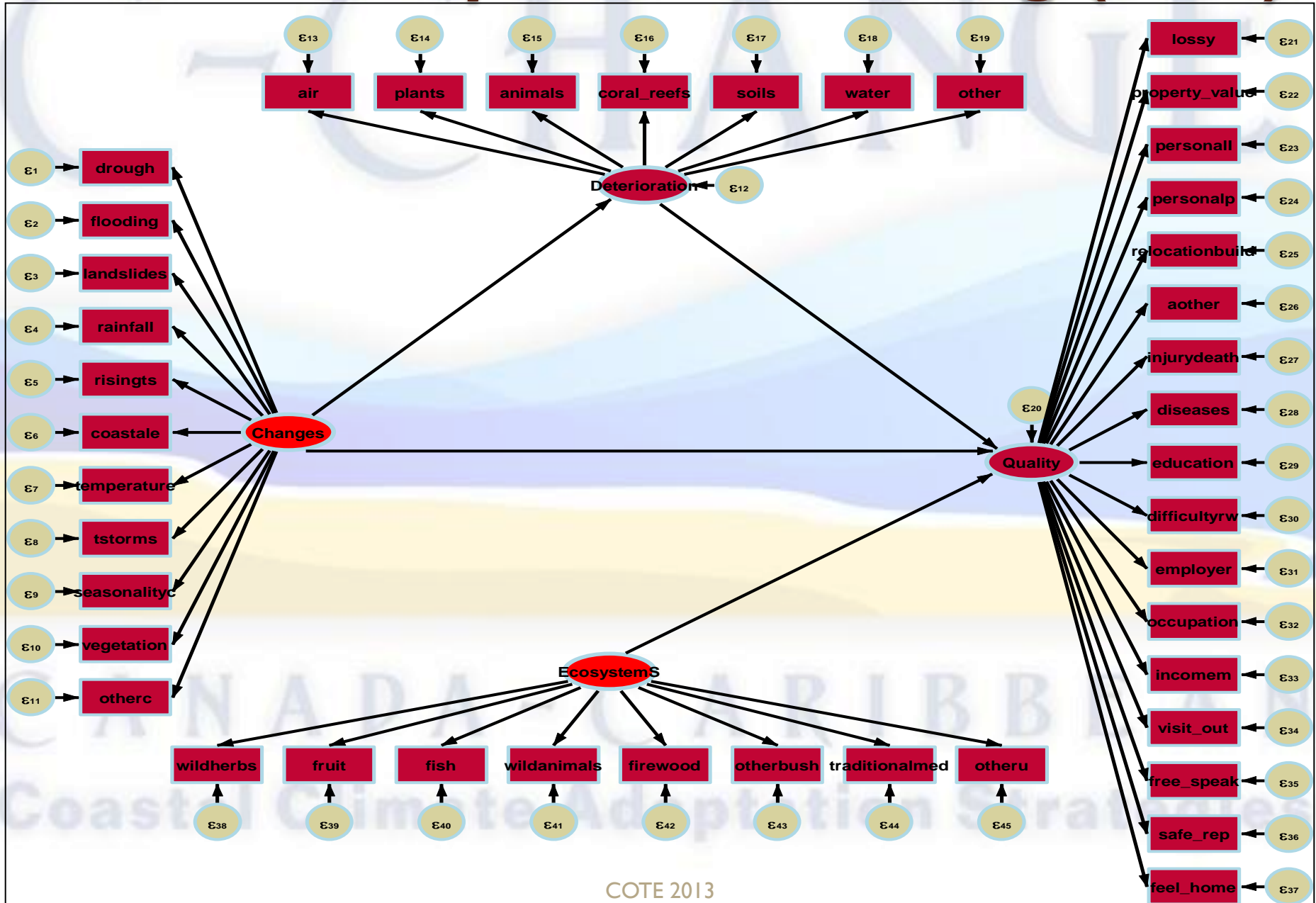
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Changes in Resources

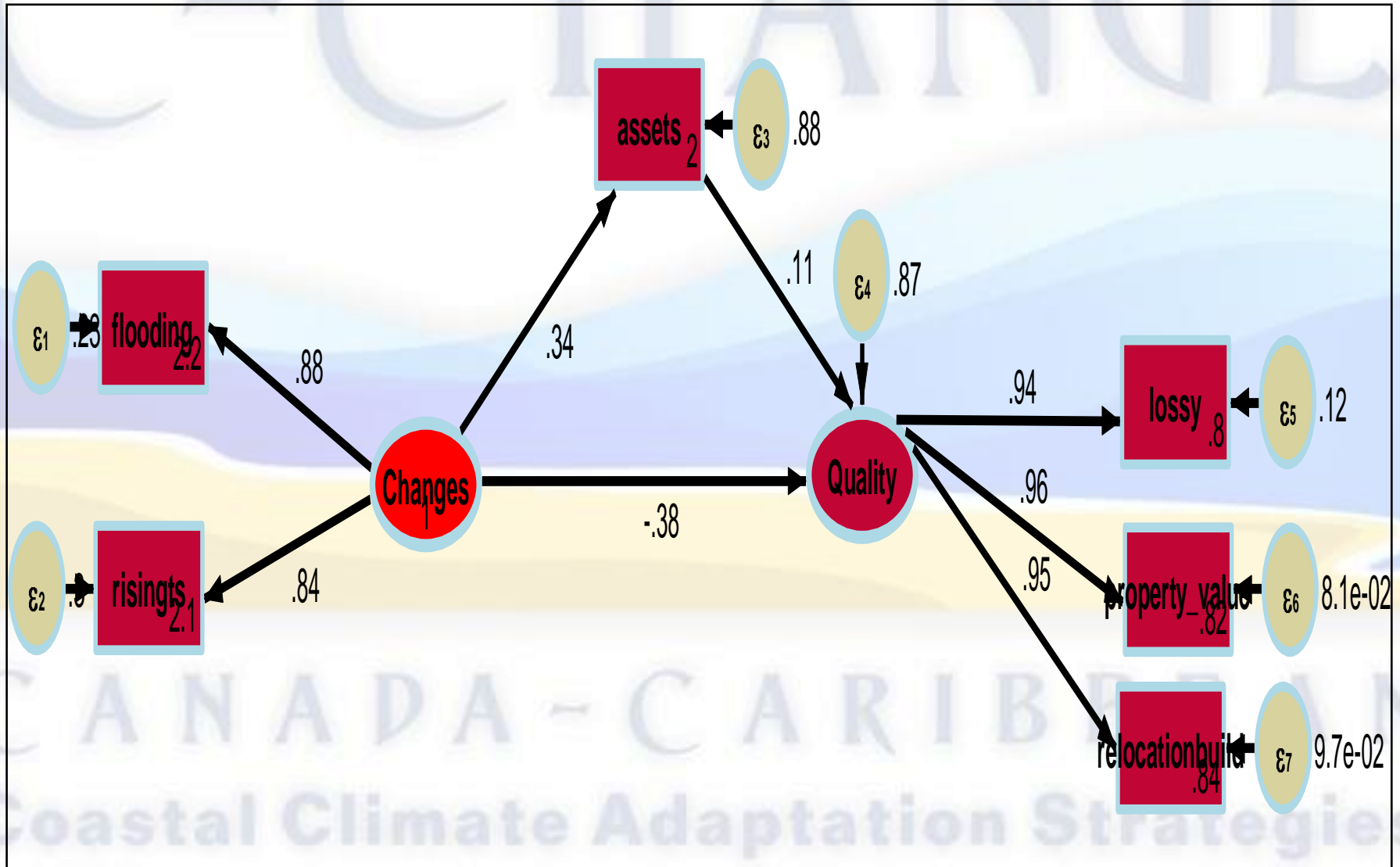
Resources	10 years ago	Present	Explanation
Fish Population	Threaten	Declined	Higher demand Migration and lowered reproduction
Coral reefs	Healthy with some bleaching	Increase evidence of bleaching	Warmer sea surface temperatures
Mangroves	Plenty	Deforested	Development
Birds	More species	Less species noted	Migration changes
Lands	Plenty more natural beach	Narrower beach	Mangrove cutting and erosion
Air	Cleaner	Dusty	More wind and climate variability
Infrastructure	Less infrastructure	Big developments and more settlement	House demand and lower availability of highland
Freshwater	Well water and/or rainwater	100% bottled water	Air pollution and loss of aquifer
Human economy	Lower population and stable economy	Nearly overpopulated	Labour supply
Fuel	Cheap (BZ\$5/gal)	Sky rocket (BZ\$10.40/gal)	High demand and less supply

Source: Community Assessment by WWF(2008)

Structural Equation Modelling (SEM)



Structural Equation Modelling (SEM)



Overall Goodness of Fit

Fit Statistics	Value Description	Acceptable Values
<u>Likelihood Ratio</u> chi2_ms(7) p > chi2 chi2_bs(15) p > chi2	3.760 model vs. saturated 0.807 4564.099 baseline vs. saturated 0.000	Reject H ₀ if p-value < 1%, 5% and 10%. Otherwise, do not reject
<u>Population error</u> RMSEA 90% CI, lower bound upper bound pclose	0.000 Root mean squared error of approximation 0.000 0.025 1.000 Probability RMSEA ≤ 0.05	<0.05
<u>Information criteria</u> AIC BIC	20751.300 Akaike's information criterion 20849.395 Bayesian information criterion	Must compare with independent and saturated model
<u>Baseline comparison</u> CFI TLI	1.000 Comparative fit index 1.002 Tucker-Lewis index	>0.95
<u>Size of residuals</u> SRMR CD	0.005 Standardized root mean squared residual 0.859 Coefficient of determination	<0.05

Equation Level Goodness of Fit

depvars	Variance			R-squared	mc	mc ²
	fitted	predicated	residual			
<u>OBSERVED</u>						
asset	2.77093	0.329086	2.44184	0.118765	0.3446231	0.118765
flooding	2.077245	1.604647	0.4725977	0.7724882	0.8789131	0.7724882
risings	2.292202	1.612885	0.6793169	0.7036401	0.8388326	0.7036401
lossy	6.449893	5.644023	0.8058698	0.8750569	0.9354447	0.8750569
property_v~e	6.963454	6.399485	0.5639695	0.9190101	0.9586501	0.9190101
relocation~d	6.930565	6.261277	0.669288	0.9034295	0.9504891	0.9034295
<u>LATENT</u>	5.644023	0.7244765	4.919547	0.1283617	0.358276	0.1283617
Quality						
Overall					0.8587583	

Mc= correlation between depvar and its prediction

Mc2= mc² is the Bentler-Raykov squared multiple correlation coefficient

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CONCLUSIONS

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In Summary

- SIDS (and coastal communities of developing countries in general) have high levels of vulnerability and low adaptive capacity
- Negative relationship between observed changes in the environment and quality of life
- They need to adopt a climate smart policy where they *Act Now, Act Together, and Act Differently*
- Action and impacts of Action must be measurable
- **To that end, this Index can be used to**
 - ⊗ measure vulnerabilities
 - ⊗ Disaggregate vulnerabilities into component areas
 - ⊗ Compare vulnerabilities across other communities and countries
 - ⊗ Highlight appropriate policies with an aim to reducing vulnerabilities
 - ⊗ Measure the impact and efficacy of such policies
- ***Some Limitations and Constraints:***
 - ⊗ A certain subjectivity in choosing variables
 - ⊗ Averaging and weighting procedure (equal weights?)
 - ⊗ Reliability of primary data collection

Thank You

➤ Name: Sherry Ann Ganase

➤ Email: sherry_ganase@hotmail.com

➤ Name: Sandra Sookram

➤ Email: sandra.sookram@sta.uwi.edu

➤ Project Website Address:

<http://www.coastalchange.ca>