From Metrics to Policy: The use of quantitative information and indicators to inform marine and environmental policy

5-Year Anniversary of Ecologic Institute in the USA
April 23, 2012

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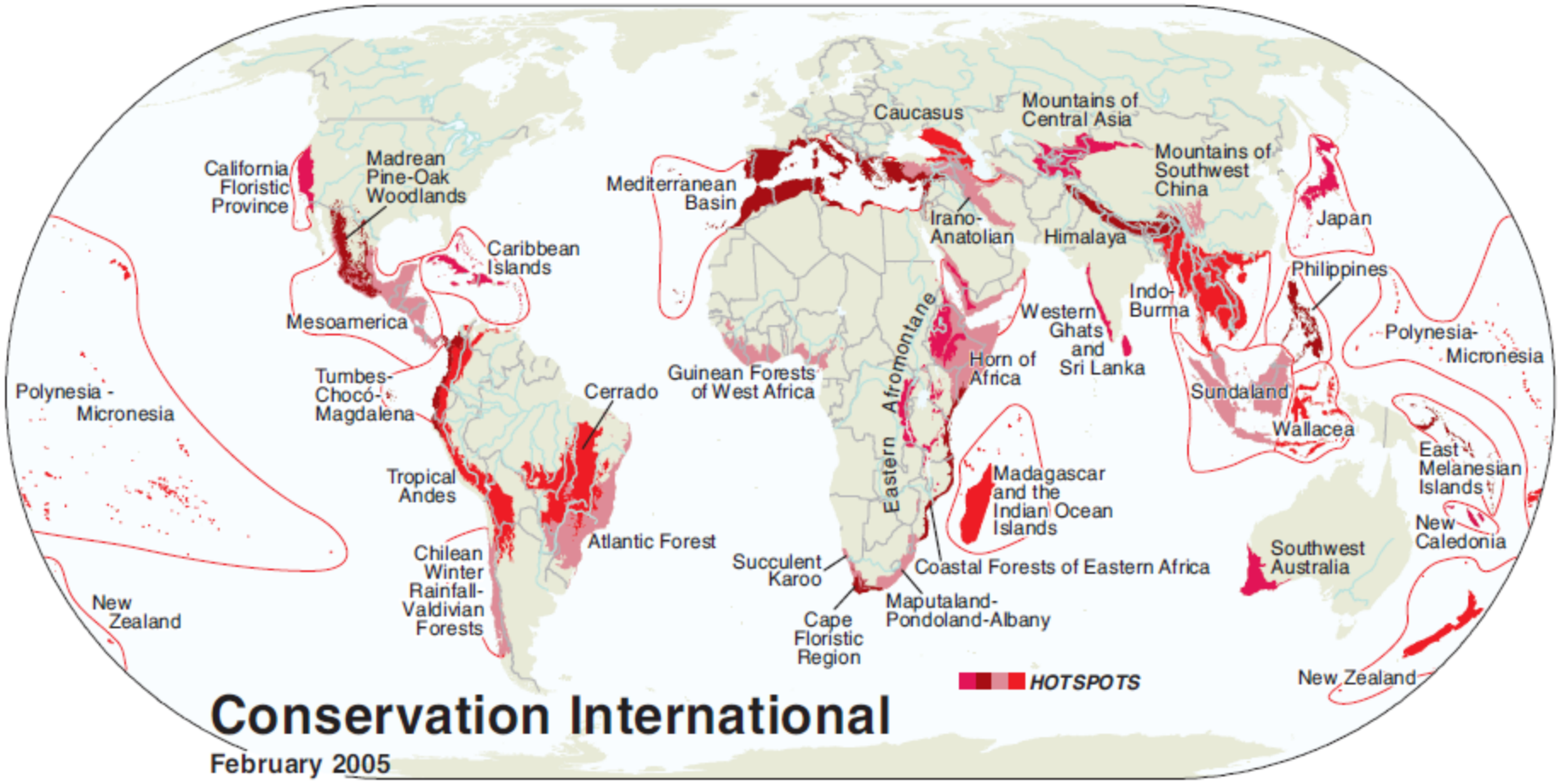
Outline

- Introduction
- Background and Purpose of the Project
- Conservation Science and Statistics
- Our Approach
- Preliminary Findings
- Next Steps
- Q&A

Conservation priority setting

Guide investment for optimal conservation outcomes



Prioritizing conservation intervention

Where are the most diverse places in the ocean?

Where are these places most or least impacted by human activities?

Where are the human populations most dependent on marine ecosystems?

Where are the human populations most dependent on marine ecosystems?

Building a conceptual framework

Policy experts

Demographers

Geographers

Economists

Marine ecologists

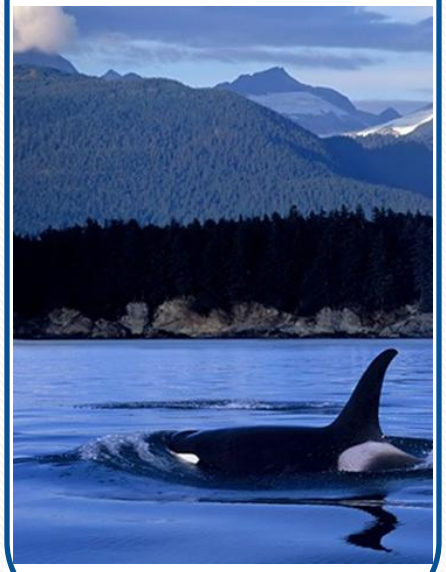
Dimensions of human dependence

Nutritional

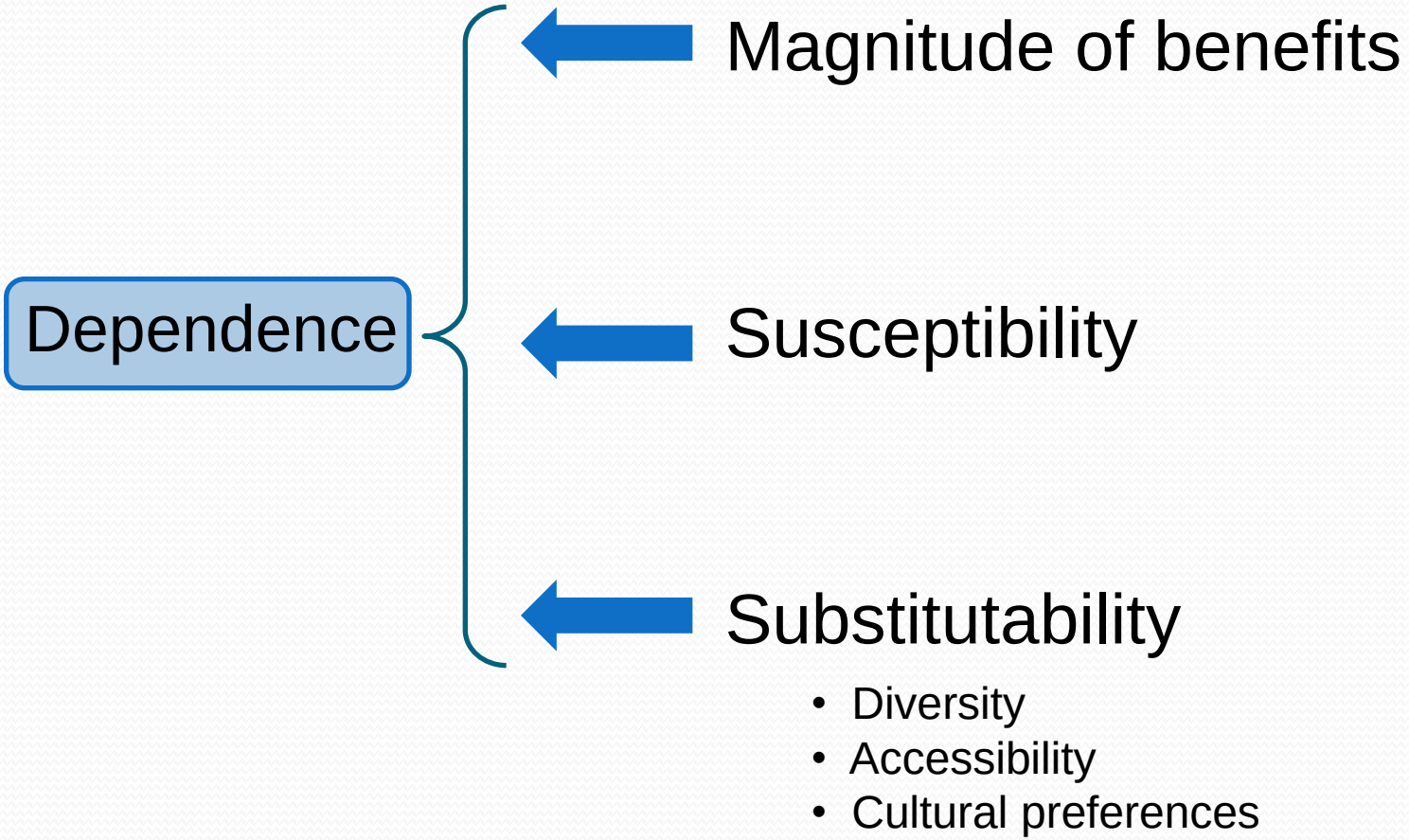
Economic

Coastal Protection

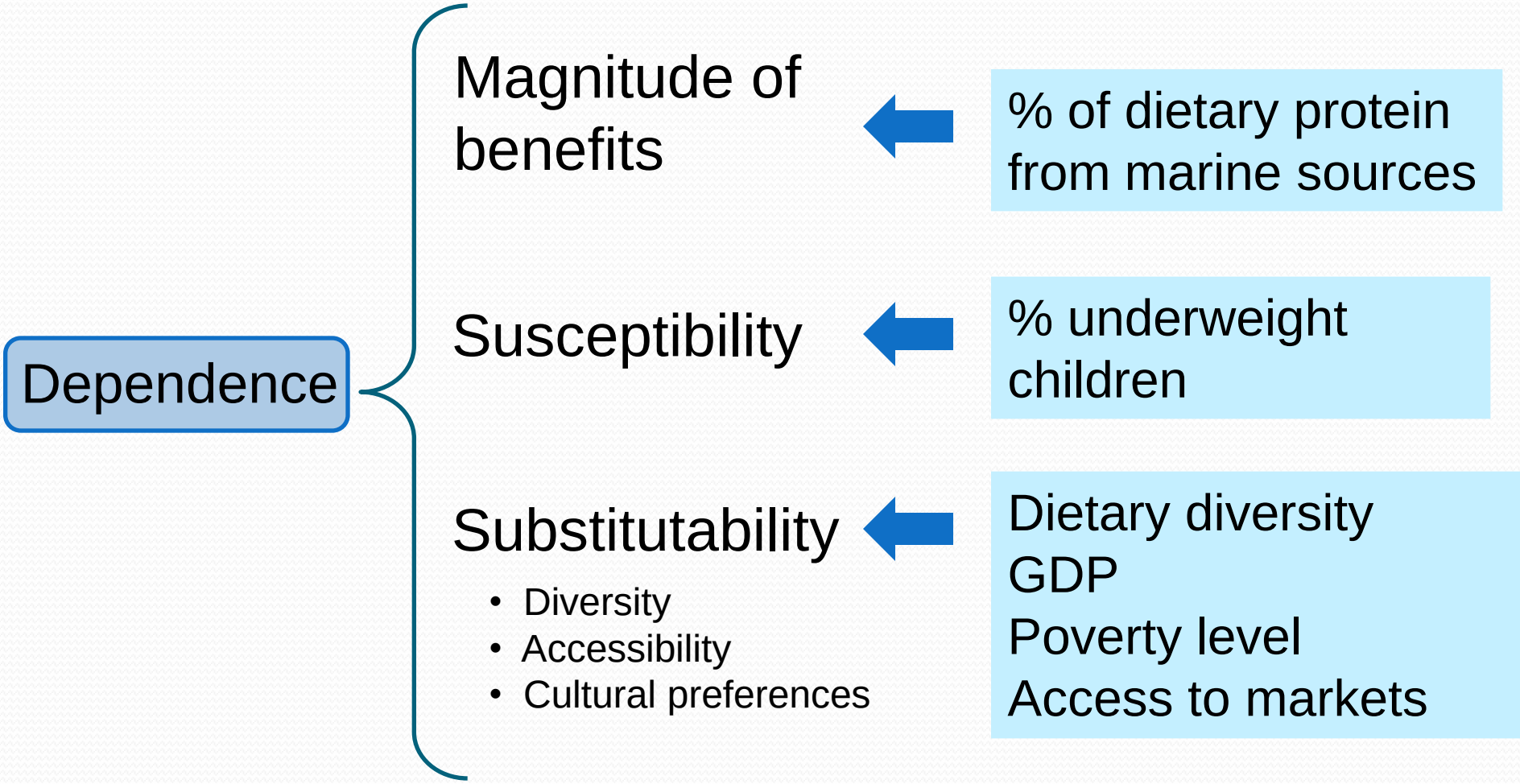
Cultural



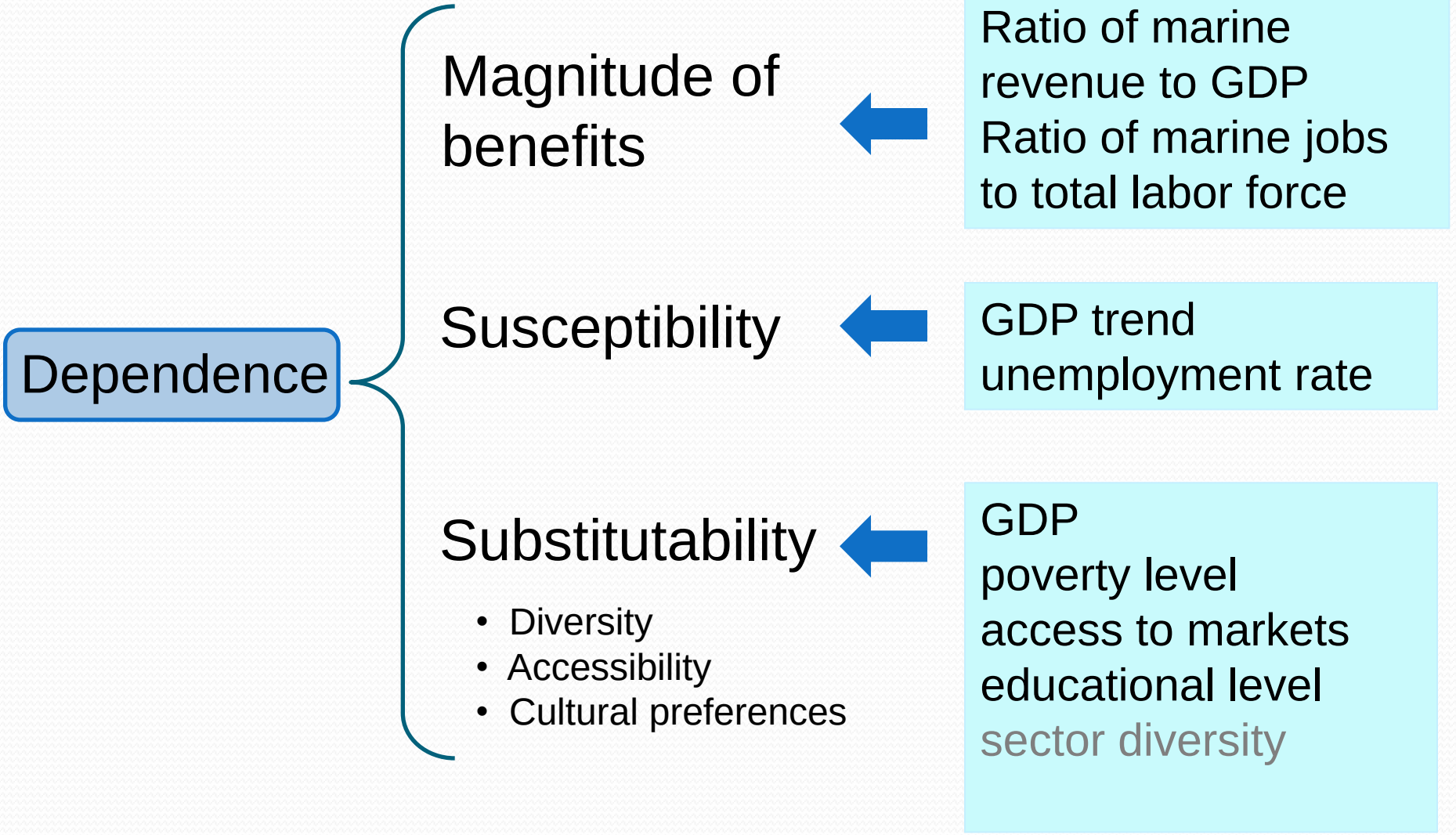
Human dependency on marine ecosystems



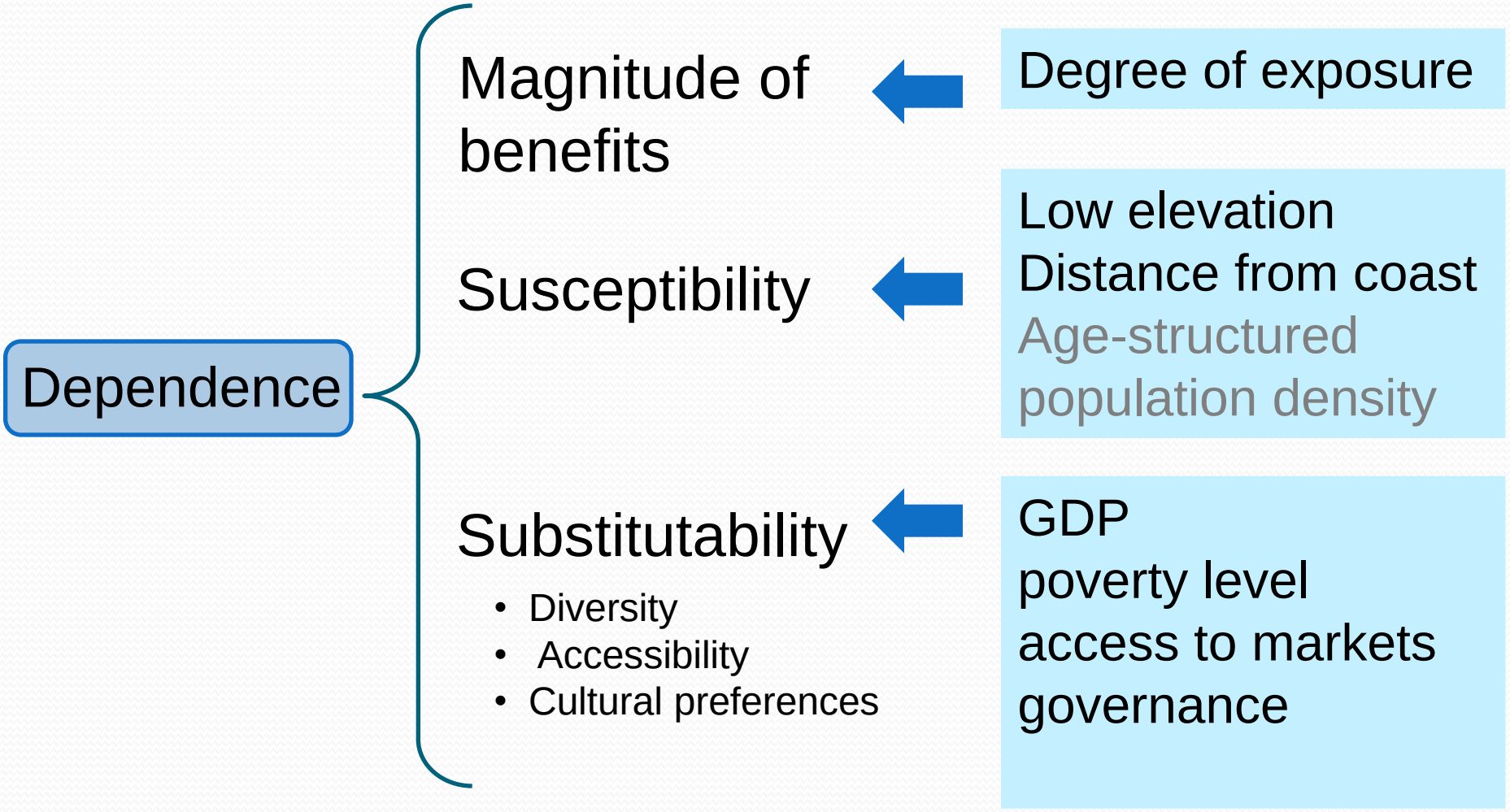
Nutritional dependence



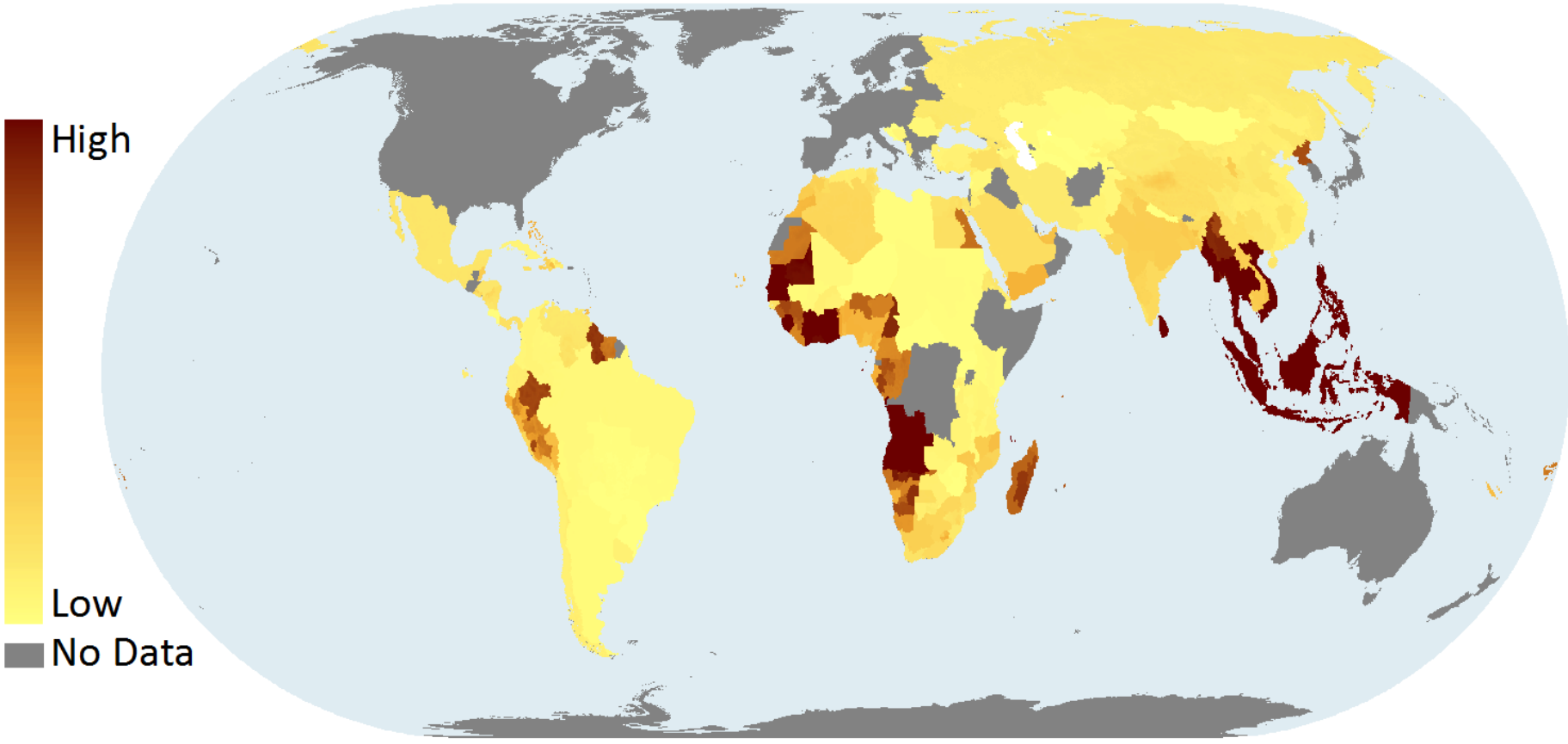
Economic dependence



Coastal protection dependence



Nutritional dependence



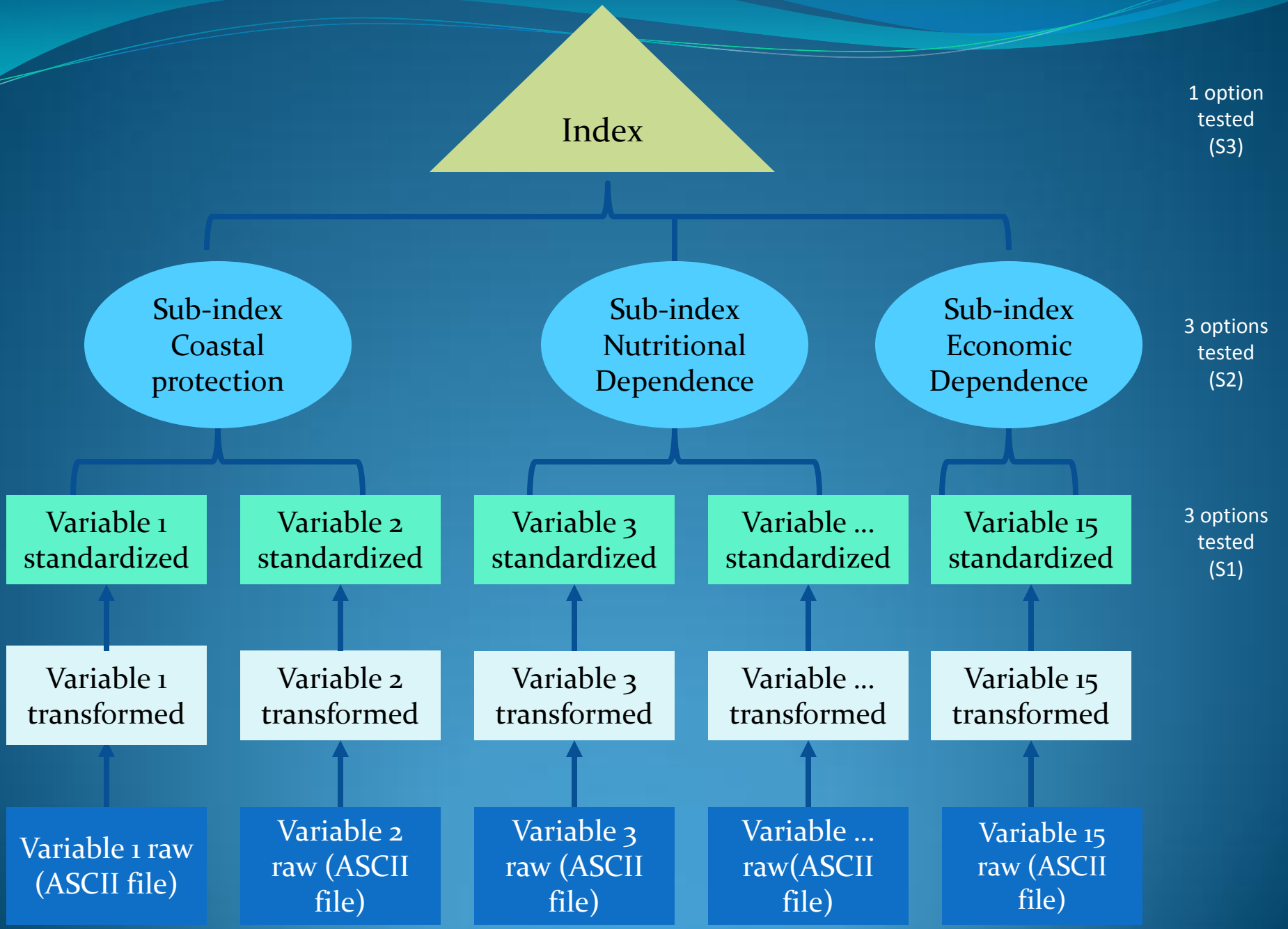
DRAFT – illustration

Conservation and Statistics

- Strengthen the scientific basis of the index through a statistical robustness analysis
- Harness a growing area of statistical methods to help test the assumptions and decisions made
- Especially important when an artificial construct is created as opposed to making conclusions based on observations, experiments, or mathematical concepts

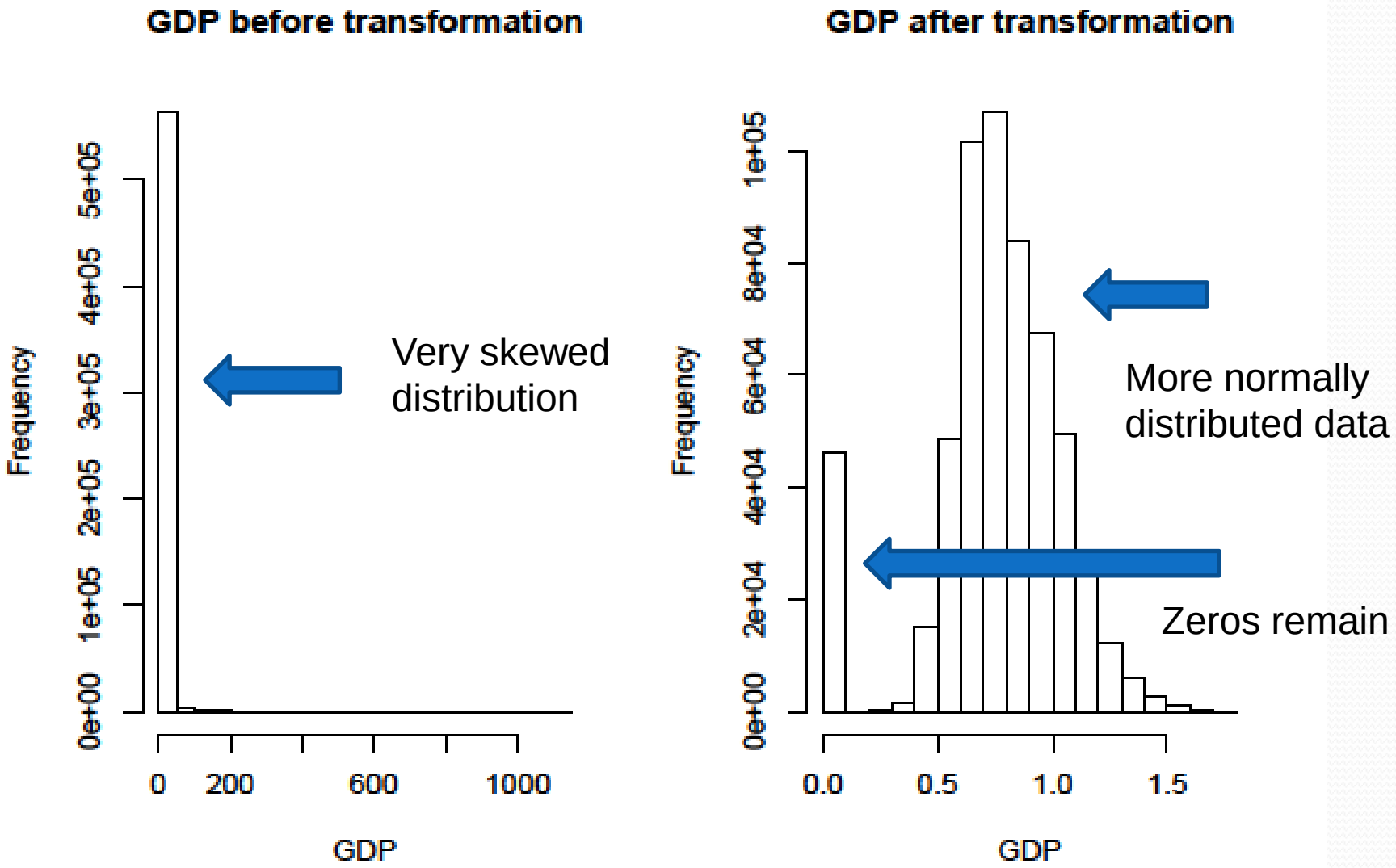
Our Approach

- Robustness analysis examines effects of the decisions/choices made in the index construction
- Considers alternatives and compares the results
- A robust index yields comparable results under different calculation scenarios
- We examined:
  - Different options to standardize the input variables
  - Different choices for aggregating the input variables


Index
Sub-index Coastal protection
Sub-index Nutritional Dependence
Sub-index Economic Dependence
Variable 1 standardized
Variable 2 standardized
Variable 3 standardized
Variable … standardized
Variable 15 standardized
Variable 1 transformed
Variable 2 transformed
Variable 3 transformed
Variable … transformed
Variable 15 transformed
Variable 1 raw (ASCII file)
Variable 2 raw (ASCII file)
Variable 3 raw (ASCII file)
Variable … raw(ASCII file)
Variable 15 raw (ASCII file)
1 option tested (S3)
3 options tested (S2)
3 options tested (S1)

Our Approach

- Raw data are heavily skewed in most cases
- Data transformations helped to normalize data distributions, i.e., make them more symmetrical and reduce number of outliers
- Many zeros and missing data points, which create bimodal distributions, but are relevant for index interpretation


GDP before transformation
Frequency
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
0
200
600
1000
GDP
Very skewed distribution
GDP after transformation
Frequency
0e+00
2e+04
4e+04
6e+04
8e+04
1e+05
0.0
0.5
1.0
1.5
GDP
More normally distributed data
Zeros remain

Our Approach

- Standardization: to make data comparable by converting range, variance, and/or location measures to comparable values
  - Minmax standardization: transforms data to uniform [0,1] range
  - Z-score transformation: transforms data to have mean 0 and variance 1
  - Rank standardization: transforms data to categorical rank distribution

Our Approach

- **Minmax standardization** is easy to interpret but does not lead to uniform mean and variance
- **Z-score standardization** often used to normalize data but results in unbounded range (incl. negative values), which may be more difficult to interpret
- **Rank standardization** transforms data from continuous to categorical and therefore entails information loss; may also lead to many ties due to the many missings or zeros

Our Approach

- Aggregation (after direction adjustment):
  - Set of formulae provided by CI
  - Simple arithmetic average
  - Simple geometric average

Our Approach

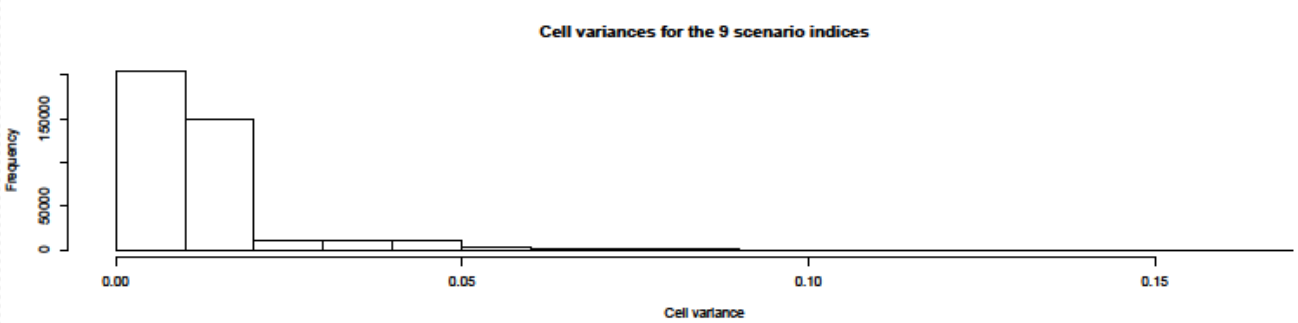
- Comparison of results:
  - At cell-level using different robustness metrics

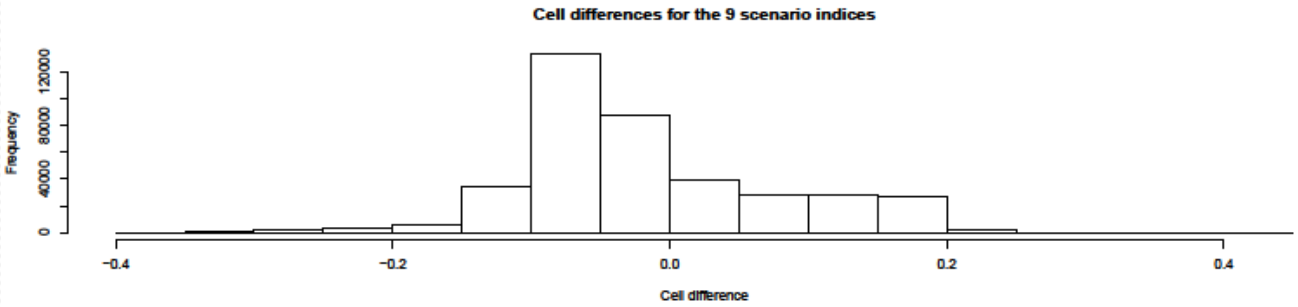
  →Find out how individual cells are responding to different calculation choices

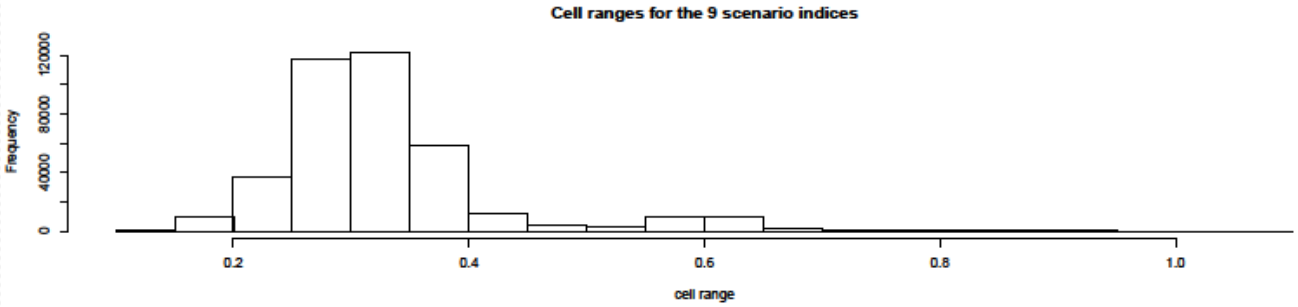
  - At global index level

  →Assess how index as a whole responds to different calculation choices

Preliminary Findings



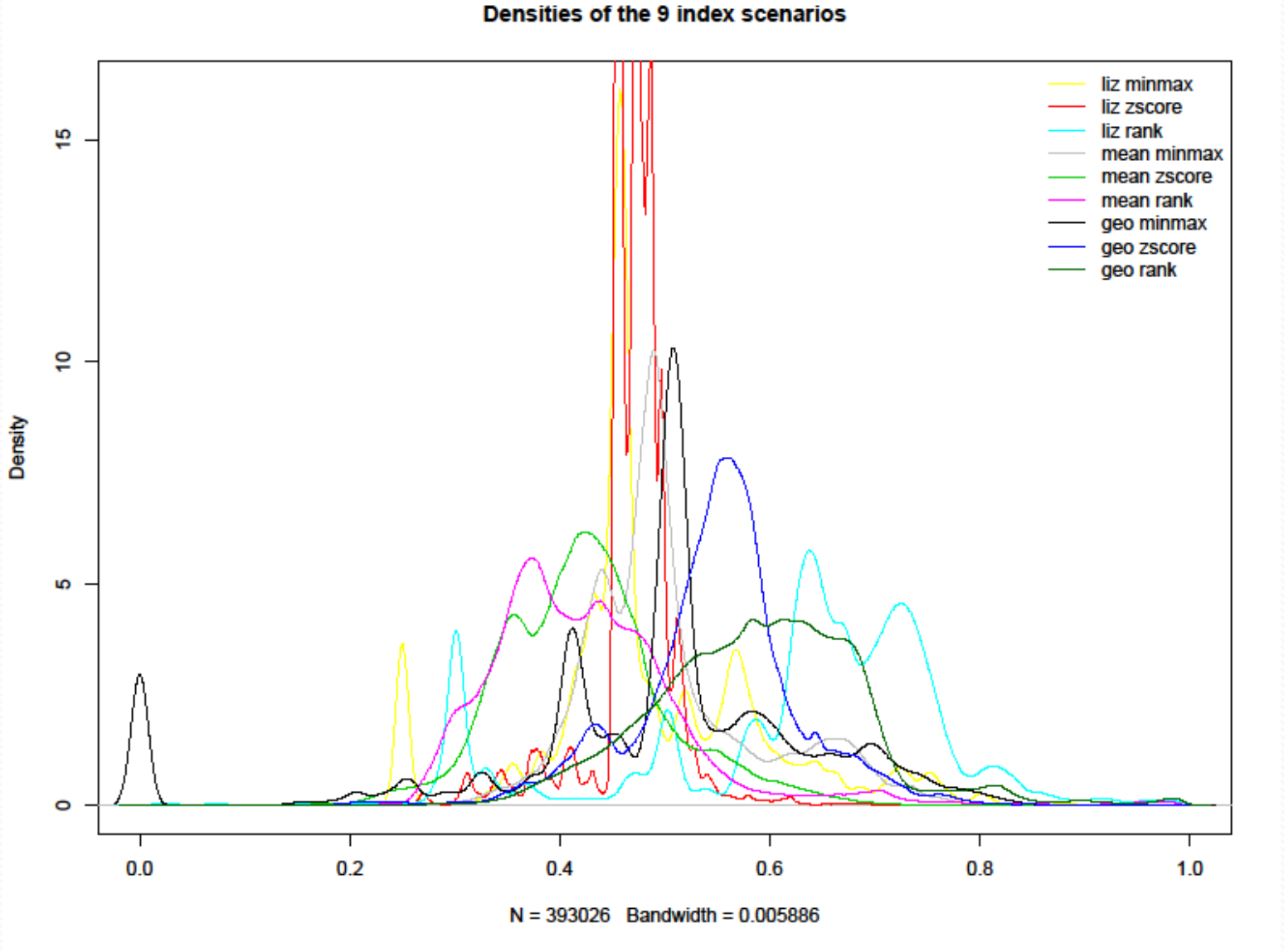




Distribution of cell variances for the 9 index scenarios (99.6% of compu-table cell variances are less than 0.01)

Cell differences from default scenario (98% of average absolute cell differences are less than 0.2 and 73% are less than 0.1)

Cell ranges (majority less than 0.4)


Densities of the 9 index scenarios
Density
0
5
10
15
0.0
0.2
0.4
0.6
0.8
1.0
liz minmax
liz zscore
liz rank
mean minmax
mean zscore
mean rank
geo minmax
geo zscore
geo rank
N = 393026 Bandwidth = 0.005886

- Make sure, no individual input variable exerts undue influence on the composite index:
  - Check for important input variables by regressing final index on standardized input variables
  - Check for multi-collinearity by examining bivariate correlations amongst input variables

Important Variables

Variable	Estimate	Pr(>|t|)
Diet	-0.050	<0.001
Education	0.022	<0.05
Fish_employ	0.015	<0.001
GDP	-0.164	< 0.001
Gdp_trend	0.050	<0.001
Gov	-0,060	< 0.001
Imp_surface	-0.035	<0.001
Lecz	0.034	<0.001
Malnourish	0.123	< 0.001
Marine_gdp	0.219	< 0.001
Protein	0.165	< 0.001
SLR_pct	0.004	<0.001
Storms	0.292	< 0.001
Travel	-0.121	< 0.001
Unemploy	0.087	<0.001

Multi-collinearity

	diet	edu	fishemp	gdp	gdpgrowth	gov	impsur	lcez	malnourish	mgdp	protein	slrpct	storms	travel	unemploy
diet	1.000	0.912	-0.413	-0.255	0.097	-0.006	-0.182	-0.051	-0.685	0.041	0.046	0.009	-0.115	0.171	-0.136
education	0.912	1.000	0.015	-0.237	0.316	-0.338	-0.090	0.279	-0.463	0.187	-0.128	-0.003	-0.087	0.036	-0.100
fish_employ	-0.413	0.015	1.000	0.058	0.135	-0.419	0.117	0.274	0.302	0.399	-0.018	0.067	0.131	-0.022	-0.194
gdp	-0.255	-0.237	0.058	1.000	0.097	-0.054	0.605	0.588	0.066	-0.344	0.207	0.011	0.254	-0.637	0.037
gdp_trend	0.097	0.316	0.135	0.097	1.000	-0.314	0.113	0.108	-0.176	0.099	-0.148	-0.040	-0.009	-0.120	-0.316
gov	-0.006	-0.338	-0.419	-0.054	-0.314	1.000	-0.146	-0.241	-0.290	-0.057	0.206	0.102	0.123	0.182	0.129
imp_surface	-0.182	-0.090	0.117	0.605	0.113	-0.146	1.000	0.853	0.178	-0.059	-0.067	0.169	0.241	-0.655	0.006
lcez	-0.051	0.279	0.274	0.588	0.108	-0.241	0.853	1.000	0.385	0.018	0.115	0.012	0.335	-0.590	-0.063
malnourish	-0.685	-0.463	0.302	0.066	-0.176	-0.290	0.178	0.385	1.000	0.204	-0.269	0.025	0.094	-0.133	0.028
marine_gdp	0.041	0.187	0.399	-0.344	0.099	-0.057	-0.059	0.018	0.204	1.000	0.276	0.034	-0.041	0.316	-0.218
protein	0.046	-0.128	-0.018	0.207	-0.148	0.206	-0.067	0.115	-0.269	0.276	1.000	0.125	0.109	0.105	-0.031
slr_pct	0.009	-0.003	0.067	0.011	-0.040	0.102	0.169	0.012	0.025	0.034	0.125	1.000	0.120	-0.026	0.006
storms	-0.115	-0.087	0.131	0.254	-0.009	0.123	0.241	0.335	0.094	-0.041	0.109	0.120	1.000	-0.216	-0.166
travel	0.171	0.036	-0.022	-0.637	-0.120	0.182	-0.655	-0.590	-0.133	0.316	0.105	-0.026	-0.216	1.000	-0.047
unemploy	-0.136	-0.100	-0.194	0.037	-0.316	0.129	0.006	-0.063	0.028	-0.218	-0.031	0.006	-0.166	-0.047	1.000

Conclusions

- Robustness analysis can support index design through feedback loop on design decisions
- Interpretation is constrained by number and types of decisions/choices tested
- A thorough, well-planned and executed robustness analysis can enhance the interpretability, acceptance and application of the index
- Index can be further tested as new or alternative decisions/choices are made and/or as the data basis changes

Future directions

- Work with partners to develop sub-national data for key indicators
- Work with partners to develop process-based coastal protection model
- Integrate results with data on ecosystem health
- Consider potential climate change impacts

Further Reading

- OECD/JRC Handbook on the Construction of Composite Indicators
- Scholarly work and software on Robustness analysis prepared by Joint Research Center of the European Commission in Ispra, Italy
- Robustness and multi-collinearity: James E. Foster, Mark McGillivray & Suman Seth (2013): Composite Indices: Rank Robustness, Statistical Association, and Redundancy, Econometric Reviews, 32:1, 35-56