



Assessing vulnerability to climate change at multiple scales: to what purpose and how?

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Outline

1. Vulnerability analysis – what is it and what is it used for?
2. VA frameworks in the climate change arena – IPCC
3. Example applications at global, regional and national scales
4. Challenges and recent trends in vulnerability analysis
5. Links to adaptation and mitigation actions

Defining vulnerability

“Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt” (Adger, 2006)

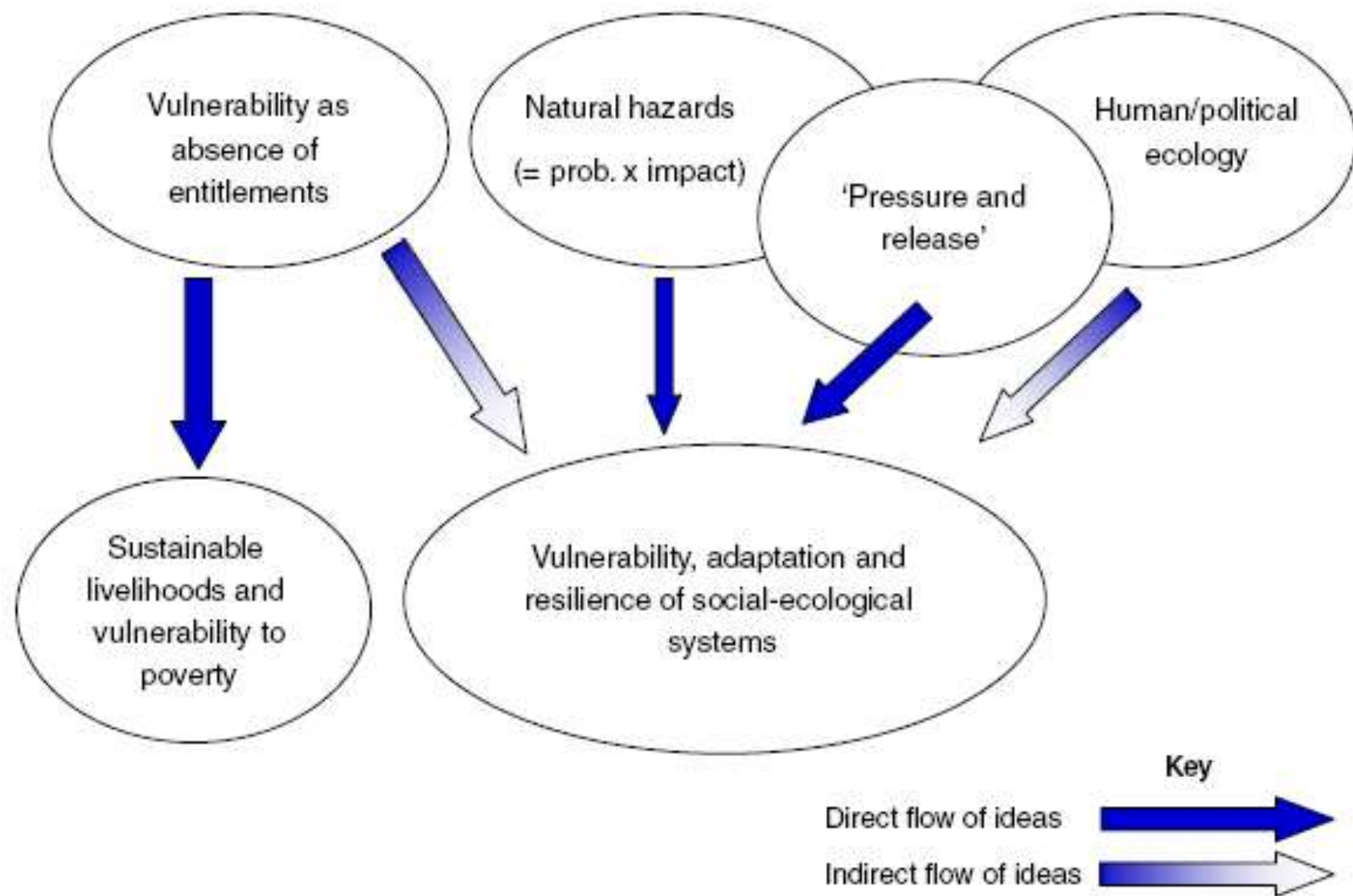
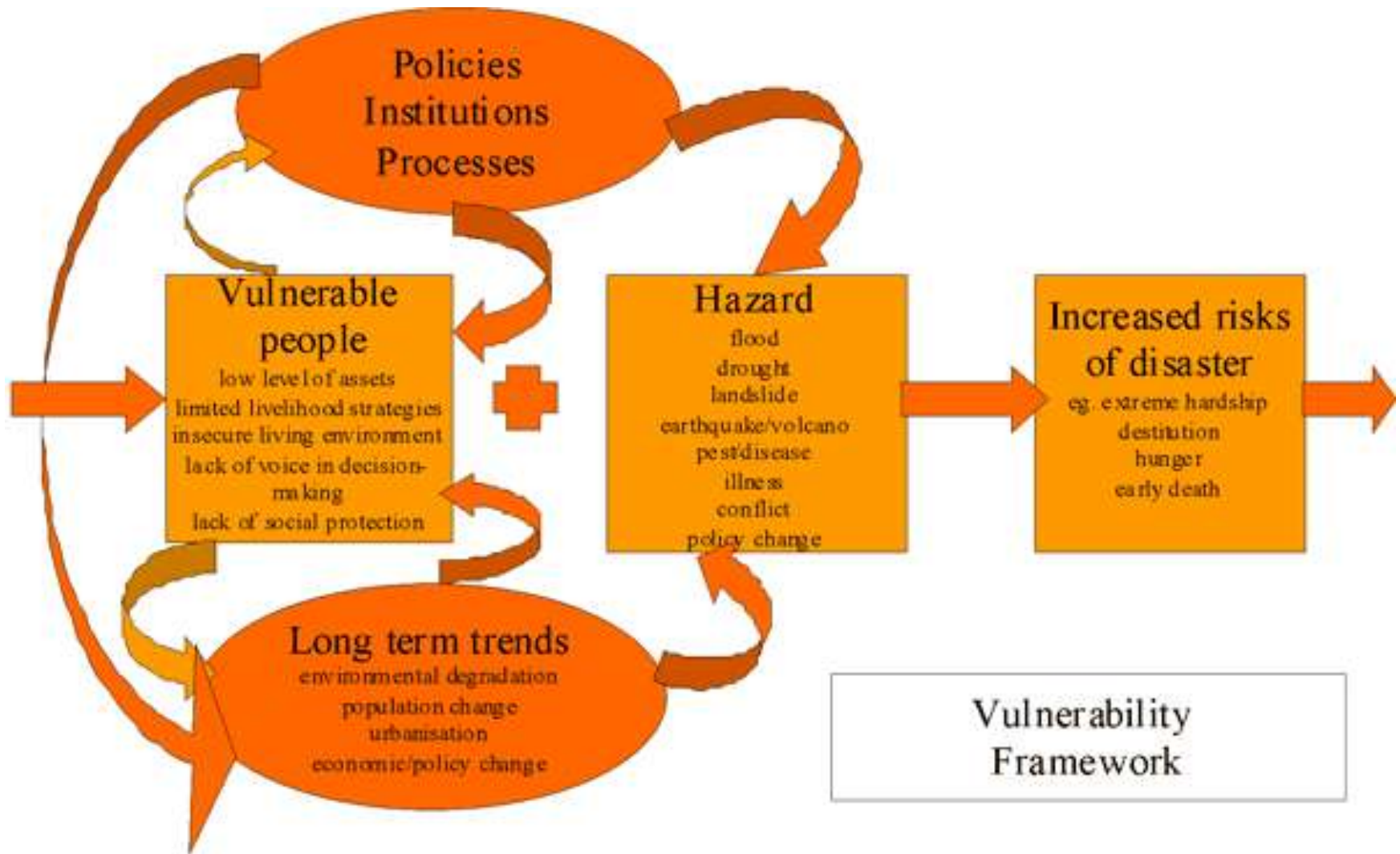


Fig. 1. Traditions in vulnerability research and their evolution.



Disaster vulnerability framework from NGO 'Practical Action'

Why do a vulnerability analysis?

The main purpose of vulnerability analysis is to improve targeting and effectiveness of adaptation actions:

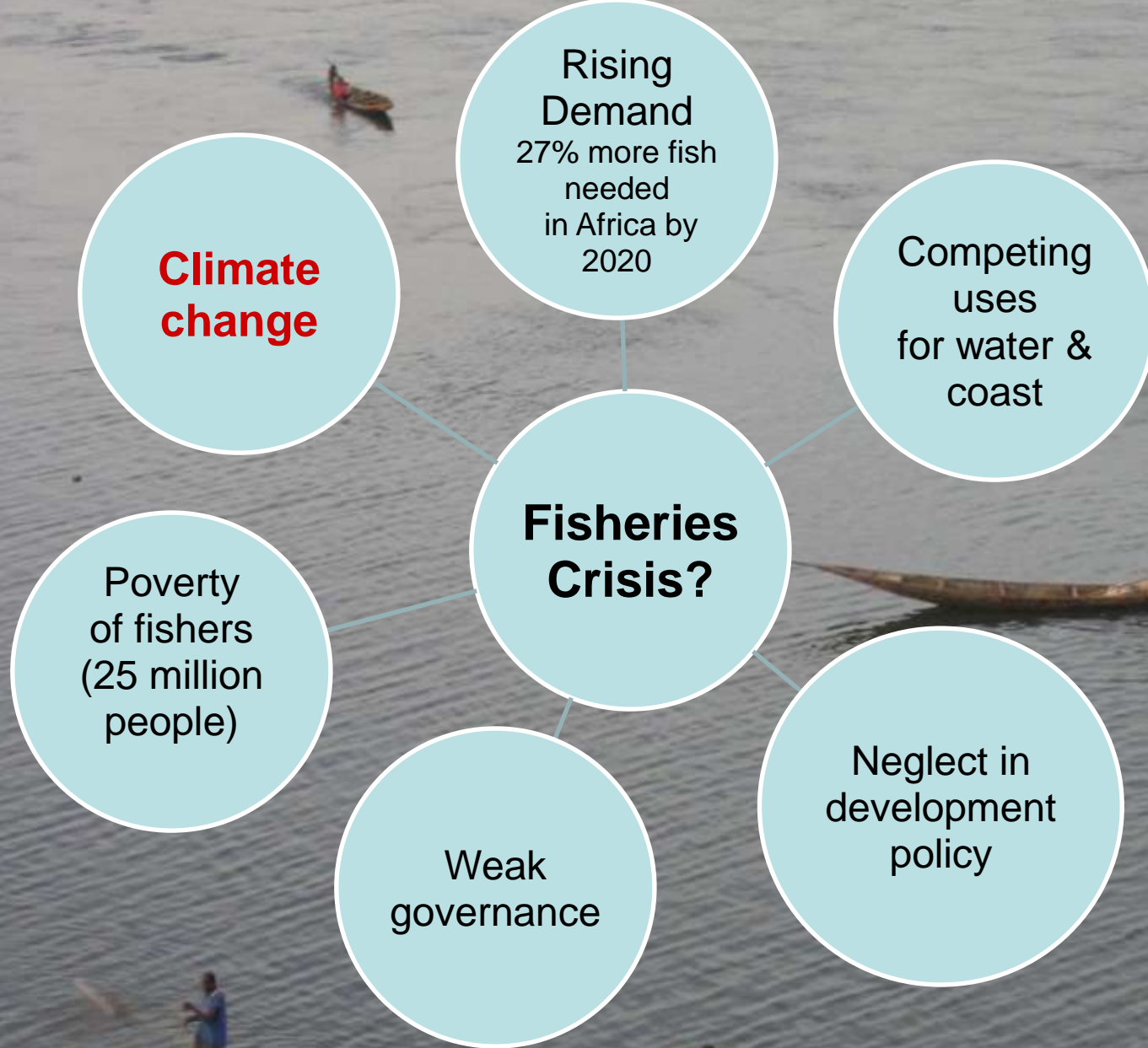
Who are the vulnerable people and how can their vulnerability be reduced? (e.g. by reducing exposure and sensitivity or increasing adaptive capacity)

Where are the vulnerable ecosystems? Can their capacity to adapt be supported by resource management?

Where will the economic consequences of vulnerability of fishery systems be felt most? How can we plan to minimize those consequences?

Which

Where will climate change create new opportunities and bring benefits? Who for?



Climate change:

vulnerability of what (or whom) to what?

- *Vulnerability of people* – individuals, social groups, households, communities, provinces, nations
- *Vulnerability of human activities* – agriculture, fishing, tourism, transport, habitation etc.
- *Vulnerability of places* – low-lying coasts, enclosed seas, deltas, upwelling systems
- *Vulnerability to particular stressors/hazards:* natural disasters, global environmental change, change in general

Potential pathways of impact: climate change and fisheries

Global warming

Ocean currents
ENSO
Sea level rise
Rainfall
River flows
Storm Severity
Storm frequency
Acidification

Effects on:

Production
Ecology

Fishing &
Aquaculture
operations

Communities
Livelihoods

Wider society &
Economy

Impacts on:

Species composition
Production & yield
Distribution
Diseases
Coral bleaching
Calcification

Safety & efficiency
Infrastructure

Loss/damage to assets
Risk to health & life
Displacement & conflict

Adaptation &
Mitigation costs
Market impacts

Vulnerability to climate change: global assessment (Allison et al, 2009)

Vulnerability

'the degree to which a system is susceptible to climate change, and is unable to cope with the negative effects of climate change'
(IPCC, 2007)

Which countries are most vulnerable to the potential impacts of climate change on their fisheries and aquaculture sectors?

IPCC Vulnerability analysis framework

(Allison et al. 2009 derived from IPCC 2001)

EXPOSURE

Nature and degree to which countries are *exposed* to predicted climate change

SENSITIVITY

Degree to which economies & people are likely to be affected by fishery-related changes

POTENTIAL IMPACTS

All impacts that may occur without taking into account planned adaptation

ADAPTIVE CAPACITY

Abilities and resources to cope with climate-related changes

VULNERABILITY

Components of vulnerability: data sources and methods

Exposure

- 2050 surface temperatures (HadCM3 model, 2 scenarios)

Sensitivity (Fisheries dependency – marine and inland)

- Landings and contribution of fisheries to employment, exports and dietary protein (FAO, World Bank)

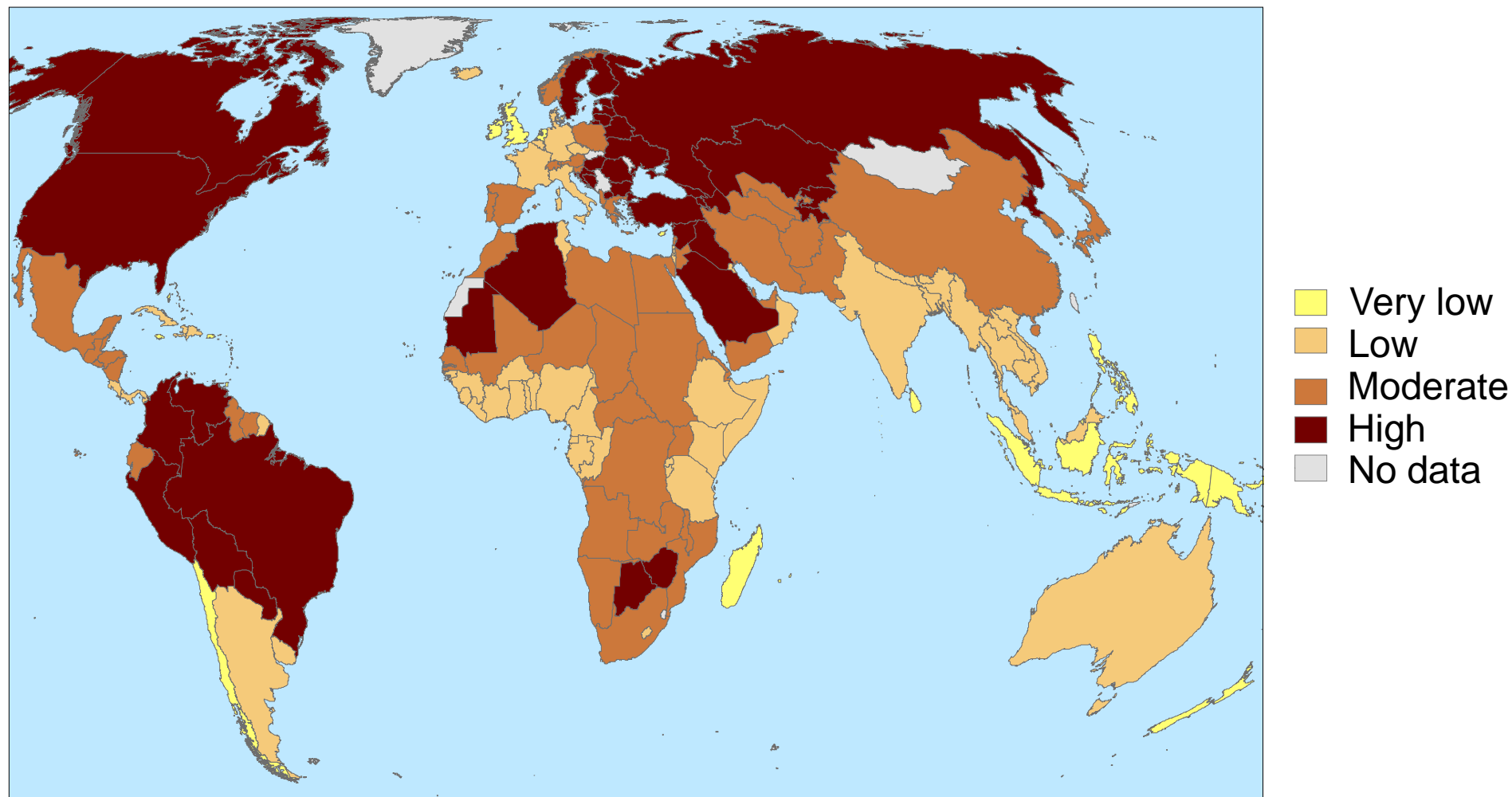
Adaptive capacity

- Human development indices (health, education, governance, and economy size)

Vulnerability

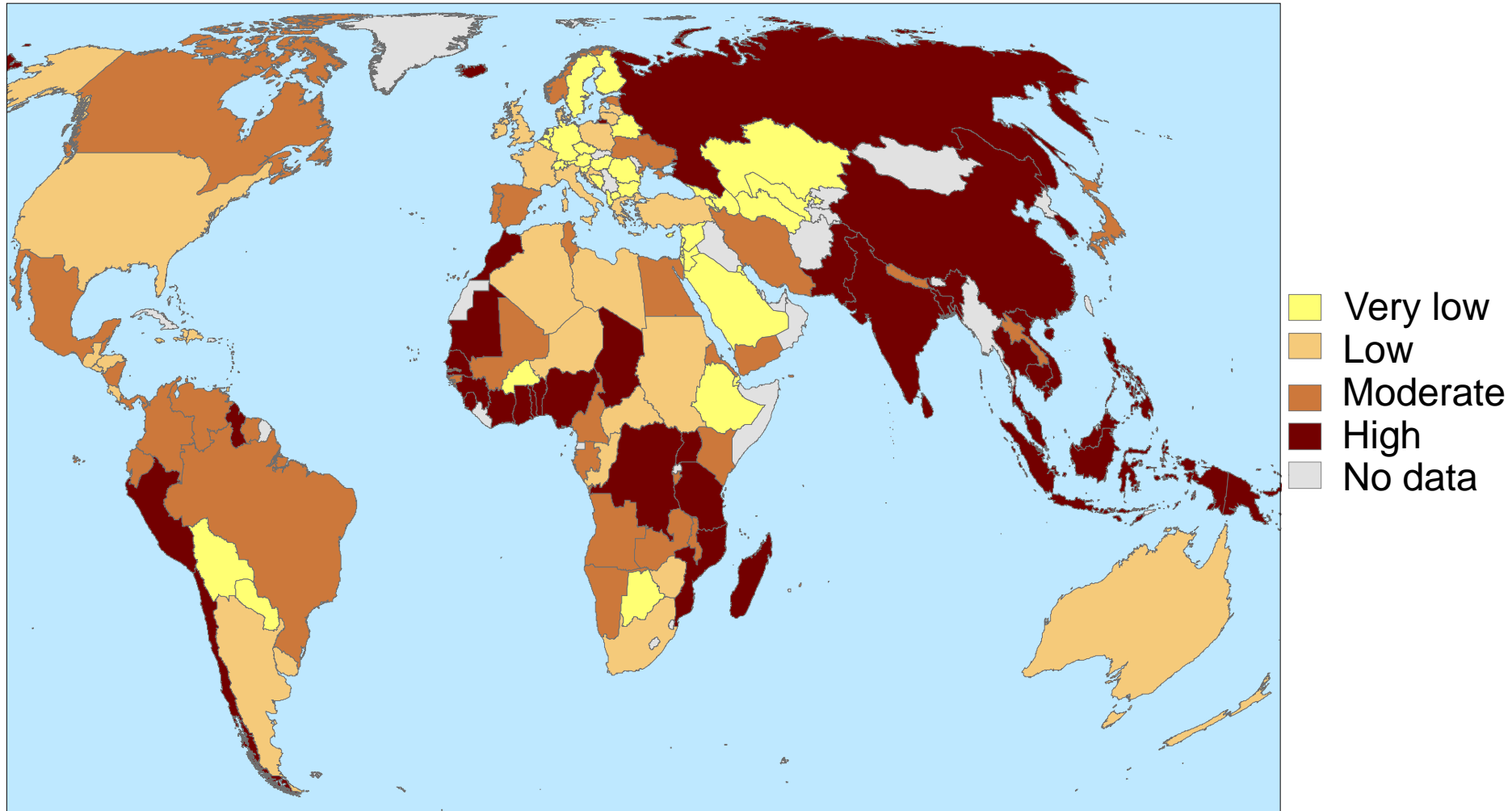
- 132 nations
- Robust to different methods of weighting and combination

Exposure to climate change – Atmospheric temperature



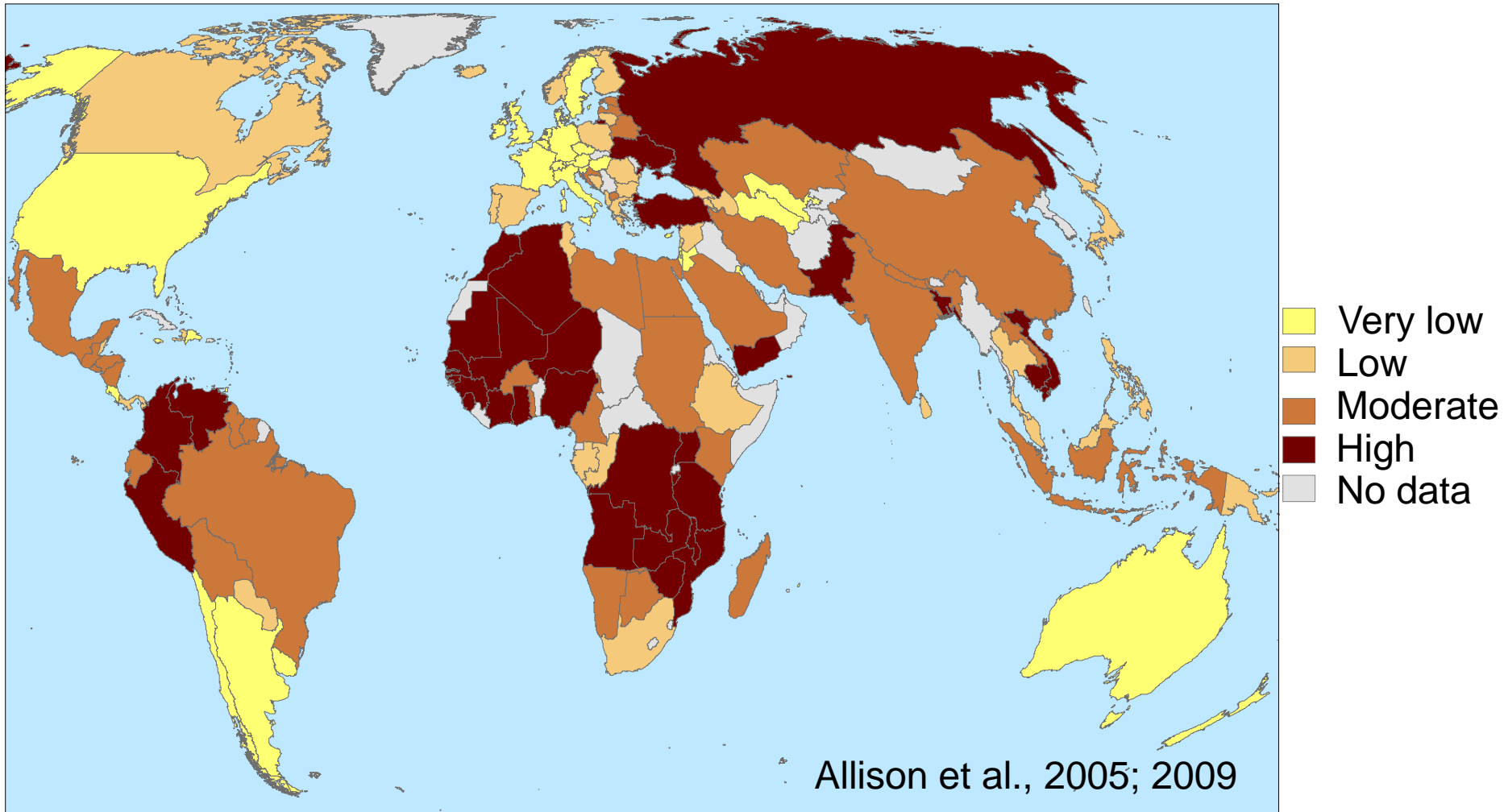
- Highest in North-temperate regions, continental land masses

Sensitivity: (Dependance of society and economy on fisheries)



- Highest in Asia, Africa, Western South America, SIDS

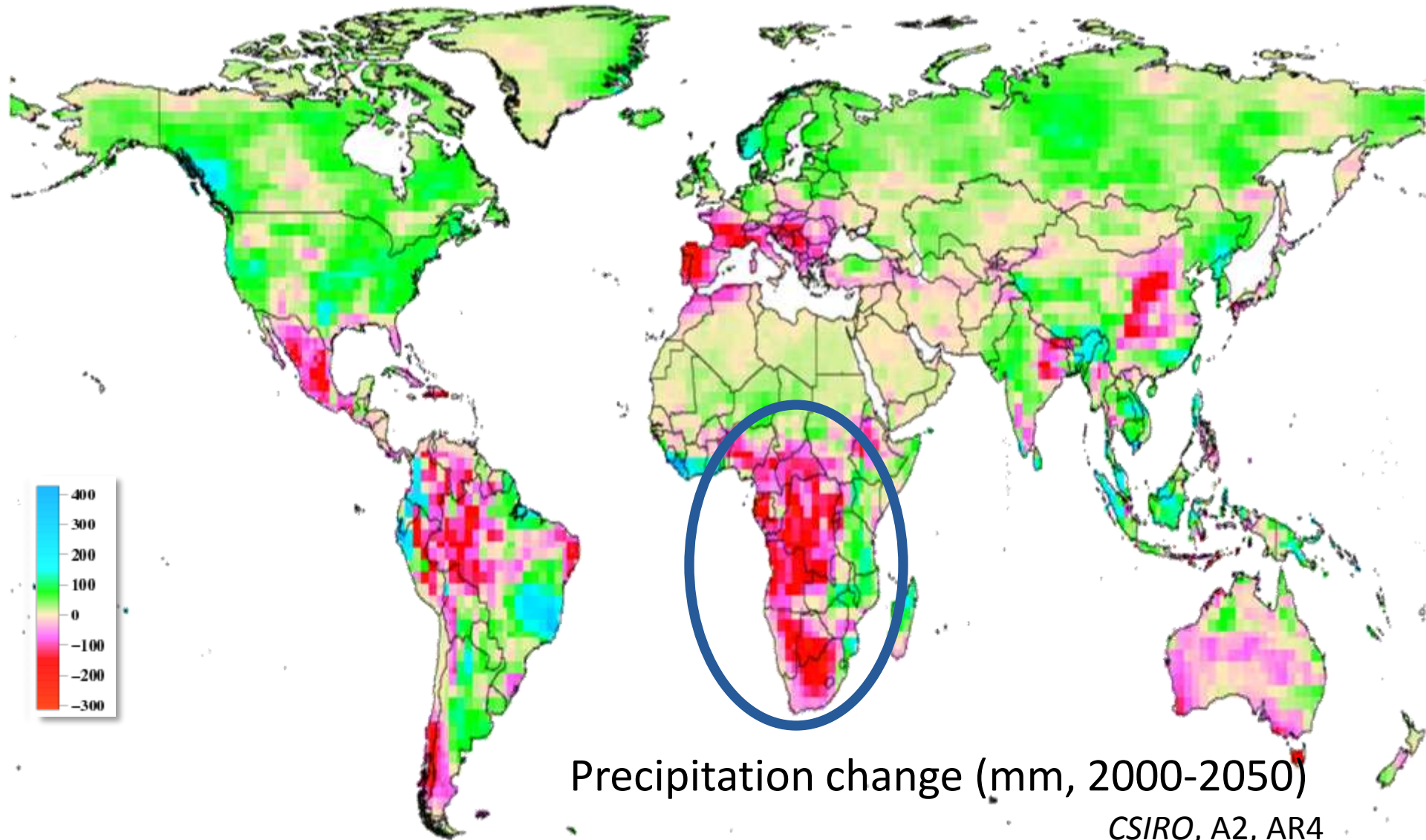
Vulnerability index – Global



Relative vulnerability of national economies to any potential change in their fisheries resulting from climate change

2/3 of most vulnerable are Least Developed Countries

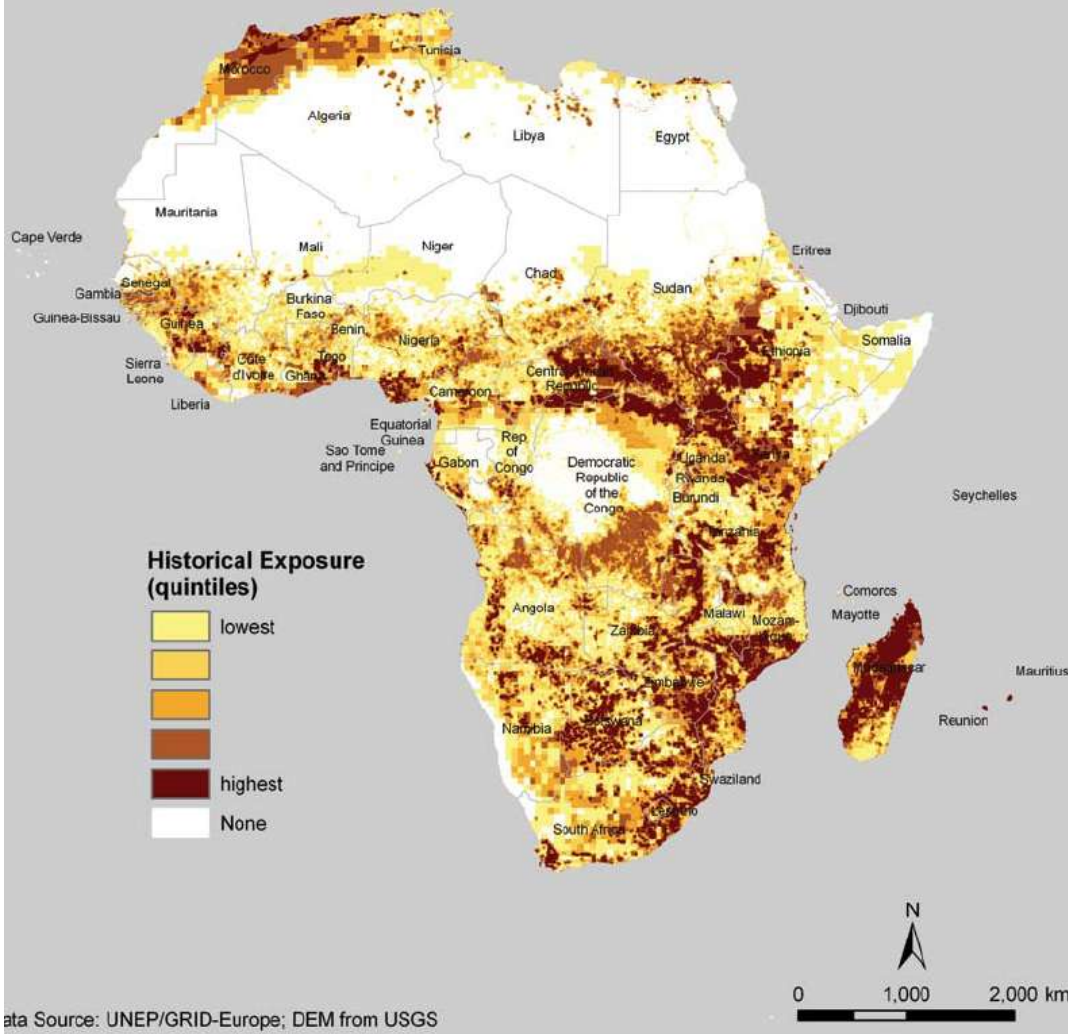
Climate impacts on land-based production will also affect fisheries and society...



Composite vulnerability analysis – multiple stresses

(Busby et al 2010) CCAPS

Climate Related Hazard Exposure in Africa



Approach and method:

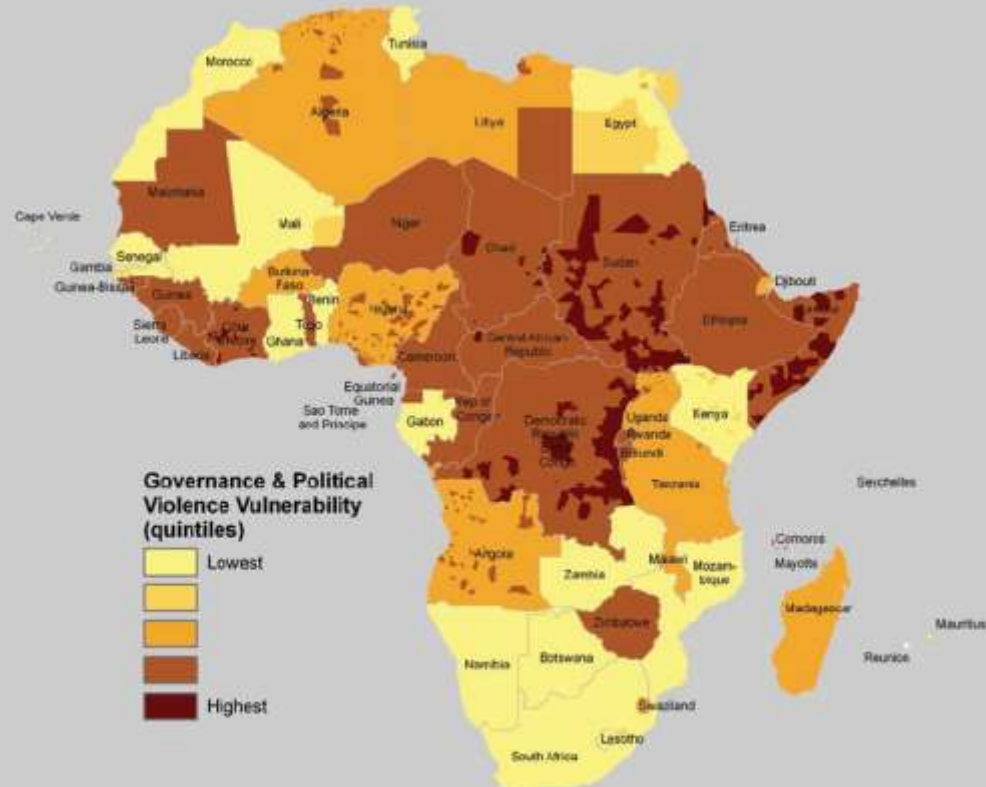
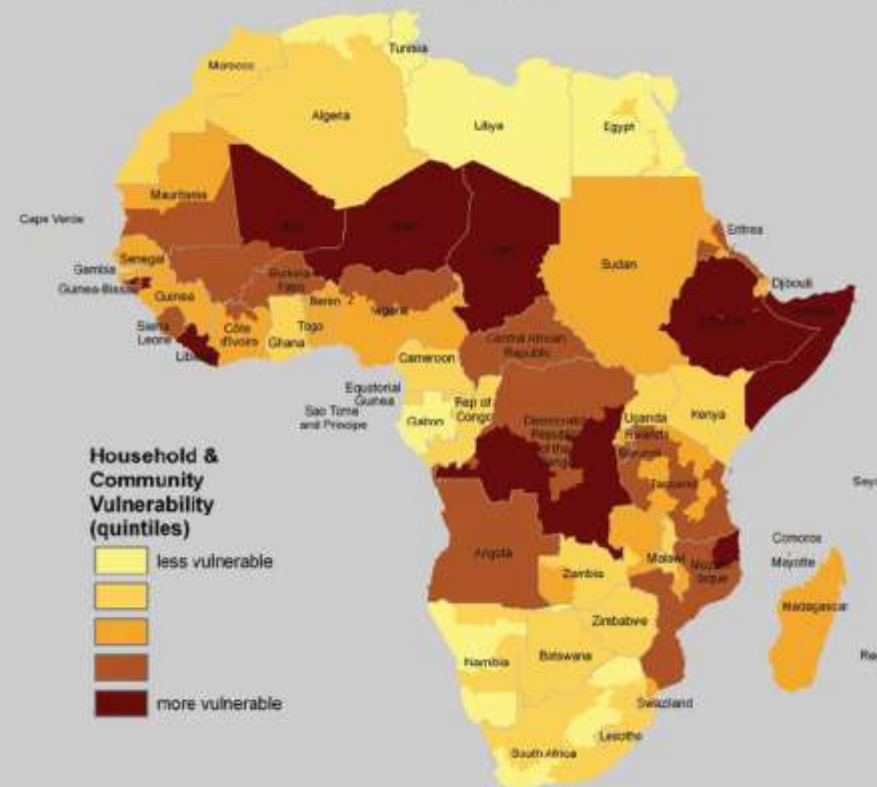
Indicator-based approach, using secondary data

- 1) Climate hazard – drought/flood frequency and severity (*exposure*)
- 2) Household and community vulnerability – human development index (*part of adaptive capacity?*)
- 3) Population density (*sensitivity?*)
- 4) Political and governance vulnerability (*combination of risk exposure and adaptive capacity*)

Unweighted, additive, ‘*composite index of vulnerability*’

Household and Community Level Vulnerability in Africa

Governance Level and Political Violence Vulnerability in Africa



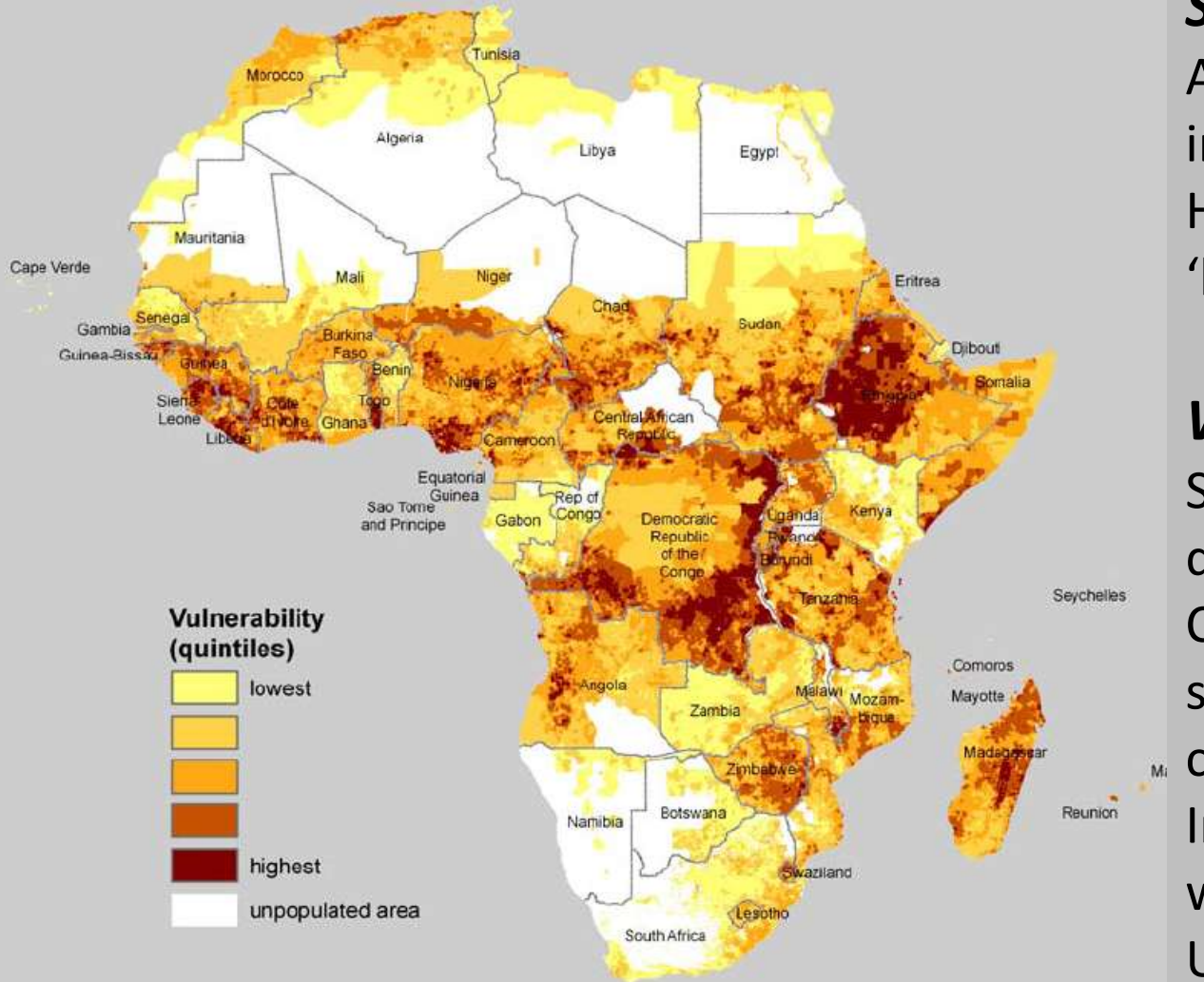
Data Source: World Health Organization; World Development Indicators; Food and Agriculture Organization of the United Nations; Food Security Statistics; Center for International Earth Science Information Network (CIESIN) (1991-2003)



Data Source: World Bank Governance Indicators; Polity IV Project; Political Regime Characteristics and Transitions; KOF Index of Globalization; Political Instability Task Force Worldwide Atrocities Dataset



Composite Vulnerability in Africa



Strengths:

Addresses multiple, interacting stresses
Highlights vulnerability 'hotspots'

Weaknesses:

Scale mismatches in data
Conflation of exposure, sensitivity, adaptive, capacity
Indices of indices... which is important?
Unclear how to respond

Data Sources: World Bank Governance Indicators; Polity IV Project: Political Regime Characteristics and Transitions; KOF Index of Globalization; Political Instability Task Force Worldwide Atrocities Dataset; World Health Organization; World Development Indicators; Food and Agriculture Organization of the United Nations Food Security Statistics; PreventionWeb; DEM from USGS; GRUMP; CIESIN



Over 400 million of the world's poorest depend on fish for food. How will they adapt to climate change?



© PaCFA 2009

Find out what's at stake

Don't let fish slip through the climate change net

Fisheries and aquaculture policy

Climate adaptation and mitigation policy



Oceans Day at Copenhagen

The Importance of Oceans, Coasts, and Small Island Developing States in the Climate Regime

December 14, 2009

8:00 to 22:00

Venue: European Environment Agency, Copenhagen

Featuring H.S.H. Prince Albert II of Monaco
Indonesian Minister Dr. Fadel Muhammad
Grenada's UN Ambassador Dr. Dessima Williams
US NOAA Administrator Dr. Jane Lubchenco
and other World Leaders



Can current and anticipated demands for fish and seafood be met in a changing climate?

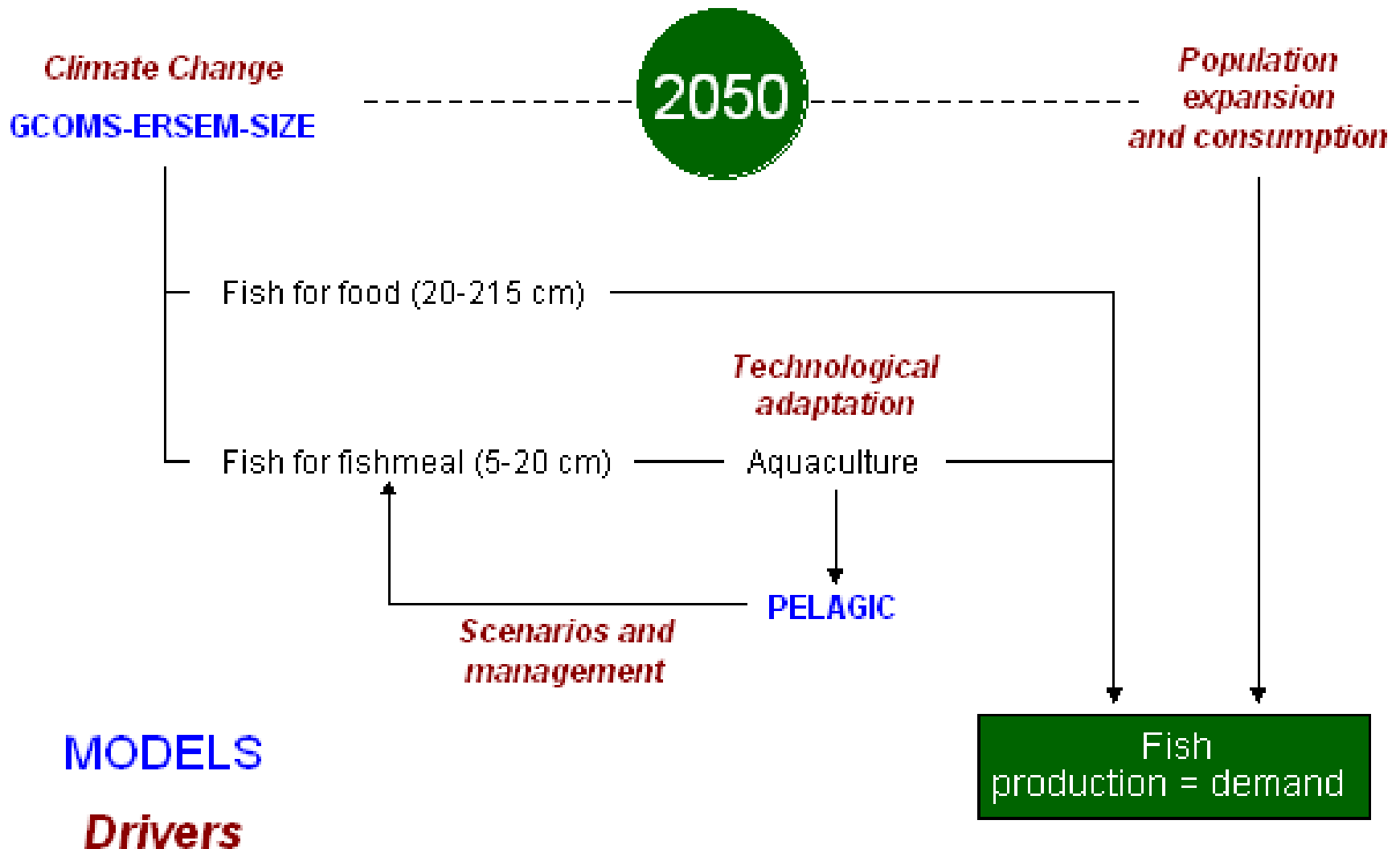
- World population to increase to 9.3 Billion by 2050
- Fish provides protein, minerals and vitamins (17kg/cap/yr)
- Marine capture fisheries close to maximum capacity
- Aquaculture growing faster than population in the last 30 years, specially in Asia





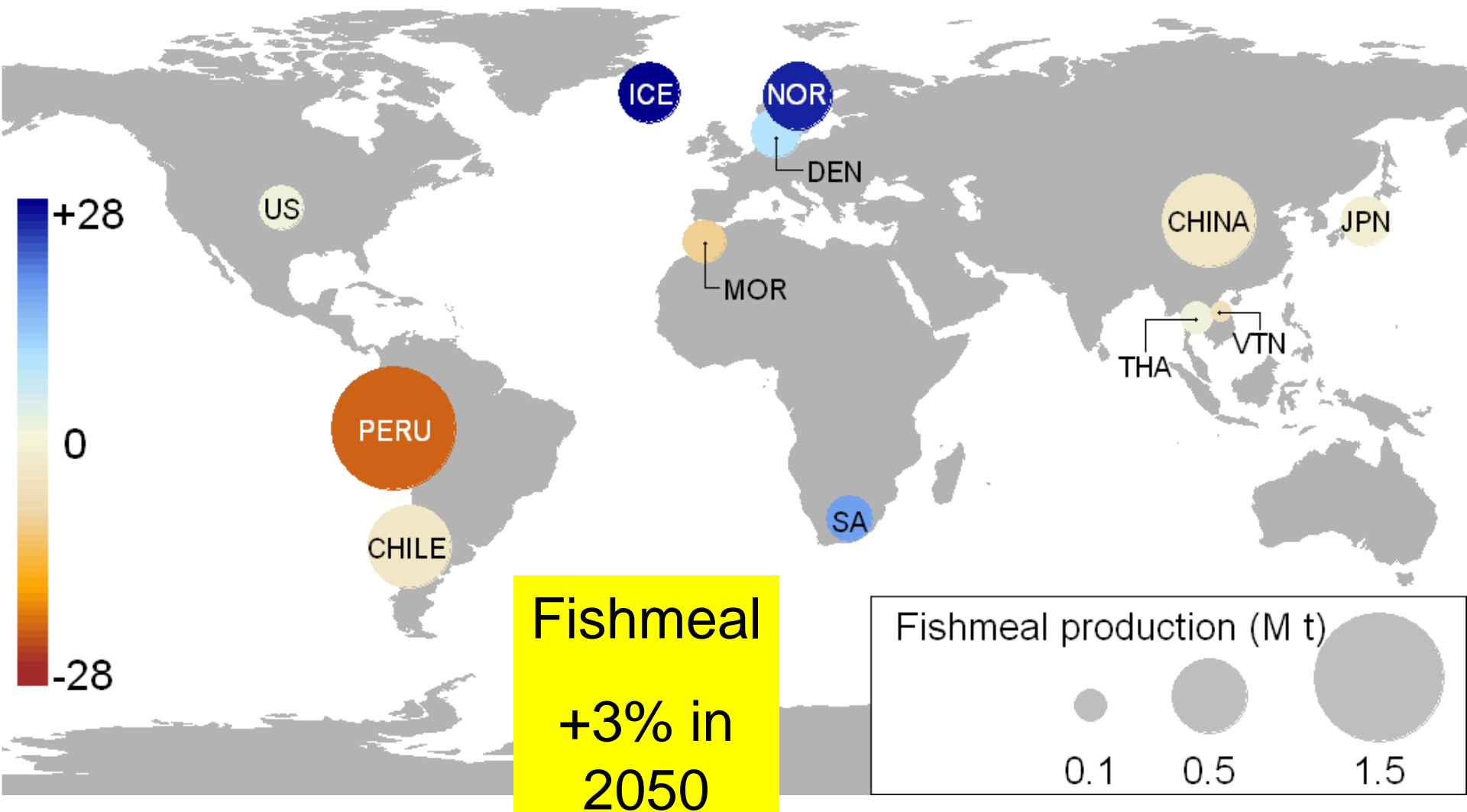
Modelling framework

20 countries with LMEs producing 80% of global catch



Climate change and reduction fisheries

Fishmeal production (% change)





Conclusions of the study

- *CC and marine fisheries* ~ Food fish production +6.5%, Fishmeal +3% by 2050
- *Aquaculture*: Likely to produce enough fish to maintain and increase current consumption if recent trends in feed technology continue. FIFO would need to reduce to 50% of current.
- *Capture fisheries*: management efficiency also required to secure fish for direct consumption and for feed (likely).
- Aquaculture impacts could be transferred from fisheries to terrestrial commodities (e.g soya).
- A potential impacts study, rather than a vulnerability analysis (similar to most in fishery sector, e.g. Cheung et al., 2009; 2010)

Merino *et al* (2012) Can aquaculture meet global seafood demand in changing climate? *Global Environmental Change* 22

What are the national food security implications of pressures on the world's coral reefs?

(Hughes *et al.*, 2012. *Env. Sci. Pol.* 23: 95-109)

Exposure

Cumulative impact score for 38 stressors:
e.g. fishing, pollution, land-use change
(from Halpern *et al.*, 2009)

Sensitivity

$$\begin{aligned} S &= \left\{ \frac{\text{Reef fisheries dependence}}{\text{Protein intake relative to threshold}} \right\} \\ &= f\left(\frac{|dW/dx|}{(W/W_0)}\right) \\ &= \frac{\text{Coral reef protein/Total protein}}{\text{Total protein/Protein threshold}} \end{aligned}$$

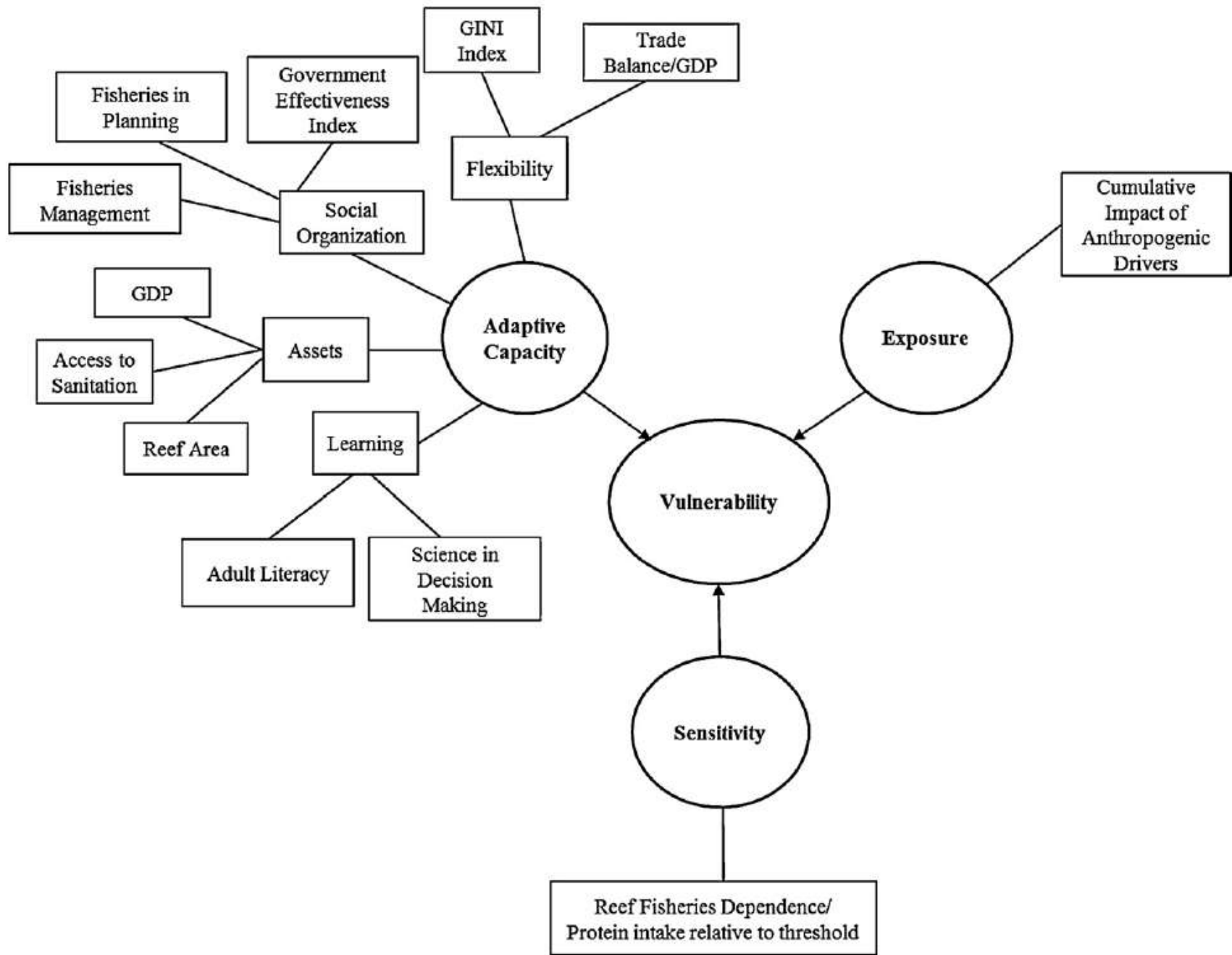
Adaptive Capacity

Assets – per capita GDP, % of population with access to sanitation
(World Bank)

Flexibility - trade balance, GINI Coefficient (World Bank)

Learning – literacy rate (UNDP), use of science in fisheries management (from Mora *et al.* 2009)

Social Organization - Government effectiveness index (World Bank), Fisheries management effectiveness (Mora *et al.*, 2009), Incorporation of reefs and fisheries issues into PRSPs or similar (following Thorpe *et al.*, 2005)

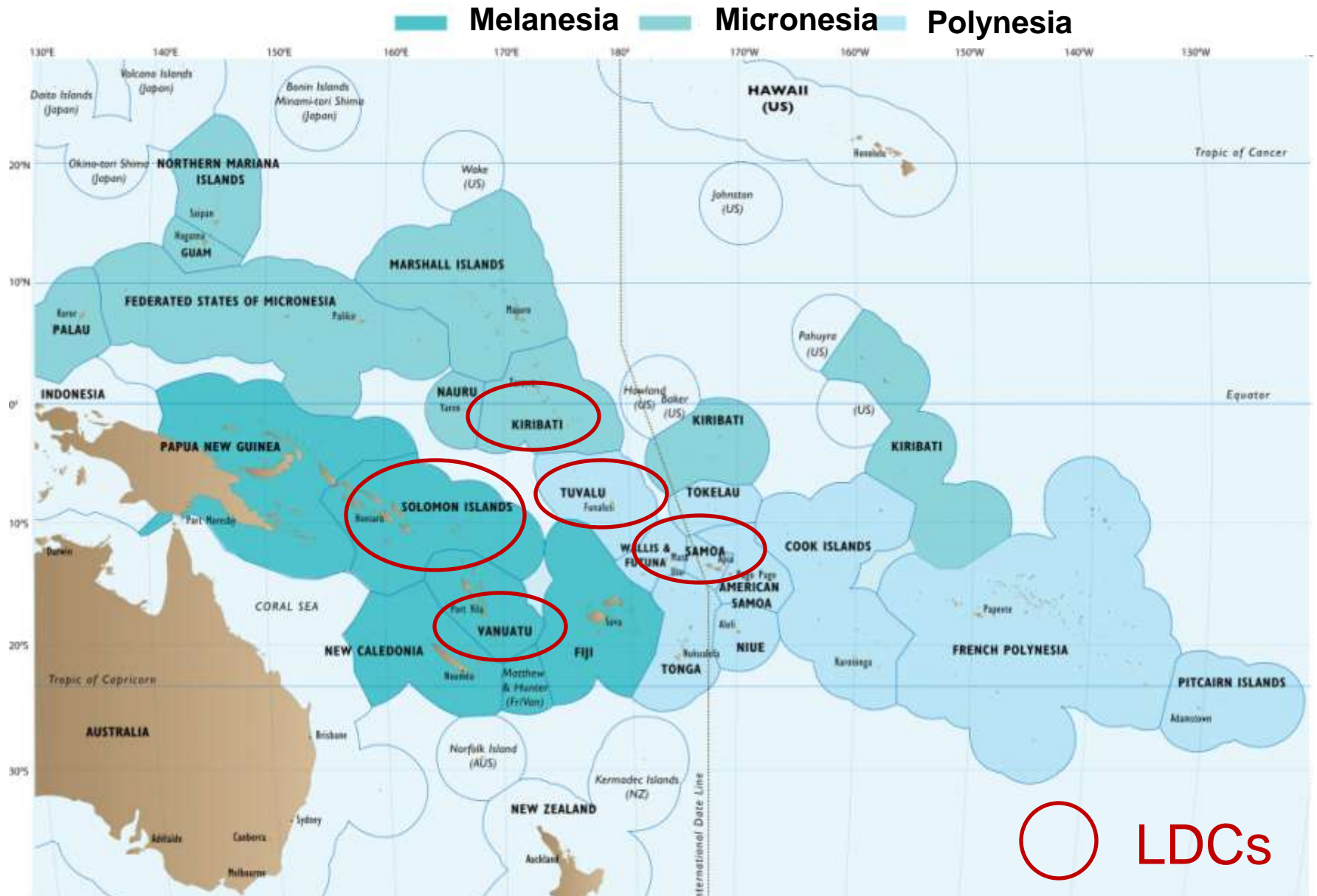


Ten countries most vulnerable (in nutrition security terms) to loss of their coral reefs

Table 2 – Standardized exposure, sensitivity, adaptive capacity, and vulnerability scores where vulnerability = (exposure + sensitivity) – adaptive capacity.^a

Country	Exposure	Sensitivity	Adaptive capacity	Vulnerability
Indonesia	1.00	0.98	0.37	2.33
Liberia	0.0050	0.92	0.00	1.65
Ivory Coast	0.00025	0.91	0.15	1.48
Kenya	0.016	0.81	0.10	1.45
Philippines	0.88	0.40	0.57	1.43
Honduras	0.019	0.90	0.23	1.41
Cameroon	0.00044	0.91	0.25	1.37
Egypt	0.10	0.87	0.45	1.24
Cambodia	0.00051	0.90	0.43	1.19
Tanzania	0.076	0.94	0.55	1.19

How will climate change affect Pacific Tuna fisheries?



Source of benefits

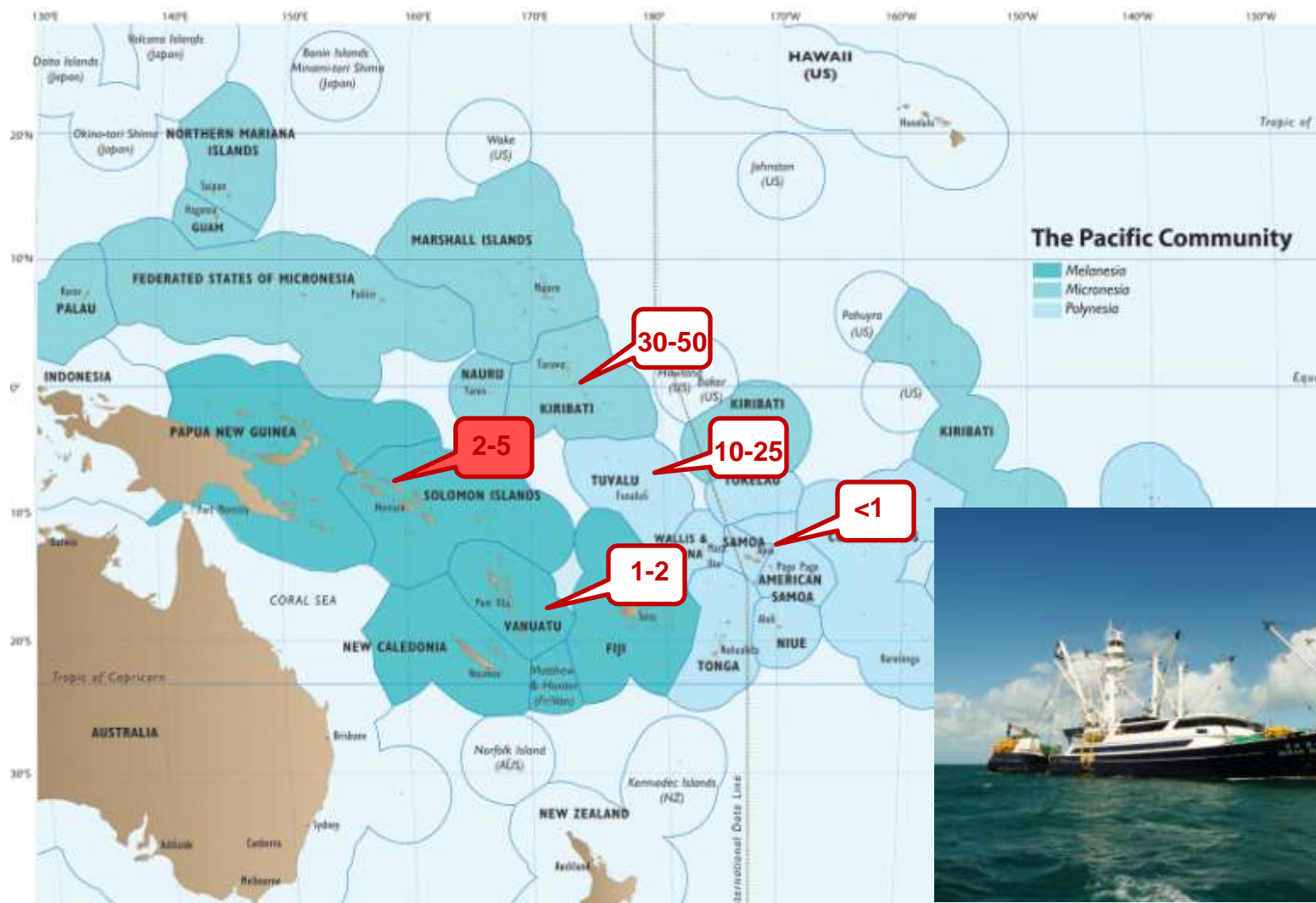
Skipjack tuna



Catch in 2009 from Western and Central Pacific Ocean

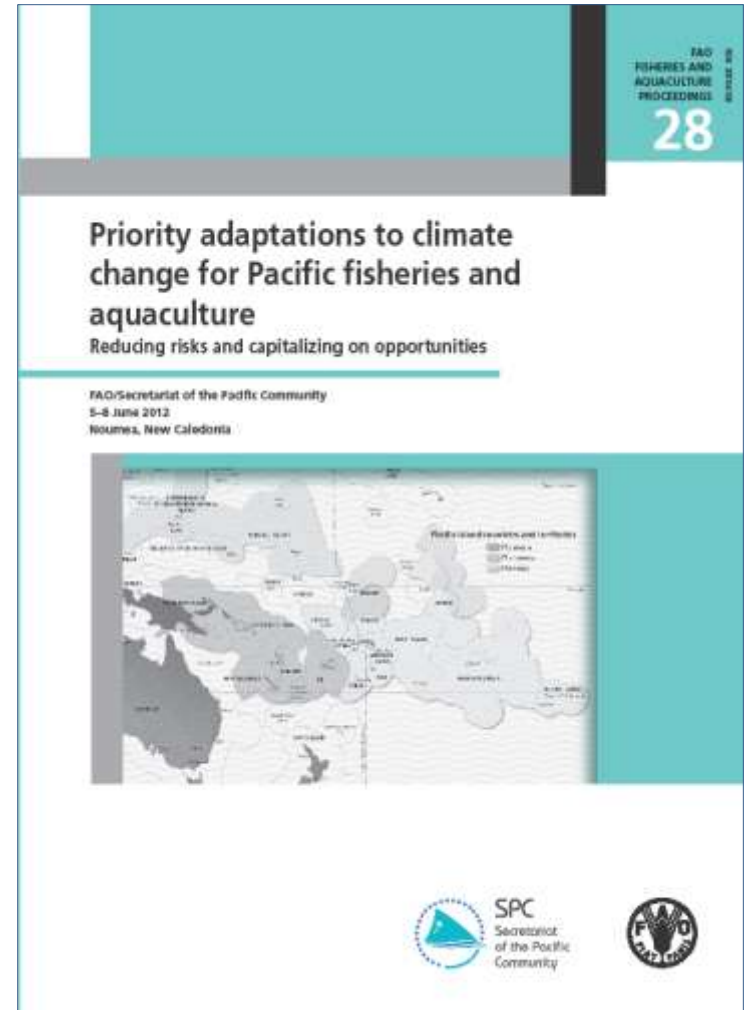
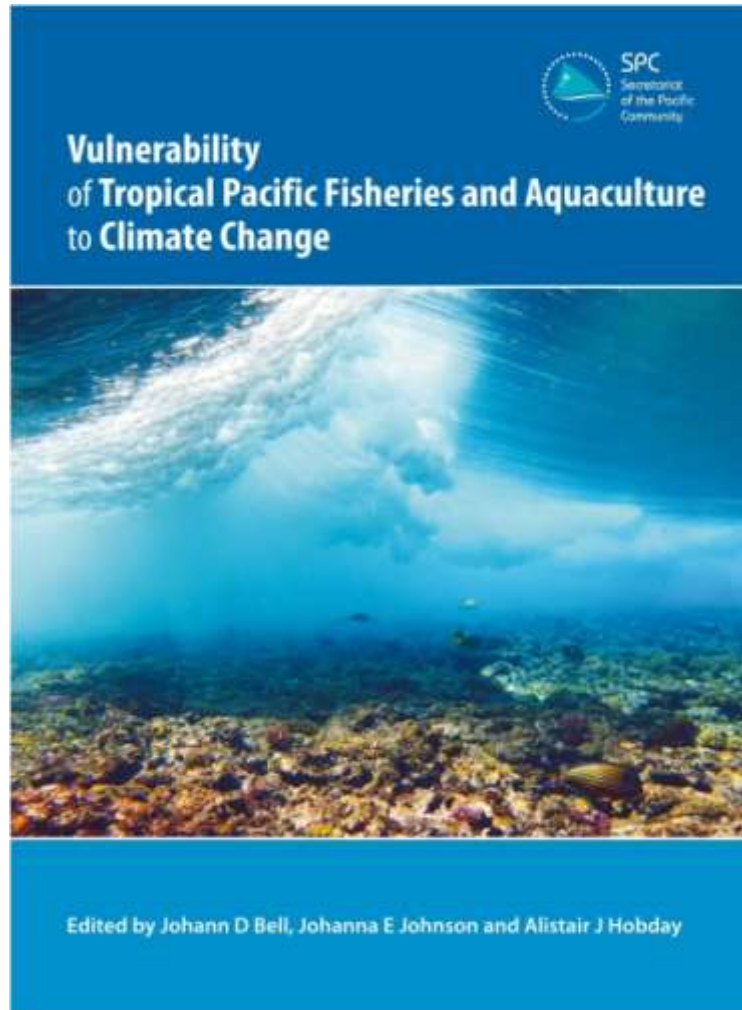
- 1.75 million tonnes
- ~ USD 2.2 billion

Contributions to government revenue (%) 1999-2008

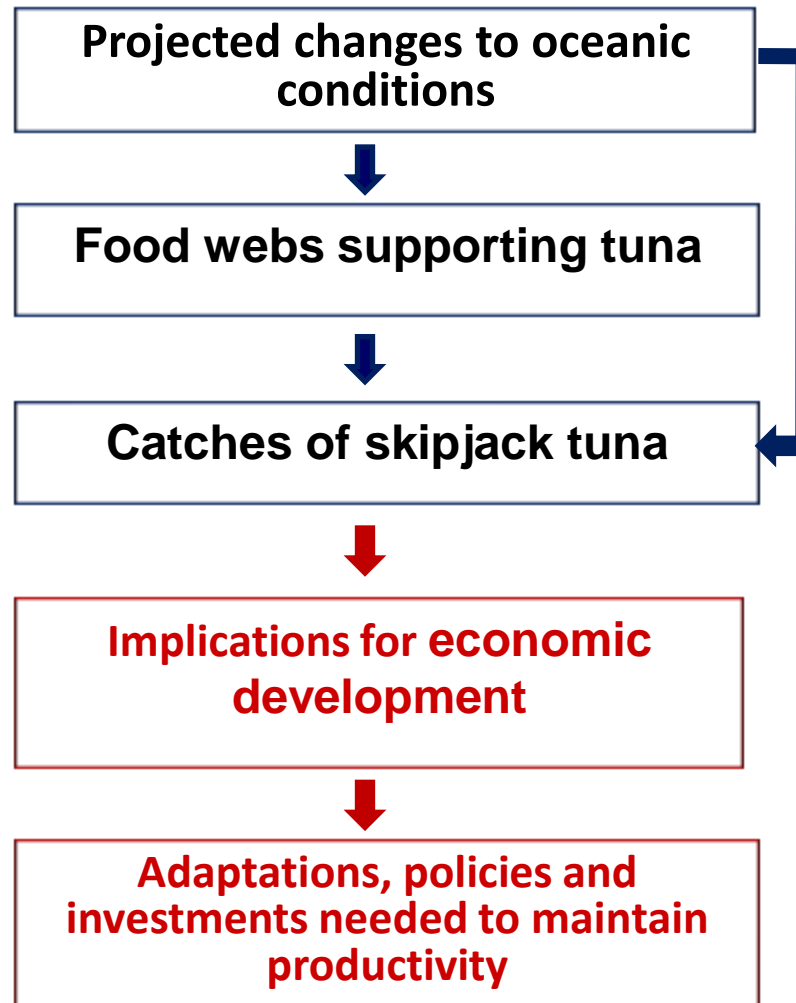


Source: Gillett (2009)

Vulnerability assessment

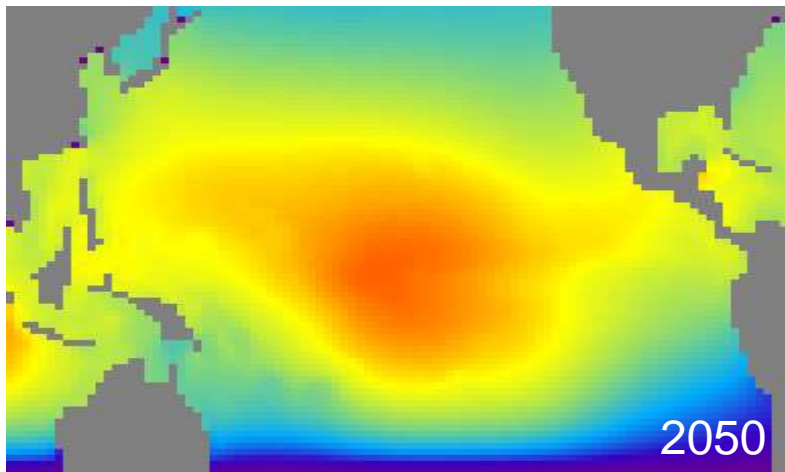
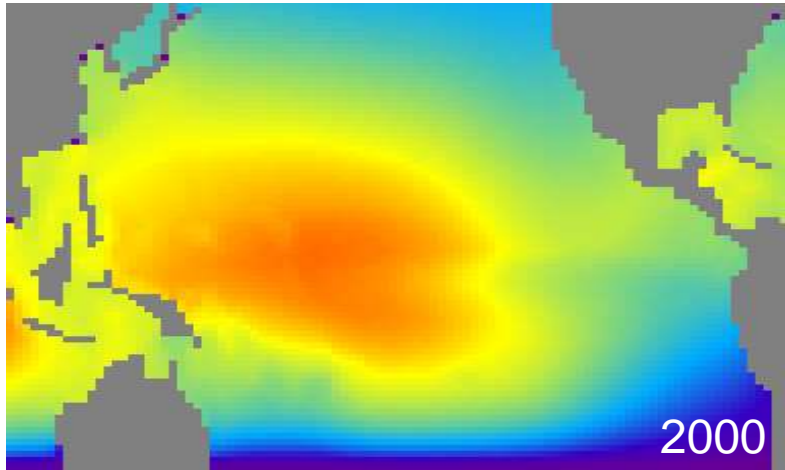


Approach used



Projected effects on skipjack tuna

A2 emissions scenario



Redistribution east due to:

- Increases in sea surface temperature in eastern Pacific
- Shift of prime feeding areas to the east

Expected benefits or losses

PICTs	1999–2008		2035		2050		2100	
	L	U	L	U	L	U	L	U
Government revenue								
FSM	6	12	+1	+2	0	+1	-1	-2
Kiribati	30	50	+11	+18	+13	+21	+7	+12
Nauru	10	25	+2	+6	+2	+5	0	0
Palau	2.5	3.2	+0.2	+0.3	0	+0.1	-0.7	-0.9
Tokelau	2	15	+1	+9	+1	+10	+1	+9
Tuvalu	10	25	+4	+9	+4	+10	+2	+6
GDP								
American Samoa	20	25	+3	+6	+2	+4	-1	-2
Marshall Islands	10	25	+2	+6	+2	+6	+1	+2
PNG	1.5	4	0	+0.1	-0.2	-0.4	-0.4	-1.2
Solomon Islands	2	5	+0.1	+0.2	-0.1	-0.3	-0.3	-0.8

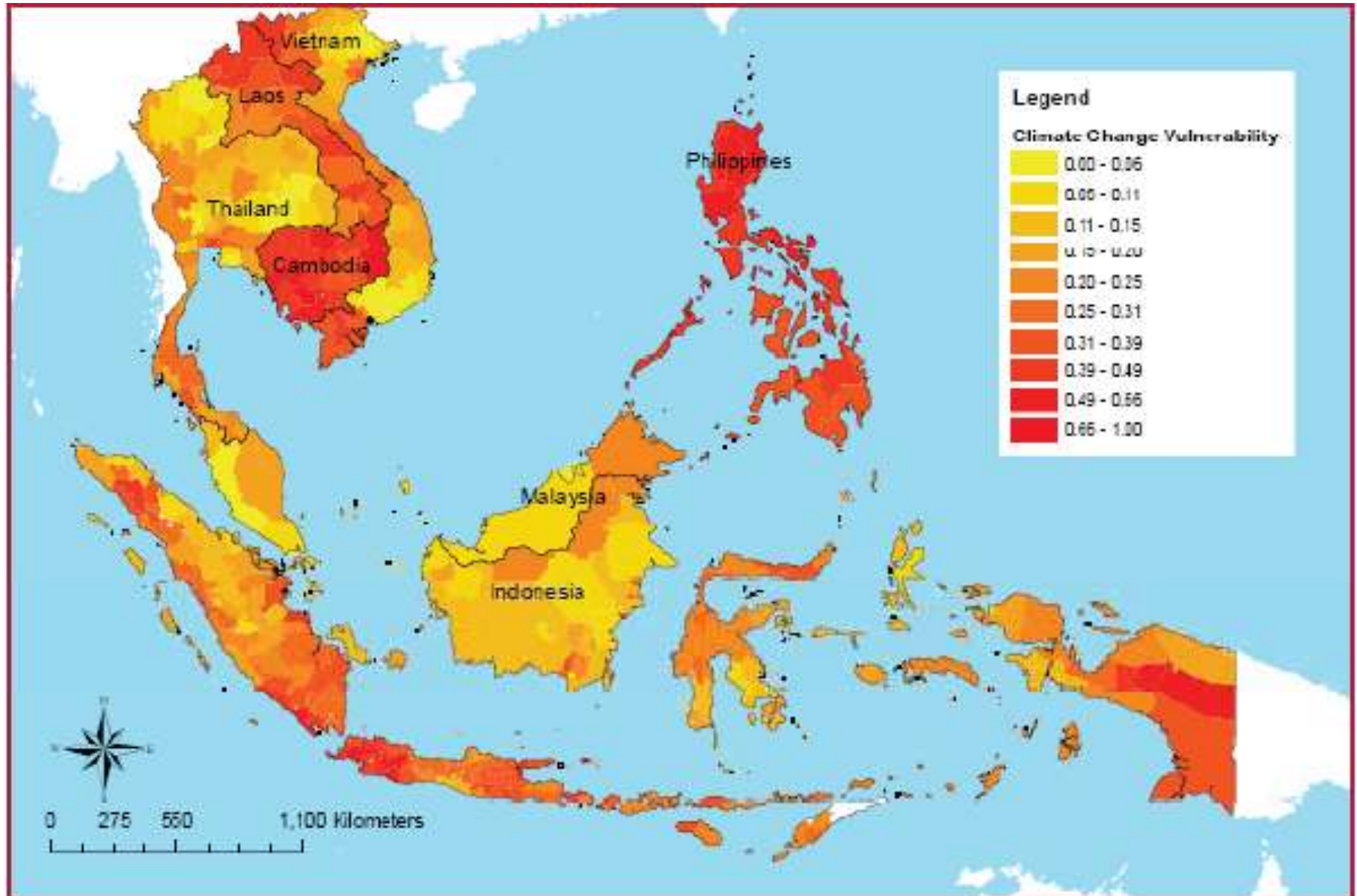
Comparative benefits & vulnerabilities

PICT	2035	2050	2100
PNG	+ Very low	- Very low	- Very low
Solomon Islands	+ Very low	- Very low	- Low
FSM	+ Low	+ Very low	- Low
Kiribati	+ Very high	+ Very high	+ Very high
Marshall Islands	+ Low	+ Low	+ Low
Nauru	+ Moderate	+ Moderate	- Very low
Palau	+ Very low	+ Very low	- Very low
Tokelau	+ High	+ High	+ Very high

(+) benefit, (-) vulnerability to negative economic impacts

Regional downscaling, multiple climate-sensitive sectors

(Yusuf & Francisco, 2009)



Where in Vietnam should climate-proofing of aquaculture be prioritized? (Badjeck et al., 2012)

EXPOSURE (E)

Sea level rise: % of province area flooded

Temperature rise: Avg temperature increase relative to 1980-99

Rainfall change: Annual rainfall change relative to 1980-99

Coastal extreme events: Aquaculture area damaged, due to storms & typhoons 1989-2008

Floods: Aquaculture area damaged by floods, 1989-2008

DEPENDENCY (D)

Direct livelihood: % hh engaged in aquaculture

Indirect employment: employees in fishery enterprises as % of total enterprise employees

Macro-economics: Fish output as % of country GDP; seafood export processing facilities

Food security: Per capita annual fish & shrimp consumption

ADAPTIVE CAPACITY (AC)

Poverty: % of population below poverty line; % of hh monthly food expenditure spent on fish & shrimp

Infrastructure: Telephone lines per 100 people; # of hospital beds per 1000 people

Education: Graduates of 2o education as % of total candidates

Disaster response to CC: # of disaster management programs; DRM investments in construction projects; DRM investments in non-construction projects

Social capital: share of fishery cooperatives as % of national total

Education: % of fishery employees with education

Black: Generic; Red: CC related; Blue: aquaculture sector

POTENTIAL IMPACTS (PI)

- impacts that will occur without adaptation

$$PI = f(E, D)$$

VULNERABILITY

-the nature & extent of losses incurred by the aquaculture sector due to CC

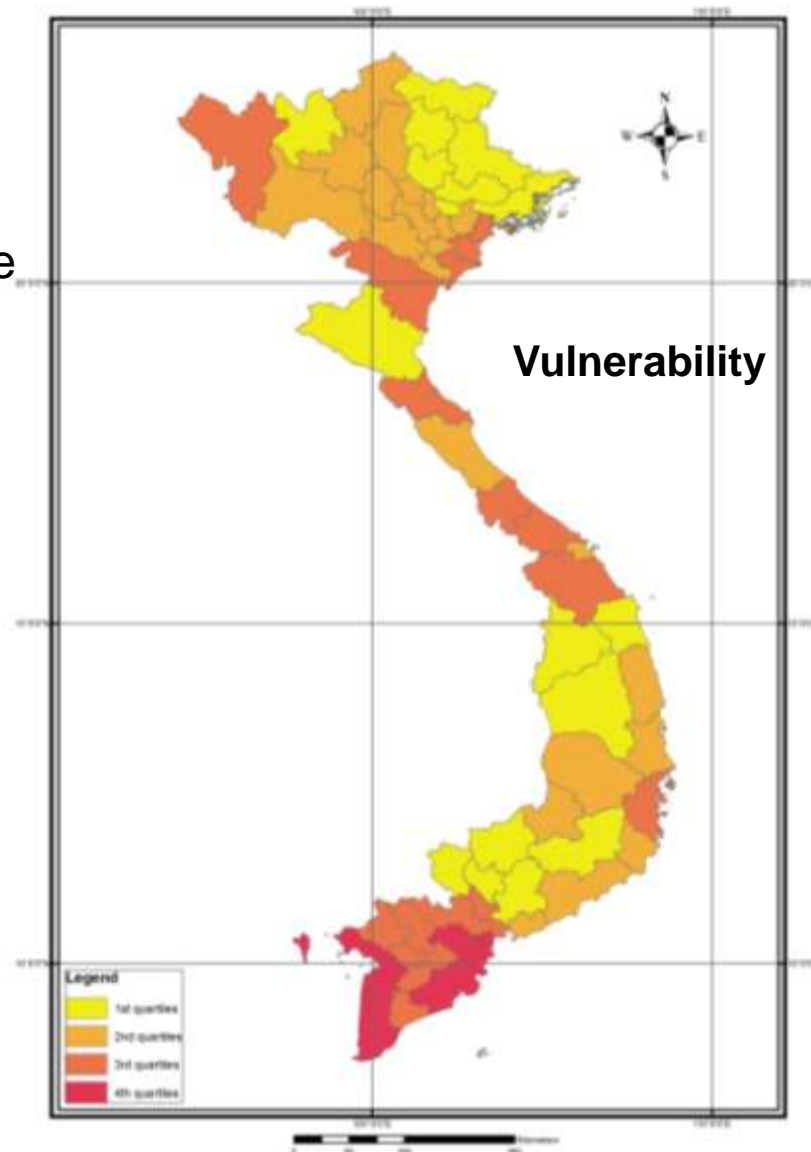
$$V = f(PI, AC)$$

Vulnerability of aquaculture in Vietnam

Dominated by coastal shrimp ponds
And catfish (*Pangassius*) in Mekong Delta

-Storms, sea level rise, temperature increase

Province Name	Region	Vulnerability Index
Sóc Trăng	Mekong River Delta	100.0
Cà Mau	Mekong River Delta	91.7
Kiên Giang	Mekong River Delta	87.3
Bến Tre	Mekong River Delta	77.9
Trà Vinh	Mekong River Delta	77.7
Tiền Giang	Mekong River Delta	76.7
Thái Bình	Red River Delta	69.7
Hà Tĩnh	North Central area & Central coastal area	61.6
Cần Thơ	Mekong River Delta	61.2
Bạc Liêu	Mekong River Delta	60.2



Application of vulnerability analysis: Food security and poverty reduction



CLIMATE
CHANGE
AGRICULTURE AND
FOOD SECURITY



Earth System
Science Partnership

CCAFS Objectives



CLIMATE
CHANGE
AGRICULTURE AND
FOOD SECURITY

1. Identify and develop **pro-poor adaptation and mitigation practices, technologies and policies** for agriculture and food systems.
2. Support the inclusion of agricultural issues in **climate change policies**, and of climate issues in **agricultural policies**, at all levels.

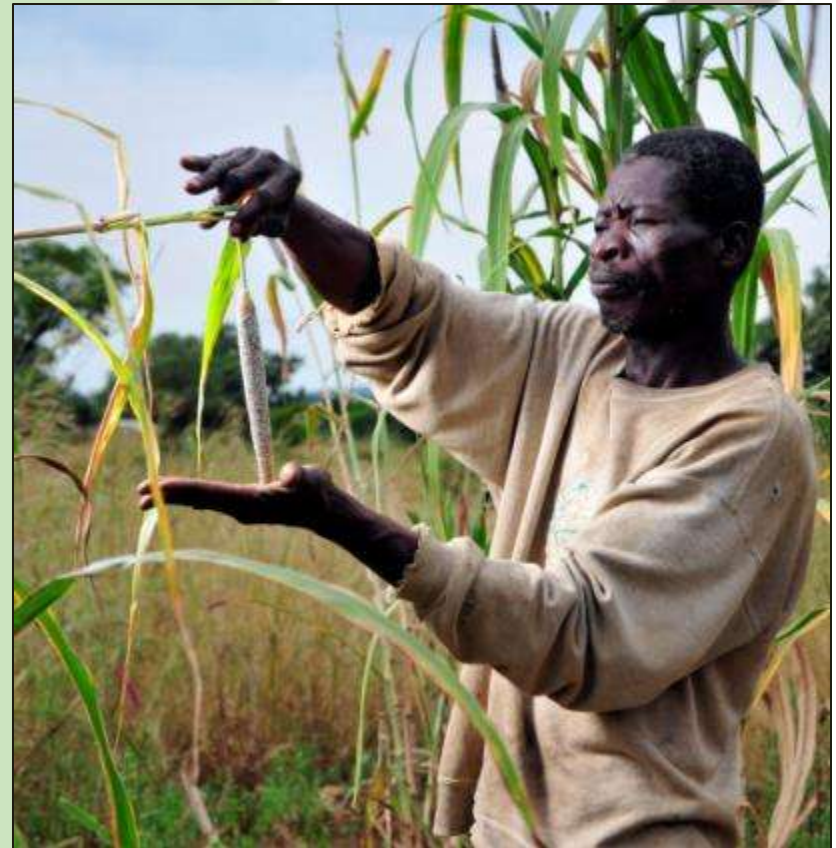
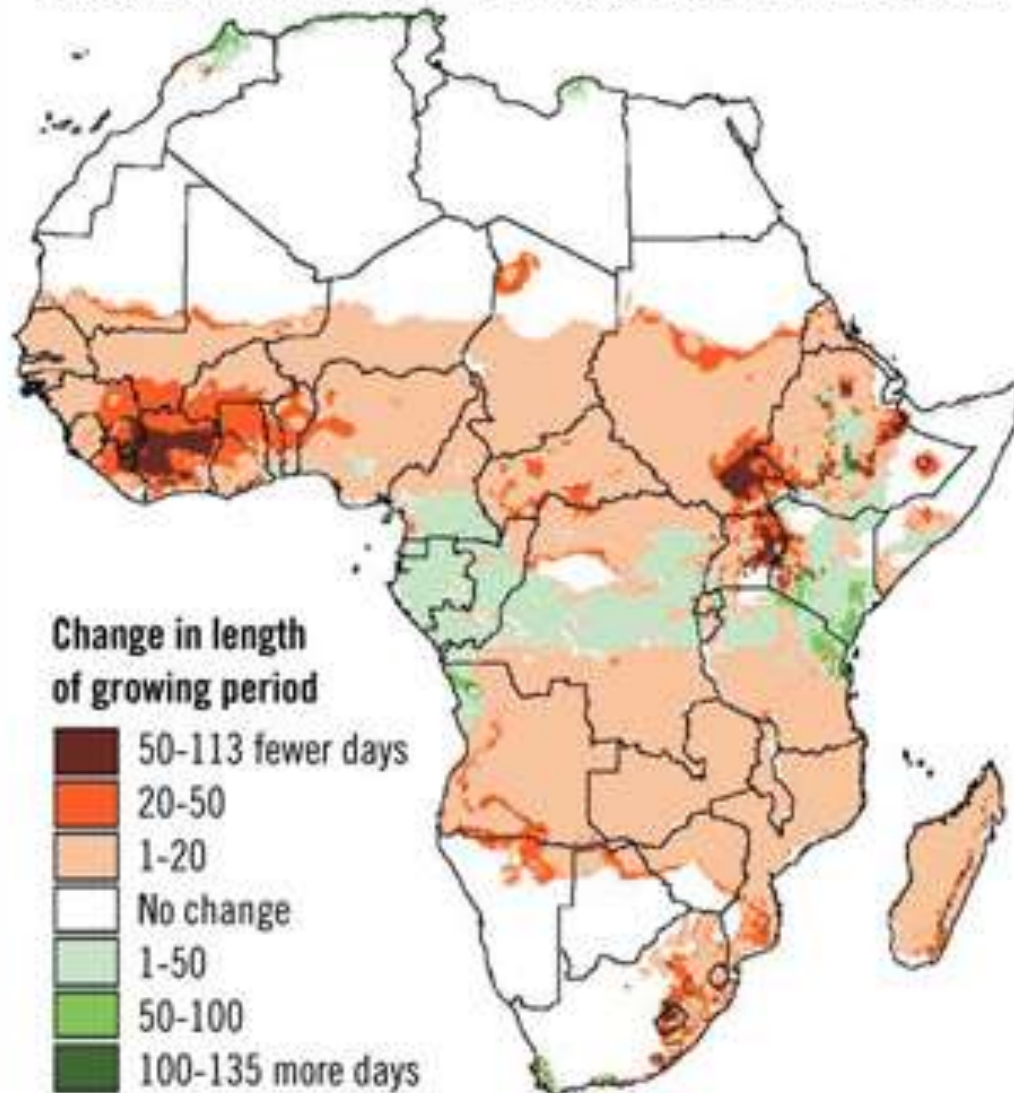


Figure 1.2 Climate change and food security

Changes in Projected Growing Season, 2000-2050

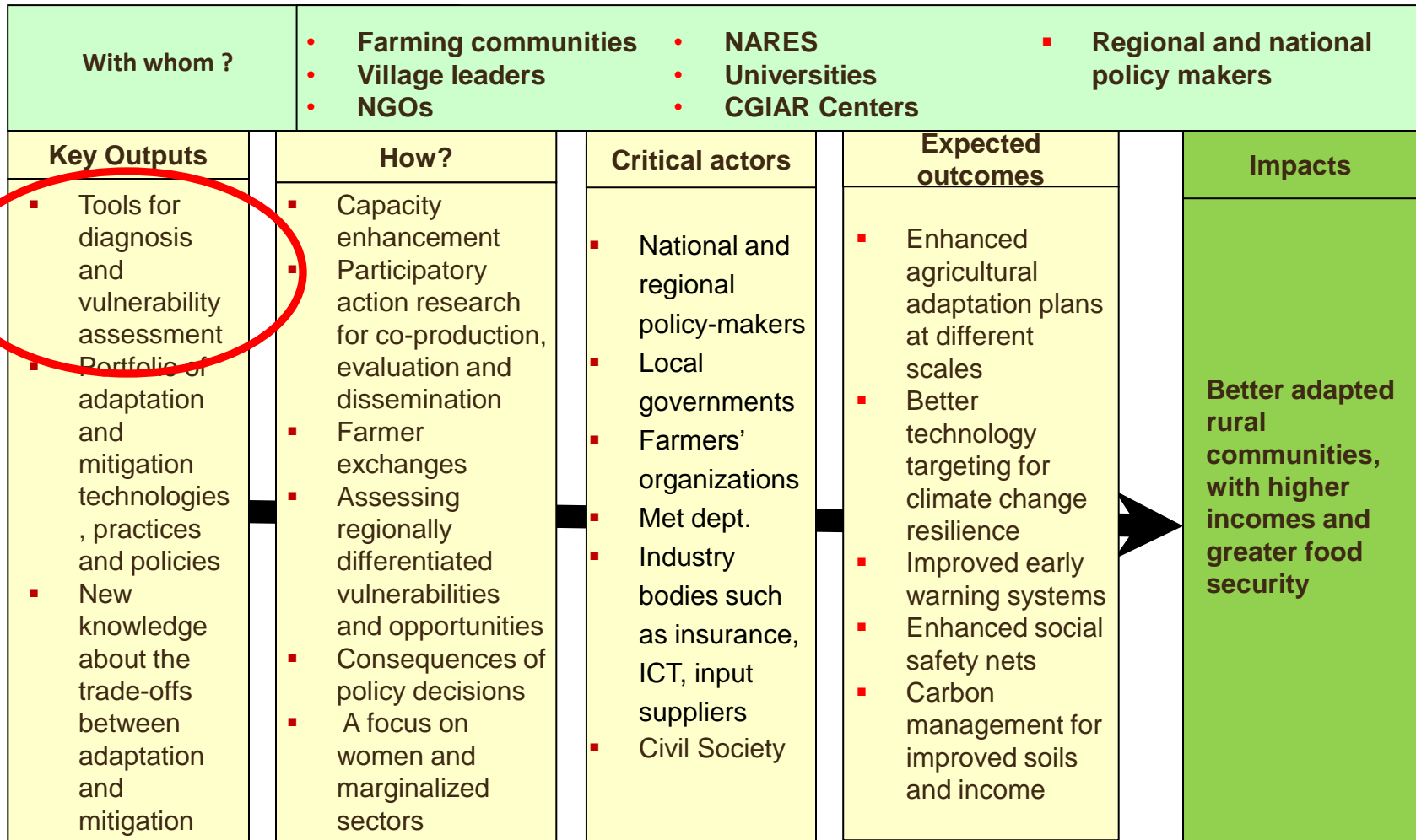


Source: Thornton et al. 2002:89

Reproduced from *World Resources 2005*. All rights reserved

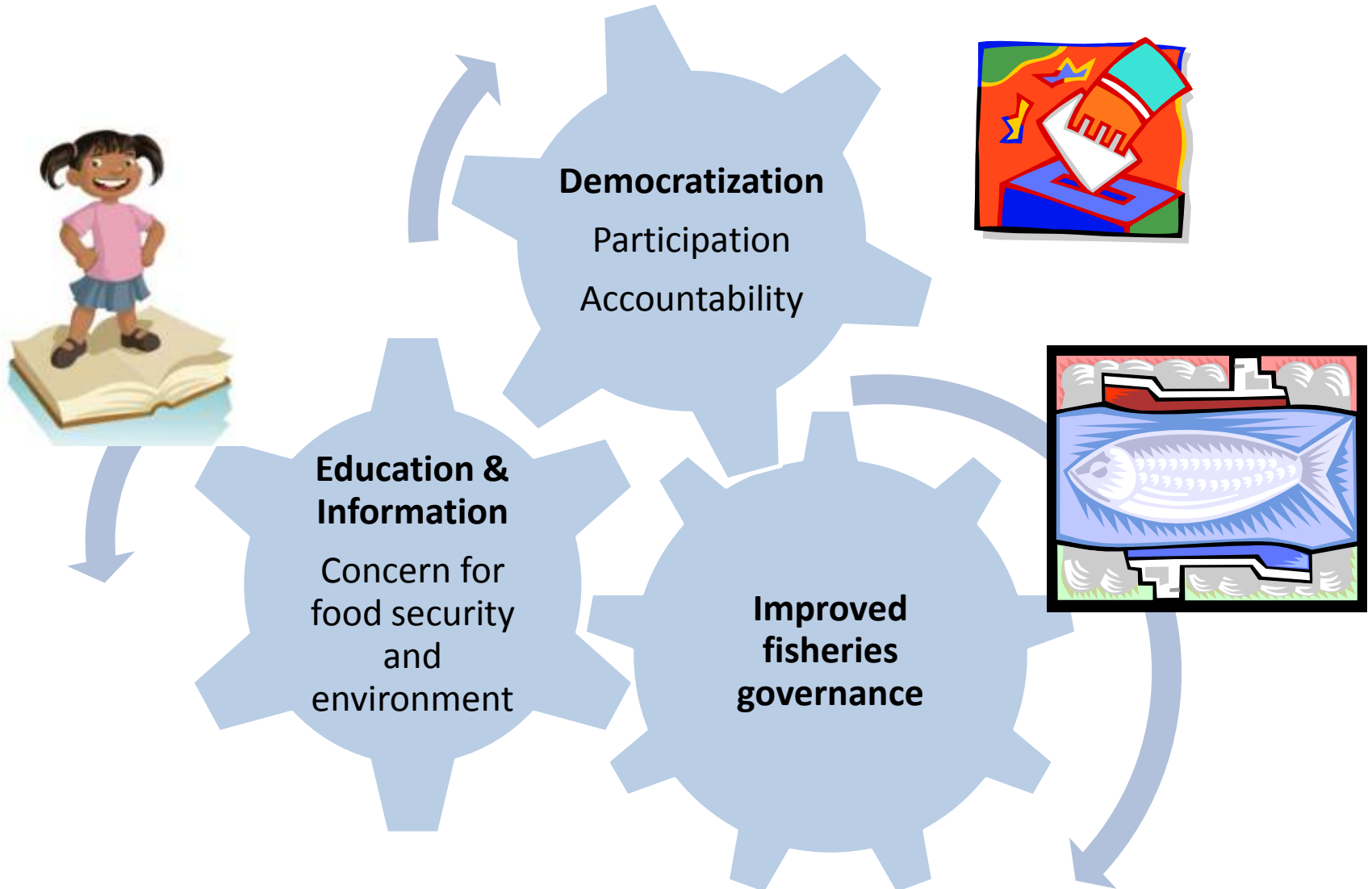
Starting
from
climate risk
exposure...

Regional Engagement for Integrated Agricultural Development: Generic Impact Pathway



Complexities...

Drivers interact - and can be positive



Synthesis

Vulnerability analysis can be quantitative, qualitative, relative and absolute, global, local, expert-driven or stakeholder-driven..or a combination of all!

The scale, approach and method of vulnerability analysis used should be determined by its purpose

The approach taken will also be determined by resources, time, expertise and availability of data

Interpretation of vulnerability analysis requires careful attention to the assumptions and choices of indicators and models used, particularly where multiple indicators of each component are used