



ARC Centre of Excellence
Coral Reef Studies

Vulnerability of coastal communities to key
impacts of climate change on coral reef
fisheries

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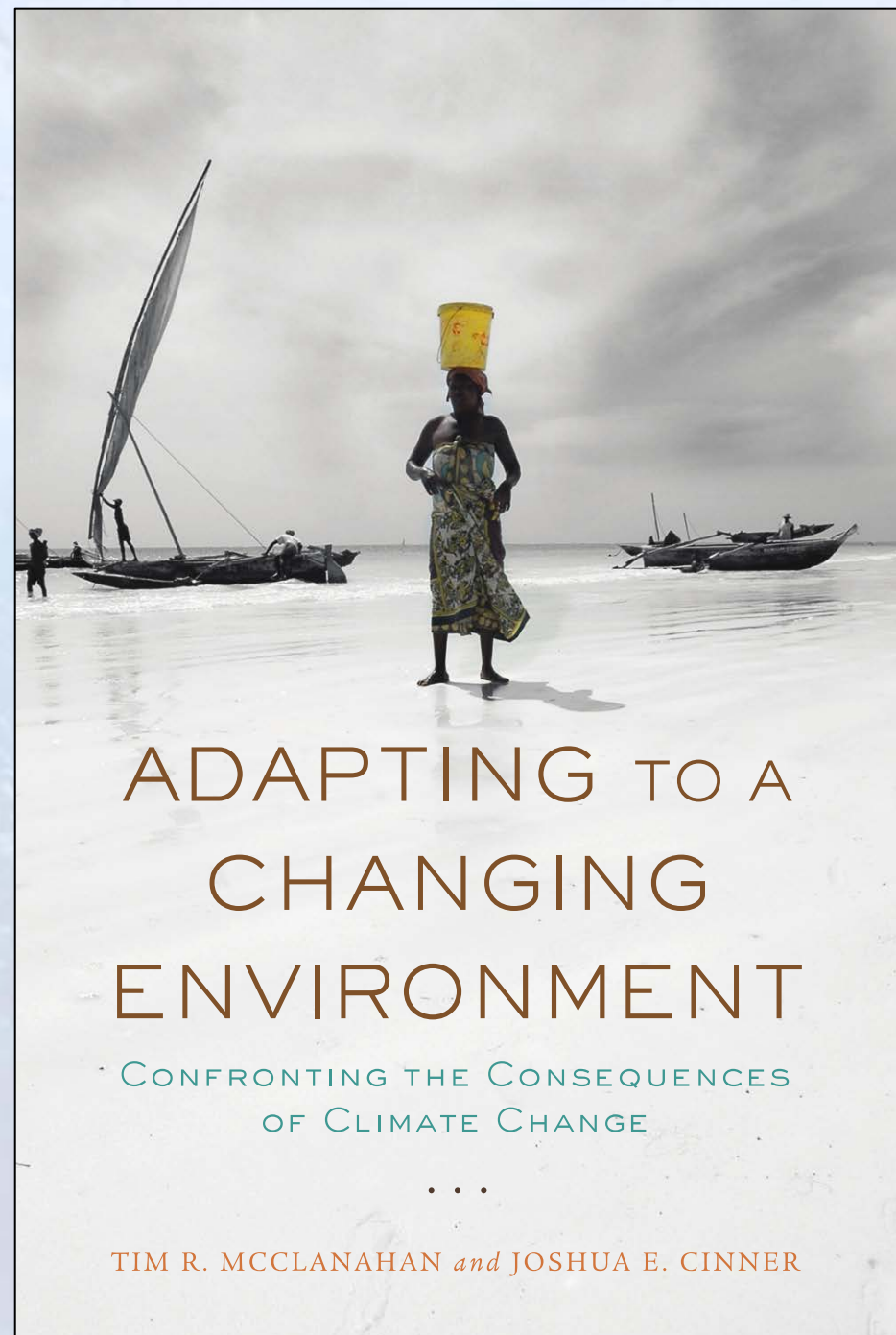
www.coralcoe.org.au

T. McClanahan, N. Graham, T. Daw, C. Folke, C. Hicks, J. Maina, M. Pratchett, S. Wilson

OUTLINE

**Operationalizing the vulnerability of
fishing communities to impacts from
coral bleaching**

**Key linkages and feedbacks with
ecology**



Introduction

Coral reefs provide critical goods & services:

- » Fishing
- » Coastal protection
- » Tourism
- » Aesthetic and spiritual values



Climate change = key threat to coral reefs and marine fisheries

- SST, OA impacting coral reefs and people that depend on them

How are reef-dependant societies being affected by, and what capacity do they have to adapt to climate change impacts?

Vulnerability

The degree to which a system is susceptible to, and unable to cope with the adverse effects of a chronic or stochastic disturbance

Varies across spatial & temporal scales, & for different people within a society

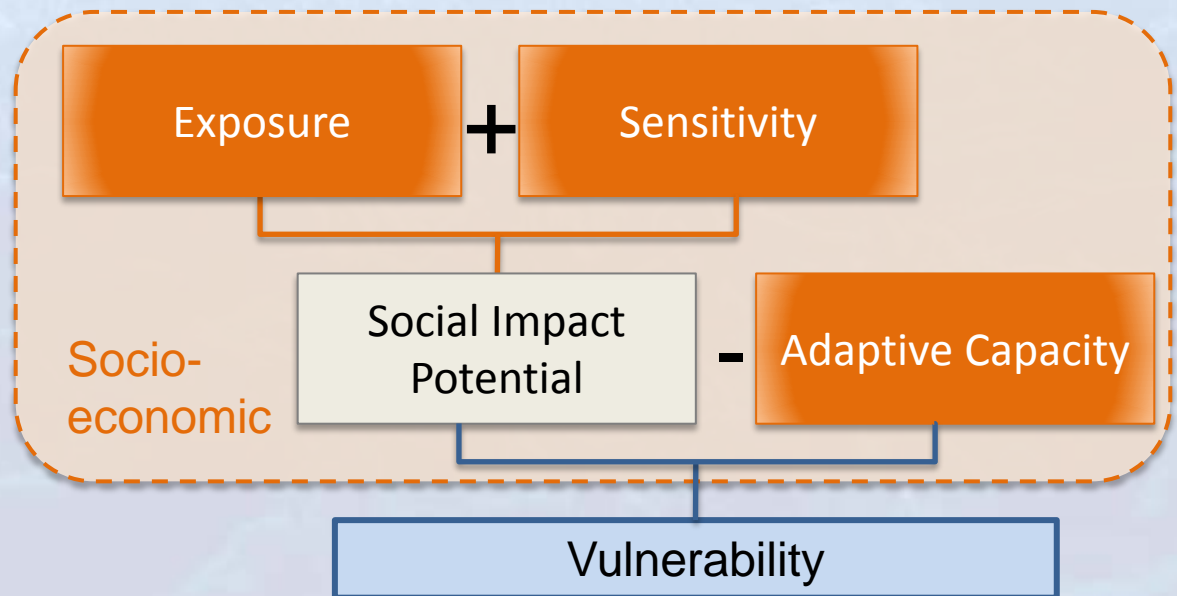
Few studies on vulnerability in the context of changes specific to coral reef ecosystems



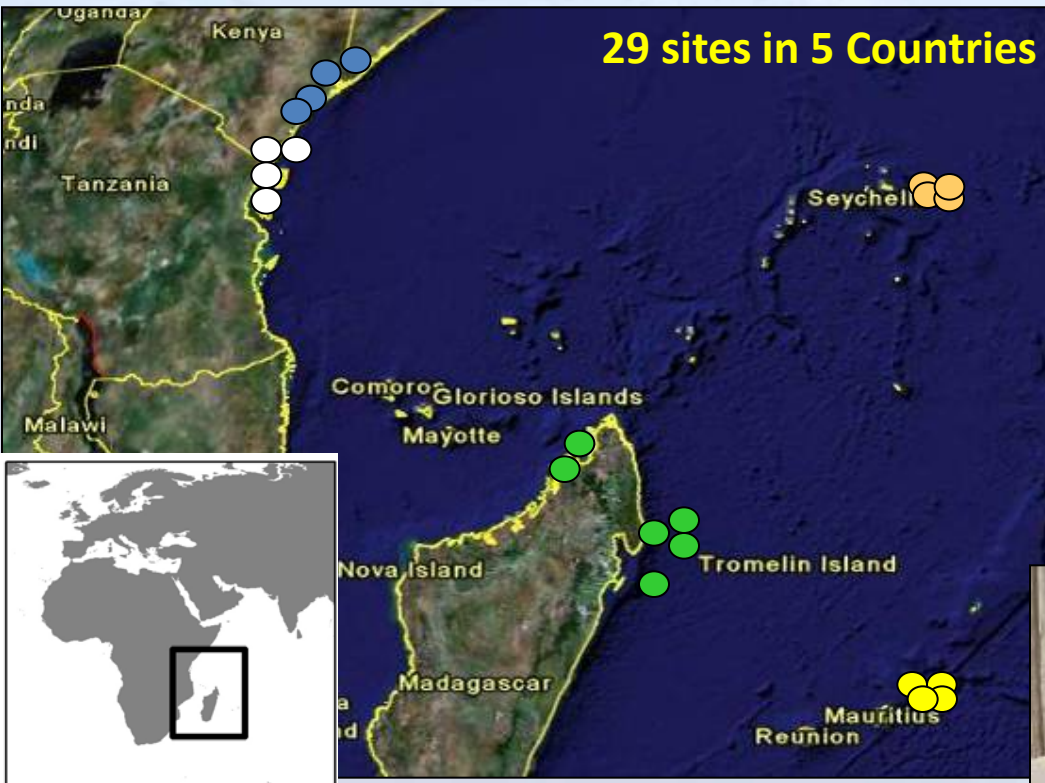
Vulnerability framework

$$V = (E + S) - AC$$

Ecological states
and processes ???



Operationalizing the vulnerability of coastal communities to the impacts of coral bleaching on reef fisheries



Millions of people depend on reef resources

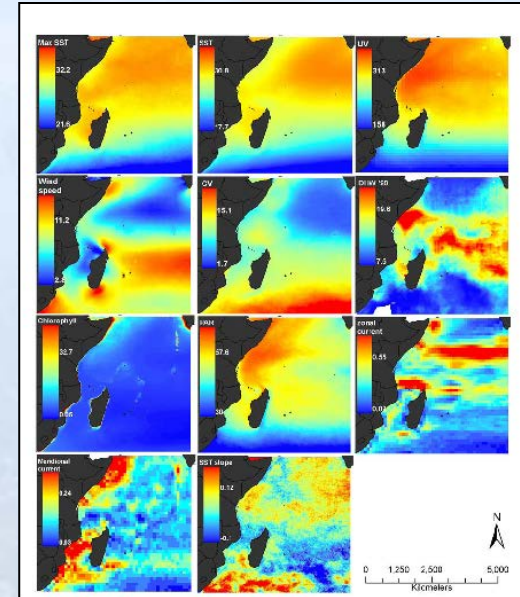
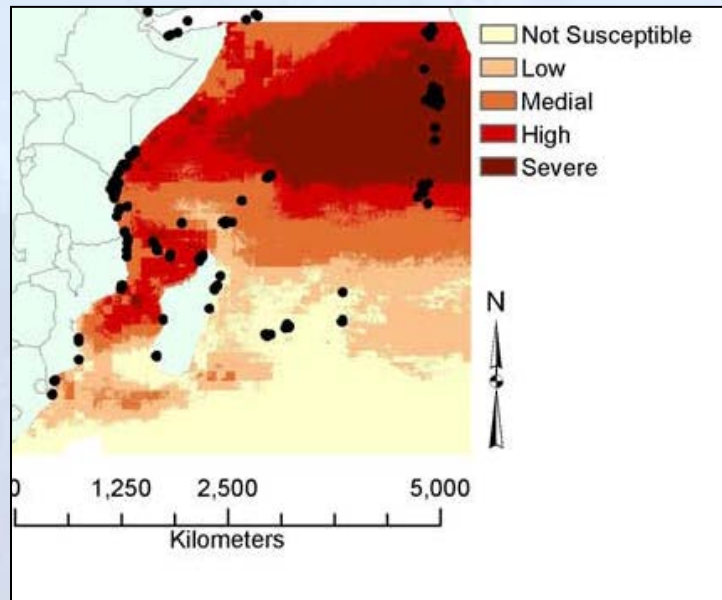
Coral reefs extensively damaged by 1998 bleaching (up to 95% mortality)



Operationalizing Exposure

Exposure = degree to which a system is stressed by climatic events and environmental conditions (Cutter 1996 *Prog. Hum. Geogr.*, Adger 2006 *Glob. Env. Ch.*)

Synthesized
into a single
exposure
model



Developed region-wide model of susceptibility to coral bleaching

- sea surface temperature
- photosynthetically active radiation [PAR]
- ultraviolet radiation [UV]
- chlorophyll
- surface currents
- wind velocity
- in situ coral bleaching data for 216 sites collected between 1998 and 2005

(Maina et al. 2008 *Ecological Modeling*)

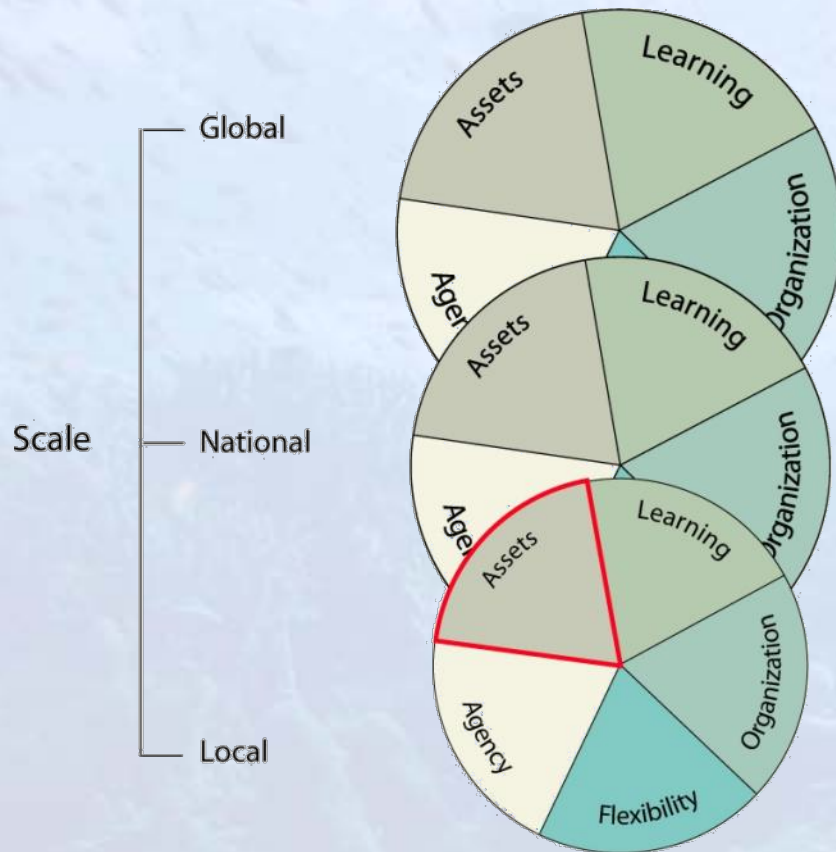
Operationalizing Adaptive Capacity

Preconditions that enable adaptation to change

Adaptive Capacity = the ability of households to anticipate and respond to changes in coral reef ecosystems and fisheries, and to minimize, cope with, and recover from the consequences

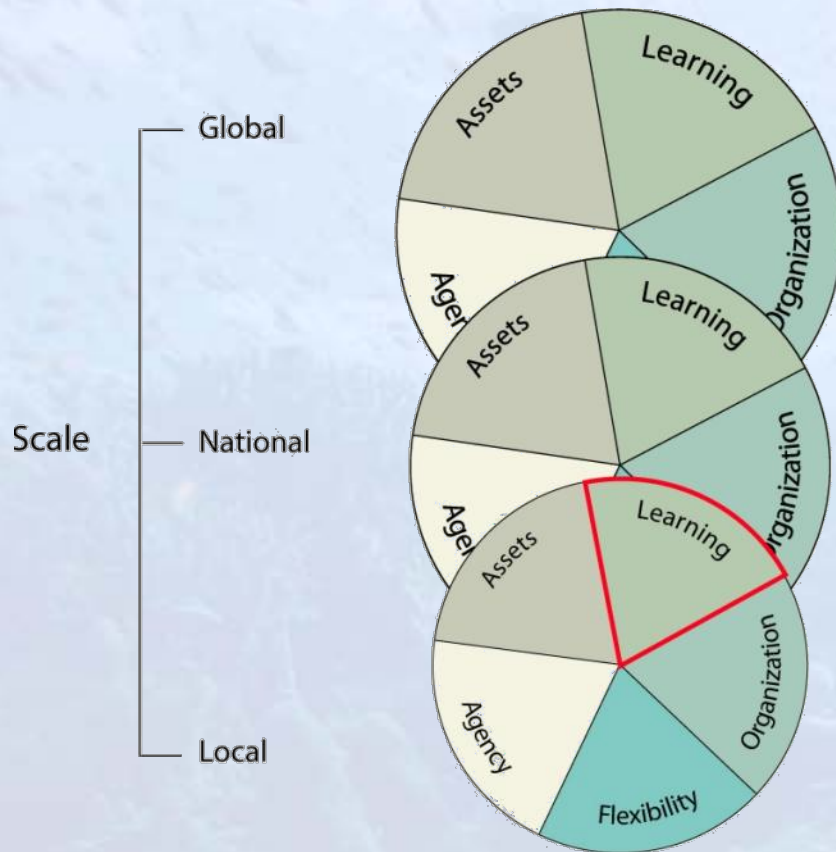


Operationalizing Adaptive Capacity



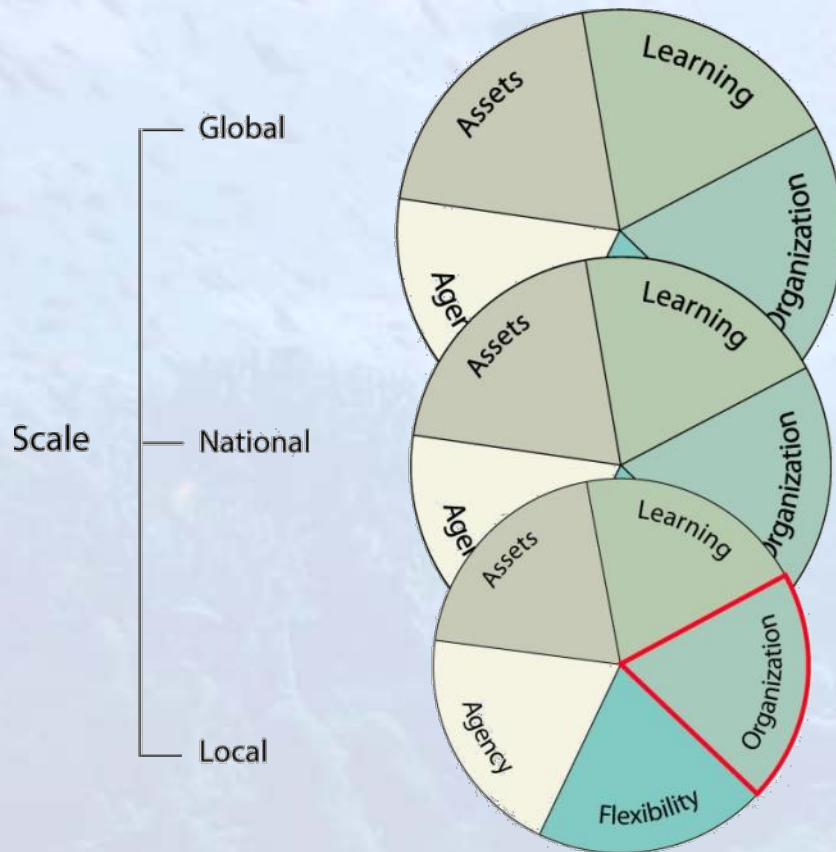
1) the **assets** that can be drawn upon in times of need,

Operationalizing Adaptive Capacity



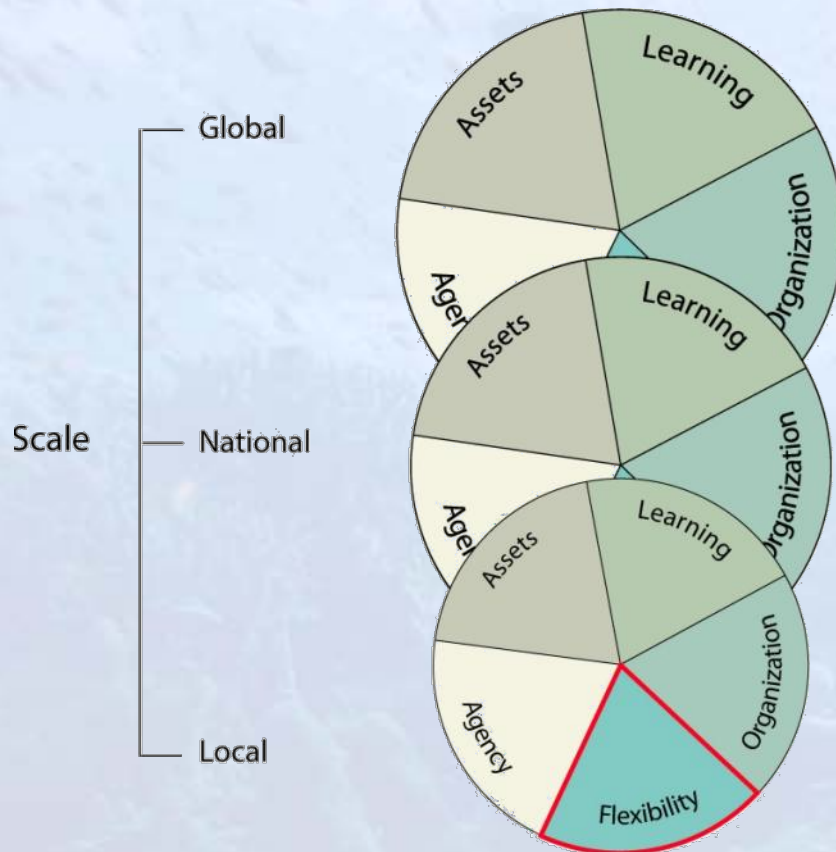
- 1) the assets that can be drawn upon in times of need,
- 2) **learning** to recognize change, attribute this change to their causal factors, and assess potential response strategies,

Operationalizing Adaptive Capacity



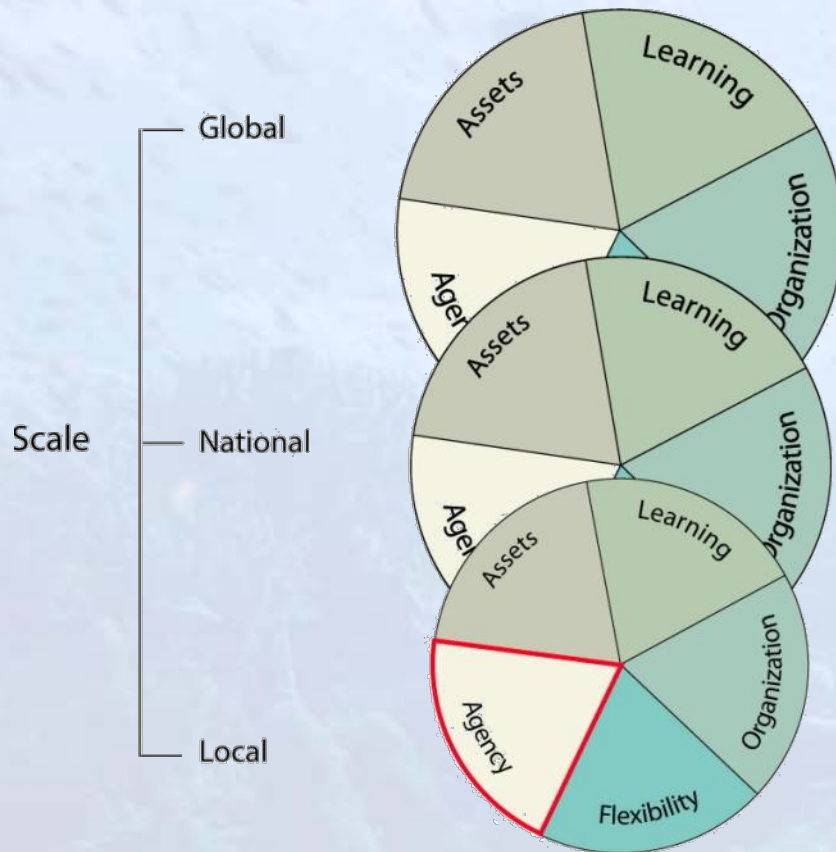
- 1) the assets that can be drawn upon in times of need,
- 2) learning to recognize change, attribute this change to their causal factors, and assess potential response strategies,
- 3) a society's ability to **organize** and act collectively,

Operationalizing Adaptive Capacity



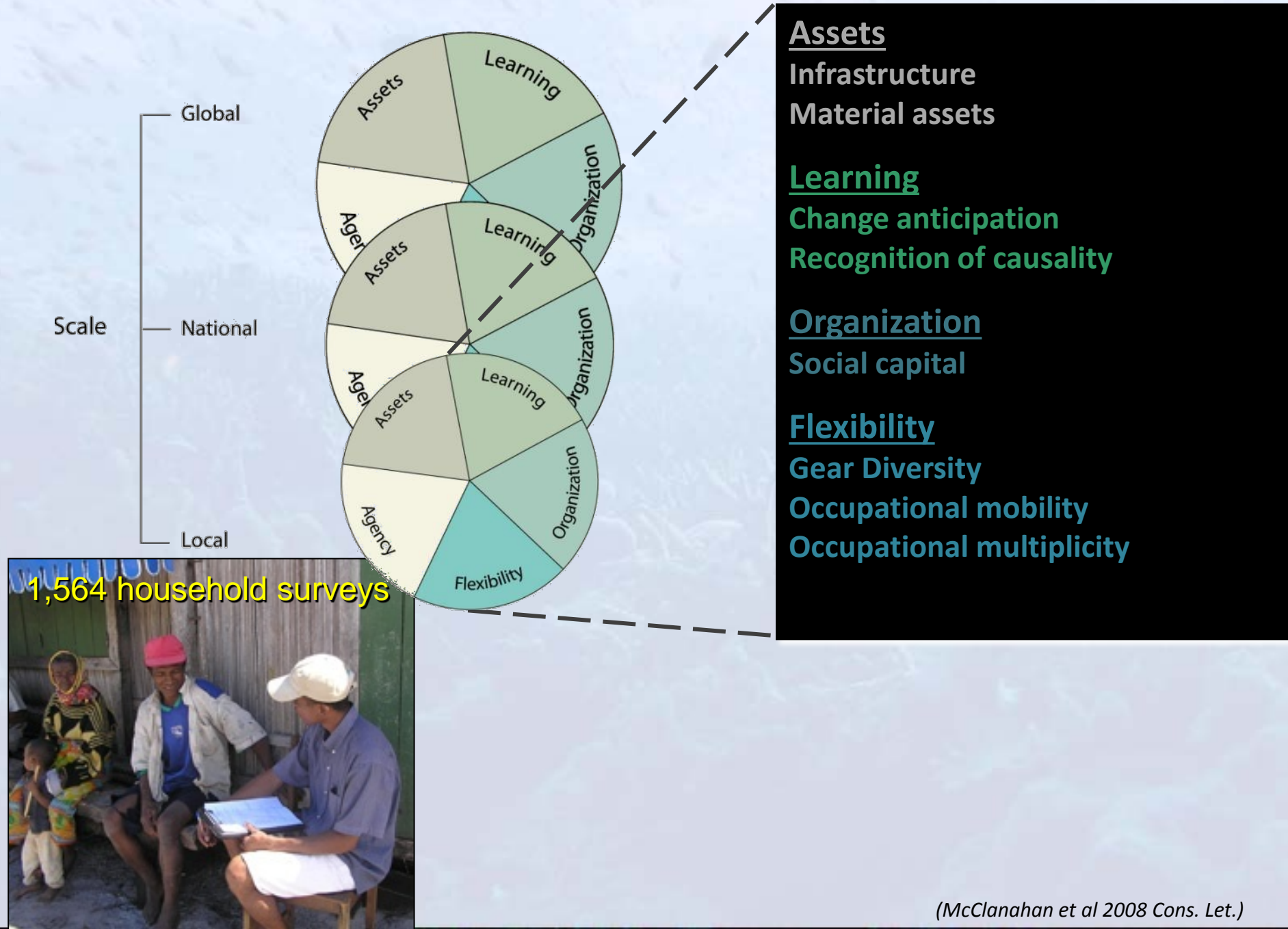
- 1) the assets that can be drawn upon in times of need,
- 2) learning to recognize change, attribute this change to their causal factors, and assess potential response strategies,
- 3) a society's ability to organize and act collectively,
- 4) the **flexibility** to change strategies, and

Operationalizing Adaptive Capacity

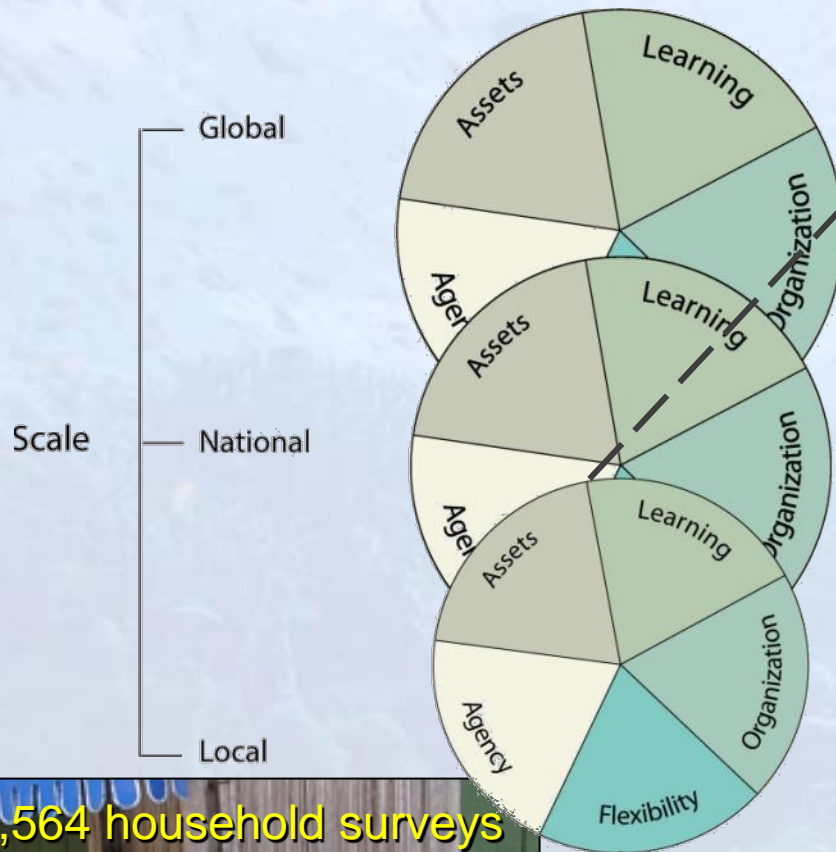


- 1) the assets that can be drawn upon in times of need,
- 2) learning to recognize change, attribute this change to their causal factors, and assess potential response strategies,
- 3) a society's ability to organize and act collectively,
- 4) the flexibility to change strategies, and
- 5) the **agency** to determine whether to change or not

Operationalizing Adaptive Capacity



Operationalizing Adaptive Capacity



Assets

Infrastructure x 0.12

Material assets x 0.15

Learning

Change anticipation x 0.11

Recognition of causality x 0.10

Organization

Social capital x .10

Flexibility

Gear Diversity x 0.13

Occupational mobility x 0.19

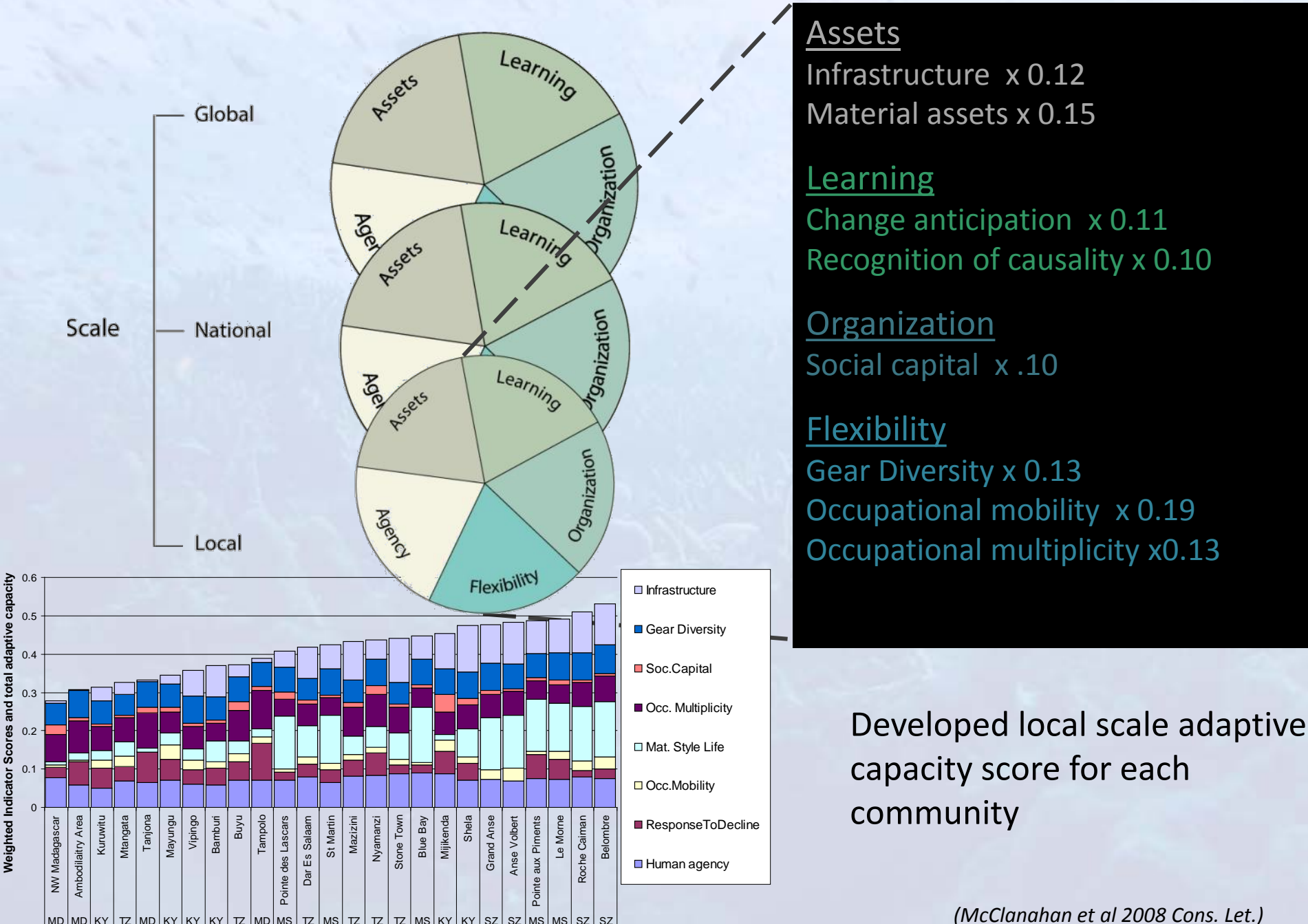
Occupational multiplicity x 0.13

1,564 household surveys



Used expert opinion of local and international social scientists to weight indicators

Operationalizing Adaptive Capacity



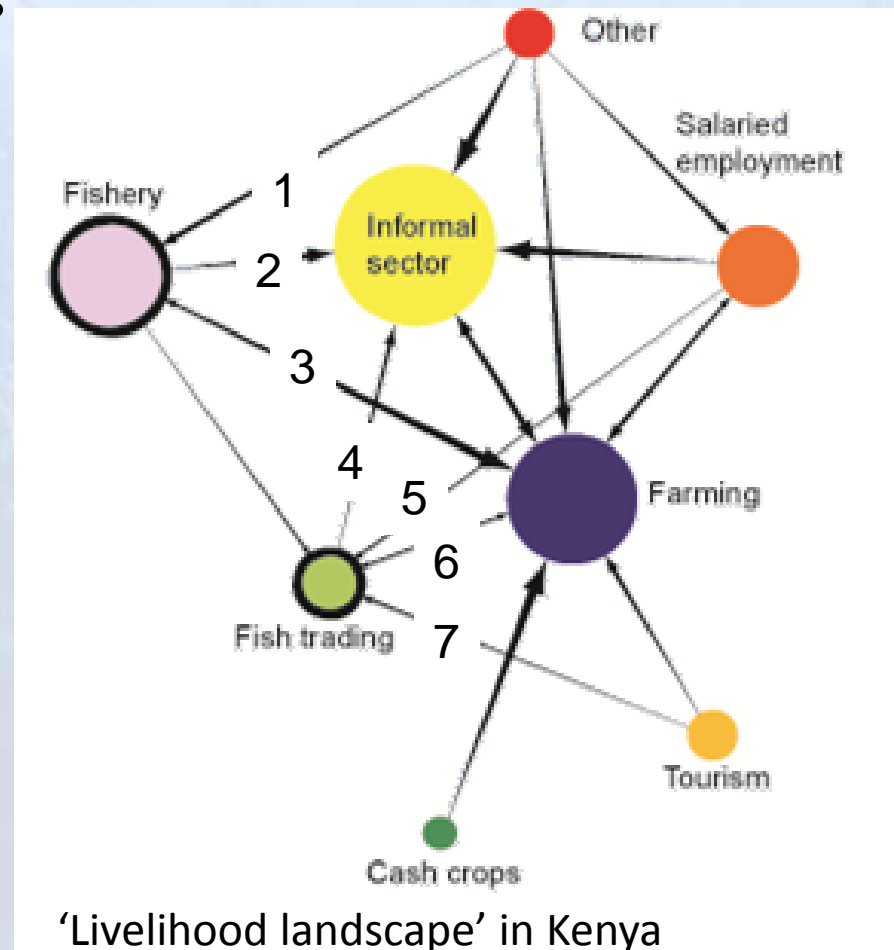
Operationalizing Sensitivity: a livelihoods landscape approach

Sensitivity = state of susceptibility to harm from perturbations or long-term trends

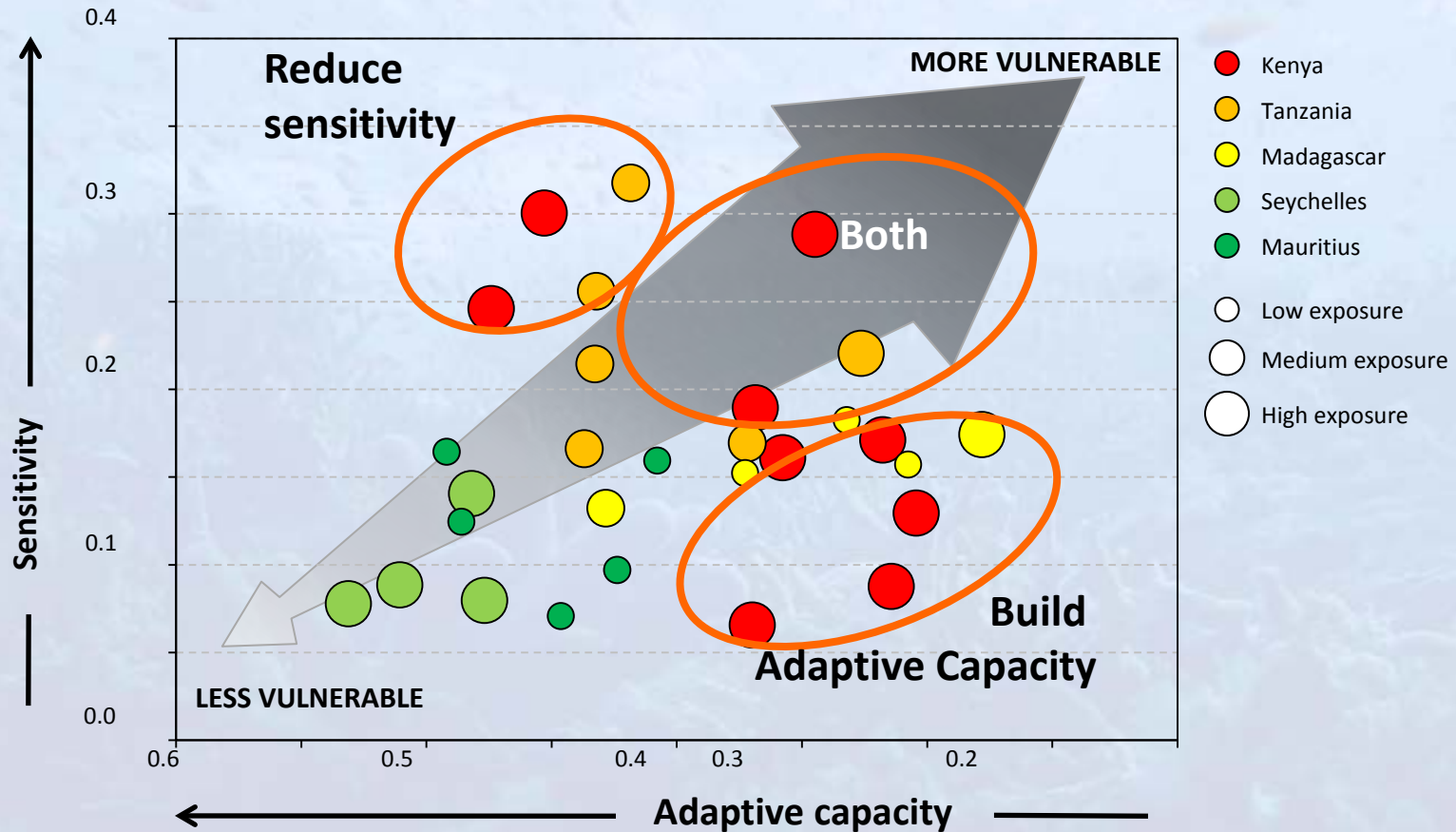
Can be affected by levels of dependence on natural resources and the technologies used to harvest resources

Novel network-based approach that incorporates:

- ✓ **Proportion** of households engaged in fisheries (*Size of bubble*)
- ✓ **Linkages** between sectors = whether these households also engage in non-fisheries occupations- (*presence and thickness of arrows*)
- ✓ **Directionality** of these linkages Direction of arrows (*based on ranking of occupations by households*)



The vulnerability of coastal communities to the impacts of coral bleaching on reef fisheries



National averages: $\text{Vulnerability} = (\text{exposure} + \text{sensitivity}) - \text{adaptive capacity}$

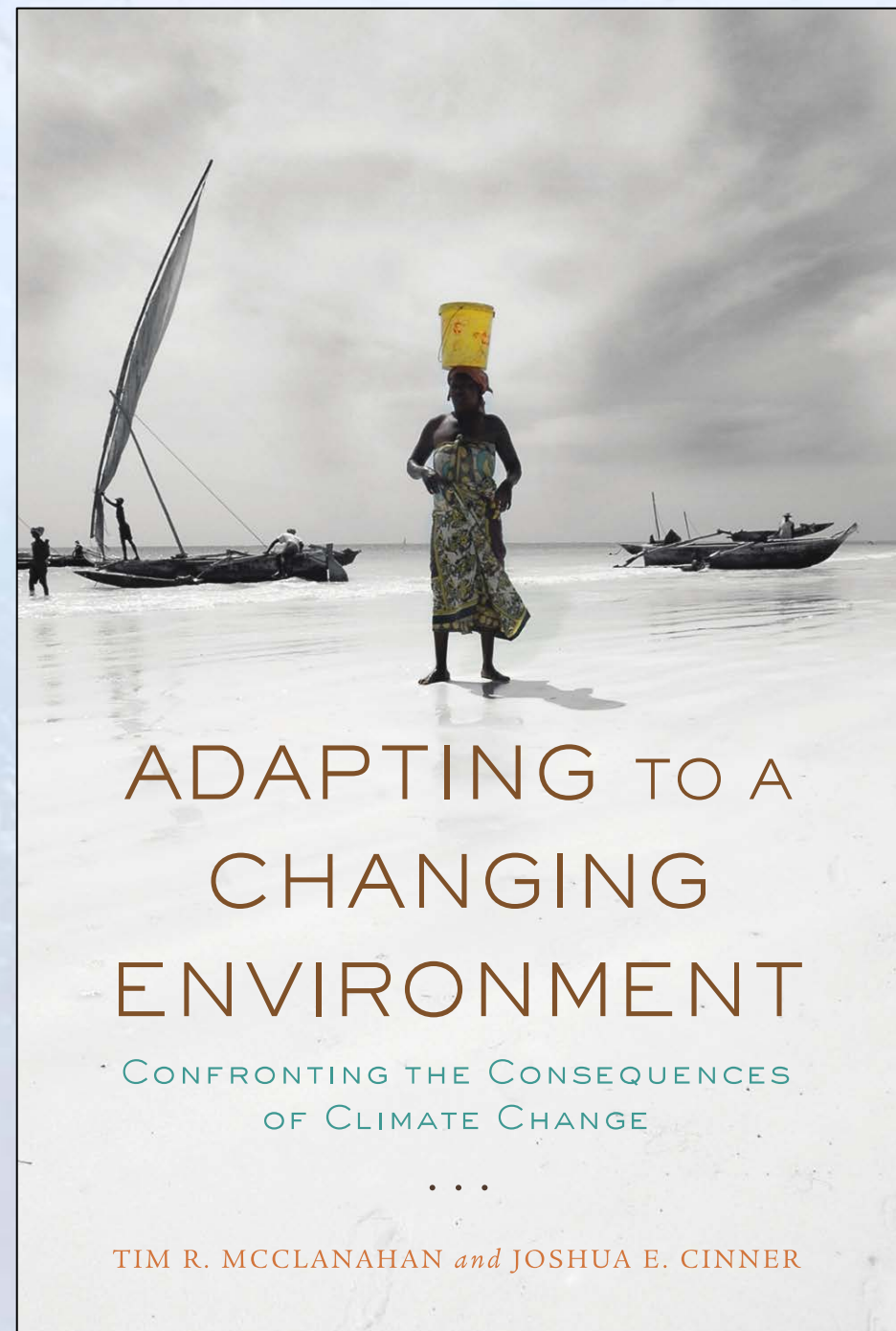
Can visualize which aspects of vulnerability are priorities for policy actions

OUTLINE

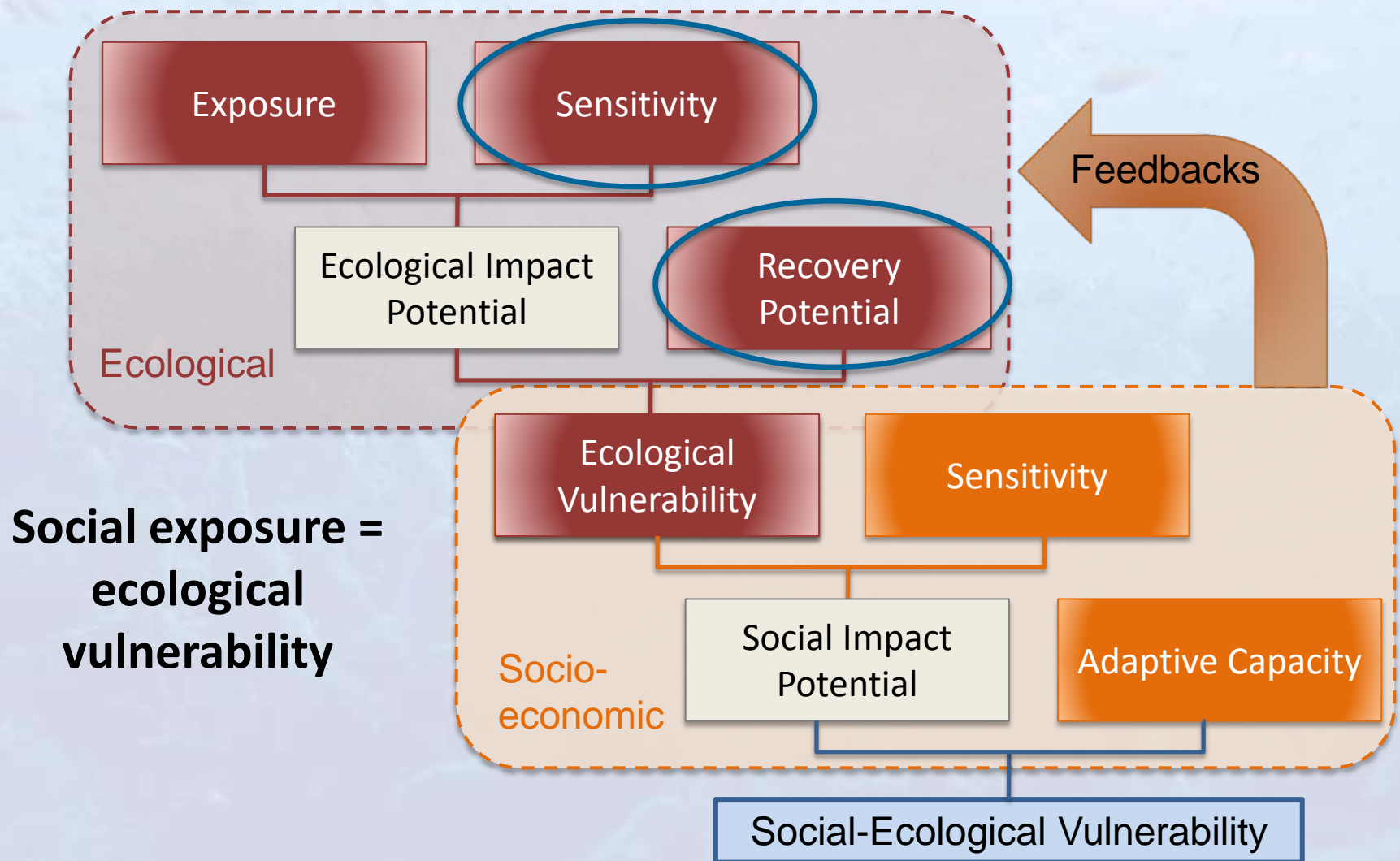
Operationalizing vulnerability of fishing communities in WIO to impacts from coral bleaching

- Exposure
- Sensitivity
- Adaptive capacity

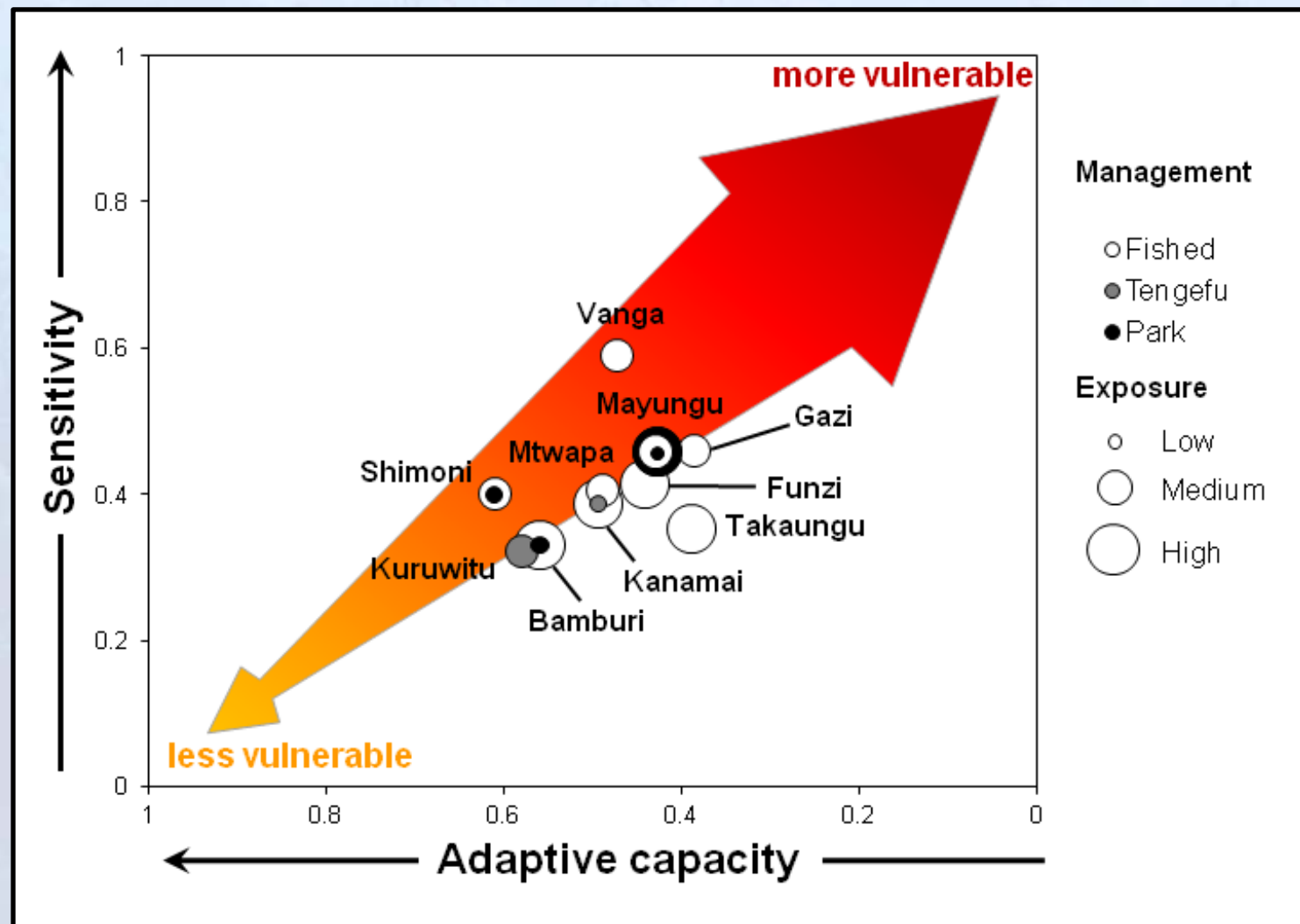
Key linkages and feedbacks with ecology



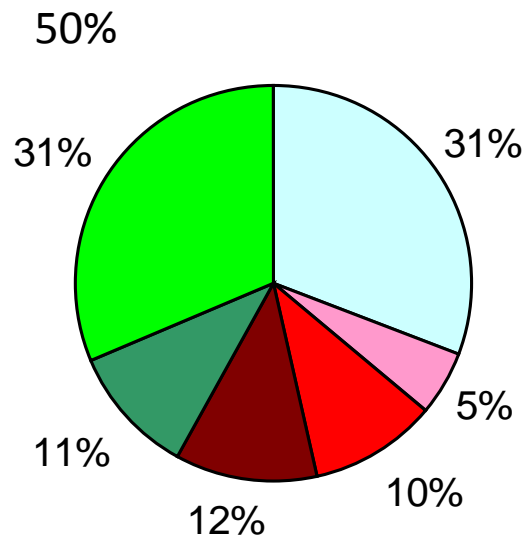
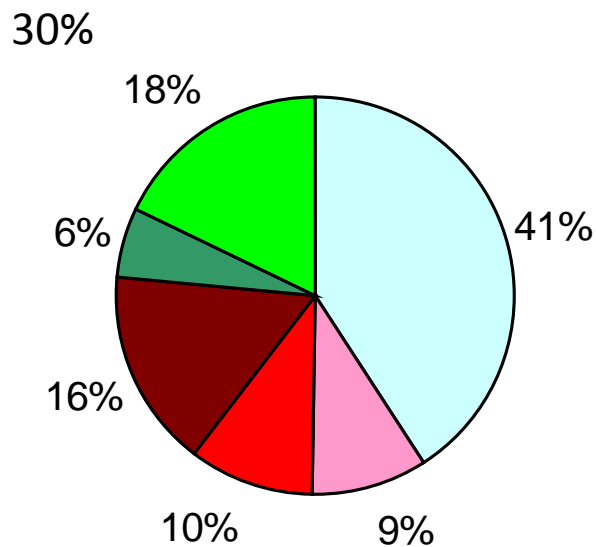
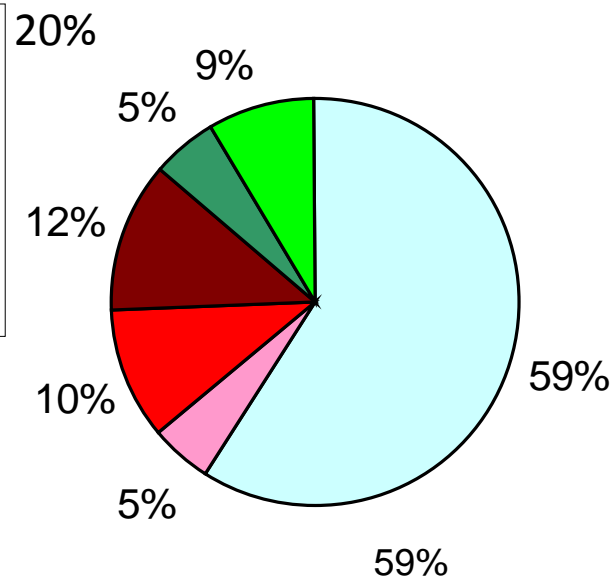
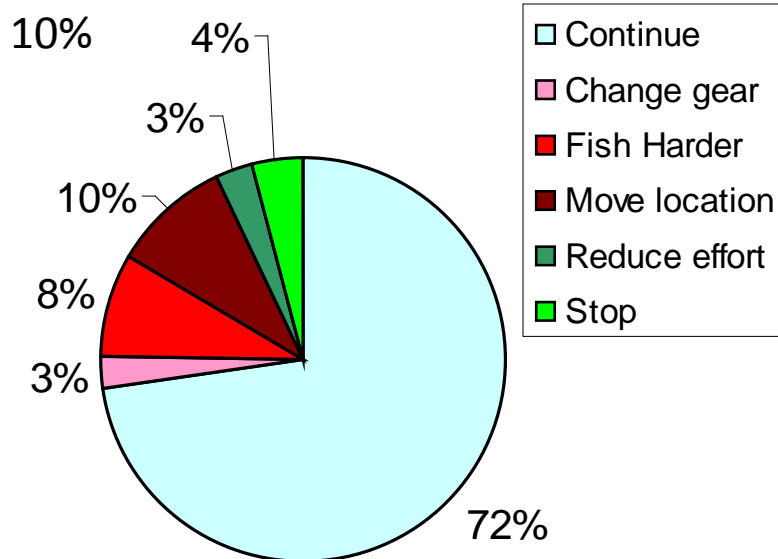
Social-Ecological Vulnerability



Social-Ecological Vulnerability



Social-ecological linkages: fishers' response to decline



From Kenya, Tanzania, Madagascar, Mauritius, Seychelles (N=570)

Social-ecological linkages: ratcheting down the fishery

- 70% effort on remaining 50% of fish (140%)

- Adding gear is 'permanent', while reduction is temp

Mostly reef-related:
Handline
Octopus & sea cuc.
Change vessel
Trap
Fish illegally

□ Continue

□ Change gear

■ Fish Harder

■ Move location

■ Reduce effort

■ stop

47%

Often adding gears
(more net, more traps)

87kms (stdev 67)

37%

Often seen as temporary
(timeframe of months)

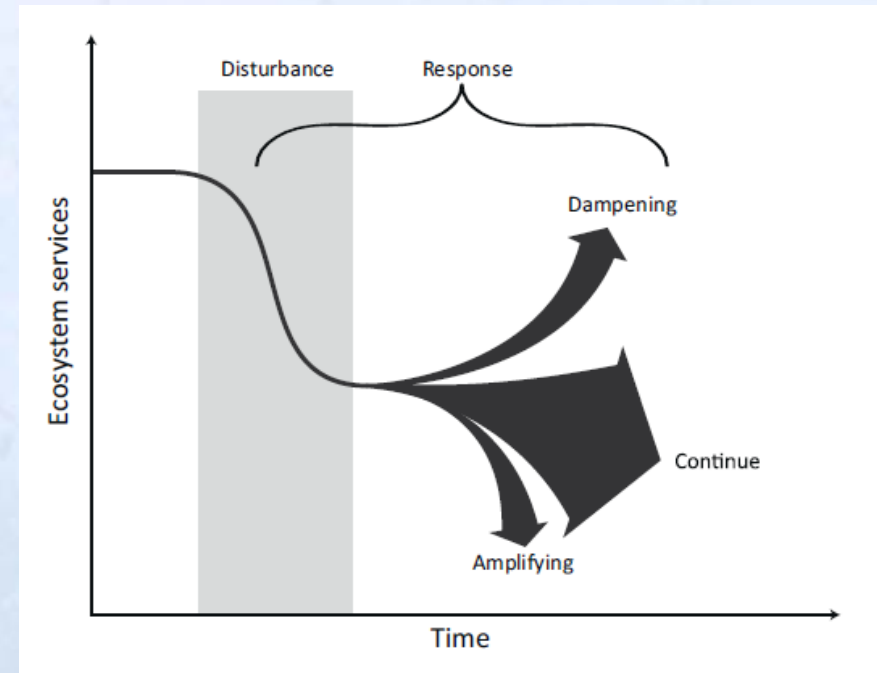


From Tanzania (N=240)

(Cinner et al. 2011. Global
Env. Change)

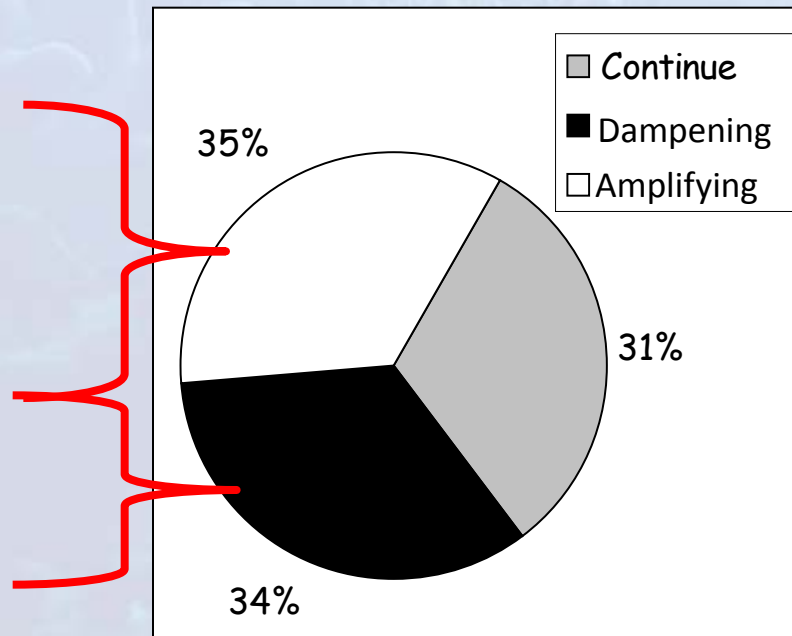
Social-ecological linkages

- **Amplifying** feedbacks- extenuate negative trends
- **Dampening** feedbacks- negative trends mitigated by decreasing fishing pressure



- Continue
- Change gear
- Fish Harder
- Move location
- Reduce effort
- stop

From Tanzania (N=240)

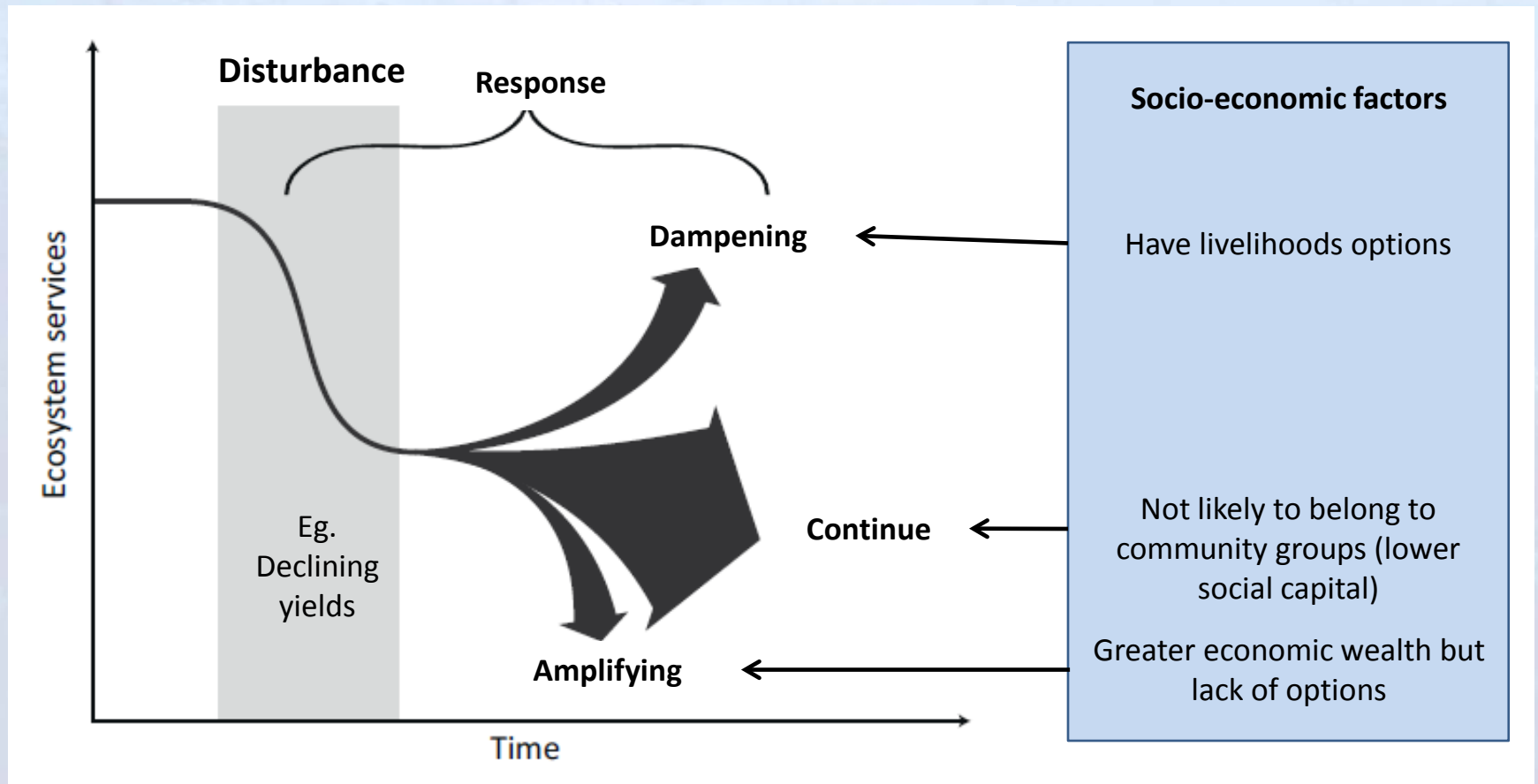


- 48% of fishers using dampening response would first use amplifying response

(Cinner et al. 2011. Global Env. Change)

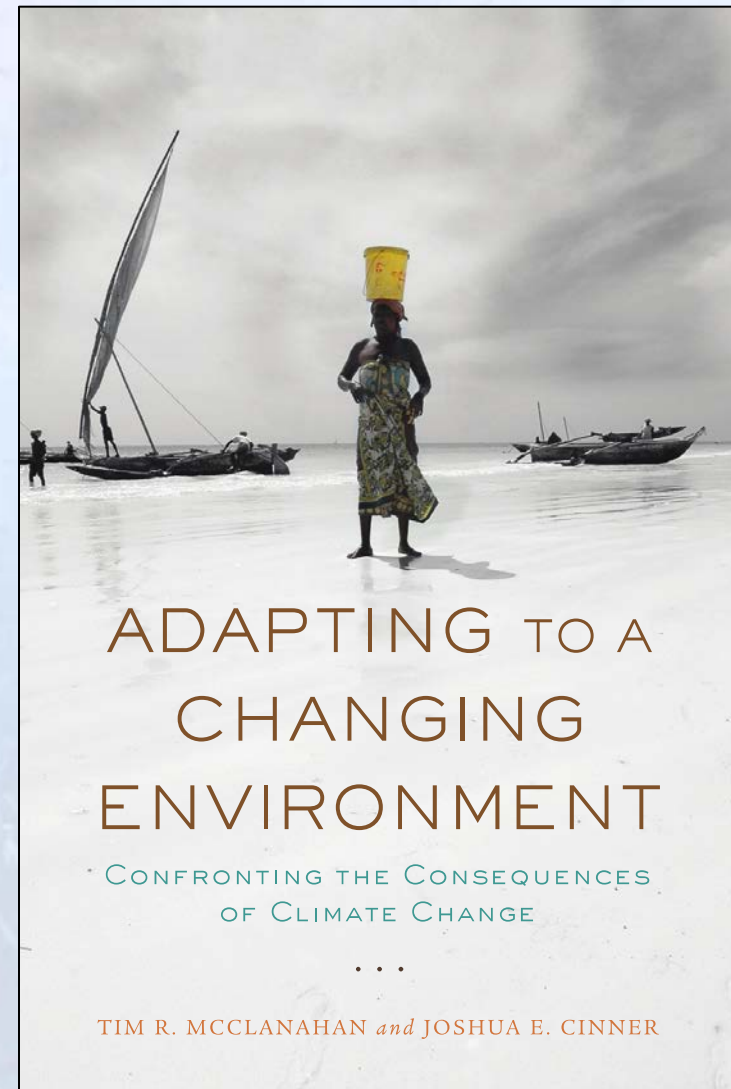
Social-ecological linkages

- Key components of adaptive capacity influence responses
- Opportunities to build dampening adaptive capacity?



Conclusions

- Unpacking concepts to determine where sources of vulnerability lie
- Consideration of key social-ecological linkages-
 - Novel vulnerability metrics
 - Is it possible to build 'dampening' adaptive capacity?



This research was supported by the Western Indian Ocean Marine Science Association,
& the Australian Research Council

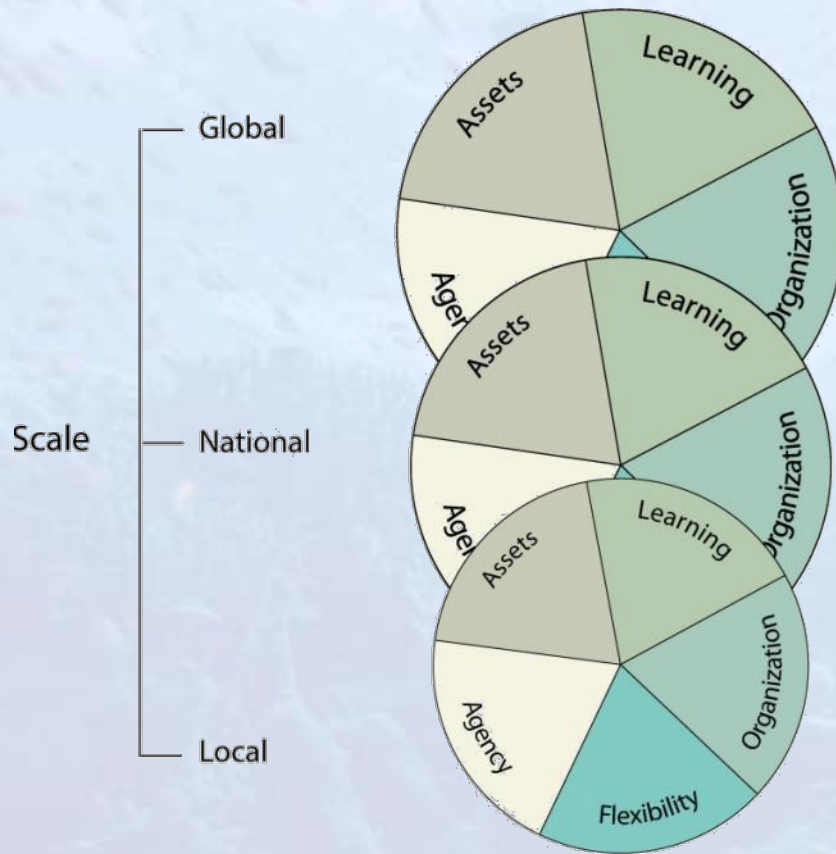


Thank you



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Building adaptive capacity



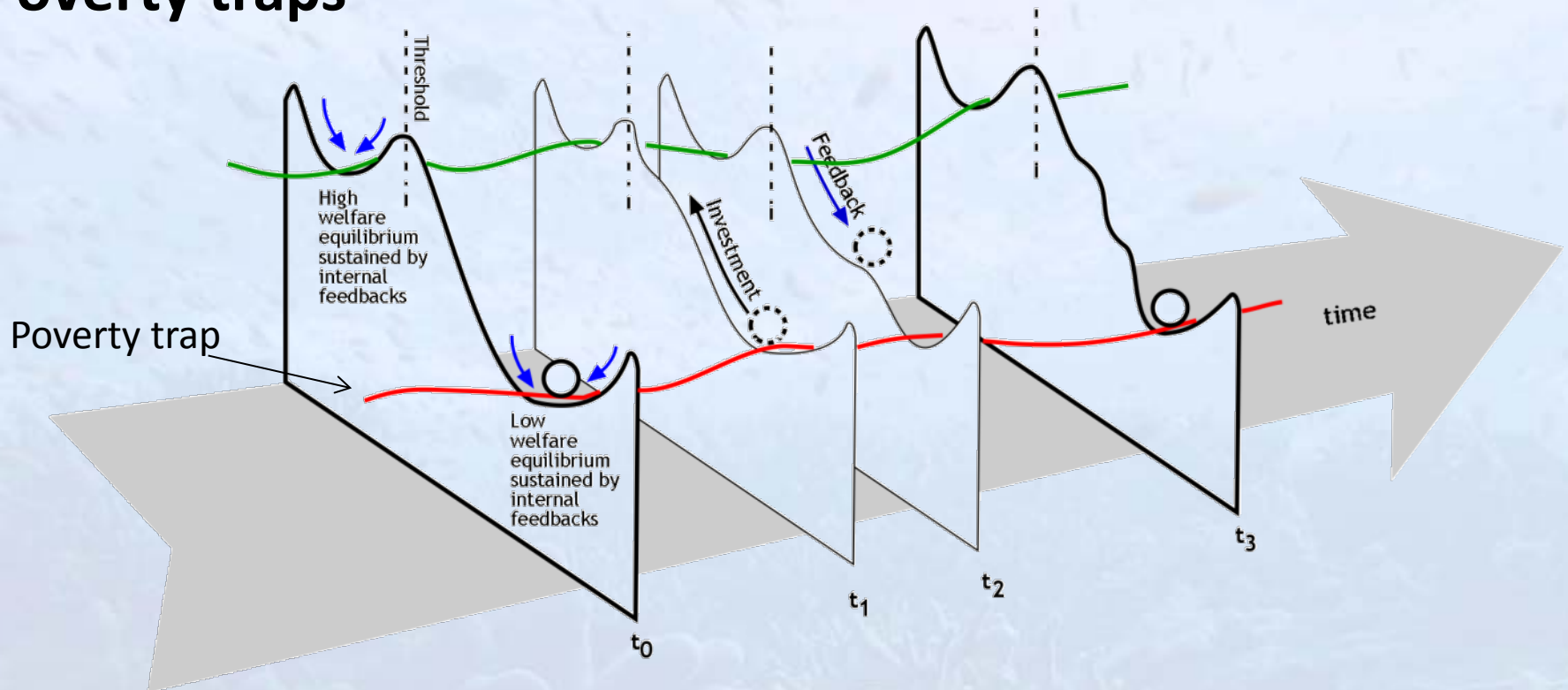
At the local scale, building adaptive capacity often overlaps with key components of sustainable development:

- poverty reduction,
- improving literacy,
- adding value to products,
- good governance

No blueprints: Not every community will need the same aspects of adaptive capacity enhanced

- May already have diverse livelihood portfolios or effective governance
- Attempts to diversify or strengthen governance, may have low marginal returns, be futile, or undermine existing sources of resilience

Poverty traps



Poverty trap- Poor people are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations

Agricultural economics literature explores how both risk-taking and behavior are very different in these two states.

In Kenya, poorer fishers feel trapped and use destructive gear

1. Operationalizing sensitivity

Sensitivity equation

(Cinner et al. in review *Global Env. Change*)

$$S = \frac{F}{(F + NF)} \times \frac{N}{(F + NF)} \times \frac{\left(\frac{r_{fn}}{2} + 1\right)}{(r_{fn} + r_{nf} + 1)}$$

S = sensitivity

F = number of households relying on fishery-related occupations

NF = number of households relying on non-fishery-related occupation

N = Number of households

r_{fn} = The number of times fisheries related occupations were ranked higher than non-fishing occupations (normalized by the number of households)

r_{nf} = The number of times non-fisheries related occupations were ranked higher than fishery occupations (normalized by the number of households).