

# A Conceptual and Methodological Framework for Studying Sustainability of CHES

and its Applications in the Poyang Lake Region of China

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## General Goals:

- Advance sustainability science by (i) concretizing and quantifying sustainability from the perspective of **CHES**, guided by the science of complexity, and (ii) proposing analyses useful for achieving sustainability and methodologies for implementing these analyses;
- Mainstream climate change into development by (i) including human adaptation into the broader sustainable development agenda, and (ii) integrating useful ideas from vulnerability analysis with a larger framework of sustainability.

## Theoretical Background: The Science of Complexity

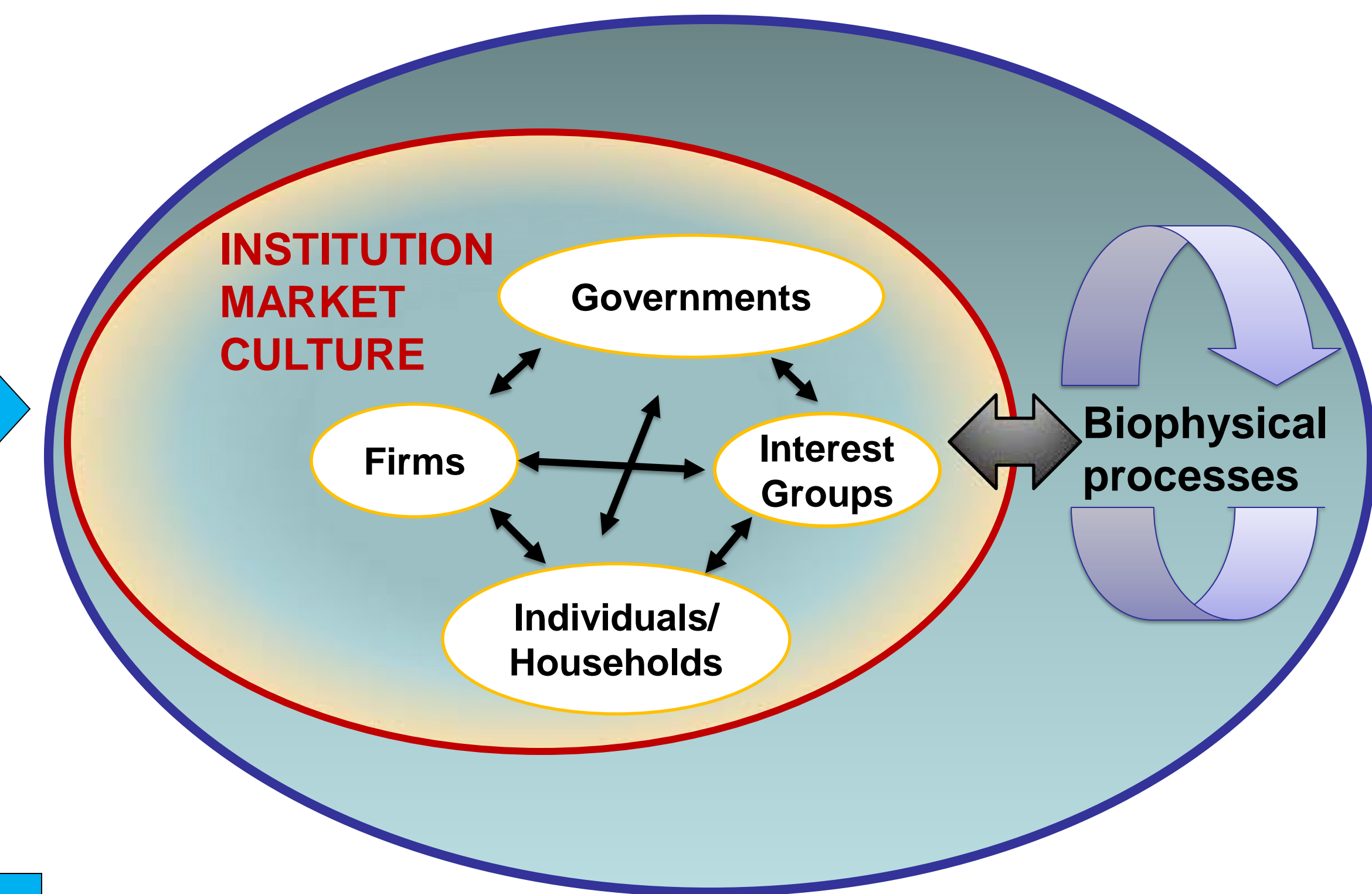
### Systems Dynamics:

- Use multiple system-level variables to represent the state
- Explain the dynamics by interconnected changes of these variables
- Differential equations & **mathematics**

### Complex Adaptive Systems (CAS)

- Explain global patterns by the actions and interactions of the agents at the micro level
- **Agent-based & network modeling**

### Coupled Human-Environment Systems (**CHES**)



## What is Sustainability?

**SUSTAINABILITY**

IS

a Global Property of a **CHES**

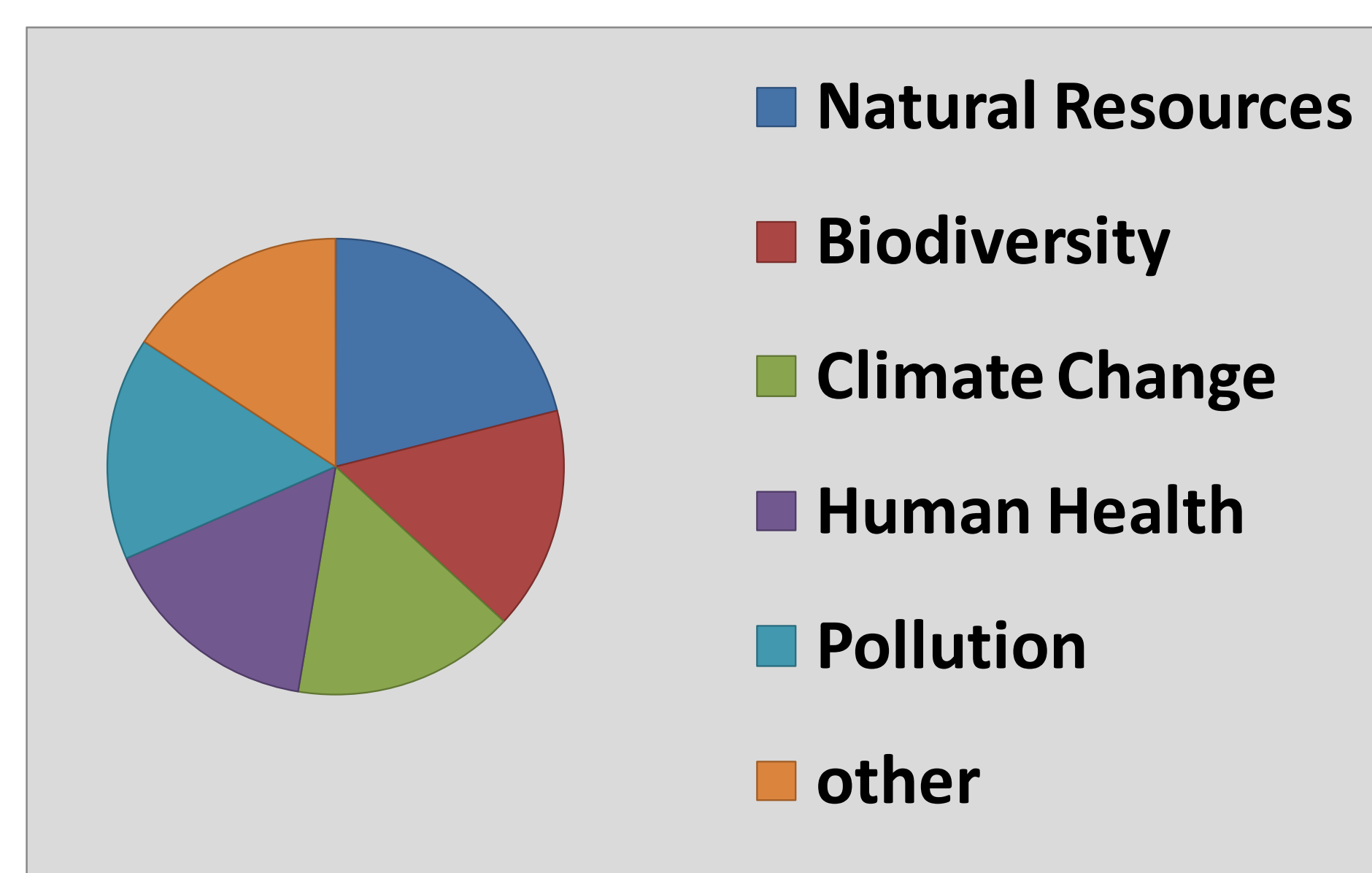
**EMERGENT** from

- ❖ the actions and interactions of multiple human players under the social-economical-political setting
- ❖ the biophysical processes of the environment
- ❖ the interactions between humans and the environment

**ESSENTIALLY** about

the **WELL-BEING** of a **CHES** in a **LONG** time horizon

## Multiple Dimensions of Sustainability



## A Conceptual Framework for Studying Sustainability in the Dimension of Climate Change/Variability

Two key concepts for characterizing sustainability of a CHES: **WELL-BEING** and **RESILIENCE**

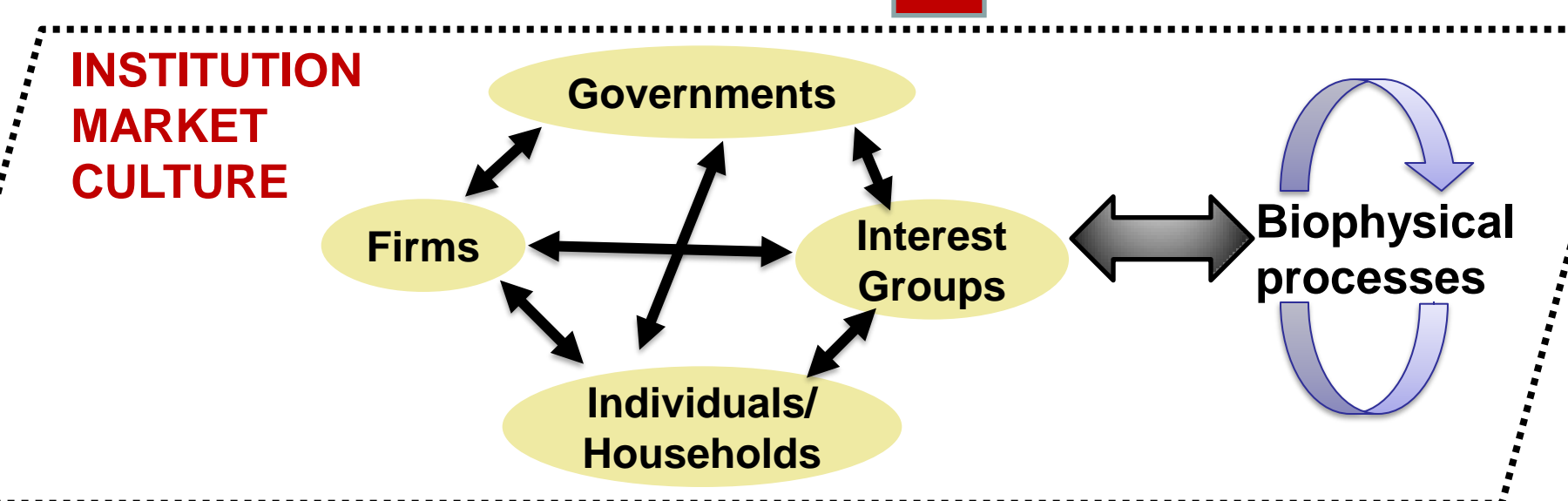
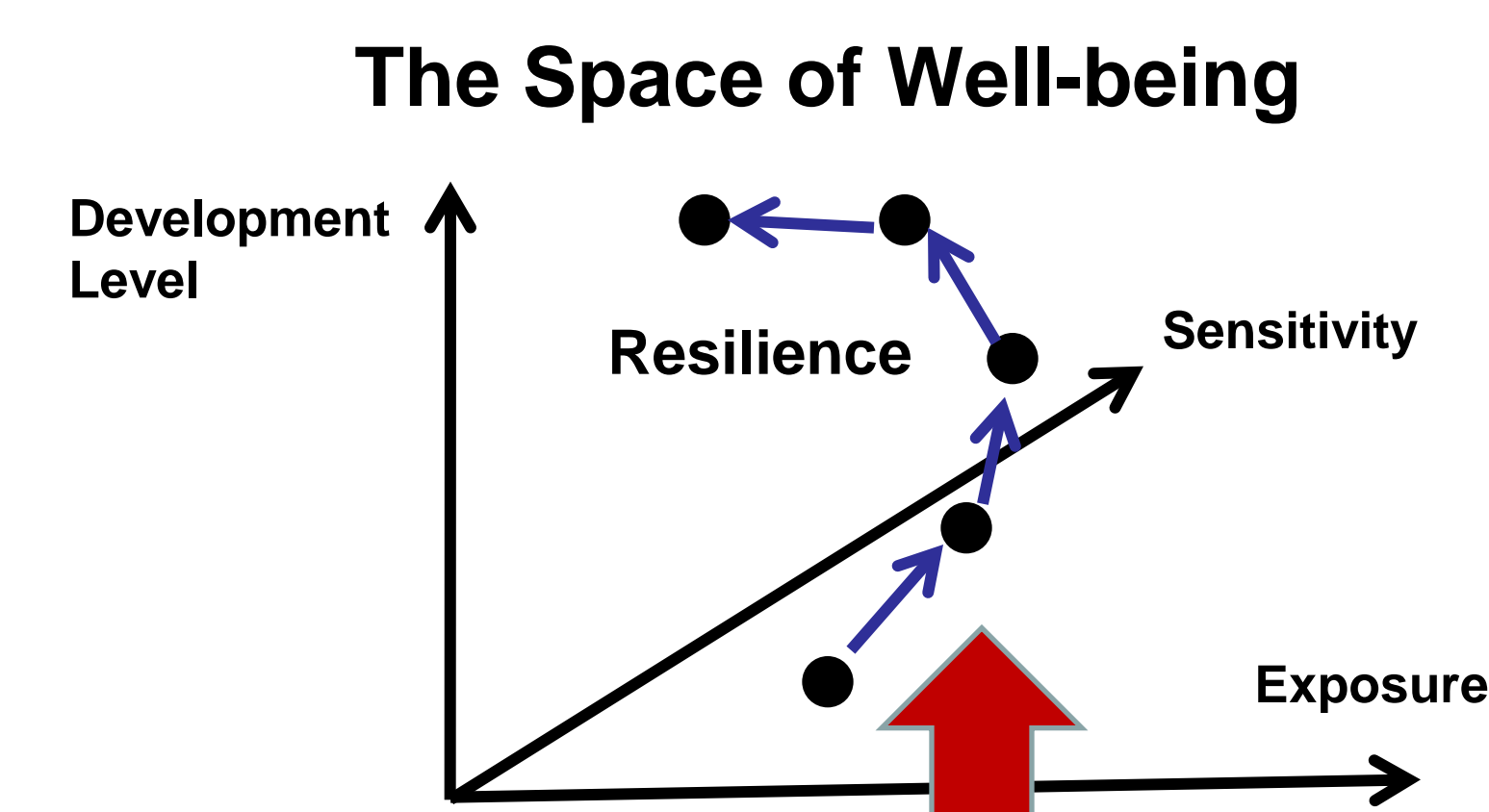
**Well-being** describes the state of a system at one point in time. **Resilience** describes the state of a system in the dynamic term.

A system is **RESILIENT** if it does not experience sudden transition between **CRITICAL** states (specified by thresholds of variables) in the face of social or environmental shocks.

A system is **SUSTAINABLE** if its development has reached a certain level, and it is resilient.

**Notes:**

- Exposure** of the human system to climate change/variability is determined by the environment;
- Development level** includes various aspects of development in economic achievement, education and health;
- Sensitivity** reflects how human development is affected by climate change/variability.



## Some Simplified States and Implications

Development	Exposure	Sensitivity	Implication
High	Low	Low	No problem
H	L	H	Stupid – needs to locate the sensitive part of the development and improve
H	H	L	Smart
H	H	H	Serious problem – need to seek for both engineering and “soft” measures to reduce sensitivity
L	L	L	Key issue is development, but make sure not to do stupid things
L	L	H	Key issue is development, also need to reduce sensitivity
L	H	L	Further develop, may need engineering work to keep sensitivity low
L	H	H	Worst case – migration away?

## Three Steps toward Sustainability

1. Figure out where the system is;
2. Understand how the actions and interactions of the agents in the system determine the current state and drive state change (*treating climate as one of many factors in the system that affect well-being*);
3. Explore the potential effects of alternative human behaviours and/or social-economic-political settings under various future scenarios (*including social and/or environmental changes*).

## Analyses and Implementations

1. Assessing well-being at large scales	<b>Remote Sensing</b> + GIS + social-economic data
2. Analyzing multi-source & multi-level causes of well-being	quantitative + qualitative analyses (surveys + interviews)
3. Predicting the future & exploring the dynamics of the system	agent-based model + network analysis + mathematics