Coastal Vulnerability

Development of a fast and efficient assessment tool

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ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Overview of Talk

- Define/describe vulnerability and related concepts
- Summary of literature regarding key lessons from vulnerability assessments
- Discuss habitat types of interest
- Compare vulnerability and impact assessment approaches
- Describe various frameworks for vulnerability assessment

Project Background

Proposed as a new EMRRP work unit – 2016

Reviewed current vulnerability assessment tools and scoped needs of USACE Districts – 2017

Developing the framework to build a tool to assist Districts during planning process - 2018

Purpose and Objectives

Purpose:

Is to develop a rapid tool to assess and relatively rank coastal areas as to their vulnerability to environmental stressors.

Objectives:

- **Incorporate important coastal habitat types;**
- **Ability to rapidly apply to coastal areas of North American;**
- **Assess the vulnerability and relatively rank areas of coastal habitat;**
- **Ability to assist in site selection of restoration and mitigation projects;**
- **Ability to clearly communicate relatively ranking of habitat areas;**
- **Scientifically justifiable and transparent.**

Image from DHI Group (https://blog.dhigroup.com/)

What is Vulnerability?

Defined as a system's ability to cope with adverse effects of stress or hazards (Bridges et al. 2015).

The system's ability to cope is further defined as absorbing the action of an environmental stressor (e.g., wave action, flooding, wind, etc.) without shifting into an alternative state (e.g., mud flat changed to open water).

Adverse effects are defined as a net negative impact to the system of interest, such as wind/wave action removing the natural vegetation layer.

Why Measure Coastal Vulnerability?

Coastal habitats provide vital environmental, economic and cultural services for a large percentage of North America's population. Coastal habitats provide critical support for terrestrial and marine plant and wildlife species as they in term support important economic (e.g., fisheries, aquaculture, etc.) activities.

Additionally, coastal habitats provide protection for human built infrastructure (e.g., houses, refineries, ports, etc.) from storm damages (e.g., wave action, flooding, wind, etc.)

The missions of the U.S. Army Corps of Engineers (USACE) includes reducing risk of damage related to storms and the restoration of aquatic natural habitat. These missions intersect at the coastline.

Intergovernmental Panel on Climate Change's (IPCC) Approach: Vulnerability

One definition, propensity of groups, systems, persons to suffer harm, (anticipate), cope with, resist and recover from impacts of CC and other stressors

Context (locality) specific (scale matters)

Depends on adaptive capacity, sensitivity and exposure to the impacts of CC, also related to the distribution of sources and prior stressors (history of group, system, …)

Key research issue: understanding its (social and natural) causal and internal dimensions (coping actions & recovery/resilience) (multiple disciplines)

IPCC's Approach: Adaptive Capacity

Ability of a "system" or group to evolve to accommodate CC or expand range of variability with which it can cope

Vector of resources and assets representing a resource to draw on to undertake adaptation

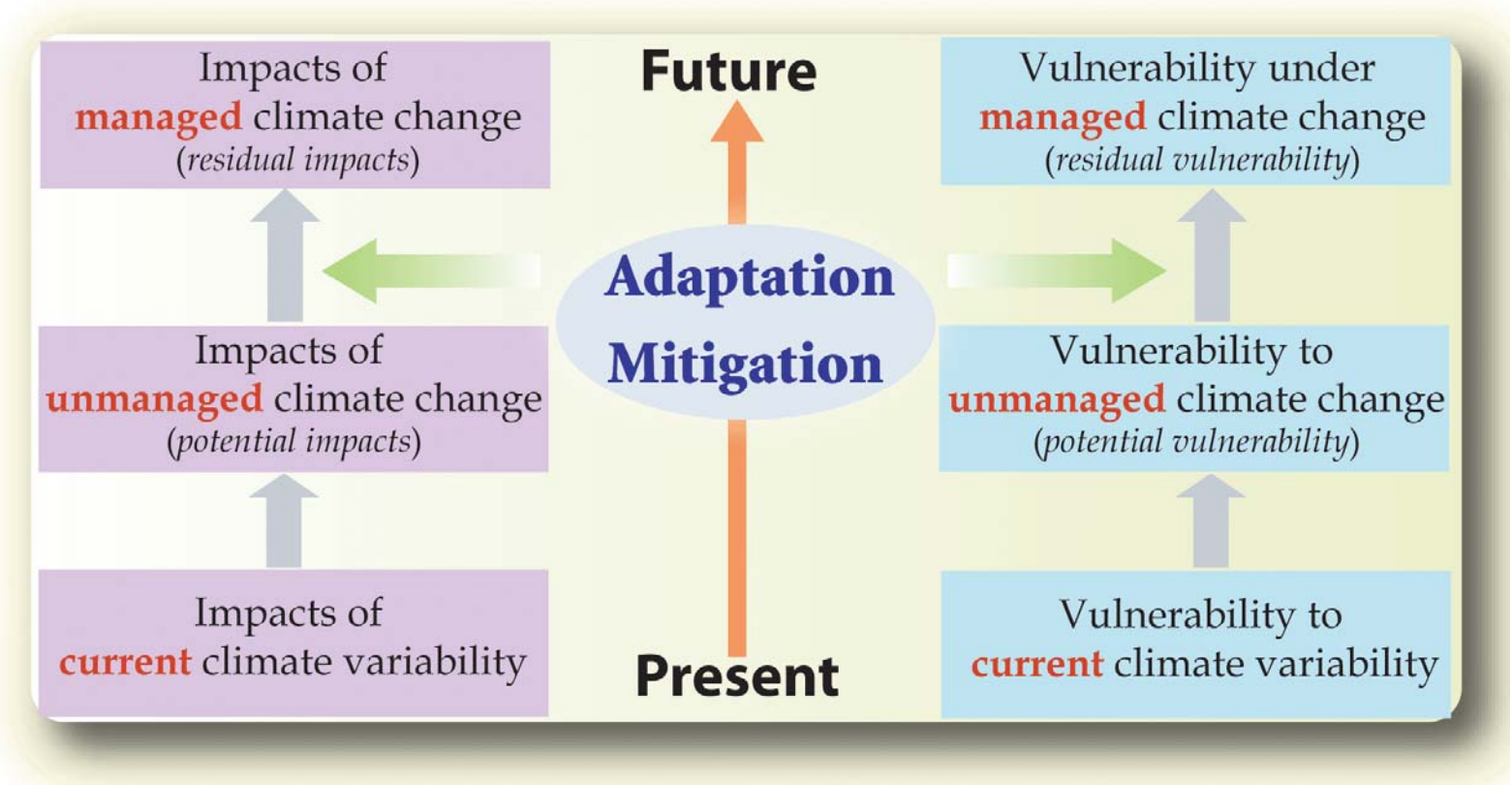
Unevenly distributed, related to: assets available to cope with CC, distribution of resources within a population, and institutions mediating exposures and coping with climate change

IPCC's Approach: Resilience

Capacity for positive adaptation despite adversity
Three features of socio-ecological resilience relevant for an approach integrating socio – natural spheres :

a) ability to buffer disturbance,
b) capability to self-organize, and adaptation
c) capacity for learning and learning how to learn, for communicating

Different States of Impacts and Vulnerability



Impact vs Vulnerability Assessment

Impact Assessment

Motivation: how bad are the risks?

Attempt to "predict" impacts

Careful attention to modeling future exposure

Capacities not emphasized

Focus on a single stress

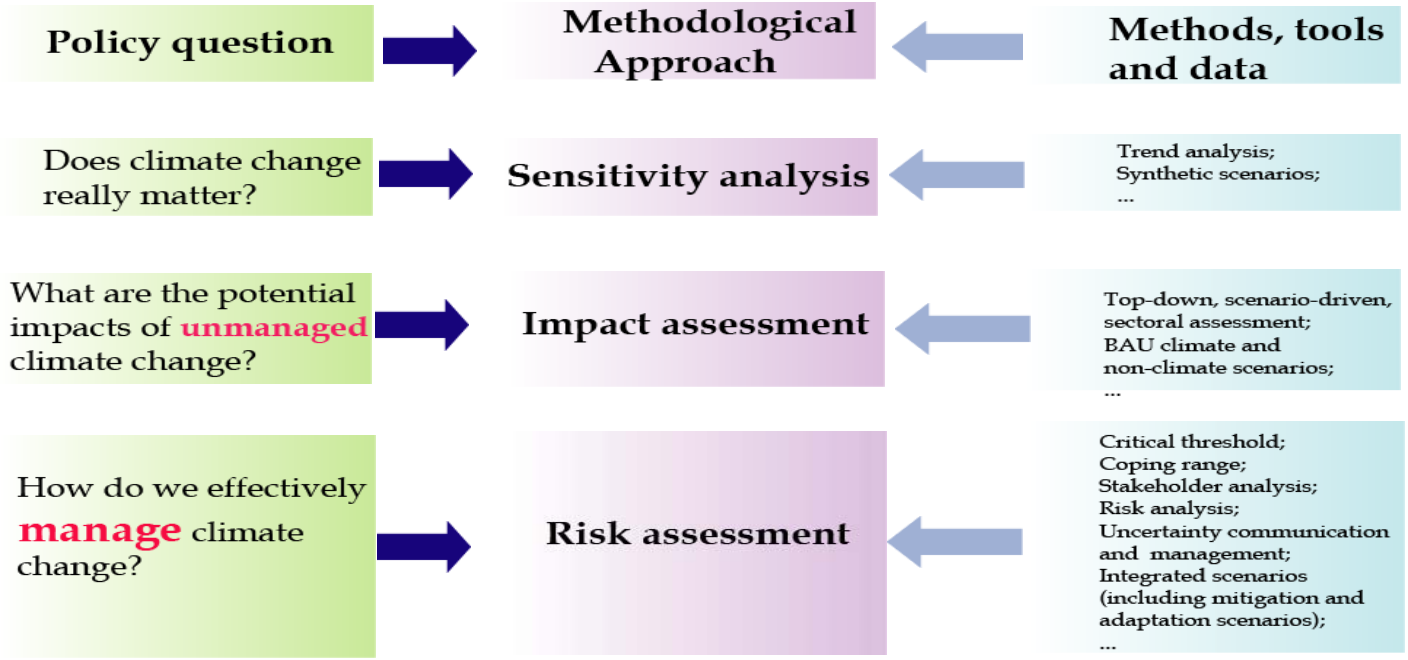
Recent experience not directly relevant

Treatment of adaptation is *ad hoc*, afterthought

Vulnerability Assessment

- Motivation: what would reduce risks?
- Investigate causes of vulnerability
- Careful attention to social causes of vulnerability, capacities to respond using sensitivity analyses
- Multiple stresses considered
- Recent experience with hazards, stresses used as analogues
- Treatment of adaptation central

Different purposes require different approaches to Vulnerability & Adaptation assessment.



Questions When Scoping a VA

- What is of concern?
  - Concerns may not be expressed in climate terms, e.g., storm intensity & frequency, but in consequences of climate impacts on people (e.g., mortality caused by flooding), infrastructure (e.g., damages to buildings), and ecosystems (e.g., loss of wetlands)
- Who & what may be affected?
- How far into the future is of concern?

Or is the concern really about current risks (which could be made worse by climate change)?

Questions When Scoping a VA

- For what purpose is the assessment to be conducted?
  - Engaging stakeholders?
  - Enhancing scientific understanding?
  - Designing adaptation strategy or formulating adaptation projects?
- Who is the targeted end-users of the results of your V&A assessment?
  - Level of technical details;
  - Treatment of uncertainties;
  - Format for presenting results

Questions When Scoping a VA

- What kind of output/information is expected?
  - Public awareness materials (e.g., climate scenarios and their potential impacts etc.);
  - Key vulnerabilities (e.g., risk/vulnerability maps);
  - A national/sectoral adaptation strategy; or
  - A combination of the above
- What resources are available?
  - Funding, personnel and expertise
  - Data
- How much time is available?

Development of Assessment Tool

Phase 1*:

- 1. Determine most important habitat types for coastal areas
- 2. Identify critical drivers and stressors for each habitat type
- 3. Construct conceptual framework for incorporating habitat types into vulnerability assessments

Phases 2-3:

- 1. Apply mathematical relationship to each habitat type linked to vulnerability to environmental disturbances.
- 2. Test assessment tool with multiple case studies
- 3. Develop guidance on how to apply assessment tool at the District level

*Current Phase

DRAFT Habitat Types

(Adapted from Coastal and Marine Ecological Classification Standard)

Beach and dune: A gently sloping zone formed by unconsolidated material at the shoreline, typically with a concave profile. The beach zone extends landward from the low-water line. Beaches subtypes include barrier, mainland, pocket, tide-modified, tide-dominated, or wave-dominated. The dune zone is an active accumulation of sand formed by wind action with some elevation and may also occur further inland

Marsh: Dominated by emergent, halophytic, herbaceous vegetation (with occasional woody forbs or shrubs) along low-wave-energy, intertidal areas of estuaries and rivers. Salt marshes often grade into (or are intermixed with) scrub-shrub wetlands in higher areas.

Shrub scrub wetland: Dominated by woody vegetation that is generally less than 6 meters tall. Scrub-shrub wetlands includes the shrub-dominated portions of high salt marshes—as well as stunted or low mangrove communities.

DRAFT Habitat Types

(Adapted from Coastal and Marine Ecological Classification Standard)

Mangrove forest: Tidally influenced, dense, tropical or subtropical forest with a shore zone dominated by true mangroves (and associates) that generally are 6 meters or taller.

Mollusk reef: An area of accumulated shell reef surrounded and intermixed with channels and unvegetated flats. Mollusk reefs are formed by the aggregation of mollusk shells into a fixed cohesive substrate. Mollusk reefs generally occur in the intertidal zone, but can sometimes occur in the subtidal zone. Included in mollusk reefs are reefs formed by mussels, oysters, or any other mollusk.

Coral reef: Physical features generated by the production of fixed cohesive substrate through the incorporation of dissolved calcium carbonate into the reef structure. Coral reefs may occur in deep/cold water or shallow/warm waters.

DRAFT Habitat Types

(Adapted from Coastal and Marine Ecological Classification Standard)

Flat: Level (or nearly level) surfaces or areas of land marked by little or no relief that are often composed of unconsolidated sediments (e.g. mud or sand). Included in flats are tidal flats composed of sand or mud in association with inlets, barrier islands, or shallow estuaries affected by wind-driven water level fluctuations.

Island: Area of land completely surrounded by water, or an elevated area of land surrounded by swamp or marsh, which is isolated at high water or during floods. A critical type of island environment, especially along the Atlantic and Gulf coast of the US, is a barrier island. Barrier islands commonly have dunes, vegetated zones, and swampy or marshy terrains extending lagoon-ward from the beach.

DRAFT Habitat Types

(Adapted from Coastal and Marine Ecological Classification Standard)

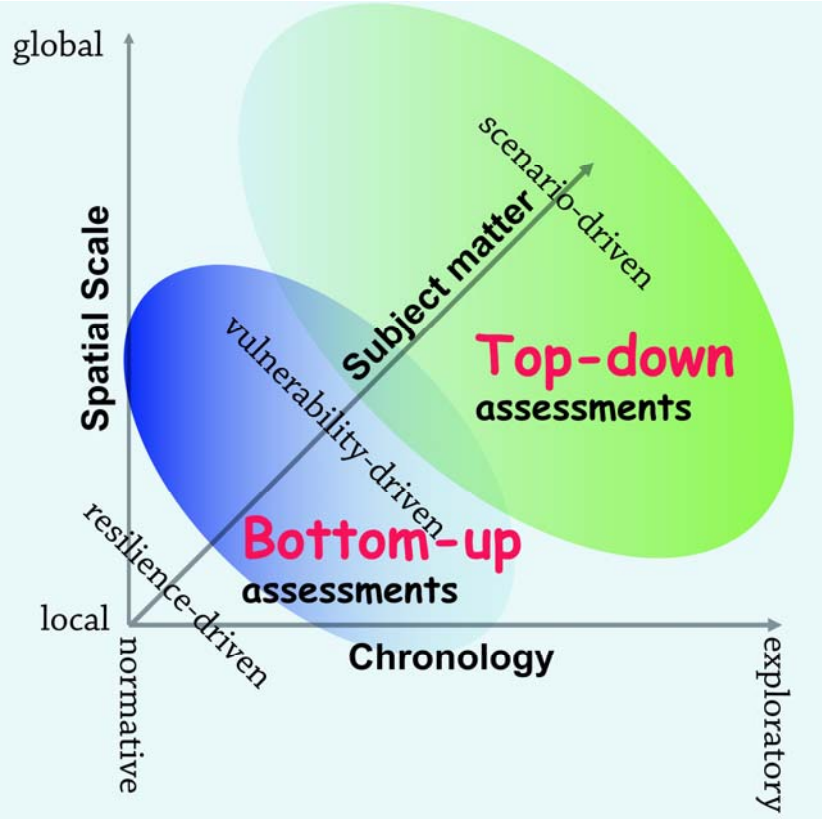
Bank or scarps: An elevated area above the surrounding seafloor that rises near the surface formed by geologic processes. Banks tend to occur on the continental shelf and are generally low-relief features, of modest-to-substantial extent, that normally remain submerged. Scarps are relatively straight, cliff-like face or slope of considerable linear extent, which breaks up the general continuity of the land by separating surfaces lying at different levels.

Aquatic vegetation bed: Subtidal or intertidal bottoms and any other areas characterized by a dominant cover of rooted vascular plants, attached macroalgae, or mosses, which are usually submersed in the water column or floating on the surface. In some cases, aquatic vegetation beds may be exposed during low tides.

DRAFT Habitat Types: Missing?

Beach and Dune	Coral Reef
Marsh	Flat
Shrub/Scrub	Island
Mangrove Forest	Bank/Scarp
Mollusk (Oyster) Reef	Aquatic Vegetation Bed (SAV)

Types of Frameworks



Approaches to V&A assessments can be categorized by the

- *subject matter*;
- *spatial scale*; and
- *chronology*

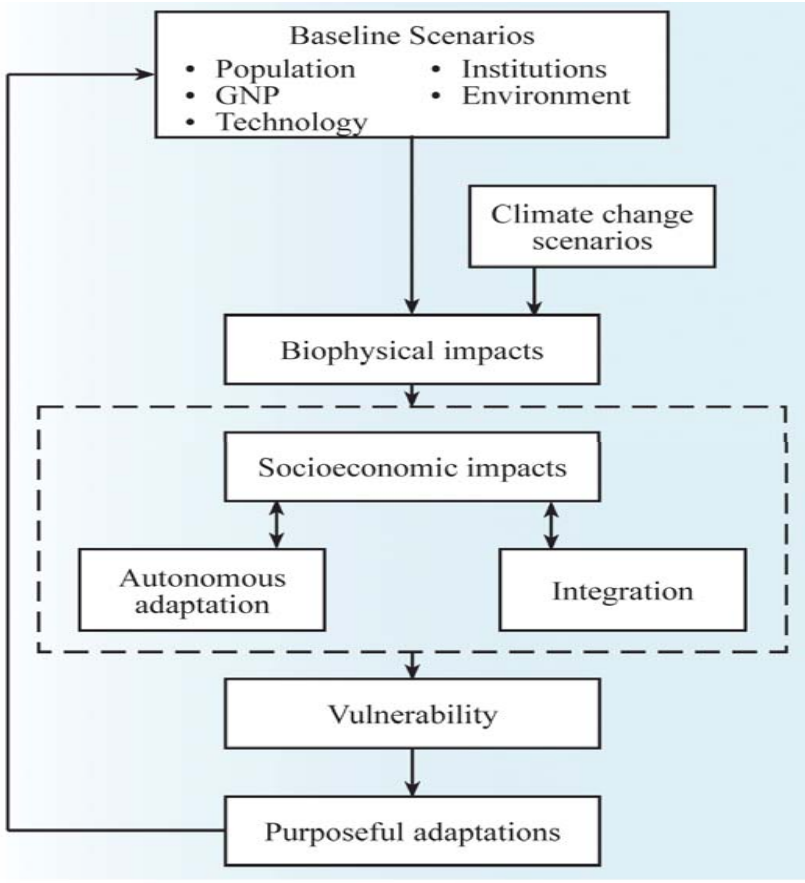
of the assessments

"Top Down" Frameworks

- Focusing on long-term (e.g., 2100 or beyond) implications of climate change
- Often scenario driven

IPCC 7 Step Process:

- Define the problem
- Select the method
- Test the method
- Select scenarios
- Assess biophysical and socioeconomic impacts
- Assess autonomous adjustments
- Evaluate adaptation strategies



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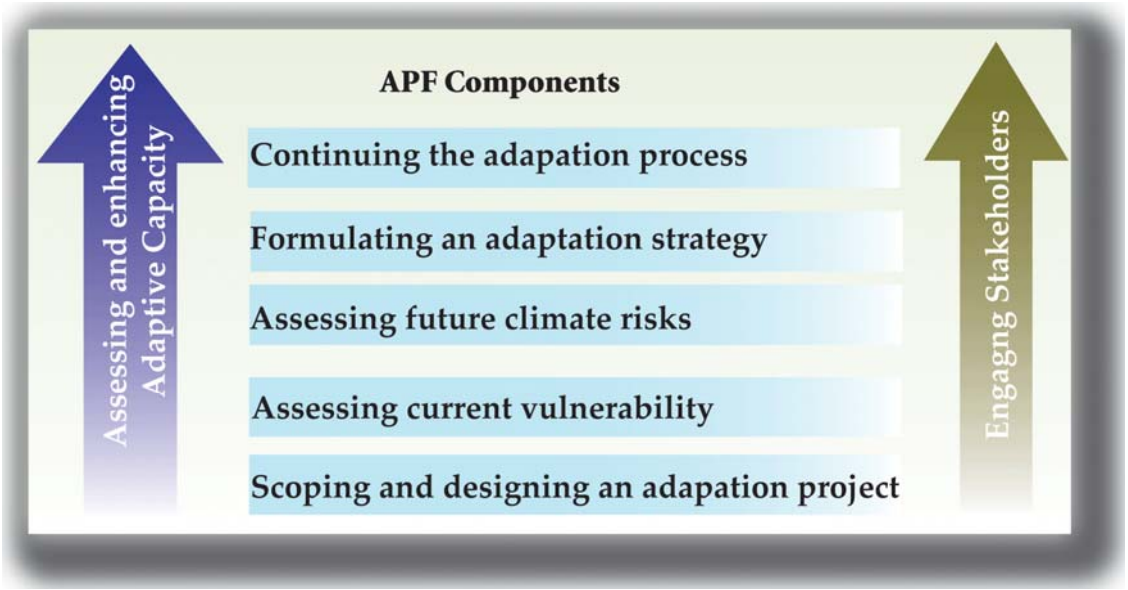
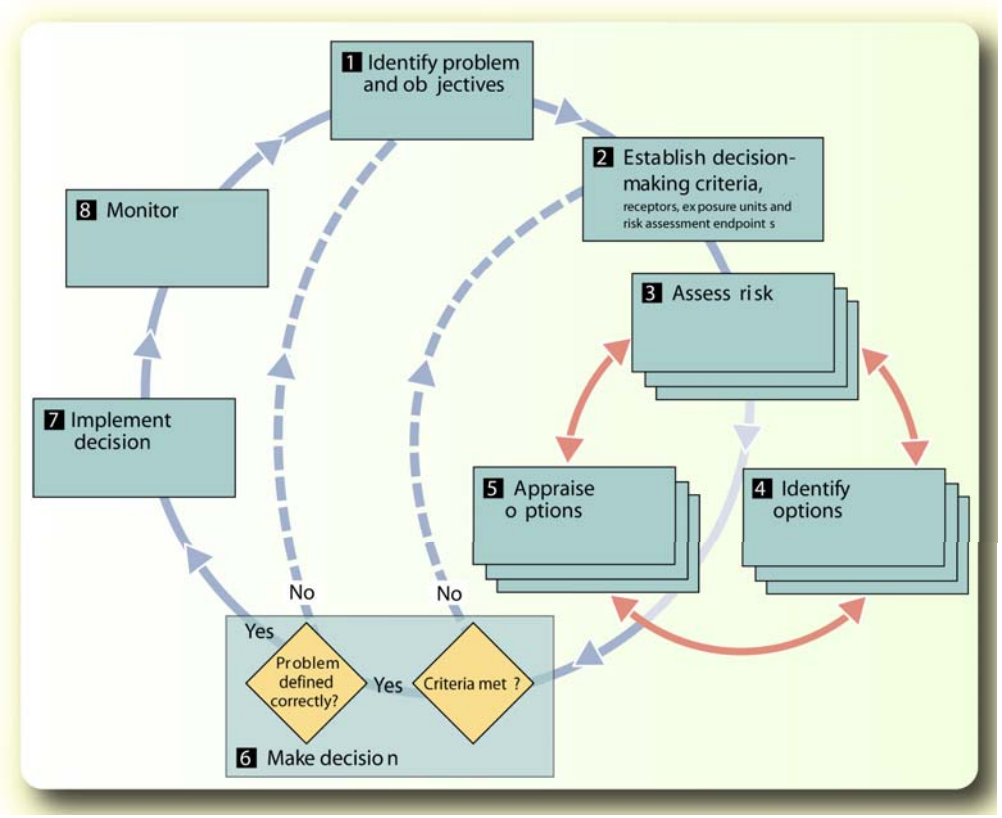
"Bottom-up" Frameworks

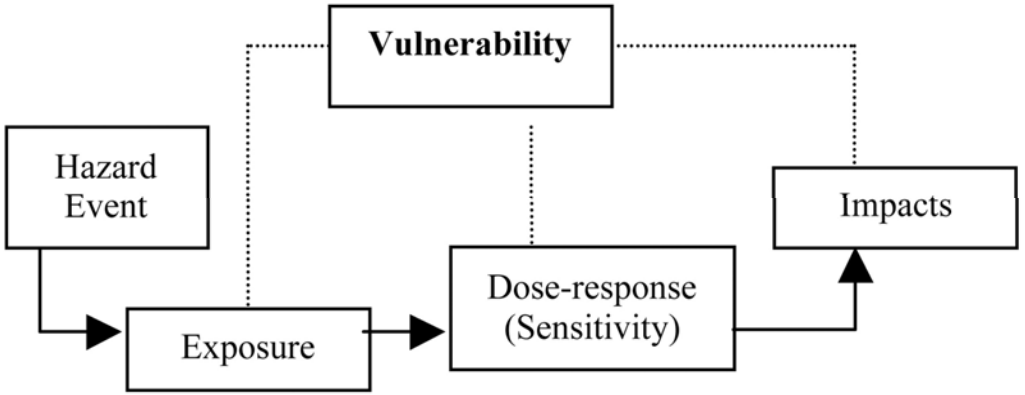
- Addressing near-term concerns
- Driven by issues identified through stakeholder consultations
  - o Analysis to be conducted as deemed necessary
  - o Application of "informal" analytical techniques



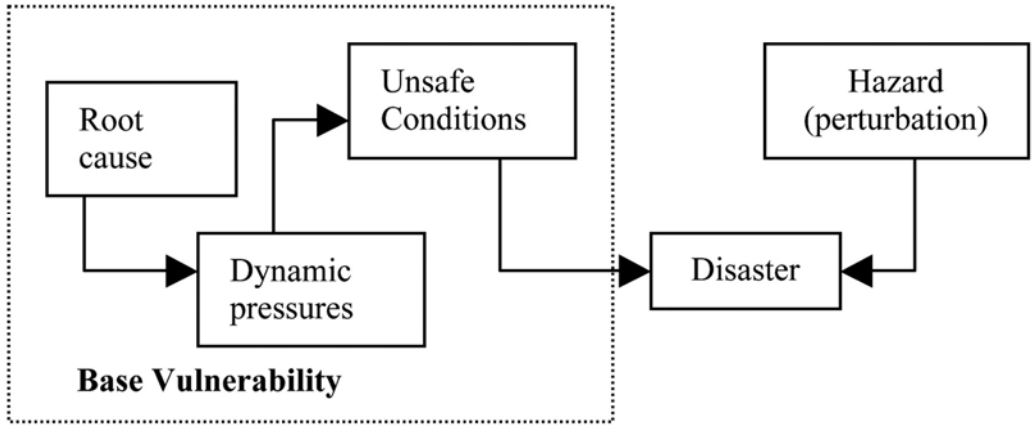
UKCIP Risk-Uncertainty-Decision-Making ("8-step") Framework



Alternative Approaches

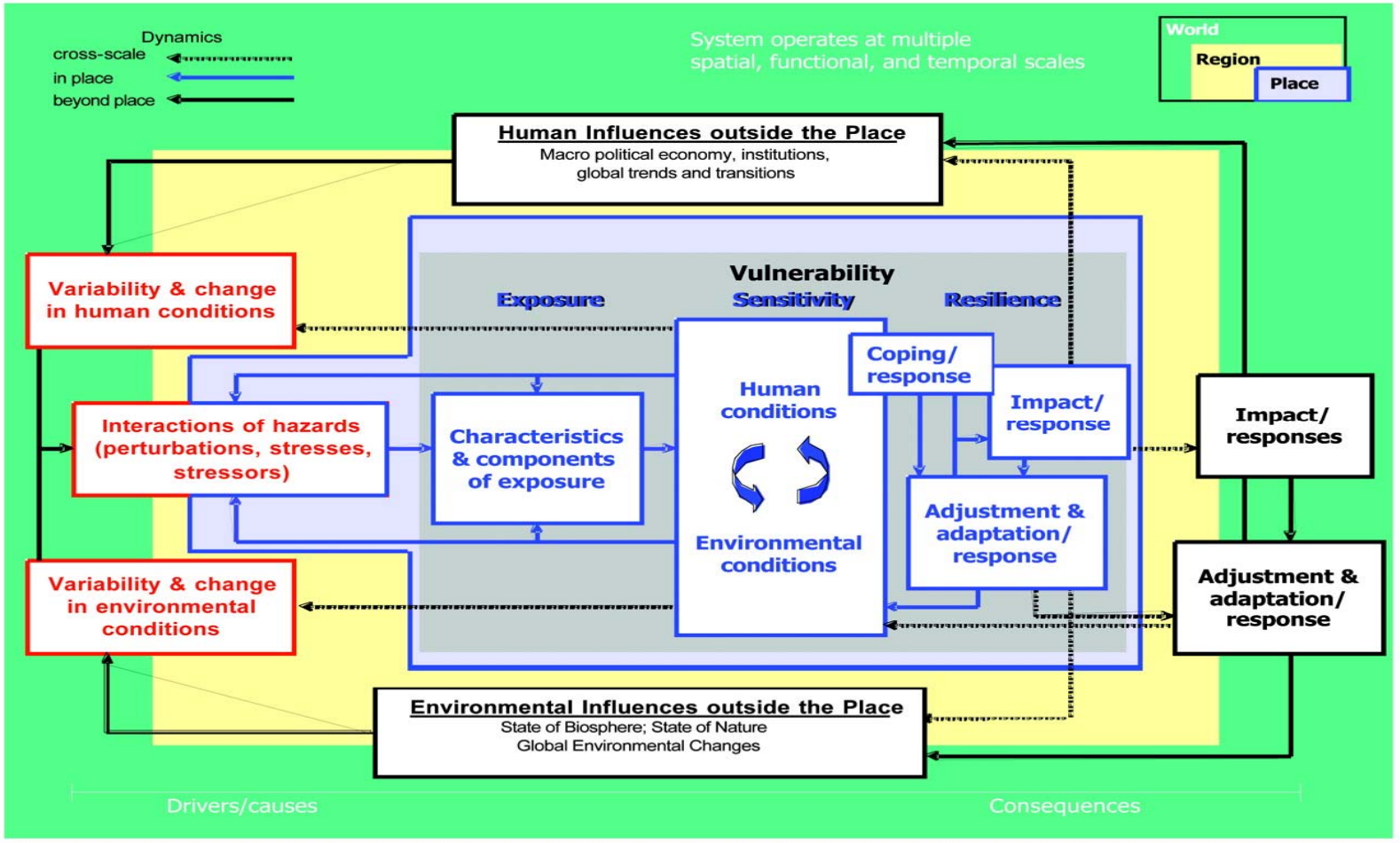


- RH framework (common to risk application). Chain sequence begins with hazard; concept of vulnerability commonly implicit as noted by dotted lines.

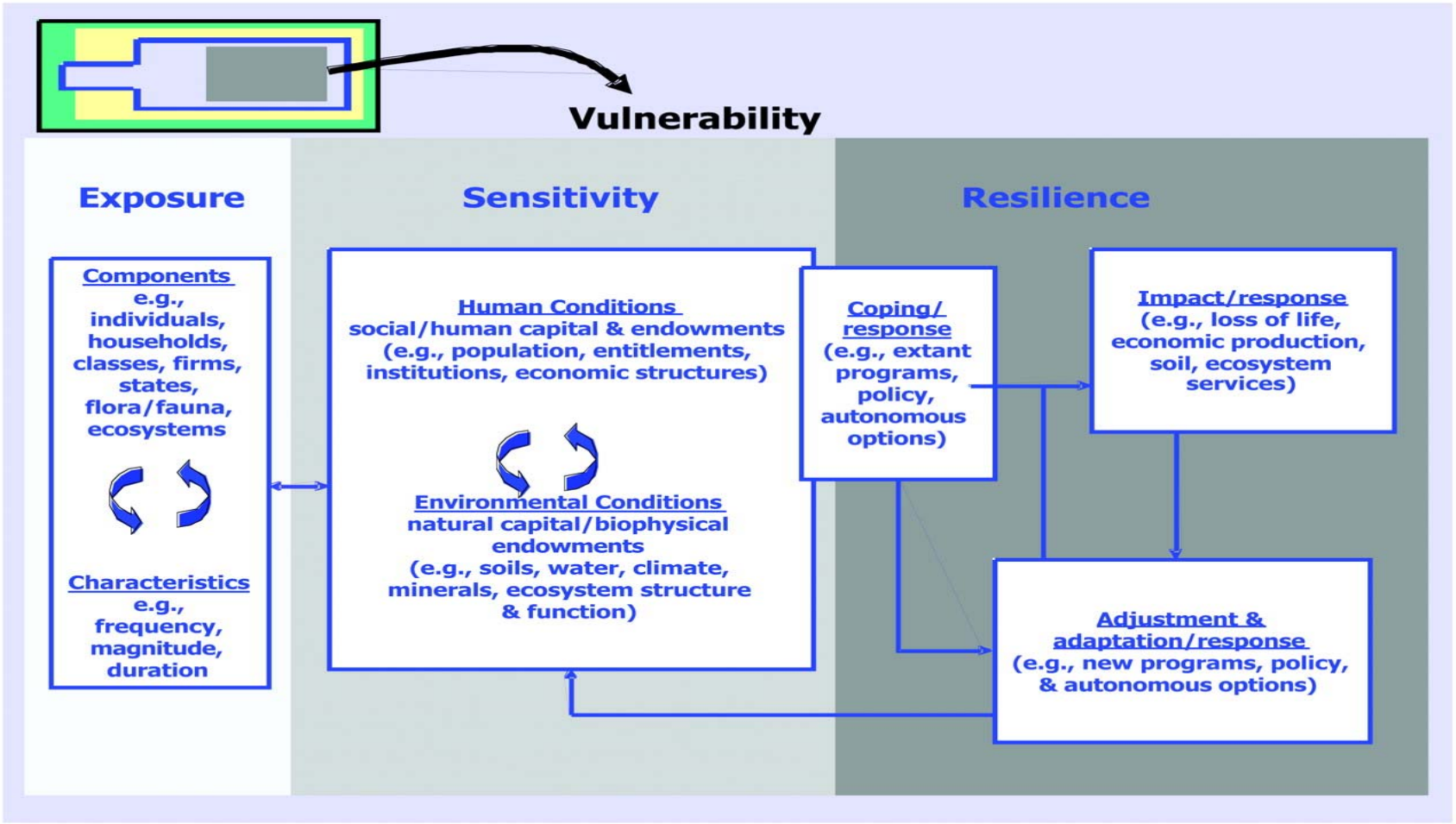


- PAR framework (common to risk research) with emphasis placed on "social" conditions of exposure; concept of vulnerability usually explicit.

Components of vulnerability identified and linked to factors beyond the system of study and operating at various scales.



Details of the exposure, sensitivity, and resilience components of the vulnerability framework.



Elements for Inclusion in any Vulnerability Analysis

- Multiple interacting perturbations and stressors/stresses and the sequencing of them;
- Exposure beyond the presence of a perturbation and stressor/stress, including the manner in which the coupled system experiences hazards;
- Sensitivity of the coupled system to the exposure;
- The system's capacities to cope or respond (resilience), including the consequences and attendant risks of slow (or poor) recovery;
- The system's restructuring after the responses taken (i.e., adjustments or adaptations); and
- Nested scales and scalar dynamics of hazards, coupled systems, and their responses

Developing/Selecting a Framework

- No particular framework can be recommended without a specific context

  Different frameworks are appropriate for different needs and have different requirements.

- What is needed in the long run is a combination of top-down and bottom-up approaches, or their elements.
- You should NOT begin with the methods or models you have in hand, but with these questions.
- Select methods and models that are most appropriate for your particular V&A assessment

Questions?

Providing Solutions to Tomorrow's Environmental Problems