

Incorporating Sensitivity and Adaptive Capacity in Climate Vulnerability Assessments for Defense Applications

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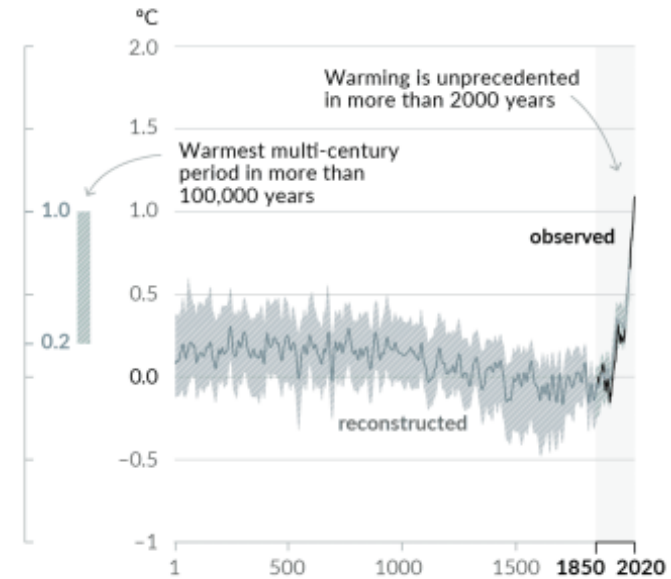
Global Climate Change

“Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years” (IPCC, 2021). This has led to a variety of impacts that threaten people and the environment including:

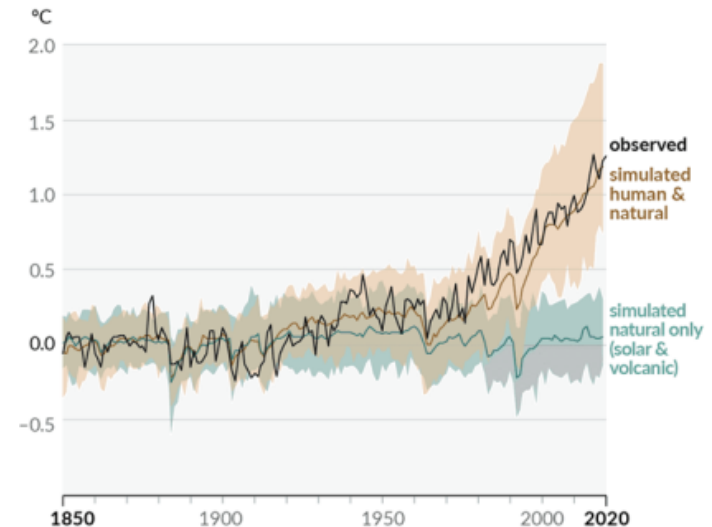
- Warming air and water temperatures
- Sea level rise
- Precipitation changes and drought
- Increasingly frequent and severe storms
- Ocean acidification
- Changes in wildfire patterns

Changes in global surface temperature relative to 1850–1900

(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and observed (1850–2020)



(b) Change in global surface temperature (annual average) as observed and simulated using human & natural and only natural factors (both 1850–2020)



Global Climate Change

“Climate change has already caused widespread impacts and related losses and damages on human systems and altered terrestrial, freshwater and ocean ecosystems worldwide” (IPCC, 2023).

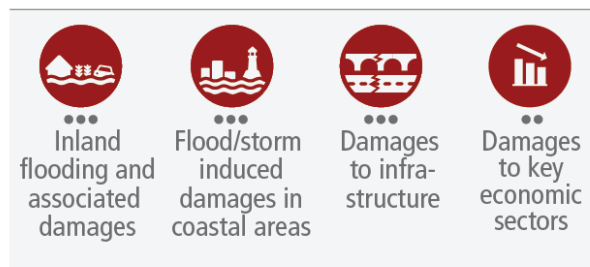
Water availability and food production



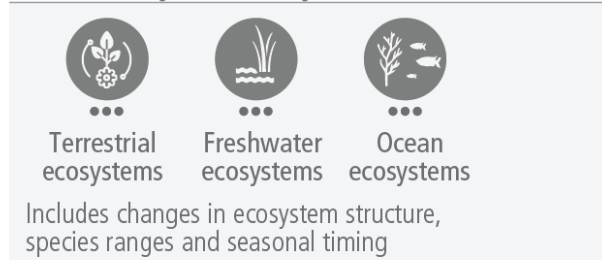
Health and well-being



Cities, settlements and infrastructure






Biodiversity and ecosystems



Key

Observed increase in climate impacts to human systems and ecosystems assessed at **global level**

-  Adverse impacts
-  Adverse and positive impacts
-  Climate-driven changes observed, no global assessment of impact direction

Confidence in attribution to climate change

- High or very high confidence
- Medium confidence
- Low confidence

Climate change and the Department of Defense

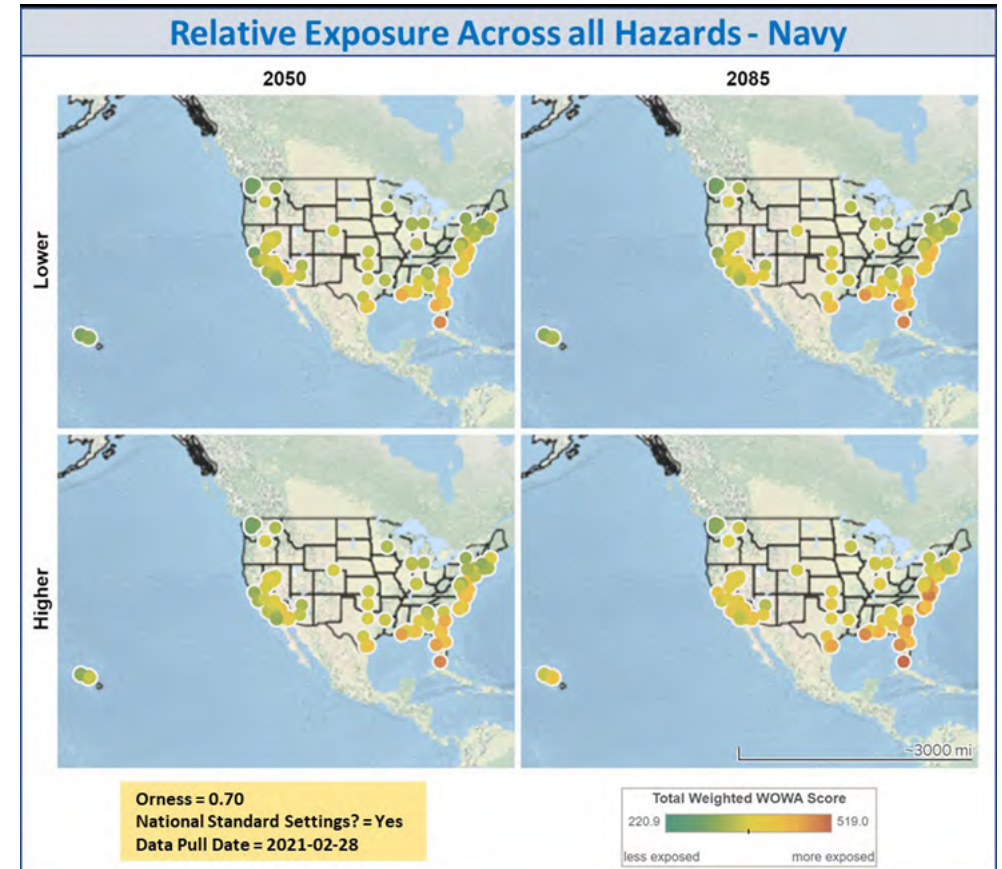
“The Department of Defense (DoD) has identified climate change as a critical national security issue and threat multiplier and top management challenge” (DoD, 2021). To meet this challenge, DoD has identified five priority lines of effort for adaptive action:

- 1: Climate-Informed Decision-Making
- 2: Train and Equip a Climate-Ready Force
- 3: Resilient Built and Natural Installation Infrastructure
- 4: Supply Chain Resilience and Innovation
- 5: Enhance Adaptation and Resilience Through Collaboration



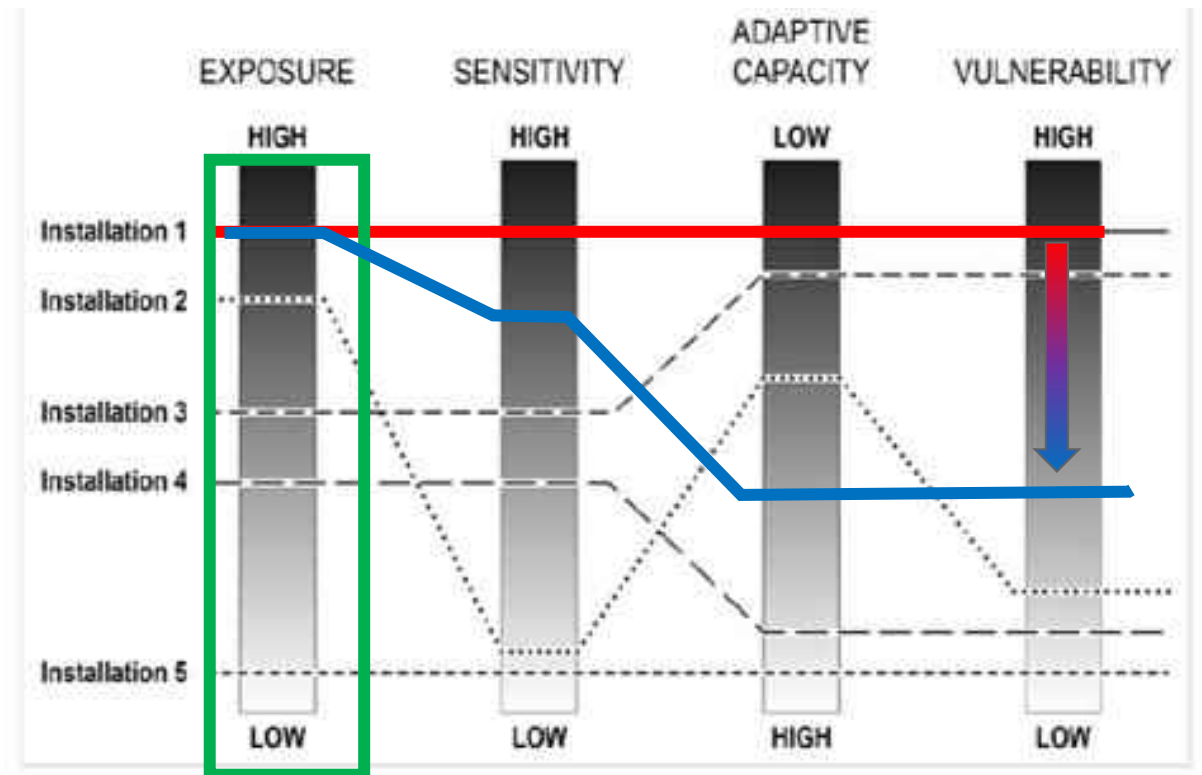
Background on DoD Climate Assessment Tool (DCAT)

- Supports DoD in planning for climate change by helping to understand the exposure of installations to a suite of 8 climate hazards
 - drought, coastal flooding, riverine flooding, heat, energy demand and performance, wildfire, land degradation, and historic weather extremes
 - 33 indicators
- Relative measure of exposure for each installation
- 2 emissions scenarios (RCP 4.5, 8.5)
- 2 time slices (2050, 2080)



Incorporating sensitivity and adaptive capacity into the DoD Climate Assessment Tool

- Assessing installation vulnerability necessitates understanding the exposure, sensitivity, and adaptive capacity of that installation.
- Including metrics of sensitivity and adaptive capacity will help prioritize resources, better understand underlying drivers of vulnerability, and support installation resilience planning



Incorporating sensitivity and adaptive capacity into the DoD Climate Assessment Tool (DCAT)

Phase 1 – Scope and develop framework

- Understand goals for integrating sensitivity and adaptive capacity into DCAT
- **Define framework including categories, indicators, and available data**
- Develop statistical methods for combining variables into an installation score, assigning weights, and visualizing results.

Phase 2 - Apply framework

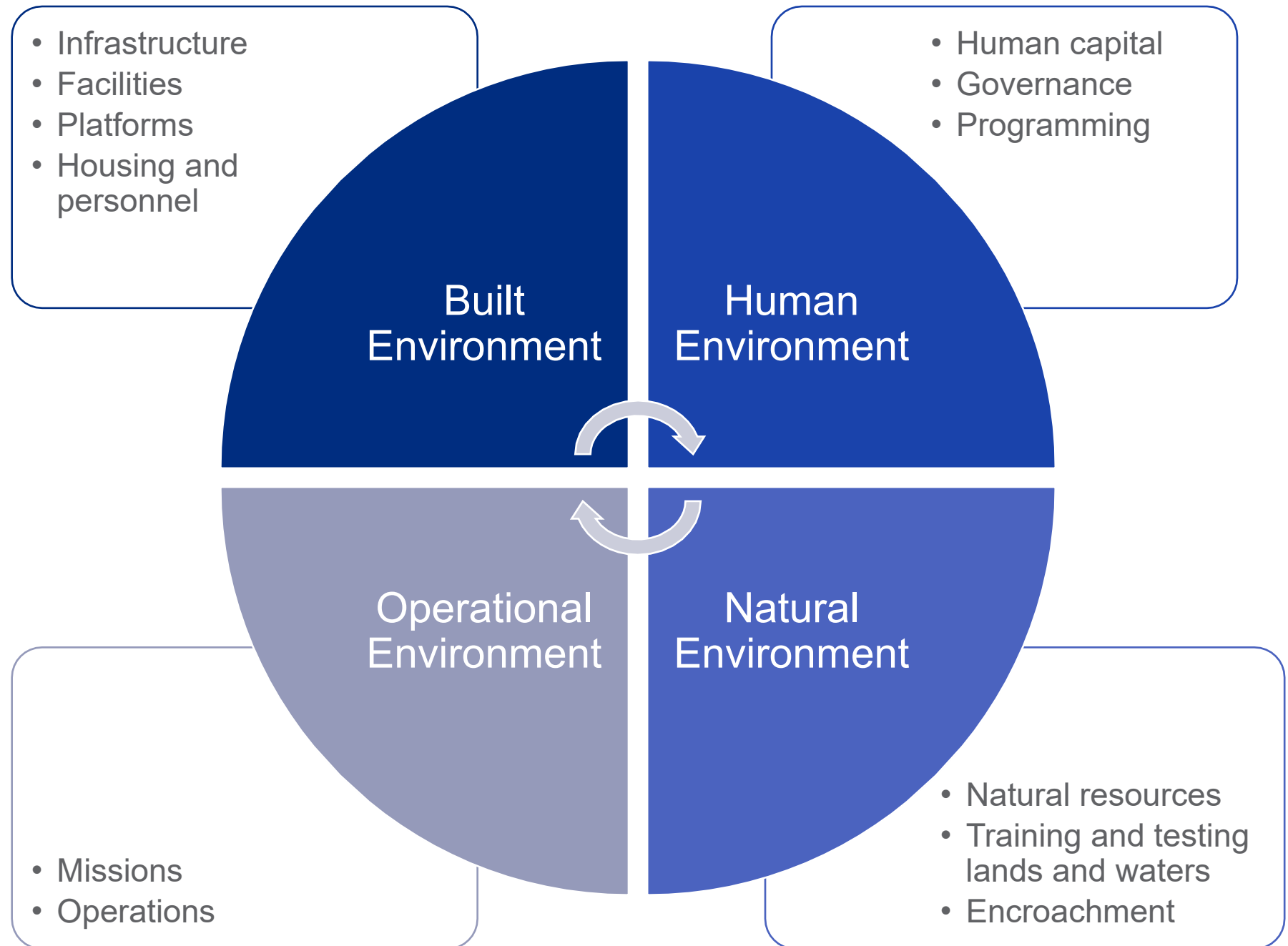
- 2 – 3 pilot cases
- Assemble data needed
- Use results to revise and improve framework

Review of literature, models, and tools for existing frameworks

A review of climate vulnerability frameworks, applications, and indicators was conducted with the following meriting inclusion in the review:

1. DoD reports, handbooks, or other publications regarding climate change
 - a. Relevant references also gleaned from these reports
2. Global or national level climate assessments (i.e., IPCC, US National Climate Assessment)
3. Selected peer-reviewed literature, white papers, and reports from the following Google Scholar searches:
 - a. “Climate vulnerability assessment”
 - b. “Indicator-based climate vulnerability assessment”
 - c. Indicator-based climate vulnerability assessment for each DCAT hazard (i.e., “drought indicator-based climate vulnerability assessment”)

Installations and climate change: potential conceptual framework



Built Environment

Physical structures, facilities, buildings, and other infrastructure that support installations, missions, and the extended community.

Sub-categories

- Infrastructure - Energy, fuel, transportation, and communications infrastructure, and water and wastewater systems.
- Facilities – Vertical construction including administrative, storage, maintenance, training, and medical facilities.
- Platforms – Assets like planes, vehicles, or ships.
- Housing and personnel – Housing, barracks, schools, childcare centers, exchanges, or other components of the built environment that provide nonoperational community support.

Institutional and individual characteristics connected to adaptation and resilience such as human health, planning, policies and technical guidance, and programming.

Sub-categories

- Human capital – Individual or population characteristics and values including health, demographics, labor force skills and knowledge, and historic and cultural resources.
- Governance – Policies, technical guidance, and orders that direct, guide, or support preparation and planning of missions, infrastructure, and people for climate change.
- Programming – Financial resources, funding, and budgetary capacity available to addresses direct or indirect climate impacts.

Human
Environment

Components of the environment and environmental management that affect installation operations and resilience such as an ecosystem that may serve as a space for training and as a buffer against climate change hazards.

Sub-categories

- Natural resources - All elements of nature and their environments of soil, sediments, air, and water.
- Training and testing lands/waters – to facilitate instruction and applied exercises for acquiring and retaining skills, knowledge and attributes required to complete specific tasks.
- Encroachment - external, as well as internal, DoD factors and influences that constrain or have the potential to inhibit the full access or operational use of the live training and test domain.

Natural
Environment

Operational Environment

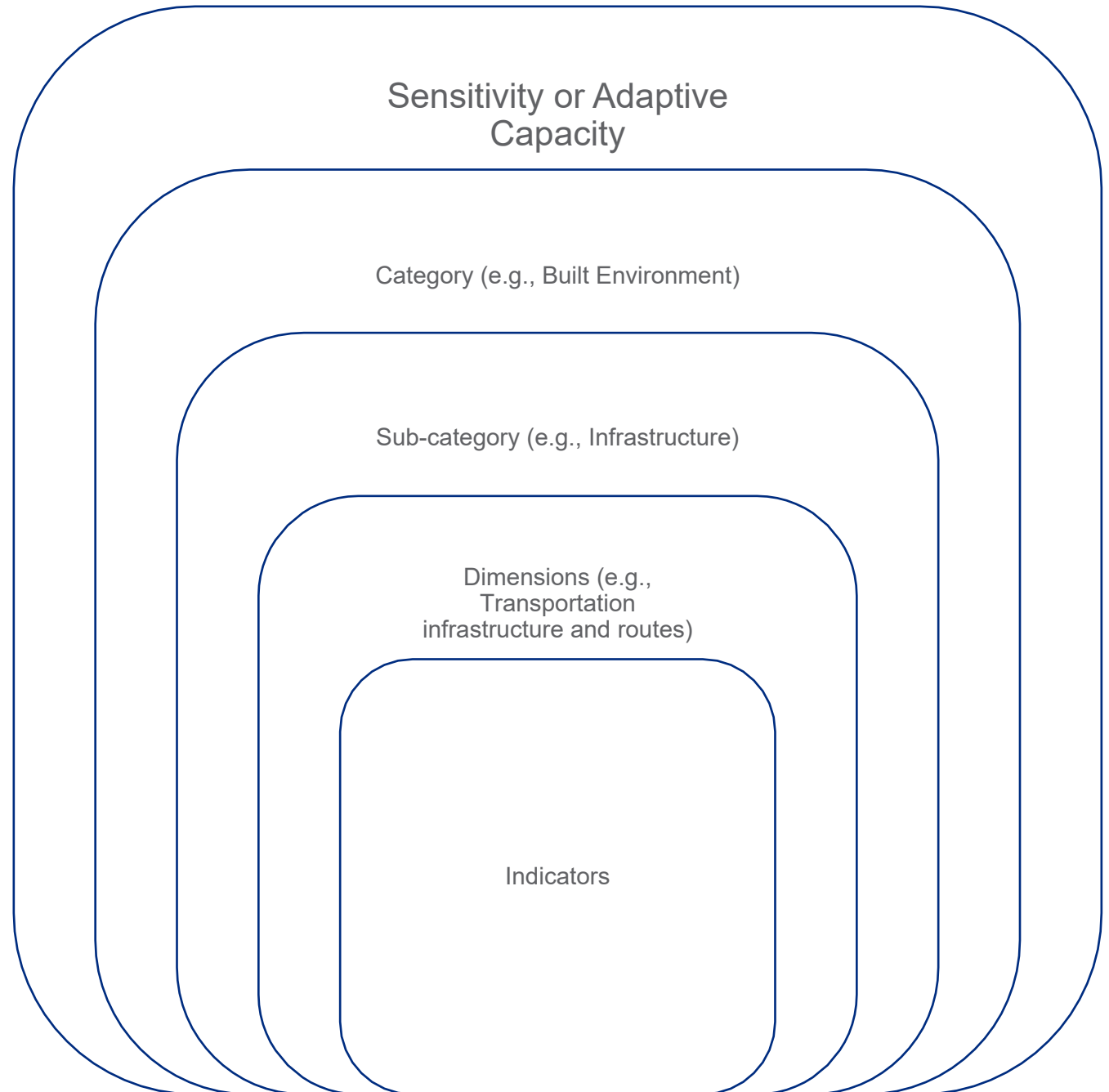
**The aggregate of the conditions, circumstances, and influences that affect the employment of capabilities and bear on the decisions of the commander. (JP 3-0)
Here, specifically the operational spaces and objectives that may be affected by climate change.**

Sub-categories

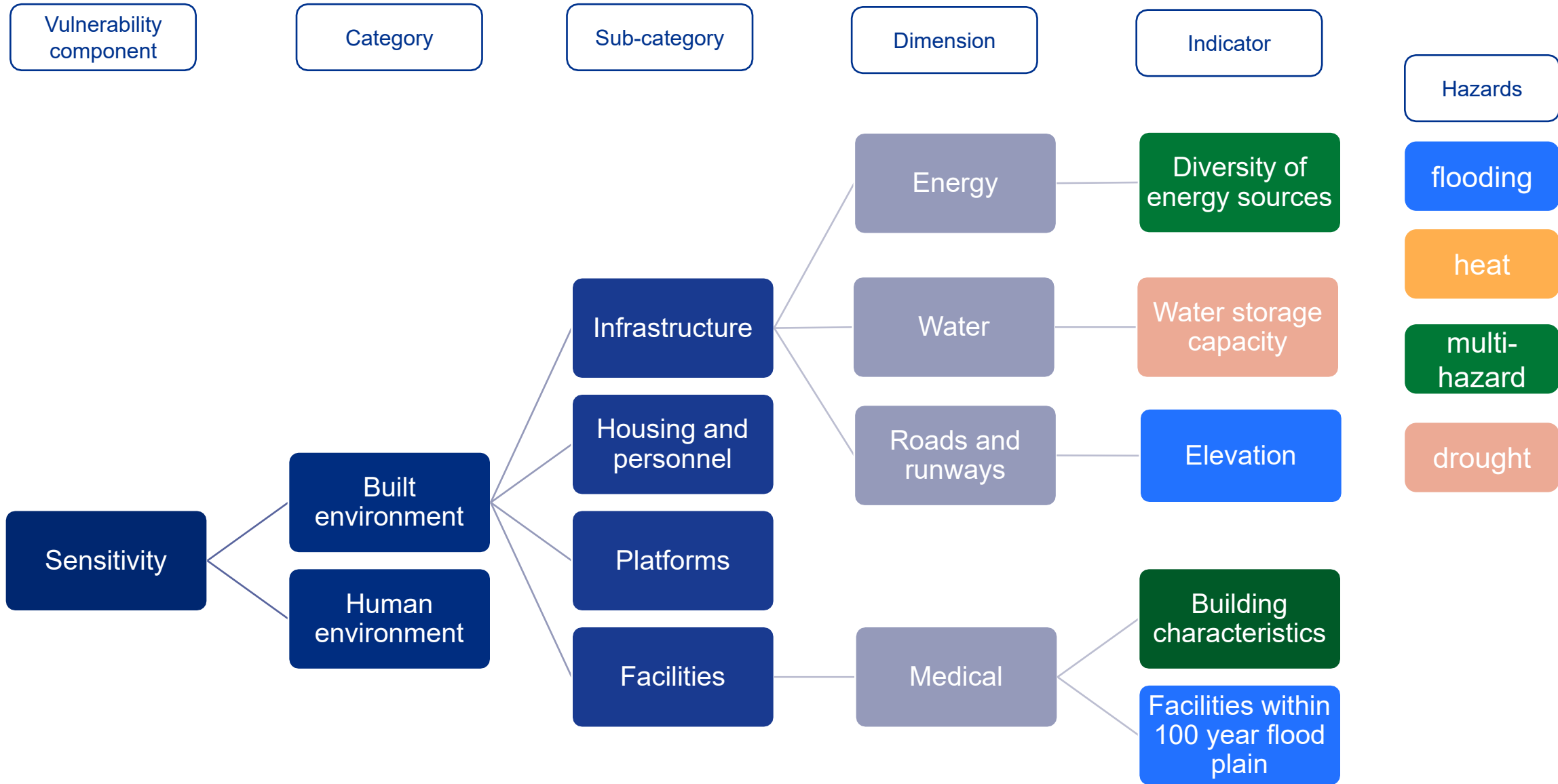
- Missions – The physical domains (air, land, or water) and mission requirements and objectives that collectively shape how a mission will be impacted by climate change and the adaptation options.
- Operations – Services that act to support missions and installation operations like logistics, emergency services, or communications.

Proposed indicator tiers for DCAT Sensitivity and Adaptive Capacity components

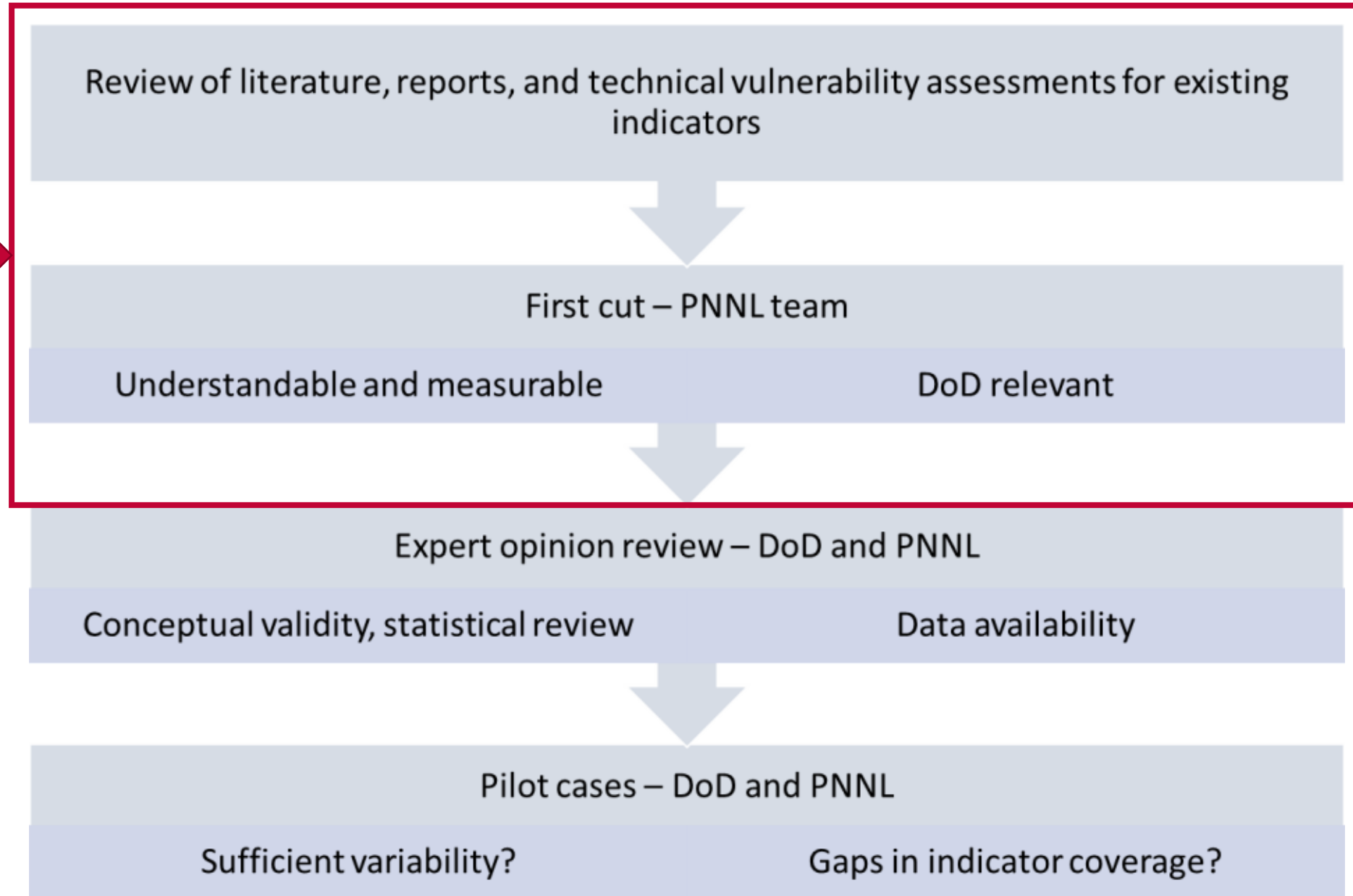
Modified from
Breslow et al.,
2016



Proposed indicator tiers



Indicator development methods



Modified from Breslow et al., (2018) and many indicator development papers (e.g., Tapia et al., 2017, James et al., 2011, Yu et al., 2021) follow similar processes.

Next steps

- Conceptual framework
 - Continue to build out dimensions and indicator tiers
- Indicators
 - Investigate data sources
 - Statistical review of potential indicators
 - DoD review of potential indicators
- Analytical methods
 - Use vulnerability calculation method(s) and compute scores with representative installation data
 - Explore the interpretations of adaptive capacity and its effect in vulnerability scoring methods
 - Explore use of Principal Component Analysis (PCA) for indicator refinement and weighting
 - Explore visualization options



Co-authors

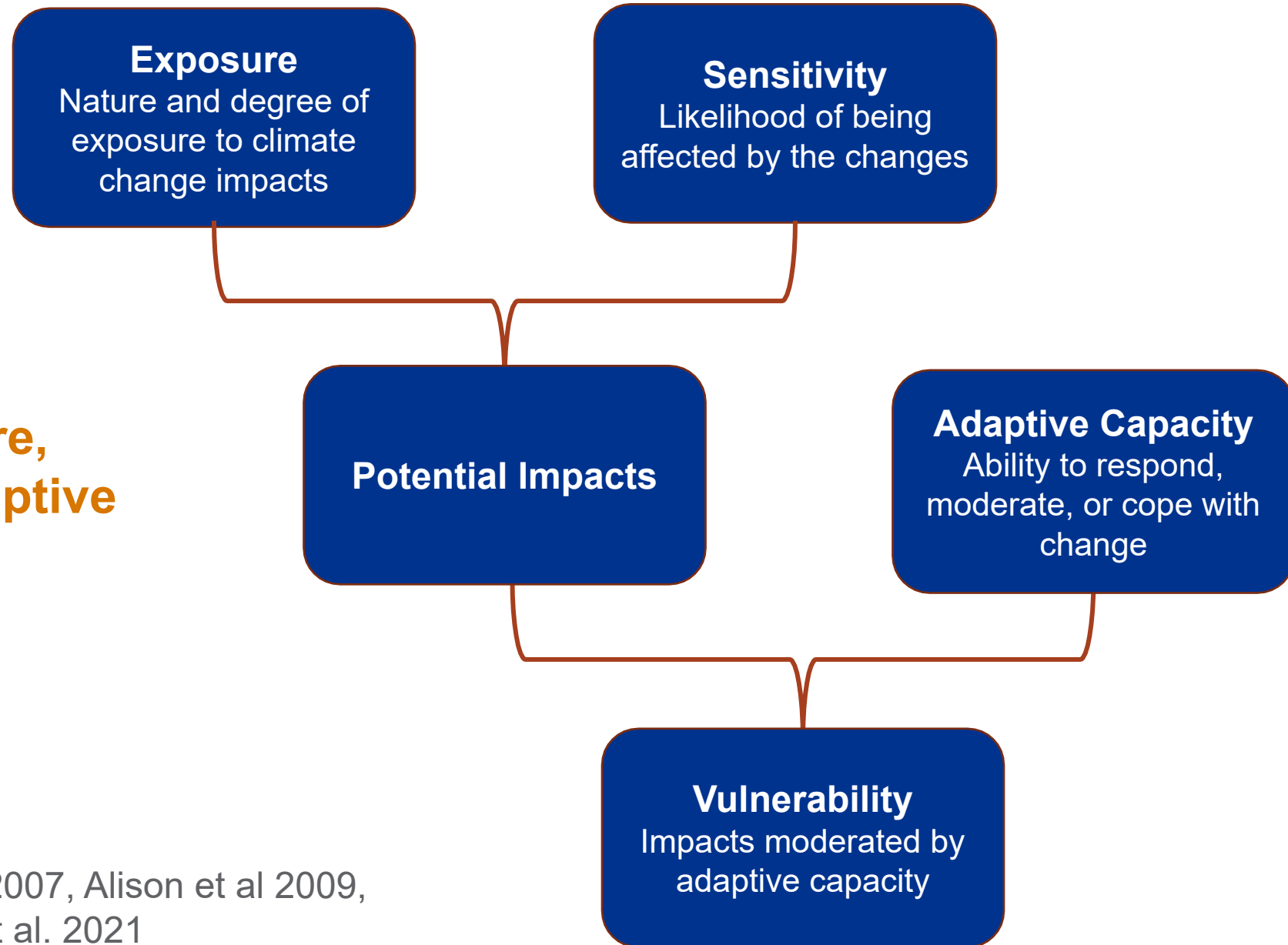
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Vulnerability as a function of exposure, sensitivity, and adaptive capacity



Indicator development methods

Candidate indicators

- 500 + indicators from 62 different sources
- 88 for exposure (captured for context), 118 for sensitivity, 149 for adaptive capacity, 94 were categorized as indicators of social vulnerability, and 51 as disaster resilience
- Frequently used indicators in the broader literature
 - Sensitivity – age, poverty, population density, water usage, and natural resource reliance
 - Adaptive capacity – income/wealth, education level, community infrastructure, social capital, existing hazard or adaptation plan
- From the results of the literature review, similar indicators were grouped together and then organized into six general themes: health, natural environment, resources, infrastructure, governance and social, and demographics
- The indicators within each theme were reviewed and assessed for potential relevance to DoD context.

Indicator development status

Theme	Initial indicator count	After round 1
Health	53	30
Natural environment	65	55
Resources (water, energy, other natural resources)	59	43
Infrastructure	120	77
Governance and social (policy, disaster preparedness)	71	47
Demographics	111	62
Total	479	314