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# Developing a Versatile Clime Intervention Risk Framework for National Security Applications

## A Stepwise Process to Assess Relative Risks of Interventions Compared to Climate Change

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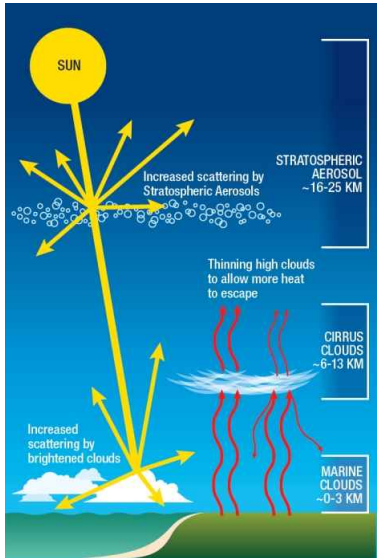
U.S. DEPARTMENT OF ENERGY

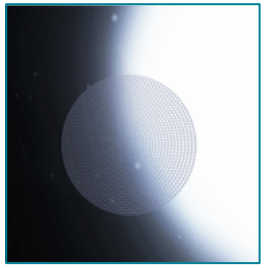
NNSA

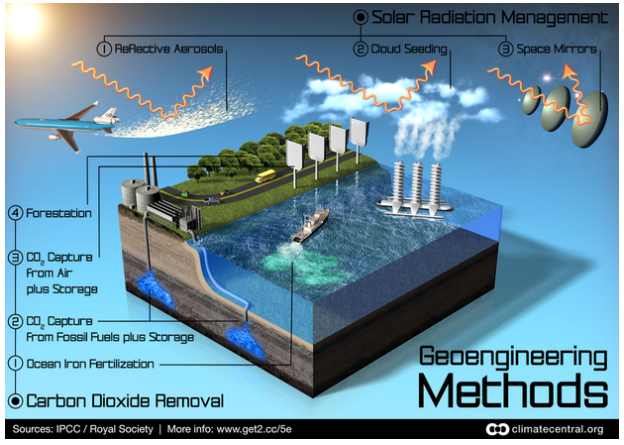
# Motivation

## The need for comprehensive risk framework

- Climate interventions (geoengineering) are emerging as seriously considered adjuvants to climate change
- Interventions are likely to create "winners" and "losers“ (real or perceived), potentially causing conflict
- International agreements or cooperation on climate interventions do not yet exist
- Policy makers will need risk assessments relevant to their specific missions






**White House is pushing ahead research to cool Earth by reflecting back sunlight**

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Catherine Clifford

KEY POINTS

- The White House Office of Science and Technology Policy is coordinating a five-year research plan to study ways of modifying the amount of sunlight that reaches the Earth in order to temporarily temper the effects of global warming.
- There are several kinds of sunlight-reflection technology being considered, including stratospheric aerosol injection, marine cloud brightening and cirrus cloud thinning.

# Developing a Flexible Framework

## Important features of the framework

- Consider the economic, environmental, and sociopolitical drivers motivating different actors and their selection of strategies
- Compare risks from performing intervention to risks from climate change
- Consider the full range of intervention consequences to address unique missions agencies
- Address uncertainties – identify critical gaps in knowledge

**Answer questions such as:**

- *Country X is considering unilateral implementation of stratospheric aerosol injection. Should we be concerned?*
- *A regional alliance of countries is discussing collaboration on weather modification to cope with the effects of climate change. What are the options available to them, and what are the potential regional and global impacts of different options?*
- *U.S. allies in Region X have expressed concerns regarding a public-private partnership sponsored by Country Y to test and potentially implement marine cloud brightening. Country Y claims the effects of these approaches will be local, with minimal implications for neighbors. Is concern warranted, and how should our allies be advised regarding potential impacts?*

# Risk Framework Phases

1

## Scenario Building

Devising scenarios of interest based on asking key questions related to:

- Future climactic conditions and international governance structure
- Potential actors, their drivers, and their resources/capabilities
- Intervention efficacy

2

## Likelihood Analysis

Estimating the plausibility of a particular intervention being deployed

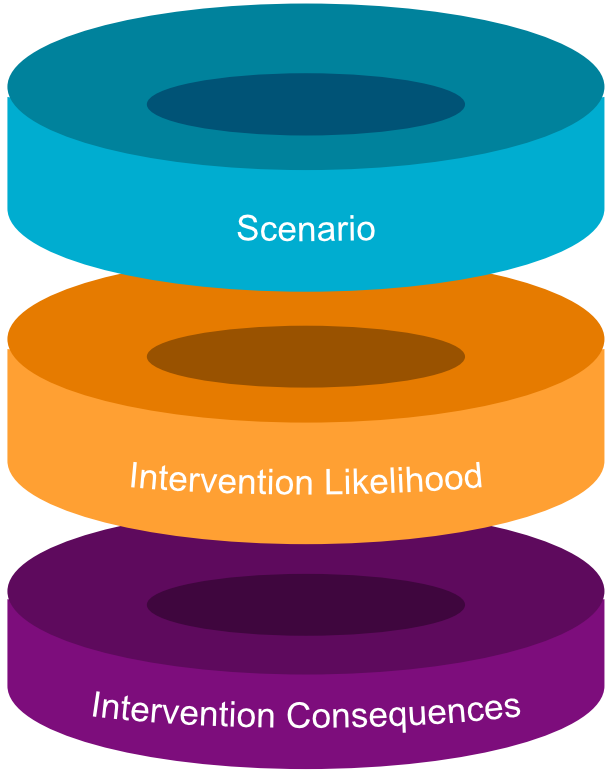
- Solar radiation management vs. carbon dioxide removal

3

## Consequence Analysis

Layered consequences associated with and resulting from intervention(s):

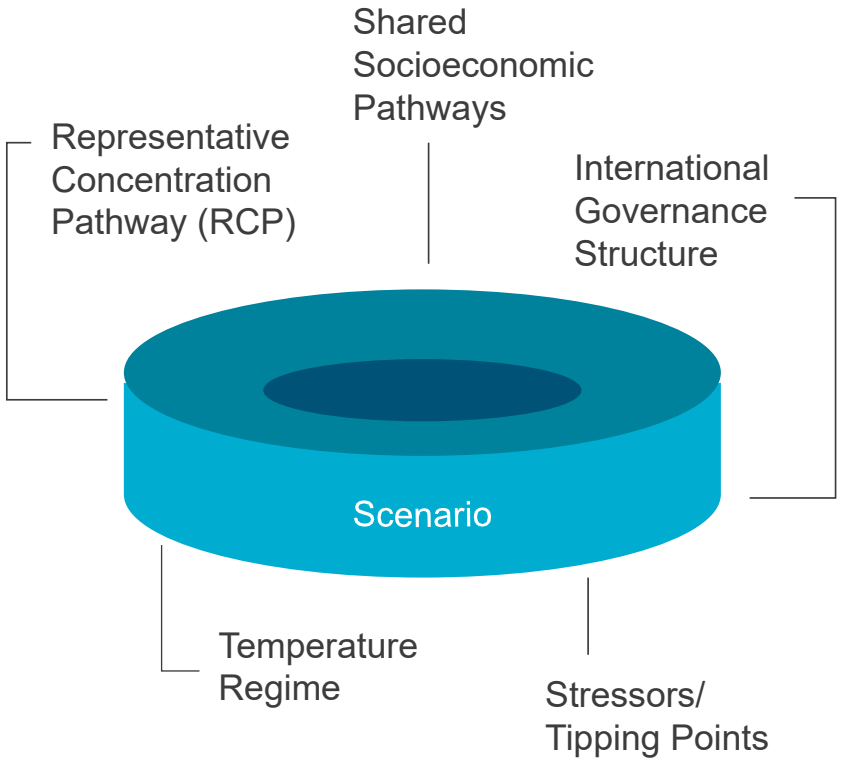
- Biophysical impacts relative to climate change trajectory (i.e., world without an intervention)
- Geo-, socio- political, and economic impacts



# 1 Risk Framework Phases: Scenario Building

Guiding questions to construct **forward-looking scenarios**:

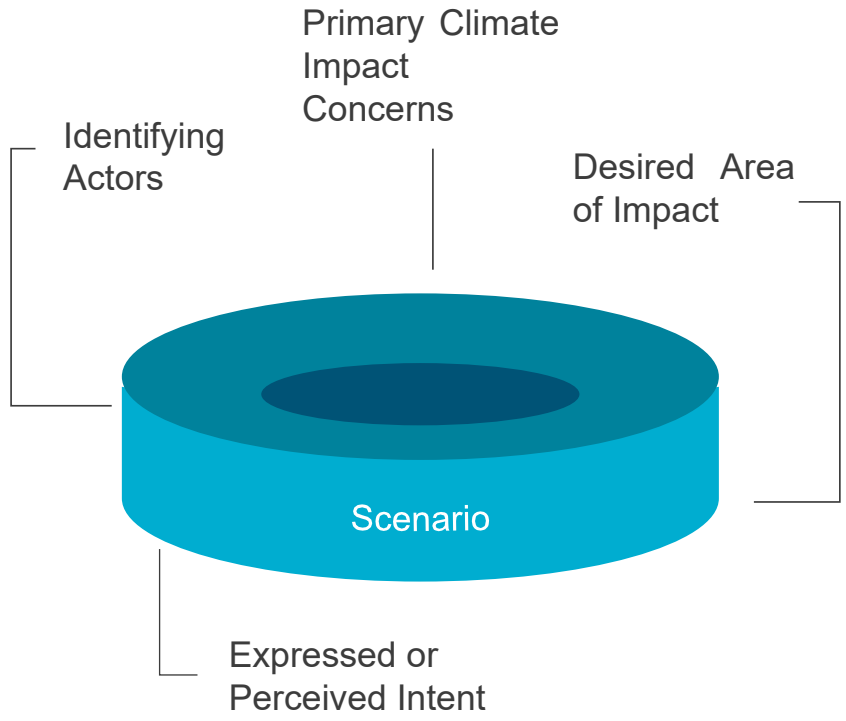
- What is the assumed climate and governance future?
  - E.g., assuming:
    - *Multilateral cooperation*
    - *Aggressive $CO_2$ abatement (RCP 3.0)*



# 1 Risk Framework Phases: Scenario Building

Guiding questions to construct **forward-looking scenarios**:

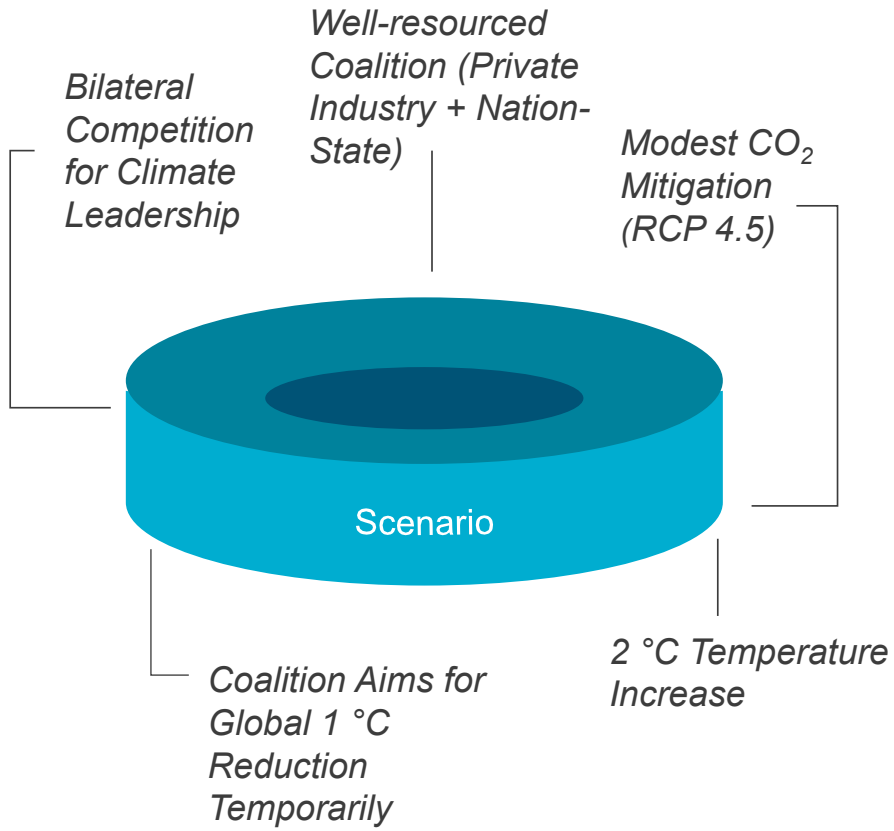
- What is the assumed climate and governance future?
- Who is the actor?
  - E.g., *a vulnerable nation state facing disproportionate impacts of climate change*
- What would motivate the actor(s) to consider deploying a climate intervention
  - E.g., *reducing heat stress*



# 1 Risk Framework Phases: Scenario Building

Guiding questions to construct **forward-looking scenarios**:

- What is the assumed climate and governance future?
- Who is the actor?
- What would motivate the actor(s) to consider deploying a climate intervention
- Ultimate pursuit of the intervention(s)

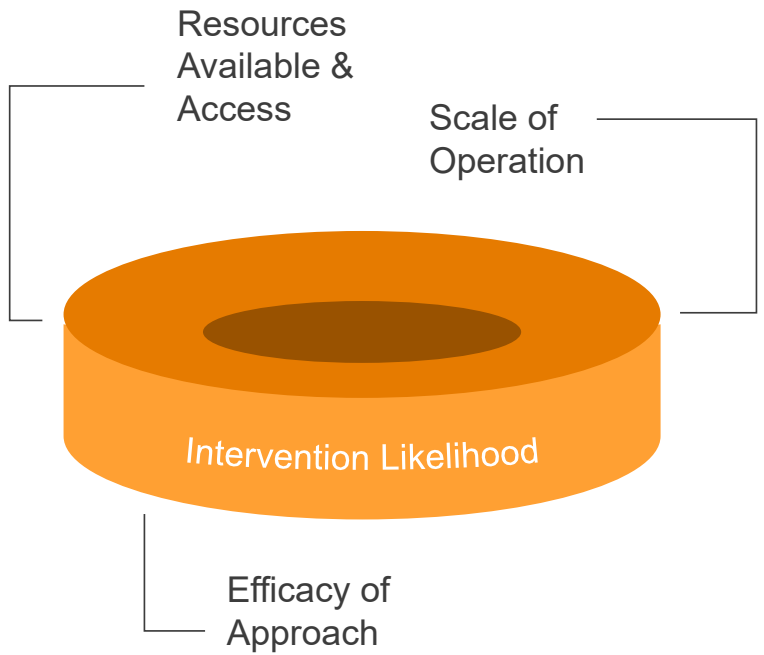



Scenario building helps to identify *unintended consequences*

# 2 Risk Framework Phases: Likelihood Analysis

Examining factors related to **likelihood of deploying/sustaining an intervention** within a given scenario:

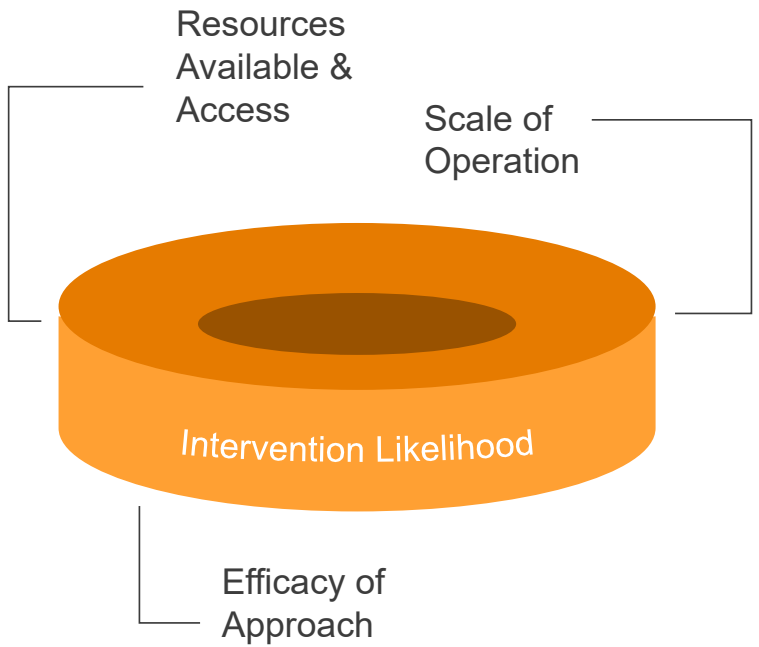
- Technological readiness, feasibility, and efficacy
  - What is the path to technological maturation?



# 2 Risk Framework Phases: Likelihood Analysis

Examining factors related to **likelihood of deploying/sustaining an intervention** within a given scenario:

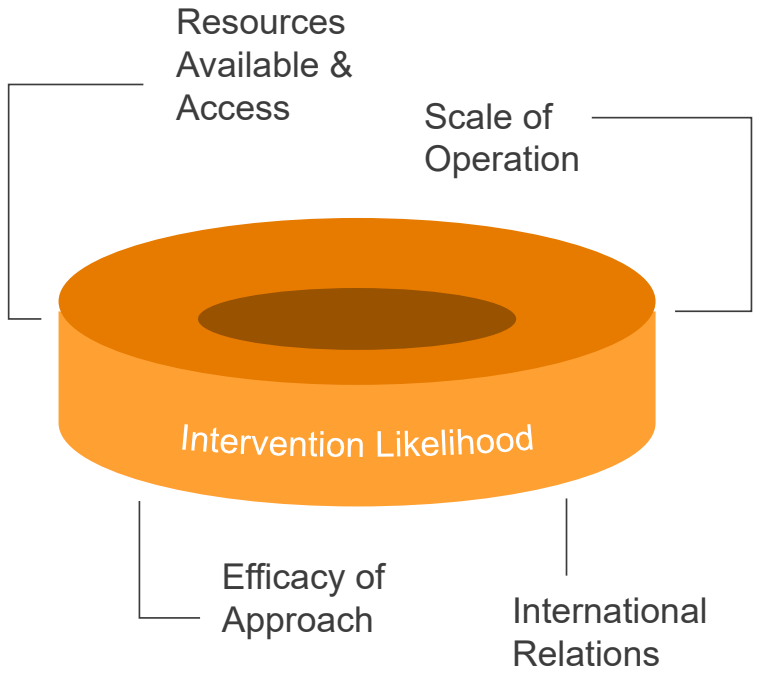
- Technological readiness, feasibility, and efficacy
- Actor financial resources and technological capabilities
  - R&D programs and expertise?
  - Access to raw materials, energy, geography?
- Meeting intent/desired outcomes
  - Does the actor have resources available to achieve their goals?



# 2 Risk Framework Phases: Likelihood Analysis

Examining factors related to **likelihood of deploying/sustaining an intervention** within a given scenario:

- Technological readiness, feasibility, and efficacy
- Actor financial resources and technological capabilities
- Meeting intent/desired outcomes
- International agreements, treaties, oversight mechanisms, or norms
  - Whether regulations would influence use of an intervention?



# 3 Risk Framework Phases: Consequence Analysis

Iterating through **resulting consequences of the intervention** under assumed conditions:

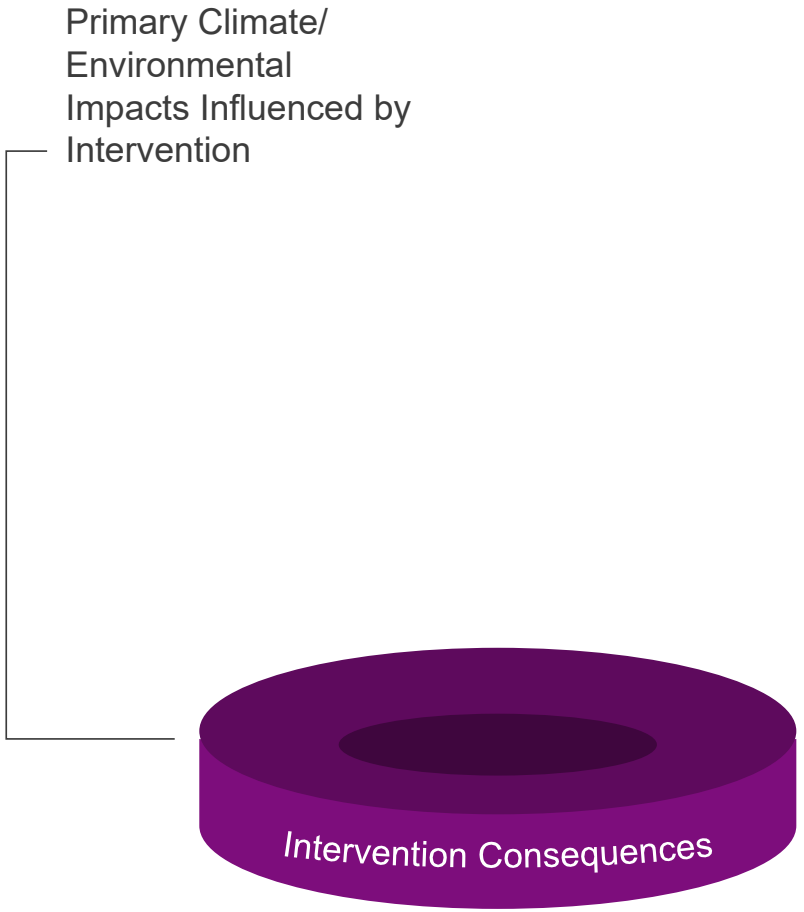
- Consequences are a function of *hazard*, *exposure*, and *vulnerability*[1]
- Relative to effects of climate change


1 IPCC

# 3 Risk Framework Phases: Consequence Analysis

Iterating through **resulting consequences of the intervention** under assumed conditions:

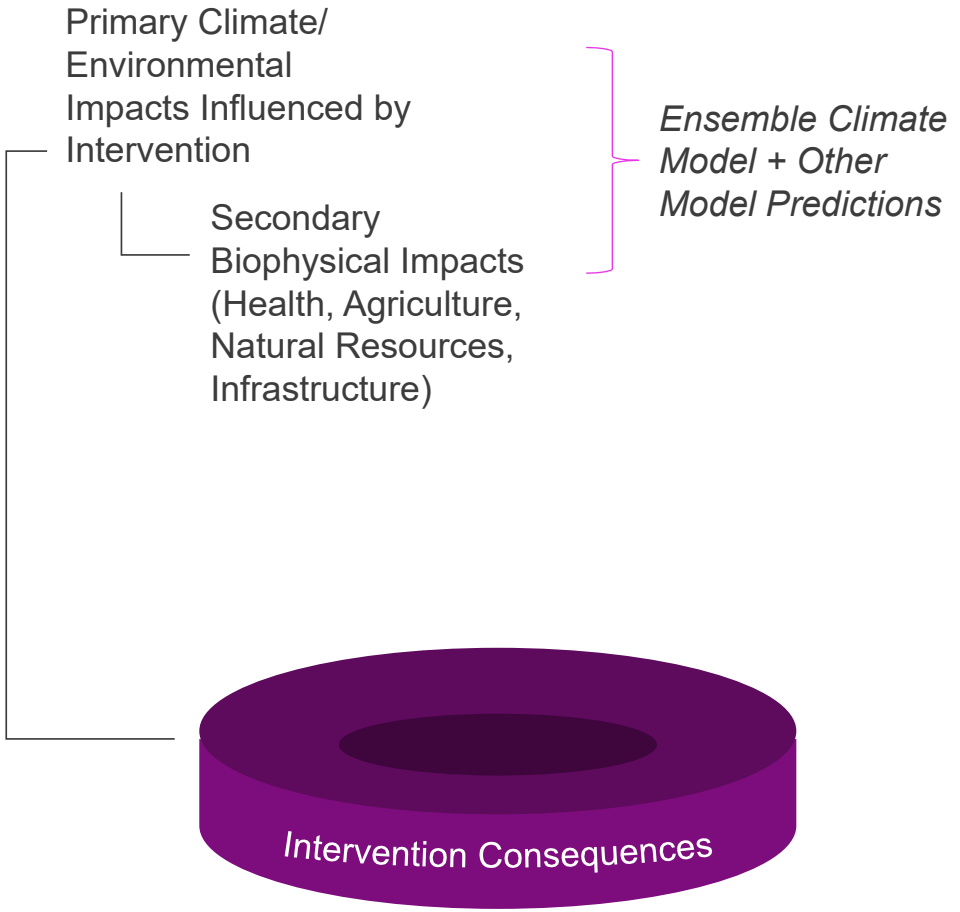
- Associated consequences on the climate (variables of impact)
  - E.g., *reduced direct solar input, atmospheric chemistry changes & ozone depletion, etc.*



# 3 Risk Framework Phases: Consequence Analysis

Iterating through **resulting consequences of the intervention** under assumed conditions:

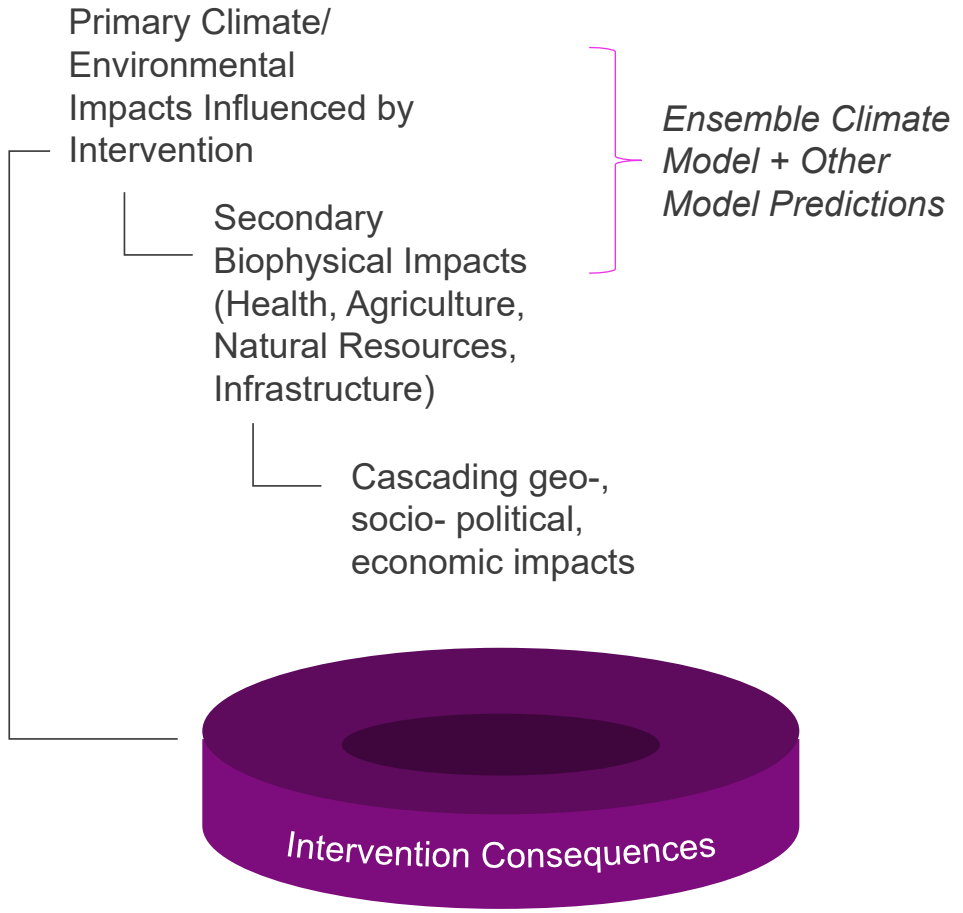
- Associated consequences on the climate (variables of impact)
- Biophysical consequences
  - E.g., *ecosystem changes, biodiversity impacts, disease ecology, precipitation changes, etc.*



# 3 Risk Framework Phases: Consequence Analysis

Iterating through **resulting consequences of the intervention** under assumed conditions:

- Associated consequences on the climate (variables of impact)
- Biophysical consequences
- Geopolitical and societal consequences
  - E.g., *food insecurity, economic depression, civil unrest, migration, etc.*
  - Other considerations: *diminished climate mitigation ("moral hazard"), termination shock*



# Conclusions and Recommendations

## Risk assessments relevant to U.S. government agency missions are needed to support future decision-making on climate interventions

## Our proposed framework can serve as a guide to forecast and better understand unintended consequences of technical and policy measures

- The conceptual framework structures *how* to think about a complex problem and potentially inform decision-making under uncertainty – despite data gaps, limitations, and unknowns
- Allows for a comparison of the relative effects of climate change to the impacts an intervention would have if deployed
- The framework can also be used to highlight areas for further R&D

## Further opportunities for Sandia to contribute to implementing and operationalizing the risk framework

- *Reducing uncertainty in risk assessments will be critical*
  - Clarify development and deployment costs and technical readiness of various interventions
  - Reduce climate model prediction uncertainty at regional and global scales
  - Add climate model features to facilitate simulation of different interventions
  - Develop technology to perform field experiments and test models
  - Improve confidence in estimated socio- and geo- political impacts of specific environmental events

# Acknowledgements

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Thank you!
Questions?

# Possible Futures – Selecting Climactic and Political Baselines

**International Governance Structure**

| Temperature Regimes | Scenario 1: Unipolar Global Order: U.S. Global Leadership | Scenario 2: Bipolar Global Order: Strong U.S. | Scenario 3: Multipolar Global Order | Scenario 4: Bipolar Global Order: Weak U.S. | Scenario 5: Unipolar Global Order: No U.S. Leadership |
|---|---|---|---|---|---|
| **Scenario A: <2.0°C Increase** | Strong norms and institutions. Upholding of treaties. Minimal climate tensions. | Geopolitical polarization. Stable balancing of bilateral power. Minimal climate tensions. | Volatile global security. Norms and institutions may collapse. Minimal climate tensions. | Geopolitical polarization. Shift or collapse of norms and institutions. Minimal climate tensions. | Shifts or collapse of norms and institutions strain global security. Minimal climate tensions. |
| **Scenario B: 2.0-4.4°C Increase** | Institutions facilitate climate cooperation. Global climate strategies depend on U.S. policy. | Bilateral competition on climate leadership, including geoengineering capabilities. | Strained global cooperation. Climate resources diverted to military. | East-West alliances may lead to fragmented or polarized approaches to climate change. | Global leader may seek new climate strategies. Climate resources diverted to military. |
| **Scenario C: 4.5-5.9°C Increase** | Shift from climate mitigation to adaptation. Strained resources to support developing countries. | Bilateral competition for scarce resources. Tensions related to climate responsibility. | Military capabilities needed for climate, defense and resource competition reduce resources for mitigation. | Increased East-West polarization related to climate leadership and natural resource competition. | Shift from climate mitigation to adaptation. Specific climate actions dependent on strategy of global leader. |
| **Scenario D: >6.0°C Increase** | Strained resources for adaptation may be allocated strategically. Possible increase in nationalism and/or domestic unrest. | Tensions related to migration and natural resource scarcity. Increased resources diverted to military and border control. | Migration and resource scarcity leads to conflict. Increases in nationalism and militarized response to climate impacts | Migration and natural resource competition across East-West borders serve as geopolitical flashpoints. | Strained resources for adaptation may be allocated strategically. Possible increase in nationalism and/or domestic unrest |


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