Important concepts

- **Vulnerability**: Susceptibility to be harmed; composite of sensitivity and coping/adaptive capacity

- **Resilience**: capacity to cope with, recover from, or adapt to hazards (seasons-to-centuries)

  - **Sensitivity**: the degree to which changes and/or variability in climate lead to changes in system attributes (the “why”)
  - **Coping/Adaptive capacity**: resources available for implementing adaptation options (the “how”)

- **Adaptation**: adjustments in anticipation of or in response to climate change and/or variability (the “what”)

Quantifying Vulnerability and Resilience

Sensitivity sectors

- Settlement
- Food
- Health
- Ecosystems
- Water

Coping and Adaptive Capacity

- Economics
- Human Resources
- Environment

National Baseline Estimates and Projections of Sectoral Indicators, Sensitivity and Coping-Adaptive Capacity, and Vulnerability-Resilience Response Indicators to Climate Change
Vulnerability assessment: framework for answering the “so what” question

- Integrates both biophysical and socio-economic dimensions and both near and long terms

- Comparison to impact assessment:
  - “Climate impact assessment addresses the magnitude and distribution of the consequences of climate variability and change. Vulnerability assessment extends the impact assessment by highlighting who (as in what geographic or socio-economic groups) is susceptible, how susceptible they are, and why.” Ribot, et al., 1996

- Quantification would facilitate integration of diverse types of information to assess significance of climate change
Why is adaptation important?

- Climate change cannot be totally avoided; current (mal)adaptations to current variability may be exacerbated by climate change.
- Adaptation is crucial to understand the response of natural and managed systems; relevant to identifying “dangerous” change.
- Developing countries’ economies and livelihoods are sensitive to climate variability; potential to reduce losses by increasing resilience.
- Anticipatory adaptation is more effective and less costly than forced, last-minute emergency response.
- Interest in adaptation is growing: National Assessment, IPCC special reports and TAR highlight its importance.
Need for indicators of vulnerability and adaptive capacity

- Aid in assessment of effects associated with different GHG stabilization levels
  - Compare extent of vulnerability in different geographical locations
  - Project vulnerability over time under different scenarios—what is a “dangerous level” of change?

- Supplement other impacts metrics (e.g., $$)

- Aid in establishing adaptation priorities

- Aid in identifying research priorities: where are case studies, more complete data sets & more comprehensive analytical tools needed?
Constructing a Prototype Indicator

- Current vulnerability (resilience) estimated—39 countries
  - Proxy selection: availability of data/projections
  - National data from several sources (FAO, WRI, …)
  - Normalization/scaling: World 1990=100
  - Aggregation: proxies combined into sectors; sectors combined into sensitivity/coping capacity indicators (geometric means); vulnerability: difference of sensitivity and coping capacity

- Future vulnerability estimated under different socio-economic and climate scenarios based on IPCC’s SRES scenarios as implemented by PNNL’s “MiniCAM”

- Monte Carlo analysis to evaluate results and implications of model structure and proxy uncertainty
## Proxy Selection for the Prototype

| Settlement sensitivity | Population at flood risk from SLR  
|                       | % Population with access to safe water  
|                       | % Population with access to sanitation  
| Food sensitivity      | Cereal production/area crop land  
|                       | Animal protein consumption per capita  
| Human health sensitivity | Completed fertility  
|                       | Life expectancy  
| Ecosystem sensitivity | % Managed land  
|                       | Fertilizer use/area cropland  
| Water sensitivity     | Water supply from internal resources and inflow from rivers  
|                       | Withdrawals to meet current and projected needs  
| Economic capacity     | GDP (market) per capita  
|                       | Income distribution equity (Gini coefficient)  
| Human resource capacity | % Population in the workforce (age dependency)  
|                       | Illiteracy  
| Environmental capacity | % non-managed land  
|                       | SO₂ emissions  
|                       | Population density  


Baseline Vulnerability-Resilience Indicator Value (World value = 0 for 1990)
Projecting future vulnerability

Scenarios of the future based on Special Report on Emissions Scenarios and modeled by MiniCAM (energy and economics internally balanced)
USA's Vulnerability-Resilience Indicator values and their uncertainties over time from the Prototype (VRIP) calculations.
Senegal's Vulnerability-Resilience Indicator values and their uncertainties over time from the Prototype (VRIP) calculations
Some conclusions from the experiment

- The model-based approach of the Vulnerability-Resilience Indicator is a potentially powerful tool in the assessment of vulnerability and policy development.

- Different starting conditions lead to different results.
- Proxies interact in diverse ways because of their contributions within sectors and at the Sensitivity/Adaptive Capacity level.
- Different scenarios lead to different types of vulnerability.
But some caveats apply

- Wealth is not the only determinant of vulnerability—many countries’ indices show no significant correlation

- Lack of knowledge about inequality within societies hampers our ability to assess who is vulnerable to what

- The projections based on the SRES scenarios are very optimistic compared to case studies or other extrapolations

- Governance is not explicitly considered (i.e., good governance is assumed)
Role for research and assessment

- Support decisions using available knowledge and scientific infrastructure

- Explore “what if” questions using scenarios that illuminate relationships, tradeoffs, and possible outcomes, given uncertainties

- Identify vulnerabilities and opportunities and so provide more focus to decisions about infrastructure, investments, and future policy choices

- Engage the public and use assessment as a tool for communicating knowledge and identifying needs
USA: percentages contribution by the proxies to the uncertainties of the VRIP indicator values in the rapid growth scenario.
USA: percentages contribution by the proxies to the uncertainties of the VRIP indicator values in the delayed development scenario

- Population density
- Sulfur emissions/total land
- Non-managed land (% of total)
- Illiteracy
- Age dependency
- Gini coefficient
- GDP/cap
- Water availability
- Fertilizer use/ag land
- Managed land (% of total)
- Life expectancy
- Birth rate
- Animal protein demand
- Cereal production/ag land
- Sanitation
- Safe water
- Population at risk due to sea level rise
Senegal: percentages contribution by the proxies to the uncertainties of the VRIP indicator values in the rapid growth scenario

- population density
- sulfur emissions/total land
- non-managed land (% of total)
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- population at risk due to sea level rise
Senegal: percentages contribution by the proxies to the uncertainties of the VRIP indicator values in the delayed development scenario.