Overview of Vulnerability Assessment Concepts and Applications

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EURAC topics

Remote Sensing

Climate Change Risk + Vulnerability Assessment
Content

→ General concepts

→ Operationalisation of concepts
  - Impact chain generation
  - Methods for data / knowledge collection

→ Examples

Vulnerability to climate change
- what needs to be considered?

Source: http://www.agci.org
understanding vulnerability → dealing with complexity

Focus & Simplification

The risk community concepts

“Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.”
(Parry 2007, p. 883)
Vulnerability:
“The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.”

Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.”
Diverse concepts but limited tool boxes for operationalisation

General concepts

Operationalisation of concepts
  - Impact chain generation
  - Methods for data / knowledge collection

Examples
Purpose and scope of the VA

Typical questions VAs are required to respond to:

- What / who and is vulnerable and where?
  > Identification of the most vulnerable parts, sectors or regions of / within a system

- What could I do?
  > Identification of adaptation measures / development of adaptation strategies

- My previous measures / activities - were they successful?
  > Monitoring adaptation measures and justification for resource allocation

Scope - differences according to:

- Focus: sectors / topics
- Context: available resources and time
- Scale: area covered, resolution desired
- Outputs: according to user demand (reports / maps / platform etc.)

Different VA approaches

Further distinction:

- exploratory ↔ in-depth
- qualitative / narrative ↔ subjective ↔ quantitative / indicator-based / objective
- spatially explicit yes ↔ no
Ecosystems:
- hydrosphere, lithosphere,
- pedosphere, biosphere,
- atmosphere, cryosphere

Ecosystem services:
- provision (food, water), regulation (climate, diseases), support (crop pollination), beauty/recreation

Natural resources driven economic space:
- agriculture, forest, fishery, hydro energy etc.
- Technique, trade and service driven economic space: factories, offices, market places etc.

People:
- individuals, groups: social, ethnic, economic, legal, etc.

Impacts of climate change

Impact chain - exposure [1]

Exposure

Sensitivity

Potential Impact

Adaptive Capacity

Vulnerability
Impact chain - exposure [2]

Impact chain - sensitivity
Impact chains - exposure and sensitivity

Adaptive Capacity

Exposure

Sensitivity

Potential Impact

Adaptive Capacity

Vulnerability

Which structures and institutions of the system allow to cope with intermediate change impacts and minimize sensitivity factors?
Select methodology for indicator-related data acquisition

Types of data acquisition methodology

- Measurements (gauge data for run-off, census data)
- Models (hydrological modelling, population distribution models)
- Existing databases / statistics (proxy indicators)
- Expert opinion (via interviews, questionnaires, workshops)

Examples - EO data
Multitemporal

Landsat: 40 years
NOAA AVHRR 35 years
MODIS: 14 years

➔ Change Detection

➔ Time Series Analysis

Source of Energy

Sensor

Receive reflected / emitted radiation
Receive reflection of active signal

Backscatter
Antenna + Sensor

+ high spatial resolution
+ high temporal resolution
+ good global coverage
+ multispectral information
+ relatively cheap, some free
- dependent on weather conditions

Optical vs. Radar

+ weather and daylight independent
+ subsurface information
  (soil moisture)
+ topographic Information
- expensive (until now)
- difficult to interpret
- WorldDEM from TanDEM-X Mission
- Commercial Mission! (PPP). Costs for commercial users: ~10 $ / km²

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**Link: Essential Climate Variables (ECV)**

<table>
<thead>
<tr>
<th>Terrestrial ECV</th>
<th>Observing System (i.e. ESA, others)</th>
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<tbody>
<tr>
<td>River Discharge</td>
<td>In situ networks,</td>
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<tr>
<td>Water Use</td>
<td>In situ networks, regional remote sensing activities</td>
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<tr>
<td>Groundwater</td>
<td>In situ networks,</td>
</tr>
<tr>
<td>Lake and Reservoir Levels &amp; Volumes</td>
<td>In situ networks, regional remote sensing activities</td>
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<td>Snow Cover</td>
<td>GLOBSNOW</td>
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<td>Glaciers and Ice Caps</td>
<td>GLOBGLACIER</td>
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<td>Permafrost</td>
<td>Regional activities (i.e. circumb-arctic)</td>
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<td>Albedo and Reflectance Anisotropy</td>
<td>GLOBALBEDO</td>
</tr>
<tr>
<td>Land Cover</td>
<td>GLOBCOVER, MODIS land cover</td>
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<tr>
<td>Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)</td>
<td>GLOBCARBON, MODIS and Seawifs products</td>
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<tr>
<td>Leaf Area Index</td>
<td>GLOBCARBON, MODIS products</td>
</tr>
<tr>
<td>Biomass</td>
<td>Regional activities, e.g. Siberia</td>
</tr>
<tr>
<td>Fire Disturbance</td>
<td>Several global products from AATSR or MODIS</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>SMOS satellite mission</td>
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</tbody>
</table>

(Herold&Wulder, GOFC-GOLD)

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Working steps for composite indicator assessment

1. Impact Chain
   - Cause
   - Effect
   - Who and what is vulnerable?
   - To which exposure / impact?

2. Metrics / Indicators
   - Method to quantify the factors of the impact chains and their relations / correlations

3. Aggregation / weighting
   - Method to combine and weigh the individual indicators

Impact chains generation and indicators selection - not an exercise for the ivory tower
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→ Examples

Example 1: Germany
“Netzwerk Vulnerabilität” (Network Vulnerability)

Fact sheet:
- Assessment of vulnerability to climate change
- National coverage, resolution: 3rd admin level (“Landkreis”)
- 16 pre-defined sectors (forest, agriculture, infrastructure, tourism, industry etc.)
- Aim to consider cross-sectoral links
- Outputs: reports and maps
- Overall objective: inform the government in developing adaptation strategies and define actions
- !! Create a network of national authorities to support this assessment !!
Impact chain example: German Network Vulnerability

Sector: Agriculture

Impact chain agriculture - zoom in
Network Vulnerability: inter-sectorial connections

All sectors: outgoing

All sectors: incoming

Network Vulnerability: example map wildfire risk

Legende

schwächste Klimaveränderung

stärkste Klimaveränderung

stärkste Zunahme

keine Änderung

stärkste Abnahme

VA in Arab Region, Beirut, 8-10 June 2015

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Example 2: Europe
Assessment of vulnerability to climate change

Fact sheet:
- ESPON financed pan-European vulnerability assessment
- European coverage, resolution: Nuts3 level
- Generic assessment of climate stimuli, sensitivity and adaptive capacity independent of sectors or impact predominantly by proxy indicators
- Weighting based on the Delphi method by selected experts
- Outputs: reports and maps
- Overall objective:
  - identifying regional typologies of climate change exposure, sensitivity, impact and vulnerability
  - evidence basis for territorially differentiated adaptation strategies

ESPON cc VA - methodology

Figure 2: Overview of the ESPON Climate vulnerability assessment methodology
- Awareness that normative decisions are necessary
  - For example: focus sectors or impacts, selection of indicators, rules for aggregation etc.

- Transparency - show intermediate results

- Communicate / visualize uncertainties

- Realism - the study design must not be too ambitious
  - balance deep vs broad

- Research needed for socio-economic scenarios

- Stakeholders included from the beginning

- The process is already a result
Thank you for your attention!