Developing an index of vulnerability to climate change for Arctic fox dens

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1. Context
Climate change in the Arctic is projected to:
- Increase air temperature
- Increase precipitation
- Increase storm magnitude and frequency

Consequences
- Thawing permafrost
- Slope instability
- High water levels (rapid spring melting)
- More hazard-triggering events (extreme weather events)

Arctic foxes use the same den year after year and highly depend on a good denning site for reproductive and protection purposes.

The increasing frequency of geohazards may be a serious threat for the stability of arctic fox dens.

2. Objective
To develop a simple vulnerability index to climate change-related hazards for arctic fox dens

How can we assess vulnerability?
(See definition above)

- Exposure: All dens are exposed to the projected changes in the Arctic

- Sensitivity: The sensitivity depends on den characteristics together with its surroundings.

- Adaptive capacity: Foxes can easily adapt to slow alterations by compensatory digging, hence we must select only moderately fast to fast-acting geohazards.

3. Method

Vulnerability definition
“Vulnerability is a function of [...] climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.”
- IPCC (2001)

Step 1: Identification of relevant hazards
- Thaw settlement
- Mass movements
- Thermo-erosion

Step 2: Choice of vulnerability indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Thaw settlement</th>
<th>Mass movements</th>
<th>Thermo-erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground ice content</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Slope gradient</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>X</td>
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</table>

Step 3: Normalization and weighting of indicators for each hazard

Mass movements Relative Vulnerability Index

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Score</th>
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</thead>
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<tr>
<td>Ground ice content</td>
<td>0.10</td>
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<td>Slope gradient</td>
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</tr>
<tr>
<td>Erosion</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Fig. 1. Percentage (%) of dens (n = 160) classified in each vulnerability class (green = low vulnerability, yellow = moderate vulnerability, red = high vulnerability) with their distribution in the study area.

4. Results

Fig. 1. Vulnerability computation framework for one hazard (here mass movements). Adapted from Kappes et al. (2012)

5. Conclusion
We assessed vulnerability of arctic fox dens to climate change using an indicator-based approach. This very flexible method is often employed in infrastructure/building management or in social vulnerability assessments. Here we show that it is also suitable for evaluating physical structures used by animal species.

Main references

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