Future exposure and vulnerability to multi-sector hotspots

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Impacts World 2017
C8: Socio-economic consequences of climate extremes and compound impacts
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Global mapping of multi-sector climate and vulnerability hotspots

Multiple Indicators (~12) across 3 sectors

Regions with multi-sector climate hotspots and vulnerable populations
Downscaling future scenarios of socioeconomic change

- **Shared Socioeconomic Pathways (SSPs)**
  - SSP 5: (Mit. Challenges Dominate)
    - Fossil-fueled Development
    - Taking the Highway
  - SSP 3: (High Challenges)
    - Regional Rivalry
    - A Rocky Road
  - SSP 2: (Intermediate Challenges)
    - Middle of the Road
  - SSP 1: (Low Challenges)
    - Sustainability
    - Taking the Green Road
  - SSP 4: (Adapt. Challenges Dominate)
    - Inequality
    - A Road Divided

- **Population**
- **Urbanization**
- **GDP**
- **GINI (inequality)**
  - Gridded to 0.125° (1/8th °)

- **Income**

Who is vulnerable to poverty (<$10/day)?

O’Neill et al. (2014)

Jones & O’Neill (2016)
Jiang & O’Neill (2017)
Dellink et al. (2017)

Gidden et al. (…, forthcoming)
### Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water stress index</td>
<td>Water stress index: as a proportion of human demands divided by renewable surface water resources</td>
<td>5 GCMs, 3 GHMs</td>
</tr>
<tr>
<td>Non-renewable GW abstraction index</td>
<td>Fraction of groundwater abstraction that is non-renewable</td>
<td>HadGEM2-ES + PCR- GLOBWB</td>
</tr>
<tr>
<td>Drought intensity</td>
<td>% change in drought intensity (deficit / duration)</td>
<td>5 GCMs, 4 GHMs</td>
</tr>
<tr>
<td>Peak flows risk</td>
<td>High fraction of ensemble agreement where substantial change in flood risk (doubling) is expected</td>
<td>5 GCMs, 4 GHMs</td>
</tr>
<tr>
<td>Seasonality</td>
<td>% change for the index of mean seasonality</td>
<td>5 GCMs, 4 GHMs</td>
</tr>
<tr>
<td>Inter-annual variability</td>
<td>% change for the index of mean inter-annual variability</td>
<td>5 GCMs, 4 GHMs</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to clean cooking</td>
<td>Fraction of population with access to clean cooking</td>
<td>MESSAGE + SSPs</td>
</tr>
<tr>
<td>Heatwave event exposure</td>
<td>Total days experienced as 5-day events above hist. p99 for locations where Tmean p99&gt;26°C.</td>
<td>5 GCMs</td>
</tr>
<tr>
<td>Cooling demand growth</td>
<td>Measure absolute change in CDD&gt;26°C.</td>
<td>5 GCMs</td>
</tr>
<tr>
<td>Hydroclimate risk to power production</td>
<td>Combined thermal and hydropower capacity impacted by changes in low flows, peak flows and variability</td>
<td>5 GCMs, 4 GHMs</td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop yield</td>
<td>Mean change in crop yield as basket of staple crops</td>
<td>GLOBIOM</td>
</tr>
<tr>
<td>Water exploitation index</td>
<td>Identify major changes of agriculturally driven water exploitation</td>
<td>GLOBIOM + LPJmL</td>
</tr>
<tr>
<td>Habitat degradation</td>
<td>Change from non-ag to agricultural land use</td>
<td>GLOBIOM</td>
</tr>
<tr>
<td>Nitrogen leaching</td>
<td>Measurement of excess nitrogen leaching due to intensive agriculture</td>
<td>GLOBIOM</td>
</tr>
</tbody>
</table>
Climate change index scoring under uncertainty

Continuous scale (0 to 3) with intermediate ranges determined
0. Negligible risk
1. Low risk
2. Moderate risk
3. High risk

2.0°C climate example: Drought intensity change
Sectoral aggregation

Combine average scores with ‘hotspot points’
- Scores are averaged within sectors and indicators can be weighted
- Hotspots:
  - Min. score 2 if 2 sectors > 2.5
  - Min. score 2 in 1 sector == 3.0
Hotspot areas

- Growing in area
- Growing in intensity
Regionalised impacts

- Northern hemisphere regions have better than average impacts
- Most Asian and southern regions are on/worse than average
Exposure & vulnerability

SSP3 2050 3.0°
10.0bi total, 7.2bi exp, 1.83bi E&V
NORTH AMERICA
LATIN AMERICA
EUROPE
ASIA
SE ASIA & AUSTRALASIA
AFRICA

3.0°
20 40 60 80 100 %
### Exposure & vulnerability

<table>
<thead>
<tr>
<th>2050</th>
<th>1.5°C / SSP1</th>
<th>2.0°C / SSP2</th>
<th>3.0°C / SSP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>8.5 bi</td>
<td>9.2 bi</td>
<td>10.0 bi</td>
</tr>
<tr>
<td>E</td>
<td>2.3 bi x2</td>
<td>4.9 bi</td>
<td>x1.5 7.2 bi</td>
</tr>
<tr>
<td>V</td>
<td>1.1 bi</td>
<td>1.3 bi</td>
<td>2.7 bi</td>
</tr>
<tr>
<td>E&amp;V</td>
<td>0.3 bi x2</td>
<td>0.7 bi</td>
<td>x2.5 1.8 bi</td>
</tr>
</tbody>
</table>

### Diagram 1: SSP1 2050 1.5°C
- 8.5bi total, 2.3bi exp, 0.3bi E&V
- North America, Europe, Asia, South Asia & Australasia

### Diagram 2: SSP2 2050 2.0°C
- 9.2bi total, 4.9bi exp, 0.72bi E&V
- North America, Europe, Asia, South Asia & Australasia

### Diagram 3: SSP3 2050 3.0°C
- 10.0bi total, 7.2bi exp, 1.83bi E&V
- North America, Europe, Asia, South Asia & Australasia
Importance of reducing inequality

- Difference: SSP1/2 to SSP3 is factor of $\sim 2$
- Holds true for range of thresholds and across GMTs
Conclusions

*Water and hydroclimate*

- Water stress indices are spatially concentrated and driven by socioeconomic drivers
- Large areas of land impacted by increases in drought intensity and variability

*Overall*

- Overall multi-sector exposure depends most on GMT
- Reducing inequality and poverty is key to reducing the Exposed & Vulnerable population, regardless of GMT