Compound climate extreme events in Africa

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Outline

➢ Introduction

➢ Drought-related compound extreme events

➢ Detection and Attribution

➢ Risk and vulnerability assessment
Compound extreme (CE) events

CEs are the combination of multiple *drivers and/or hazards* that contribute to societal or environmental impact (risk).

- **Drivers:** weather and/or climate processes, variables and phenomena
- **Hazards:** Changes in variability and extremes, Long-term changes/trends in average conditions
- **Primary means of interaction:** temporal compounding, spatial compounding, preconditioning, and concurrence of multiple variables
Compound extreme events: hazards and drivers

Table 1 | Climate-related hazards with compound physical drivers as well as exacerbating societal drivers

<table>
<thead>
<tr>
<th>Hazard(s)</th>
<th>Climatic drivers</th>
<th>Societal drivers</th>
<th>Refs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought</td>
<td>Precipitation, evapotranspiration, antecedent soil moisture, temperature</td>
<td>Water management, land-use change</td>
<td>48,49,56</td>
</tr>
<tr>
<td>Physiological heat stress</td>
<td>Temperature, atmospheric humidity, diurnal cycle</td>
<td>Urbanization, irrigation</td>
<td>96</td>
</tr>
<tr>
<td>Fire risk</td>
<td>Temperature, precipitation, relative humidity, wind, lightning</td>
<td>Forest management, ignitions</td>
<td>97,98</td>
</tr>
<tr>
<td>Storm risk</td>
<td>Wind speed, humidity, large-scale atmospheric circulation</td>
<td>Urbanization, deforestation</td>
<td>99</td>
</tr>
<tr>
<td>Coastal flooding</td>
<td>River flow, precipitation, coastal water level, surge, wind speed</td>
<td>Hard infrastructure, removal of natural coastal barriers</td>
<td>100,101</td>
</tr>
<tr>
<td>Flooding at river confluences</td>
<td>Precipitation, river water levels, large-scale atmospheric circulation</td>
<td>Water management, urbanization</td>
<td>58</td>
</tr>
<tr>
<td>Concurrent heat and drought</td>
<td>Temperature, precipitation, evapotranspiration, atmospheric humidity</td>
<td>Water management, soil management, land-use change</td>
<td>48,49</td>
</tr>
<tr>
<td>Concurrent wind and precipitation extremes</td>
<td>Wind speed, precipitation, orography, large-scale atmospheric circulation</td>
<td>Few or none</td>
<td>75</td>
</tr>
<tr>
<td>Concurrent heat and air pollution</td>
<td>Temperature, solar radiation, sulfur dioxide, NOx, ozone, particulate matter</td>
<td>Urbanization, agricultural and industrial activities</td>
<td>99</td>
</tr>
</tbody>
</table>

Examples of how compounding climatic drivers and societal drivers interact to produce connected climate extremes, modified from Table 1 of ref. 9. The societal drivers listed are non-exhaustive; additionally, only those that contribute directly to the hazard are considered, rather than those that contribute to the impact. Long-term anthropogenic climate change plays into many of these hazards, but is omitted here for simplicity. References are for societal drivers only (for climatic-driver references, see ref. 9).
Impacts of compound extreme events

Fig. 2 | Major losses caused by extreme climate events over 1980–2019 and their connective elements. Lines trace the annual global sum of estimated economic losses caused by tropical cyclones (green), floods (blue), droughts (orange) and wildfires (red). Annotations indicate the largest events in high-loss years followed by several of the (first row) physical and (second row) societal drivers that shaped the total impacts. Economic-loss data are from Aon, Catastrophe Insight Division.
Precipitation-related compound events

Ridder et al. (2020), Nature Communication
Precipitation- and temperature-related compound events

Ridder et al. (2020), Nature Communication
Compound events of interest

- Long-term changes in drought-related compound extremes in Africa
- The 2020-2022 drought over Eastern Africa

“Climate variability, climate change, vulnerability and exposure are creating an exceptional level of risk for food security and livelihoods”

Data and methods

➢ Change detection
What combination of hazards/drivers to assess?
Probability of occurrence, magnitude, persistence?
Definition of event(s)

➢ Detection methods
Statistical methods: event coincidence analysis

➢ Data
In-situ, EO and blended satellite products
Length of record
Attributing changes in compound extremes

- Attribution

- Statistical method that consider climate modelling uncertainty

- Bivariate fraction of attributable risk (FAR)

Climate models
Risk and vulnerability assessment

➢ Risk = Hazard × Vulnerability × Exposure

➢ Top-down Vs bottom-up approaches

➢ Vulnerability assessment for sectors of priority:
  Reviewing scientific literature and government documents
Conclusion

Drought-related compound climate extremes

- Change detection and attribution
- Risk and vulnerability assessment
- Inputs for adaptation