Where are the most vulnerable areas to climate induced insecurities and risks in Nigeria?

1. Objectives and research questions

The main objective of the spatial hotspots analysis is to map the climate-conflict nexus, and identify the geographic co-occurrence of specific combinations of conflict, climate conditions, and socio-economic vulnerabilities. The process follows four steps: determination of conflict clusters, determination of climate clusters, identification and mapping of conflict-climate interactions, and identification and mapping of socio-economic vulnerabilities. The purpose of the spatial hotspots analysis is to provide answers to the following research question:

Where are the hotspots of climate hazards, conflict, and socio-economic vulnerability?

In response to this question, a traffic light code is created following three categories (green color: limited conflict - good climate, yellow color: moderate conflict - harsh climate, and red color: high conflict – harsh climate). All other co-occurrences are colored in gray, for simplicity. The hotspots of climate insecurities correspond to the socio-economic vulnerabilities overlapping with the yellow and red categories of the traffic light code.

2. Methods and data

The hotspots analysis develops four steps: determination of conflict clusters, determination of climate clusters, identification and mapping of conflict-climate interactions, and identification of socio-economic vulnerabilities. The conflict and climate clusters are determined through pattern-based spatial cluster analysis using a regular grid of 30 km2 of resolution. The labels for the resulting groups are defined by a conflict or climate gradient from descriptive statistics. The socio-economic vulnerability conditions are determined by extreme percentiles (10% and 90%, depending on the variable), based on the assumption that the most extreme conditions (in either tail of the probability distribution) are the most likely spots for urgent intervention. Finally, a simple traffic light code is used to identify the hotspots of climate-conflict and socio-economic vulnerability. Conflict data are from ACLED; climate data are from CHIRPS, TerraClimate, and AgERA5; and socio-economic variables are from the Institute for Health Metrics and Evaluation (IHME), Facebook's wealth maps, amongst others. Most of these data are directly available through Google Earth Engine.

3. Results

- Conflict events across Nigeria during 1997-2021 are distributed over three areas of the country: around north-central cities of Abuja, Kaduna, Zaria, Kano; southern areas (Enugu, Owerri, Benin, and Lagos), but also in north-eastern states as Borno and Adamawa. (Figure 1.A). Three clusters were identified based on statistical analyses. The high conflict cluster is estimated in Delta, Edo, Ondo, Ekiti, Osun, Lagos, and southern of Oyo states; the capital Abuja, Jos, Kaduna, Gusau, Sokoto, and surroundings of Mubi cities. The moderate conflict cluster

surrounds the high conflict areas. The conflict events are diverse and representative between high, moderate, and limited conflict clusters. The violence against civilians, protests, battles, and riots are the main conflict events. Nevertheless, in the three conflict clusters, the major number of fatalities are attributed to battles, violence against civilians, and explosions .

- The interaction between conflict and climate clusters is presented through a traffic light color code (Figure 1.B). **The red color indicates the co-occurrence of high conflict and harsh climate conditions**. Here specifically, the negative climate conditions are determined by high variability in rainfall, a high number of days with moisture stress, long dry spells, high levels of water deficit, high temperatures, and increases in temperature over the last 30 years. Yellow color corresponds to the co-occurrence of **moderate conflict and harsh climate conditions**. The location of high conflict but also harsh climate occurs in the western region between the limits of the local authorities of **Kware and Wurno**; simultaneously, these conditions are present in the northern limits of Marte and Ngala, and Jere and Konduga local authorities. The moderate conflict and harsh climate are present in the northern of Sokoto, Zamfara, Katsina, and most of the area of the Borno states. Meanwhile, the green color determines the intersection between limited conflict and good climate settings, as can be seen in the **Ondo, Edo, Cross River, south-eastern of Benue, Tabara, and Adamawa states**; **Niger, Bauchi, Kaduna, and Plateau states** also presents good climate and limited conflict conditions. All other combinations (which cover a substantial portion of the country) are colored in grey, for simplicity in the visualization.

- Figure 1.C shows the socio-economic hotspots (left), and they are overlaid by the conflict-climate interactions (right). The social vulnerabilities are determined by the resource and mobility impact pathway. In the map, the vulnerabilities are presented by the following categories: undernutrition (U), inequality (I), migration (M), low productivity (LP), and their co-occurrences. Despite of the reduced number of **high conflict and harsh climate interactions, they co-occurred with hotspots where migration and inequality issues are present (local authorities of Kware and Wurno), low productivity (northern limits of Marte and Ngala) and inequality and low productivity (Jere and Konduga local authorities)**.

- A high number of hotspots determined mainly by **inequality and low productivity hotspots are present in the south-western areas of Nigeria, where limited conflict and good climate co-occur**. **Inequality and migration issues occurred in northern areas of the country in the border limits with Niger**.

A. Conflict distribution: geographical location and distribution per type of conflict
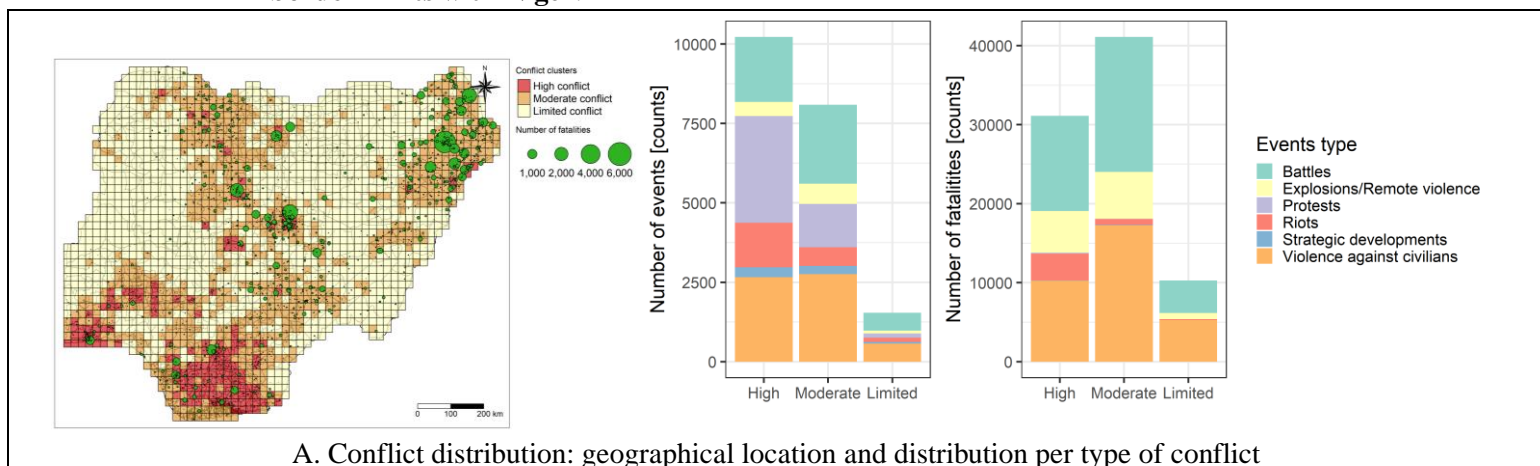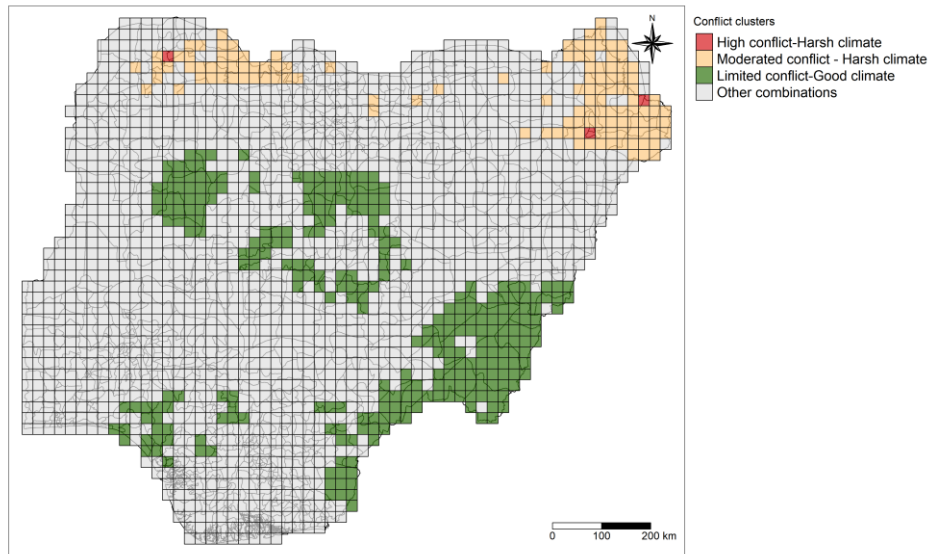
B. Conflict-climate interactions
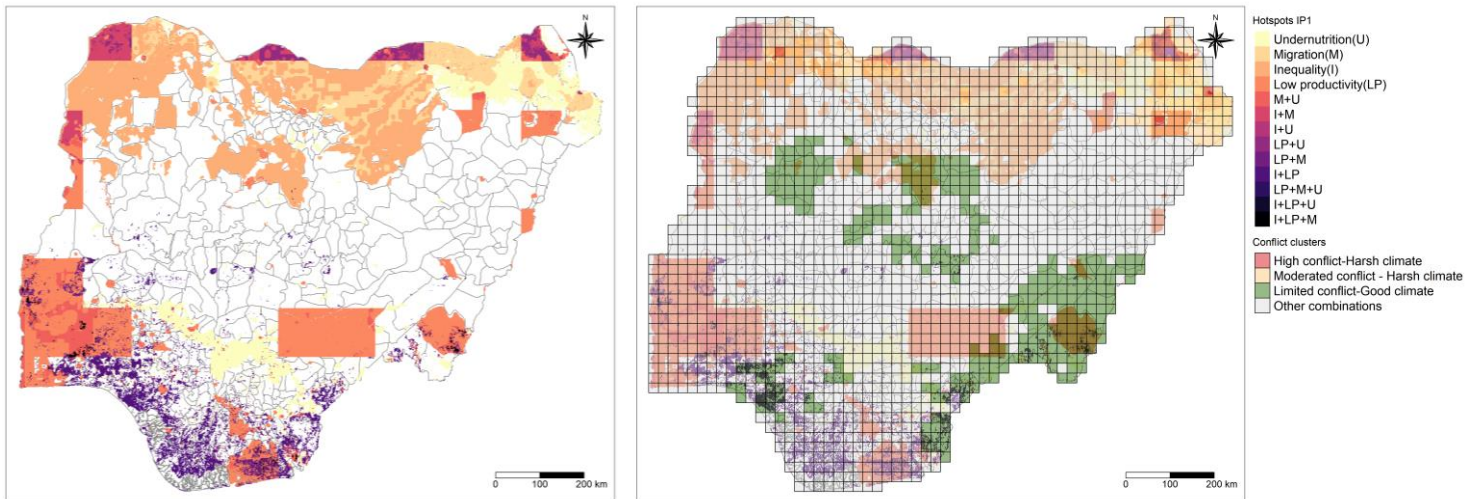
C. Hotspots

Figure 1: Conflict distribution, conflict-climate interactions, and spatial hotspots