CGIAR FOCUS Climate Security

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What is the underlying structure of the climate, conflict, and socio-economic system in Sudan?

A network analysis

Ashleigh Basel, Henintsoa Onivola Minoarivelo, Alessandro Craparo, Peter Läderach and Grazia Pacillo

This factsheet gives answers on how climate exacerbates root causes of conflict in Sudan, using a network analysis. Results show that the base of the Sudanese network is underpinned by a pastoralist society and agricultural productivity and that increased evapotranspiration has direct impacts on net primary production.

This publication is part of a factsheet series reporting on the findings of the CGIAR FOCUS Climate Security Observatory work in Africa (Kenya, Mali, Nigeria, Senegal, Sudan, Uganda, Zimbabwe).
The research is centered around 5 questions*:

1 How does climate exacerbate root causes of conflict?

Impact pathways

Kenya Mali Nigeria Senegal Sudan Uganda Zimbabwe

Econometric analysis

Kenya Mali Nigeria Senegal Sudan Uganda Zimbabwe

Scopus analysis**

2 Where are the climate insecurities hotspots?

Spatial analysis

Kenya Mali Nigeria Senegal Sudan Uganda Zimbabwe

3 What is the underlying structure of the climate, conflict, and socio-economic system?

Network analysis

Kenya Mali Nigeria Senegal Sudan Uganda Zimbabwe

4 Are climate and security policies coherent and integrated?

Policy coherence analysis

5 Are policy makers aware of the climate security nexus?

Social media analysis

Kenya Mali Nigeria Senegal Sudan Uganda Zimbabwe

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* Questions 1, 2, 3, 5 are analyzed at country level through a Climate Risk Lens (impact pathways, economic, spatial, network and social media analyses). The policy coherence and scopus analyses are at continental level.

**Scopus is one of the largest curated abstract and citation databases, with a wide global and regional coverage of scientific journals, conference proceedings, and books. We used Scopus data for analyzing: (1) how global climate research addresses the dynamics between climate, socio-economic factors, and conflict, and (2) how the countries studied are represented in the database.

For more information please contact: p.laderach@CGIAR.ORG

1. OBJECTIVE AND RESEARCH QUESTION

The main objective of this analysis is to quantify the underlying structure of the climate, socio-economic and conflict system. Understanding how the three main themes (climate, conflict and socio-economic) are connected, is key to defining intervention and mitigating conflict. The main research question we aim to address is: *What is the underlying structure of the climate, conflict, and socio-economic system in Sudan?*

2. METHODS AND DATA

Using network analysis, a statistical model is built to quantitatively display the connections between several variables pertaining to climate variabilities, security threats and socio-economic risks, in order to identify the underlying structure of this complex system of relationships.

Climate variables were compiled using Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) data.[1] Conflict data were gathered from the Armed Conflict Location & Event Data Project (ACLED). Socio-economic data are collated from the Institute for Health Metrics and Evaluation (IHME).

3. RESULTS

What is the underlying structure of the climate, conflict, and socio-economic system?

Despite large stretches of desert and semi-desert environment, agriculture still constitutes a major source of livelihood in Sudan, employing about 50 percent of the labour force.[2] The country's dependence on rainfed agriculture translates climate extremes such as unpredictable rains into late harvests and crop losses.[3] In a country where agriculture is a major contributor to gross domestic product, foreign exchange earnings, and livelihoods, these changes are especially critical.[4] The threats from climate variability can therefore amplify and reproduce other socio-economic insecurities in the country. Indeed, Sudan has endured many tensions around access to resources such as land and water.[5] Government conflicts have also occurred such as the War of Darfur, while recent coups concerning military control continue.[6,7] Sudan therefore presents a complex system in which to explore the interrelationships between climate extremes, social insecurities, and risks as well as conflict.

Among 20 variables, the network model retained 13 variables. Each category of variables is represented in the network model (different colours), suggesting the relevance of many sectors of the socio-economic landscape to the climate-conflict nexus, for Sudan (Figure 1).

The base of the Sudanese network is underpinned by pastoralist society and agricultural productivity (nodes 8, 9). However, these two elements are governed by education and other socio-economic metrics. Higher evaporation due to increasing temperatures can highly affect water supplies in ecosystems that rely on already limiting water access such as Sudan.[3,4] In the network structure it is evident how increased evapotranspiration (node 2), has direct impacts on net primary production (node 6). Over the last several decades the semi-desert region in Sudan has shifted southwards, expanding the current desert areas.[2] While semi-desert regions can be utilized by farmers and pastoral communities, fully desert regions become increasingly inaccessible. As these land resources

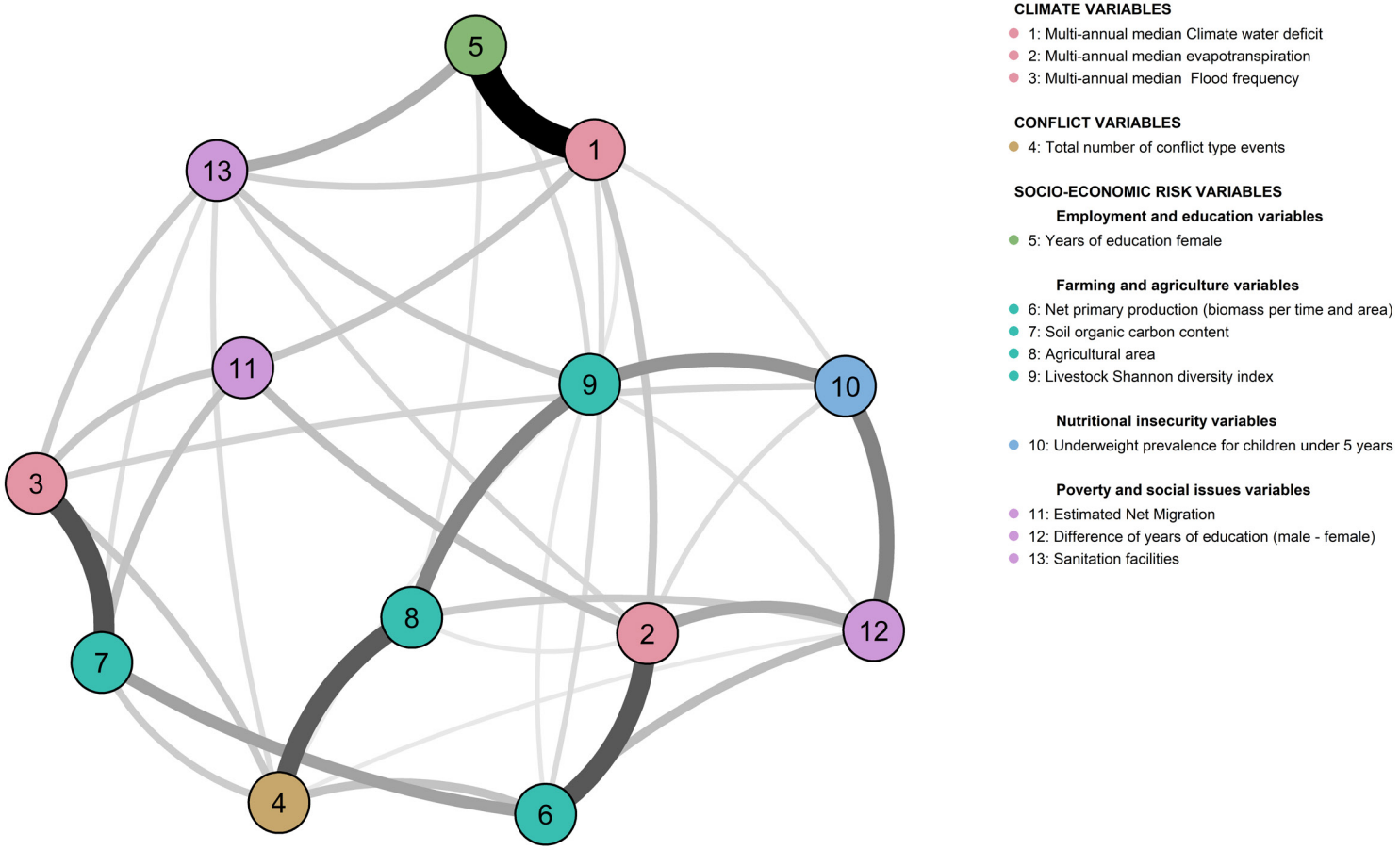

Figure 1: Relationship between climate, conflict and socio-economic risks as a network model for the Sudan case. The width of each edge corresponds to the strength of the relationship between each pair of variables.

dwindle, so too does competition increase between communities that rely on them for income and livelihoods.[8] These factors can exacerbate the risk of conflict between the farmers and pastoral communities, as they continue to compete (node 2 to node 6 to node 4).[8]

Besides dwindling land resources farmers are also at risk of other climate extremes. The Nile Delta which is shared by ten countries (Sudan, Egypt, Ethiopia, Eritrea, Tanzania, Uganda, Burundi, Rwanda, D.R. Congo, and Kenya) is home to over 160 million people.[9] Many countries are highly dependent on the Nile's water, as they are situated in arid or semi-arid regions.[9] Communities are therefore often placed in close proximity to this valuable resource. Unfortunately, this also means that when torrential floods hit Sudan, floodwaters can swamp nearby communities causing mass destruction. The floods can destroy houses, crops, roads, and basic infrastructure, resulting in the displacement of people (direct link between nodes 3 and 11).[10] Such fragility in a system can cause mass economic and livelihood losses in a community, these contribute to local grievances which can heighten the risks of conflict events. Indeed, the network indicates further direct links between flood frequency (node 3) and conflict events (node 4).

Moreover, climate-induced livelihood stress has culminated in maladaptation, whereby people engage in alternative strategies to survive. Resource scarcity and livelihood loss can drive population movements. Rural communities in the north of Sudan can be especially impacted by climate and conflict dynamics, which then act as a major push for migration. At the same time there are cross border disputes between Sudan and Ethiopia over the fertile border-lands. Sudan has recently displaced thousands of Ethiopian farmers from this area in December 2020.[11] Cross-border disputes, in fragile climate contexts can only exacerbate socio-political risks and further the complex conflict nexus.

ANNEX

We use a regularized partial correlation network [12], as part of Markov random fields, to model the climate-socio-economic-conflict relationships. A network is a graphical representation of the relationships (edges) between different entities (nodes). The variables, represented by the nodes, are categorized as (a) climate variables, (b) conflict variables, and (c) socio-economic risk variables which are further grouped into (c.1) employment and education variables, (c.2) variables linked to farming and agriculture, (c.3) nutritional insecurity variables, and (c.4) poverty and social issues variables . The edges between nodes, representing the partial correlation coefficients encode the remaining statistical association between two variables after controlling for all other information possible (conditional independence associations). These partial correlation coefficients were estimated from a matrix of Spearman's rank correlation coefficients for continuous variables. Polychoric correlations were used for categorical variables, polyserial and biserial correlations used between variables of different types. To eliminate non-significant relationships, the partial correlation network was regularized using a Lasso regularization[13] with an EBIC model selection[14].

Climate variables were compiled from Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)[14], TerraClimate, and AgERA5, for the time period 1981-2020. Conflict data were gathered from the Armed Conflict Location & Event Data Project (ACLED) for the time period 1997-2021. Socio-economic data are from the Institute for Health Metrics and Evaluation (IHME), spanning the time period 2000-2019.

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CGIAR aims to address gaps in knowledge about climate change and food security for peace and security policies and operations through a unique multidisciplinary approach. Our main objective is to align evidence from the realms of climate, land, and food systems science with peacebuilding efforts already underway that address conflict through evidence-based environmental, political, and socio-economic solutions.