CGIAR FOCUS Climate Security

FACTSHEET 2021/18

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

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 Senegal, using a network analysis. Results show that high poverty and inequality are key underlying structures in Senegal which determine the path to conflict.

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

Click on the links above to view the other Factsheets

* 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 Senegal?*

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 Demographic Health Survey (DHS).

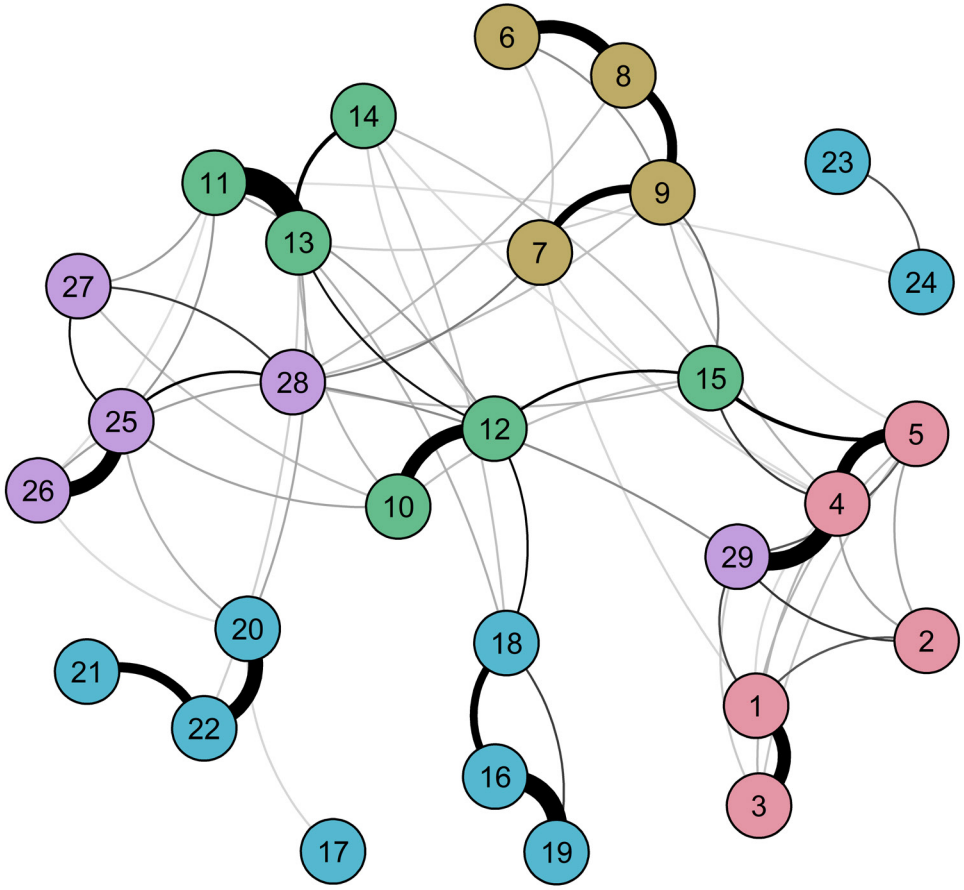
3. RESULTS

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

Climate extremes and shocks threaten countries that rely heavily on rainfed agriculture. Senegal which sits in the Sahel of West Africa is a highly climate vulnerable country and illustrates some of the most intense cases of climate change.[2] Projections in the future anticipate even further increases in temperatures with more erratic drought and flood events. Senegal will likely see major burdens to their economy, which relies heavily on agriculture for employment and GDP. Additionally, areas in Senegal have endured one of Africa's longest civil conflicts, making the climate change issue a complex problem.

Among 38 variables, the network model retained 29 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 Senegal (Figure 1).

Looking at the network variables within the same category (e.g., climate, employment and education, poverty and inequality risks) tend to be closely related. For example, all poverty and inequality variables are clustered among themselves (except total households that own agricultural land). Total households that own agricultural land (node 29) sits more closely within the climate drivers (nodes 1-5). Viewing this nexus from a systems perspective, the network model illustrates the **heavy vulnerability of crop-based agriculture to climate** (node 29) which is centrally and strongly situated in the climate cluster of nodes and especially **temperature** (node 4). This high-level of agricultural reliance on rainfall combined with observed crop vulnerability to maximum temperatures during the growing season has proven to result in reduced yield outputs in most cases. Climate change is expected to cause a reduction in sorghum, maize and millet yield by 20-50% by 2050.[3] Following on from the agricultural



CLIMATE VARIABLES

- 1: Rain 3 months before
- 2: Max temp 3 months before
- 3: Rain 12 months before
- 4: Mean temp 12 months before
- 5: Max temp 12 months before

CONFLICT VARIABLES

- 6: Explosions-remote violence - 12 months after
- 7: Strategic developments - 12 months after
- 8: Violence against civilians - 12 months after
- 9: Total conflicts - 12 months after

SOCIO-ECONOMIC RISK VARIABLES

Employment and education variables

- 10: Number of men in the HH - unemployed
- 11: Number of men in the HH - no education
- 12: Total number unemployed men and women in the household
- 13: Total number of uneducated men and women in the household
- 14: Total number working men and women in the household
- 15: Percentage of individuals unemployed at the disctrict

Nutritional insecurity variables

- 16: Number of wasted women in the household
- 17: Number of stunting women in the household
- 18: Number of women in HH with low or very low Rohrer Index
- 19: Number of women in HH with BMI <16.9 (severe or moderately thin)
- 20: Number of stunted children in the HH
- 21: Number of wasted children in the HH
- 22: Number of underweight children in the HH
- 23: HH has at least one young child that is not fed with the min food diversity
- 24: HH has at least one young child that has not been fed according to the minimum meal frequency

Poverty and inequality risk variables

- 25: Poor households
- 26: Very poor households
- 27: Very rich households
- 28: Ratio of very poor to very rich households at district level
- 29: Total households that own ag.land

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

vulnerability, the next most evident connections are **the percentage of individuals unemployed at the district** (node 15) and **the ratio of very poor to very rich households** (node 28). Importantly, all of these variables then have predominant connections to conflict variables (nodes 6–9).

A central issue in the climate-economy debate is the extent to which economic agents can respond to these climate stressors.[4] In order to adapt, farmers will need to adjust their production techniques to different climate conditions.[5, 6] Economic agents in developing countries are believed to be constrained in their ability to adapt.[4] Evidently, this adaptation deficient can cause major linkages between climate and conflict outbreaks within a country. Indeed, the network shows direct linkages between rainfall and temperature variables and conflict.

These climate stressors however also exacerbate previously existing socio-economic risks. Within the network, there are direct links between **climate** and **employment**. With employment heavily reliant on agricultural production[7], climate stressors are likely to have a significant impact on the income of a large share of the population. Through this, there is a complex interrelationship between climate (node 4, 5) resulting in a loss of employment security (node 12, 15) and in turn conflict (node 9).

Direct linkages are also evident between **conflict** and **inequality**. Indeed, we can see the link between conflict (node 7, 9) and the ratio of poor to very poor households (node 28). Despite having made significant progress, Senegal still suffers from high poverty showing a noticeable inequality between rural and urban areas.[8] The Eastern provinces of Matam and Tambacounda have some of the highest poverty rates in Senegal. Inequalities may enhance both grievances and group cohesion among the relatively deprived and thus facilitate mobilization for conflict. In Matam and Tambacounda communities are particularly vulnerable to radicalization and violent extremism.[8]

Interestingly we can also see that nutritional insecurity is the only set of nodes that does not have a direct relationship with conflict. This is not to say that nutritional insecurity does not drive conflict but rather that indirect relationships (i.e. relationships mediated by other variables) are shown to also exist, reinforcing the complexity of the system. Here, we see strong links between employment and education to nutritional insecurity variables. These mediate the relationship between conflicts and socio-economics.

ANNEX

We use a regularized partial correlation network[9], 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) poverty and inequality risk variables, (c.2) nutritional insecurity variables, and (c.3) employment and education 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[10] with an EBIC model selection.[11]

Climate variables were compiled using Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)[1] (1996-2016). Conflict data were gathered from the Armed Conflict Location & Event Data Project (ACLED) (1997-2015). Data on socio-economic vulnerabilities were collected from the Demographic and Health Surveys (DHS) from several rounds (1997, 2005, 2010-2013).

REFERENCES

1. Maystadt JF, Ecker O. 2014. Extreme Weather and Civil War: Does Drought Fuel Conflict in Somalia through Livestock Price Shocks? *American Journal of Agricultural Economics* 96(4) 1157-1182. https://doi.org/10.1093/ajae/aau010
2. United Nations Development Programme, & United Nations Development Programme. 2007. *Climate shocks: Risk and vulnerability in an unequal world. Human Development Report 2007/2008: Fighting climate change: Human solidarity in a divided world.* p.71-107.
3. Ahmed, A., Suleiman, M., Abubakar, M. J. & Saleh, A. Impacts of climate change on agriculture in Senegal: A systematic review. *J Sustain Environ Peace* 4: 30–38 (2021).
4. Crick F, Eskander,SM, Fankhauser S, Diop M. 2018. How do African SMEs respond to climate risks? Evidence from Kenya and Senegal. *World Development* 108, 157-168.
5. Wang J, Mendelsohn R, Dinar A, Huang J. 2010. How Chinese farmers change crop choice to adapt to climate change. *Climate Change Economics* 1(03): 167-185.
6. Seo SN, Mendelsohn R. 2008. An analysis of crop choice: Adapting to climate change in South American farms. *Ecological economics* 67(1): 109-116.
7. Cheong D, Jansen M, Peters R. 2013. Shared harvests: Agriculture, trade and employment. ShaRED haRvEStS: agriculture, trade, and Employment, 1.
8. USAID. 2017b. Senegal Conflict Vulnerability Assessment: Final Report. https://www.usaid.gov/sites/default/files/documents/1860/20180213_Senegal_CVA_Report_External.pdf
9. Epskamp S, Fried EI. 2018. A tutorial on regularized partial correlation networks. *Psychological Methods* 23(4): 617–634. https://doi.org/10.1037/met0000167
10. Friedman J, Hastie T, Tibshirani R. 2008. Sparse inverse covariance estimation with the graphical lasso. *Biostatistics* 9(3): 432–441. https://doi.org/10.1093/biostatistics/kxm045
11. Chen J, Chen Z. 2008. Extended Bayesian information criteria for model selection with large model spaces. *Biometrika* 95(3): 759–771. https://doi.org/10.1093/biomet/asn034

PHOTO ANDY JARVIS

About CGIAR FOCUS Climate Security

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.