POLICY BRIEF

The impact of deforestation on climate in Sahelian West Africa

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What is the issue?

Land cover change (LCC), including deforestation in Sahelian West Africa, has reached unprecedented levels, posing significant threats to regional ecosystems, livelihoods, and climate change mitigation efforts. This deforestation is driven by the interconnected pressures of agricultural expansion, population growth, and rising demand for fuelwood, and it is further exacerbated by the intensifying impacts of climate change[3]. The Sahel, a region already vulnerable to climatic extremes, has experienced rising temperatures and prolonged drought episodes[4]. These climate stressors diminish forest resilience, accelerate desertification, intensify land degradation and disrupt hydrological cycles, further endangering fragile ecosystems[3]. The combined effects of deforestation and climate change undermine food security, economic stability, and regional biodiversity conservation[5].

What did we do?

The extent of land cover (vegetation) was assessed by comparing the preindustrial period to the present, using a fully coupled regional atmospheric model (WRF) and a land surface model (Noah-MP) with dynamic vegetation, applied at a 15 km horizontal resolution over Sahelian West Africa.

Key messages

- Deforestation in Sahelian West Africa has intensified since the preindustrial era, impacting approximately 103 million people[1].
- Land surface temperatures in Sahelian West Africa have risen significantly in 2024, reaching some of the highest temperatures globally, with peaks of 45.5°C. This increase is mainly driven by deforestation[2].
- Deforestation is worsening droughts, reducing rainfall, and causing lower agricultural yields, leading to increased famine and poverty[3].
- Land restoration is essential for reducing surface temperatures, enhancing precipitation, and improving livelihoods.

The impact of deforestation on mean and extreme climate indices (temperature and precipitation) was evaluated using the same models and approach. Additionally, a bias assessment was conducted to validate the model. This model is considered one of the most advanced tools currently available for climate change assessment.

What did we learn?

1- The regional extent of land cover change (deforestation) in the Sahelian region of West Africa

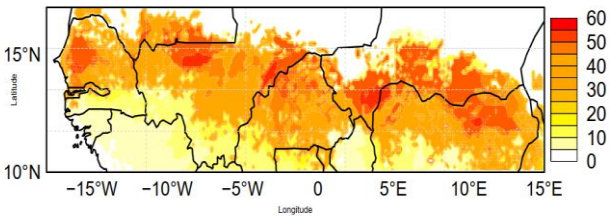

Figure 1: Land cover change fraction (%) in Sahelian West Africa using WRF-Hydro model

2- The Impact of LCC on Regional Temperature and Rainfall

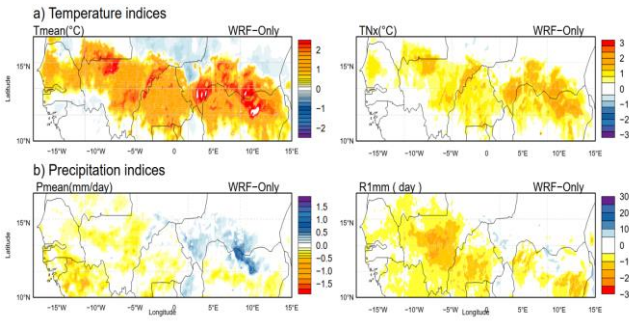

Figure 2: Temperature and precipitation/rainfall responses to LCC

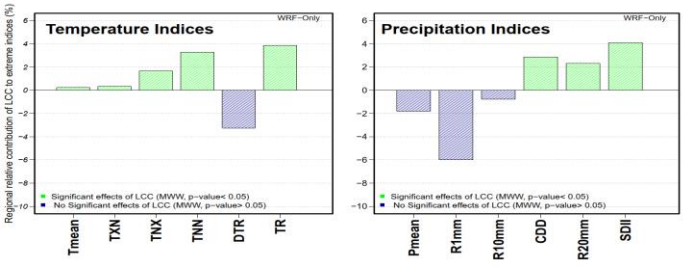

Figure 3: Regional relative contribution of LCC (%) on extreme climate indices

The extent of land cover change (LCC) exhibits significant spatial variability across the Sahelian West African region, as shown (Figure 1) by the fully coupled climate model (WRF) and land surface model (Noah-MP), with an average change of approximately 19%. These analyses capture the effects of land cover modifications on the region's surface characteristics. The most substantial changes were observed in the region's eastern part, where the LCC fraction reached up to 45%. This indicates considerable land cover

Figure 2 highlights the regional changes in temperature and rainfall/precipitation (mean and extreme indices) in response to LCC from preindustrial times to the present (2022). For temperature (Figure 2a), the region experiences a warming effect of up to +2°C in maximum temperature and +1.5°C in the extreme indices (TNx) due to anthropogenic LCC. Similarly, rainfall has decreased by up to -0.5 mm/day, and the number of wet days (R1mm) has been reduced by up to -10 days/y in response to LCC (Figure 2b).

The regional relative contribution of LCC has a greater negative impact on extreme temperatures and rainfall than on mean conditions (see Figure 3). Furthermore, extreme temperatures are affected more significantly than extreme rainfall.

For example, LCC has significantly increased land surface temperature by up to +3.8%, as reflected in the rise in the number of tropical nights (TR, defined as days when the minimum daily temperature exceeds 20 °C). On the other hand, extreme rainfall is also negatively affected, contributing to an increase in consecutive dry days (CDD, defined as consecutive days with rainfall < 1 mm), while simultaneously increasing the frequency of very heavy rainfall days and the simple daily intensity index (SDII, defined as the average rainfall on wet days with rainfall > 1 mm.

What are the policy implications?

1- Promoting climate-resilient reforestation/ afforestation programs:

- Large-scale afforestation and reforestation initiatives, such as the Great Green Wall project, can combat desertification and restore degraded lands.
- Incentivize local participation by offering economic benefits, including job creation and agroforestry opportunities.
- Establishing monitoring systems with community involvement can increase accountability and reduce deforestation.
- Invest in training programs for sustainable land use and forest conservation to reduce dependency on forest resources.
- Facilitate access to new technologies, such as the WRF-Hydro model, to identify effective strategies for mitigating climate change.

2-Scaling up renewable energy to reduce Wood fuel dependency:

- Promote alternative energy sources such as solar cookers, biogas, and improved cookstoves to reduce the demand for firewood, a major driver of deforestation.
- Target rural households with affordable renewable energy technologies and offer incentives for adopting cleaner energy options.
- Develop programs to diversify income sources for communities reliant on forest exploitation.
- Mobilize resources from global climate funds to support forest conservation initiatives in the Sahel.

What next?

- What measures can be taken to reduce the heavy dependence of the rural population on wood fuel?
- Further studies are needed, such as proposing a fully coupled regional modeling approach to project the potential future impacts of various land management strategies and scenarios.
- A better understanding of the complex interactions between the land surface and the atmosphere is crucial for climate change mitigation.
- Validation is essential to assess the performance of different regional climate models used in West Africa in accurately representing and predicting findings.

Need more information?

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References

1. Dagar, J. C., Gupta, S. R., & Teketay, D. (2020). Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges-Vol. 1. Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges-Vol.1, October, 1–554. https://doi.org/10.1007/978-981-15-4136-0

2. https://watchers.news/2024/03/12/thousands-of-high-temperature-records-broken-across-africa/

3. Duku, C., & Hein, L. (2021). The impact of deforestation on rainfall in Africa: A data-driven assessment. Environmental Research Letters, 16(6). https://doi.org/10.1088/1748-9326/abfcfb

4. Sy, S., Noblet-ducoudré, N. De, Quesada, B., Dieye, A. M., Gaye, A. T., & Sultan, B. (2017). Land-Surface Characteristics and Climate in West Africa : Models ' Biases and Impacts of Historical Anthropogenically-Induced Deforestation. Sustainability, 1–24. https://doi.org/10.3390/su9101917

5. Symes, W. S., Edwards, D. P., Miettinen, J., Rheindt, F. E., & Carrasco, L. R. (2018). Combined impacts of deforestation and wildlife trade on tropical biodiversity are severely underestimated. Nature Communications, 9(1). https://doi.org/10.1038/s41467-018-06579-2