infobrief

CIFOR-ICRAF *infobriefs* provide concise, accurate, peer-reviewed information on current topics in forest research

No. 381, March 2023

DOI: 10.17528/cifor/008824 | cifor-icraf.org

Deforestation and its potential disruption of the weather patterns of the Democratic Republic of the Congo

Insights from the Kahuzi-Biega National Park landscape

Christian Amani[1] and Pham Thu Thuy[1]

Key messages

- Regions surrounding the Kahuzi-Biega National Park (KBNP) and other areas of South Kivu Province in the eastern part of the Democratic Republic of the Congo have been losing their natural forests for decades.
- There is a positive correlation between deforestation and CO_2 emissions. Our research shows that deforestation increases temperature and negatively impacts rainfall, although not significantly.
- Deforestation and its effects on the local climate are very likely to disrupt local agricultural practices and severely impact the unique biological diversity of the region.
- Understanding the important role of forests in regulating climate not only helps to develop appropriate climate change adaptation and mitigation strategies but also to attain better biodiversity conservation and food security, and to go beyond just carbon sequestration services.

Introduction

Natural ecosystems offer a variety of goods and services to humankind. Human populations have depended on natural ecosystems for their survival, especially in the tropical regions where poverty and its consequences remain pervasive. Apart from the provisioning of ecoservices (Arnold et al. 2011; Nasi et al. 2011; Sunderland 2011), natural forests have also proved to be vital in maintaining and regulating climate and weather patterns at local, national, regional and global scales (Philippon et al. 2019; Ebodé et al. 2020; Artaxo et al. 2022). However, despite their crucial importance for both our planet and our human species, natural forests are being lost and impacted worldwide, through deforestation and degradation mainly due to anthropogenic causes, with agriculture being the top driver. Scientific evidence shows that the pace is much more alarming in the tropics (Laurance 1999; Hansen et al. 2013; Jaboury et al. 2015; Murrins et al. 2021).

Known to harbour the second largest bloc of tropical rainforest in the world, the Democratic Republic of the Congo (DRC) is estimated to have lost half a million hectares of its natural forests in 2021 (World Resources Institute n.d.). However, in an area as large as Western Europe and therefore offering interesting variations, both in its forest coverage and in anthropogenic impacts on natural forest ecosystems, a clear understanding of the drivers of deforestation and forest degradation, taking into account these regional realities, is paramount to helping national policymakers devise adaptive strategies.

The eastern part of the DRC (particularly in the Kivu region) has been marked by massive deforestation and forest degradation for years (Zhuravleva et al. 2013; Nackoney et al. 2014; Teso and Karume 2019) and forest loss seems to have accelerated, due to a number of factors, including: (1) wars and political turmoil in neighbouring countries (e.g. waves of Rwandan refugees in the 1990s) and in the DRC itself (Simpson and Geenen 2021); (2) human demography; (3) energy consumption needs (most of the population relies heavily on charcoal and firewood for cooking, etc.); (4) mining (Redmond 2001; Nelleman et al. 2010); and (5) agriculture (Ickowitz et al. 2015).

1 CIFOR-ICRAF

In many rural areas, even the once available small patches of natural vegetation have been wiped out, either replaced by farmland, plantations (mainly eucalyptus trees) and other anthropogenic signatures (village extensions, infrastructure, etc.). As a consequence, natural vegetation *sensu stricto* only exists in protected areas. Because effective protection is a huge challenge, the evidence points to many cases of human encroachments at the boundaries of protected areas and various anthropogenic activities (mining, forest logging, poaching, etc.).

The region hosts the Kahuzi-Biega National Park (KBNP), one of five protected areas in the DRC listed as UNESCO World Heritage sites. The KBNP covers 600,000 hectares and comprises two clearly distinguishable entities that form its highland and lowland sectors. The park is almost entirely located in South Kivu Province, a region known to possess one of the highest human population densities in Central Africa with more than 300 individuals/km^2.

Methodological approach

Changes in the landscape, marked by deforestation and forest degradation, are likely to affect the local climate. Given the current land use, land-use change and forestry (LULUCF) trends in the KBNP landscape, we decided to focus on LULUCF factors and try to uncover any potential disruption of the local weather patterns.

We assembled a 60-year archive of climate data (from 1960 to 2020) and analysed the main trends in temperature and rainfall parameters. Data are stored at the Lwiro research centre ("Centre de recherche en sciences naturelles de Lwiro"), a centre dating back to the Belgian colonial era and located just 5 km from the KBNP.

To assess the potential impacts of deforestation on the local climate patterns, we complemented the climate data with those of the Global Forest Watch (n.d.) for the 2001–2021 period. These data gave information on tree cover loss and emission factors (CO_2e loss per hectare) at both the national and subnational levels.

All analyses (basic statistics and time series modelling) were performed using R software version 4.2.1 (R Core Team 2022). We divided the available climate data into six separate decades to display the current temperature and rainfall trends in relatively short time periods, and used the available data on deforestation to understand how forest loss was likely to impact the local climate.

Major observations and overall trends

Insights from weather patterns

Results show that there have been significant changes in temperature over the last six decades (Kruskal–Wallis chi-squared = 327.13; df = 5; p-value < 0.001). Temperatures appear to be increasing, as shown by the distribution means (Figure 1a) and medians (Figure 1b). Figure 2 shows that there is a constant positive trend that started during the decade 1981–1990 and which remains significant across the time period.

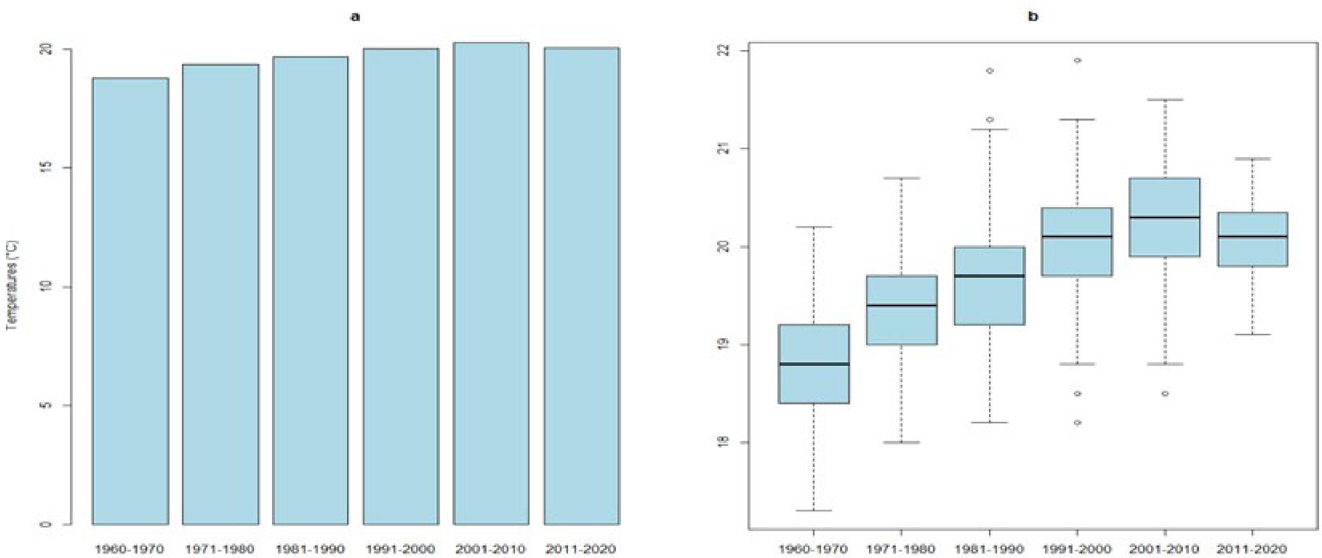

Figure 1. Changes in temperature values over the last 60 years: (a) representation of the mean temperatures; (b) boxplots showing median temperatures for each of the six decades in the surrounding areas of the KBNP.

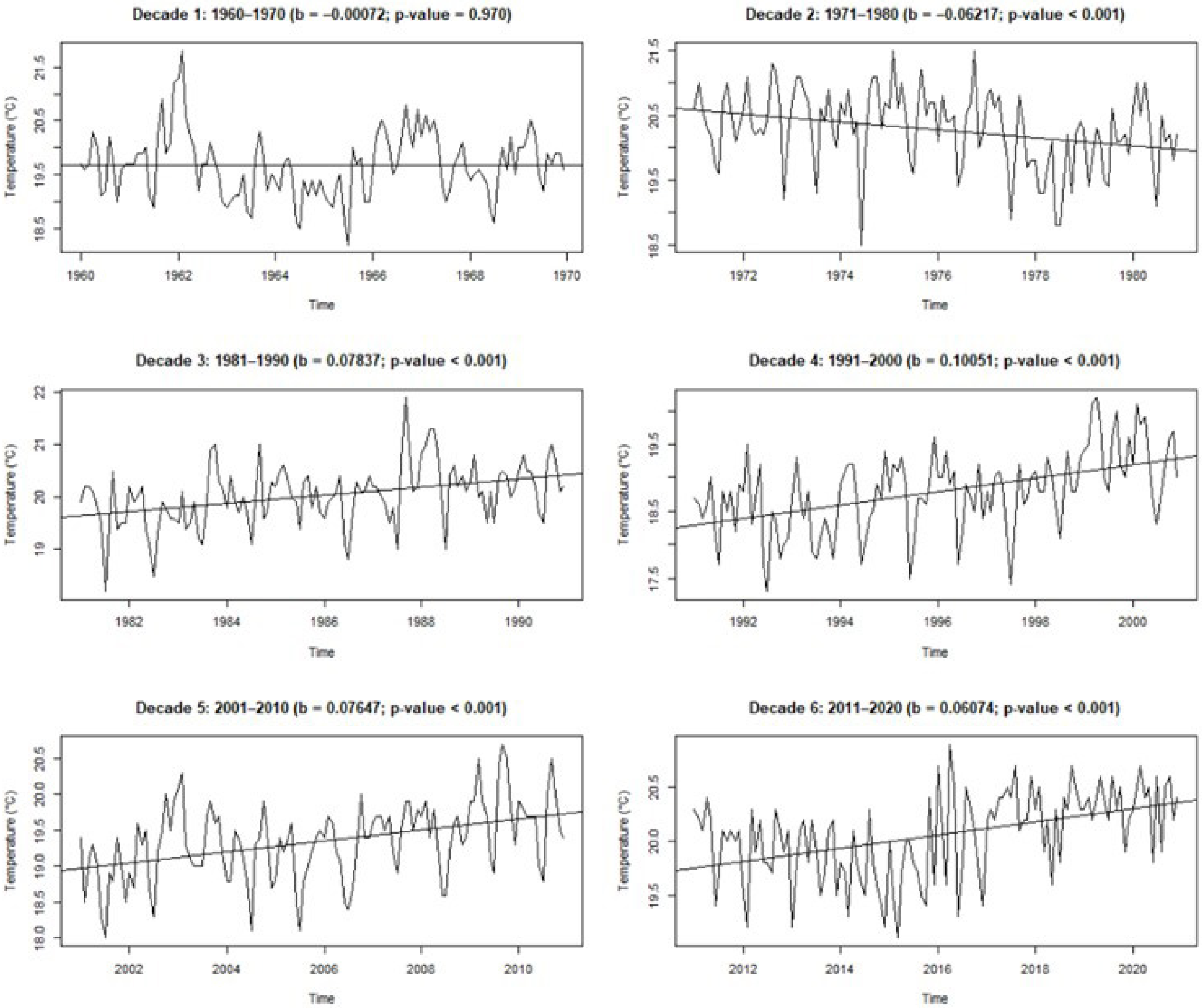

Figure 2. Trends in temperature patterns.

Note that a constant trend in temperature increases from 1980 onwards.

When rainfall data are taken into consideration, no significant difference exists (Kruskal–Wallis chi-squared = 0.60763; df = 5; p-value = 0.9877). However, there seems to be a decrease in precipitation values (Figures 3 and 4).

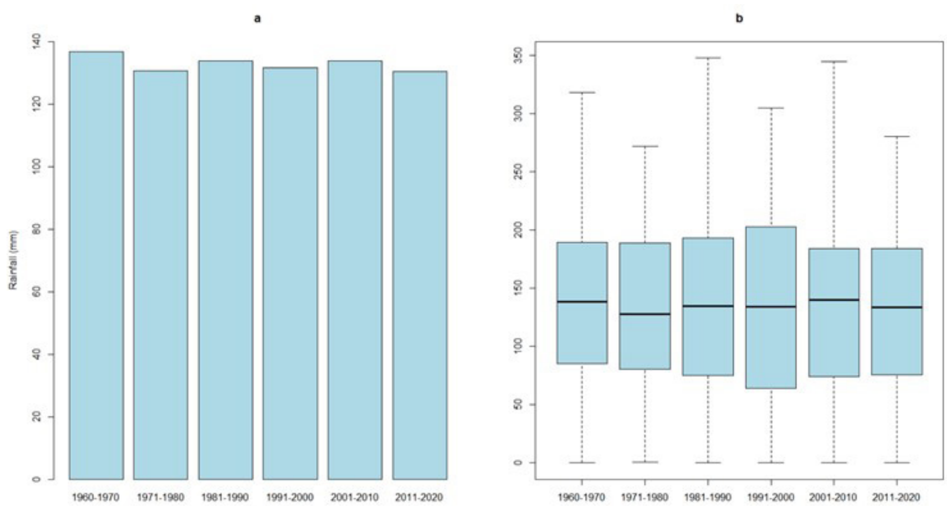

Figure 3. Variations in precipitation values. Means and medians are displayed in figure parts (a) and (b), respectively.

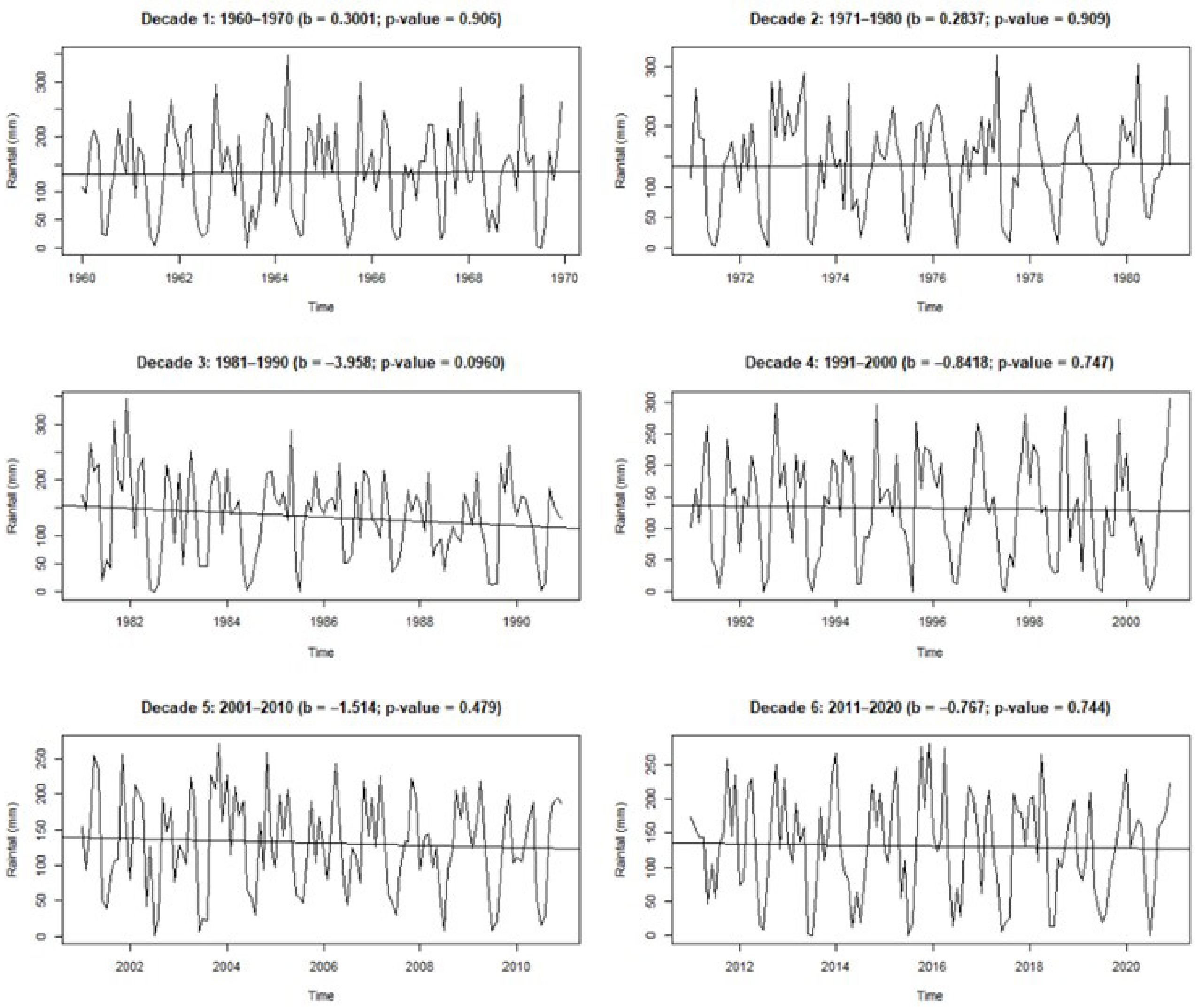

Figure 4. Trends in rainfall patterns. There has been a decrease in precipitation over the last four decades.

Deforestation and its impact on the local climate

Over the last two decades (2001–2020), South Kivu Province is estimated to have lost 642,539 hectares of its forests. As Figure 5 shows, there is a positive deforestation trend. However, when deforestation is considered at the territorial level, the eight territories of South Kivu appear to be affected differently (Kruskal-–Wallis chi-squared = 135.08; df = 5; p-value < 0.001). As Table 1 shows, Shabunda is the territory that lost most of its forests in the last two decades.

During the same period, and as a direct consequence of deforestation, a total of 381,380,375 megagrams of carbon dioxide equivalents (Mg CO_2e) were emitted into the atmosphere, with an annual average of 190,690,019 Mg CO_2e. Results show a significant perfect positive correlation ($r = 0.99$; $t = 92.537$; p-value = 0.001) between deforestation and CO_2 emissions (Figure 6). There is a positive correlation between deforestation and the temperature increase ($r = 0.605$; $t = 3.2267$; p-value = 0.005) and a negative correlation when deforestation and rainfall are taken into account ($r = -0.172$; $t = -0.741$; p-value = 0.468).

Table 1. Forest cover loss (hectares) at territorial level in South Kivu for the period 2001–2020.

Territory	Total	Mean	SD
Fizi	98130	4673	2888
Idjwi	2313	110.1	98
Kabare	26667	1270	911
Kalehe	67541	3216	2598
Mwenga	119769	5703	3019
Shabunda	304182	14485	8040
Uvira	14567	693.7	303
Walungu	9370	446.2	231

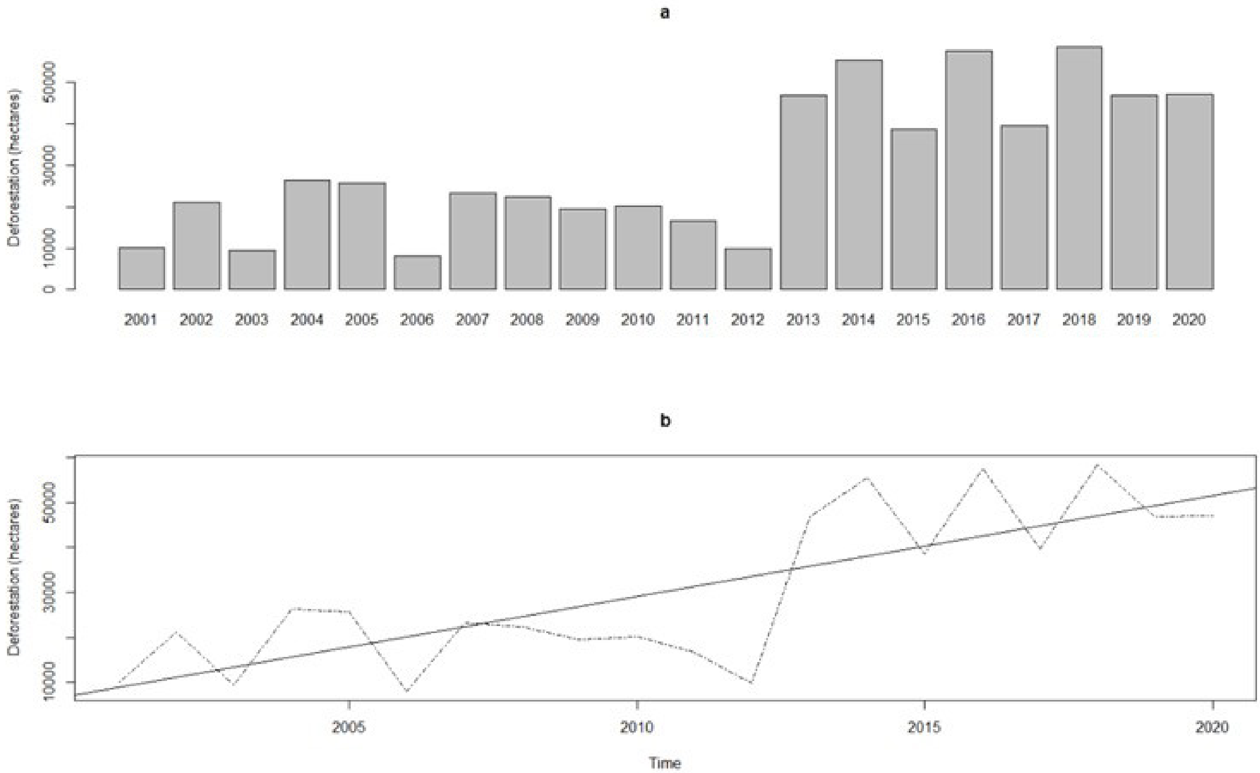

Figure 5. Deforestation in South Kivu from 2001 to 2020. (a) deforestation values per year; (b) positive and significant deforestation trend (b = 2245.1; p-value < 0.001).

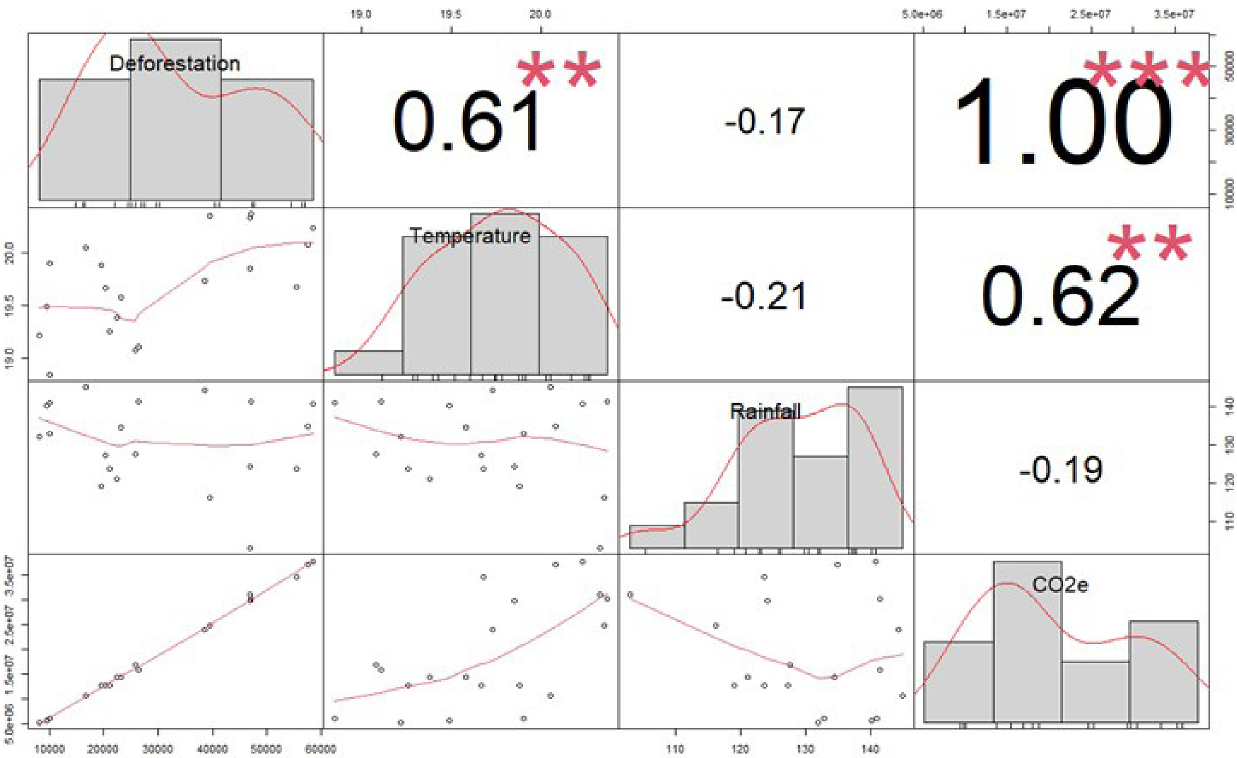

Figure 6. Deforestation and its potential effects on the local climate (: p-value < 0.01; ***: p-value < 0.001).**

Discussion

Plants, and more particularly trees, are renowned for their cooling capacity of the land, given their capacities to draw massive quantities of water from the soil and release it into the atmosphere (as moisture) through their leaves, a natural process known as 'evapotranspiration'. Therefore, cutting down trees and any other de-vegetation activities suppress this cooling effect of plants and trees and reduce rainfall patterns. The consequences of deforestation on local temperatures and rainfall have been confirmed by many studies (O'Brien 1996; D'Almeida et al. 2007; Abiodun et al. 2008; Lee et al. 2011; Salih et al. 2012; Amjad et al. 2019; Lawrence et al. 2022). Duku and Hein (2021) have also shown the strong impact of deforestation on rainfall in Africa.

As our results have shown, losing forests is likely to cause disruptions in the local weather patterns. Mubalama et al. (2020), who also analysed the weather data (for the 1980–2019 period) and farmers' perceptions regarding potential climate change in the KBNP landscape, came to the same conclusions.

Deforestation and its consequences on disrupted climate and weather patterns can also impact local communities' livelihoods as well as biodiversity. A study by Leite-Filho et al. (2021) concluded that agricultural revenues were diminished in the Brazilian Amazon, following reduced rainfall due to deforestation. In the same vein, Lawrence and Vandercar (2015) warned of the consequences of continuing deforestation trends on agricultural productivity in the tropics, because of the induced increase in mean temperature and rainfall disruptions. In our study area, Batumike et al. (2021) have shown that local people have been aware of reduced rainfall and fog, and increased temperatures, resulting in reduced crop yields and the rarity of some forest products such as caterpillars, mushrooms and honey. This concurs with the findings of Mubalama et al. (2020) who reported that, apart from recognizing increased temperatures and reduced rainfall, local people were progressively devising new strategies (early planting, improved varieties and crop rotation, etc.) to cope with the current weather patterns. Adaptation of forest management and local livelihoods to climate change requires an understanding of the effects of climate on forests, prediction of how these effects might change over time and incorporation of this knowledge into management decisions (Keenan 2015).

Other worrying signs that might be related to the ongoing deforestation and subsequent weather disruptions as regards the local biodiversity can also be seen in this region, known to be one of the world biodiversity hotspots. For instance, Berzaghi et al. (2018) have found that current land cover changes in the KBNP landscape affect the ecological niches required for the survival of species such as two Albertine Rift bush-shrikes (*Laniarius*). Some local native plant species also appear to be affected. This is the case for *Erythrina abyssinica*. This multi-usage *Fabaceae* tree species, locally known as 'cigohwa', seems to be expressing variations into some of its traits. *E. abyssinica* 'traditionally' shed its leaves in July and August (also its flowering period), as part of its natural adaptive strategies to the dry season. Direct personal observations have shown that this phenomenon appears to be taking place much earlier or irregularly.

Conclusion

Our brief indicates a potential disruption of weather patterns in the Kahuzi-Biega National Park landscape. Our findings also show an increase in temperatures that is positively correlated with deforestation and reduced rainfall. These changes in local weather patterns are likely to impact agriculture, biodiversity and the well-being of local communities.

While global communities focus on the role of forests in climate change mitigation through carbon sequestration services, our findings highlight the need for policymakers to fully recognize the important role of forests in regulating viable climate and rainfall patterns which are critical for crop production, biodiversity conservation, food security and human health. Ignoring these facts can lead to policy failure in anticipating the climate risks entailed by deforestation, and prevent the design and implementation of climate change adaptation and mitigation approaches. Such a failure can ultimately make living conditions difficult for local communities.

Further research is required to fully understand the environmental, social and economic benefits of protecting forests in order to stabilize the climate, beyond reducing carbon emissions. The fact that temperatures appear to be lower during the last decade while deforestation remains high calls for a thorough investigation into explanatory factors (e.g. impact of global temperature increase due to fossil fuel burning, continental temperature increase, etc.).

Acknowledgements

This research is part of CIFOR's Global Comparative Study on REDD+ (www.cifor.org/gcs). The funding partners that have supported this research include the Norwegian Agency for Development Cooperation (Norad Grant No. QZA-21/0124), International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety (BMU Grant No. 20_III_108), and the CGIAR Research Program on Forests, Trees and Agroforestry (CRP-FTA) with financial support from CGIAR fund donors.

The authors are also grateful to the reviewers for their remarks and insights that helped improve the quality of the Infobrief.

References

Abiodun BJ, Pal JS, Efiesimama EA, Gutowski WJ and Adedoyin A. 2008. Simulation of West African monsoon using RegCM3 Part II: impacts of deforestation and desertification. *Theoretical and Applied Climatology* 93:245–261.

Amjad D, Kausar S, Waqar R and Sarwar F. 2019. Land cover analysis and impacts of deforestation on the climate of District Mansehra, Pakistan. *Journal of Biodiversity and Environmental Sciences* 14(6):103–113.

Arnold M, Powell B, Shanley P and Sunderland TCH. 2011. Editorial: Forests, biodiversity and food security. *International Forestry Review* 13(3):259–264.

Artaxo P, Hansson HC, Machado LAT and Rizzo LV. 2022. Tropical forests are crucial in regulating the climate on Earth. *PLOS Climate* 1(8):e0000054. https://doi.org/10.1371/journal.pclm.0000054

Batumike R, Bulonvu F, Imani G, Akonkwa D, Gahigi A, Klein JA, Marchant R and Cuni-Sanchez A. 2021. Climate change and hunter-gatherers in montane eastern DR Congo. *Climate and Development* 14(5):431–442. https://doi.org/10.1080/17565529.2021.1930987

Berzaghi F, Engel JE, Plumptre AJ, Mugabe H, Kujirakwinja D, Ayebare S and Bates JM. 2018. Comparative niche modeling of two bush-shrikes (*Laniarius*) and the conservation of mid-elevation Afromontane forests of the Albertine Rift. *The Condor* 120(4):803–814. https://doi.org/10.1650/CONDOR-18-28.1

D'Almeida C, Vörösmarty CJ, Hurtt GC, Marengo JA, Dingman SL and Keim BD. 2007. The effect of deforestation on the hydrological cycle in Amazonia: a review on scale and resolution. *International Journal of Climatology* 27:633–647.

Duku C and Hein L. 2021. The impact of deforestation on rainfall in Africa: a data-driven assessment. *Environmental Research Letters* 16:064044. https://doi.org/10.1088/1748-9326/abfcfb

Ebodé VB, Mahé G, Dzana JG and Amougou JA. 2020. Anthropization and climate change: impact on the discharges of forest watersheds in Central Africa. *Water* 12(10):2718.

Global Forest Watch. n.d. Accessed 9 February 2023. www.globalforestwatch.org

Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SAA, Tyukavina A, Kommareddy A. 2013. High-resolution global maps of 21st-century forest cover change. *Science* 342:850–853. https://doi.org/10.1126/science.1244693.

Ickowitz A, Slayback D, Asanzi P and Nasi R. 2015. Agriculture and deforestation in the Democratic Republic of the Congo: A synthesis of the current state of knowledge. Occasional Paper 119. Bogor, Indonesia: CIFOR.

Jaboury G, Zuzana B, Garcia-Ulloa J and King LA. 2015. Conceptualizing forest degradation. *Trends in Ecology and Evolution* 30(10):622–632. http://dx.doi.org/10.1016/j.tree.2015.08.001

Keenan RJ. 2015. Climate change impacts and adaptation in forest management: a review. *Annals of Forest Science* 72:145–167.

Laurance WF. 1999. Reflections on the tropical deforestation crisis. *Biological Conservation* 91: 109–117

Lawrence D, Coe M, Walker W, Verchot L and Vandecar K. 2022. The unseen effects of deforestation: Biophysical effects on climate. *Frontiers in Forests and Global Change* 5:756115. https://doi.org/10.3389/ffgc.2022.756115

Lawrence D and Vandecar K. 2015. Effects of tropical deforestation on climate and agriculture. *Nature Climate Change* 5:27–36.

Lee X, Goulden ML, Hollinger DY, Barr A, Black TA, Bohrer G, Bracho R, Drake B, Goldstein A, Gu L, et al. 2011. Observed increase in local cooling effect of deforestation at higher latitudes. *Nature* 479:384–387.

Leite-Filho AT, Soares-Filho BS, Davis JL, Abrahão GM and Börner J. 2021. Deforestation reduces rainfall and agricultural revenues in the Brazilian Amazon. *Nature Communications* 12:2591.

Mubalama LK, Masumbuko DM, Mweze DR, Banswe GT and Mirindi PA. 2020. Farmers' perceptions towards climate change and meteorological data in Kahuzi-Biega National Park's surroundings, Eastern D.R. Congo. *International Journal of Innovative Research and Development* 9(6):178–192.

Murrins MJ, Carter S, Herold M. 2021. Tropical forest monitoring: challenges and recent progress in research. *Remote Sensing*: 13, 2252. https://doi.org/10.3390/rs13122252

Nackoney J, Molinario G, Potapov P, Turubanova S, Hansen M and Furuichi T. 2014. Impacts of civil conflict on primary forest habitat in northern Democratic Republic of the Congo, 1990–2010. *Biological Conservation* 170:321–328. http://dx.doi.org/10.1016/j.biocon.2013.12.033

Nasi R, Taber A and Van Vliet N. 2011. Empty forests, empty stomachs? Bushmeat and livelihoods in the Congo and Amazon basins. *International Forestry Review* 13(3):355–368.

Nellemann C, Redmond I and Refish J. eds. 2010. *The last stand of the gorilla – Environmental crime and conflict in the Congo Basin. A rapid assessment.* United Nations Environment Programme, GRID-Arendal. www.grida.no

O'Brien KL. 1996. Tropical deforestation and climate change. *Progress in Physical Geography* 20(3):311–335.

Philippon N, Cornu G, Monteil L, Gond V, Moron V, Pergaud J and Ngomanda A. 2019. The light-deficient climates of western Central African evergreen forests. *Environmental Research Letters 14*(3):034007.

R Core Team 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Redmond I. 2001. Coltan Boom, Gorilla Bust: The Impact of Coltan Mining on Gorillas and other Wildlife in Eastern DRC. A Report for the Dian Fossey Gorilla Fund Europe and the Born Free Foundation (https://www.bornfree.org.uk/gorilla-conservation).

Salih AAM, Körnich H and Tjernström M. 2012. Climate impact of deforestation over South Sudan in a regional climate model. *International Journal of Climatology* 33(10):2362–2375. https://doi.org/10.1002/joc.3586

Simpson FO and Geenen S. 2021. Batwa return to their Eden? Intricacies of violence and resistance in eastern DR Congo's Kahuzi-Biega National Park. *The Journal of Peasant Studies* https://doi.org/10.1080/03066150.2021.1970539

Sunderland TCH. 2011. Food security: why is biodiversity important? *International Forestry Review* 13(3):355–368.

Teso MP and Karume K. 2019. Assessing forest cover change and deforestation hotspots in the North Kivu province (D.R. Congo), using remote sensing and GIS. *American Journal of Geographic Information System* 8(2):39–54.

World Resources Institute. n.d. Accessed 9 February 2023. www.wri.org

Zhuravleva I, Turubanova S, Potapov P, Hansen M, Tyukavina A, Minnemeyer S, Laporte N, Goetz S, Verbelen F and Thies C. 2013. Satellite-based primary forest degradation assessment in the Democratic Republic of the Congo, 2000–2010. *Environmental Research Letters* 8:024034.

Norad

IKI INTERNATIONAL CLIMATE INITIATIVE

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety