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Climatic patterns and buffering effects of agroforestry: Cacao production facing climate change in Amazonian Bolivia

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Abstract

Climate change is known to increase frequency and severity of extreme weather events such as droughts and heat waves, with potentially drastic effects on ecosystem functioning, agricultural production and smallholder farmers' livelihoods. Various studies showed that diverse and multi-strata production systems like agroforestry systems have the ability to buffer impacts of such extreme weather events on crops, representing one promising strategy to support agricultural systems' resilience in the face of climate change.

We explored daily temperature and precipitation data recorded throughout 2020–2023 in three different cacao cropping systems (full-sun monoculture, agroforestry, dynamic agroforestry), a secondary forest fallow, and under open air in the SysCom long-term trial in the Bolivian Amazonian lowlands. We found clear differences in systems' daily maximum temperatures. Buffer effects increased with tree density and canopy cover: open air < monoculture (2.3 °C) < agroforestry (4.4 °C) and dynamic agroforestry (5.1 °C) < secondary forest fallow (8.8 °C). However, no buffer effect was found against low temperatures, which is problematic as in recent years, cold spells during peak harvest season affected cacao yields in the region. We recorded 33 heat waves (>35 °C reached during min. 2 days) and 6 cold spells (<15 °C during min. 2 days). The same buffer effect pattern was observed during these extreme temperature events.

Comparison of our local data with regional climate data shows several differences, highlighting the role of data scale and local measurements to identify trends over time and study sporadic climate events. For example, our rainfall data showed that wet seasons were interjected by dry months with <100 mm rainfall, while this was not observed in the regional dataset.

The next step will be to relate system-wise microclimatic records to our data on cacao productivity and cacao bean quality. The increased occurrence of climatic events such as erratic rainfall patterns and extreme high or low temperatures in the recent years requires a better understanding of their impact on cacao phenology and productivity in order to define appropriate management.

Keywords: Agroforestry, Bolivia, cacao, climate change, rainfall, temperature extremes

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