Sys Com Bolivia

8th European Agroforestry Conference EURAF 2026
22 – 26 June 2026 in Neuchâtel, Switzerland

euraf 2026
8th European Agroforestry Conference
Neuchâtel – Switzerland




Strategic canopy management for enhanced climate resilience and water cycling in highly complex agroforestry systems

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Background

Climate change: weather extremes increase (e.g. heat waves, droughts, cold spells)

Cacao: sensitive to temperature extremes & water depletion

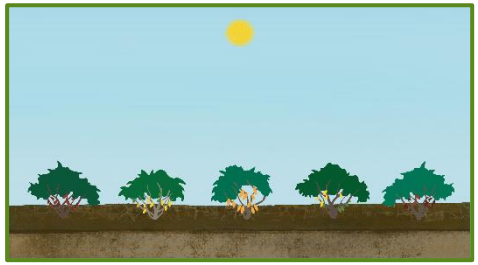
Agroforestry: provides multitude of ESS, incl. buffering effects of climatic extremes

Pruning: strategic management of shade canopy cover

Synthesis of results from a long-term system comparison (SysCom) trial in Bolivia on **shade tree canopy management** & influence on **water cycling** and **climate resilience**, and relevant **take aways for AFS in Europe**.

The SysCom Bolivia LTE trial

Conventional



Monoculture

Agroforestry

- Established in 2008
- Research plots: 5.5 ha
- 6 treatments x 4 rep.
- Plot size: 48 x 48 m
- Data collection: 24 x 24 m

Organic

Monoculture

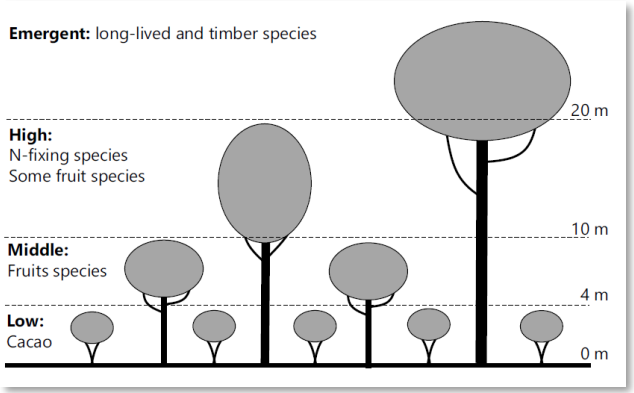
Agroforestry

Successional/dynamic Agroforestry

Diversity / Complexity Gradient

Cacao production systems in the trial

Diversity / Complexity Gradient



Saj et al., 2025

Agroforestry (AF)

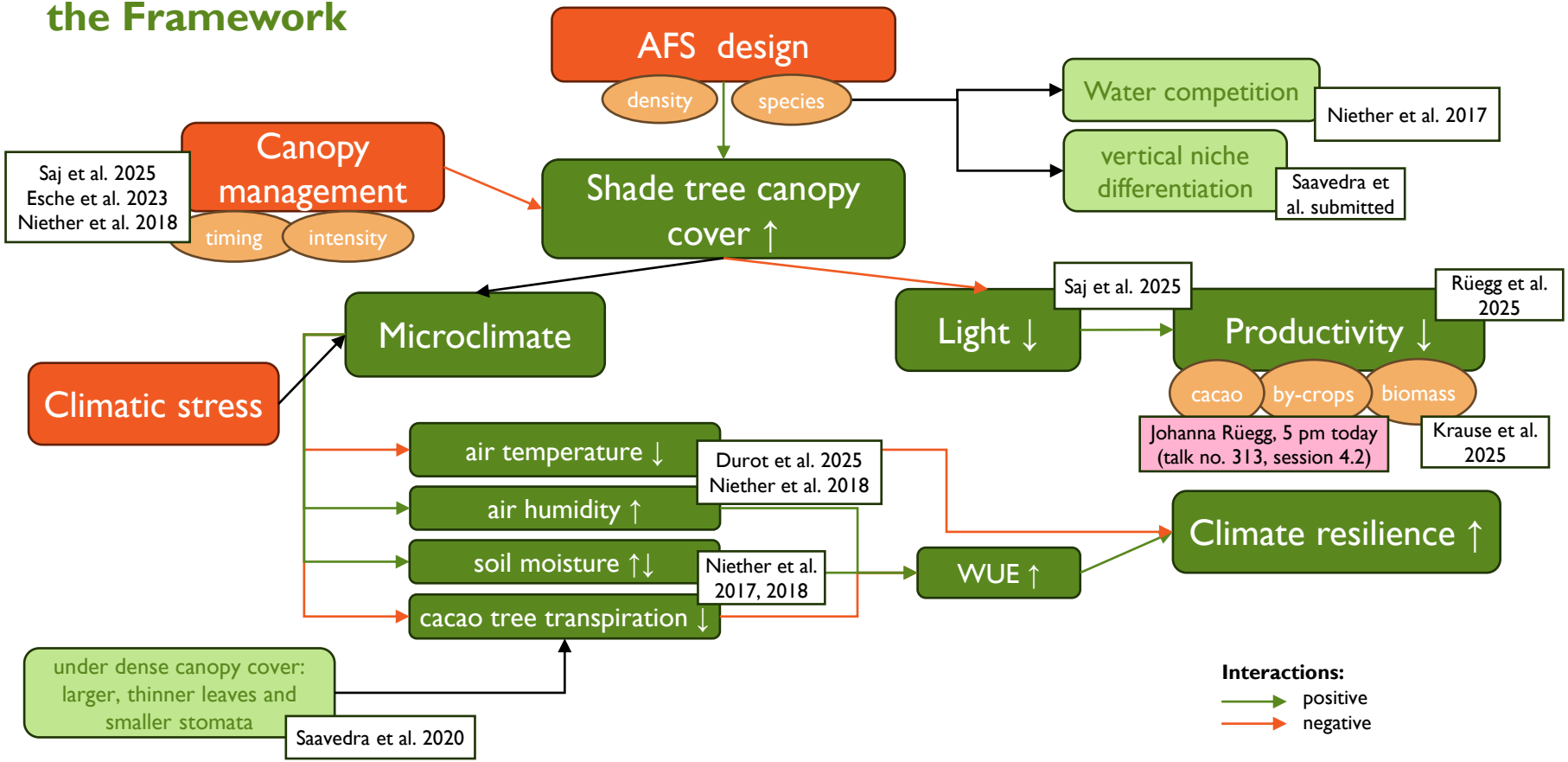
- ca. 300 shade trees/ha
- (5 timber species, 4 fruit species, 2 biomass species, 1 palm)
- other crops: banana, coffee

Dynamic Agroforestry (DAF)

- ca. 800 shade trees/ha
- (~19 timber species, ~ 8 fruit species, ~20 biomass species, 3 palms. Incl. natural regeneration)
- other crops: banana, coffee, ginger, curcuma & more

2x annual shade tree pruning (April, Nov-Dec)

the Framework



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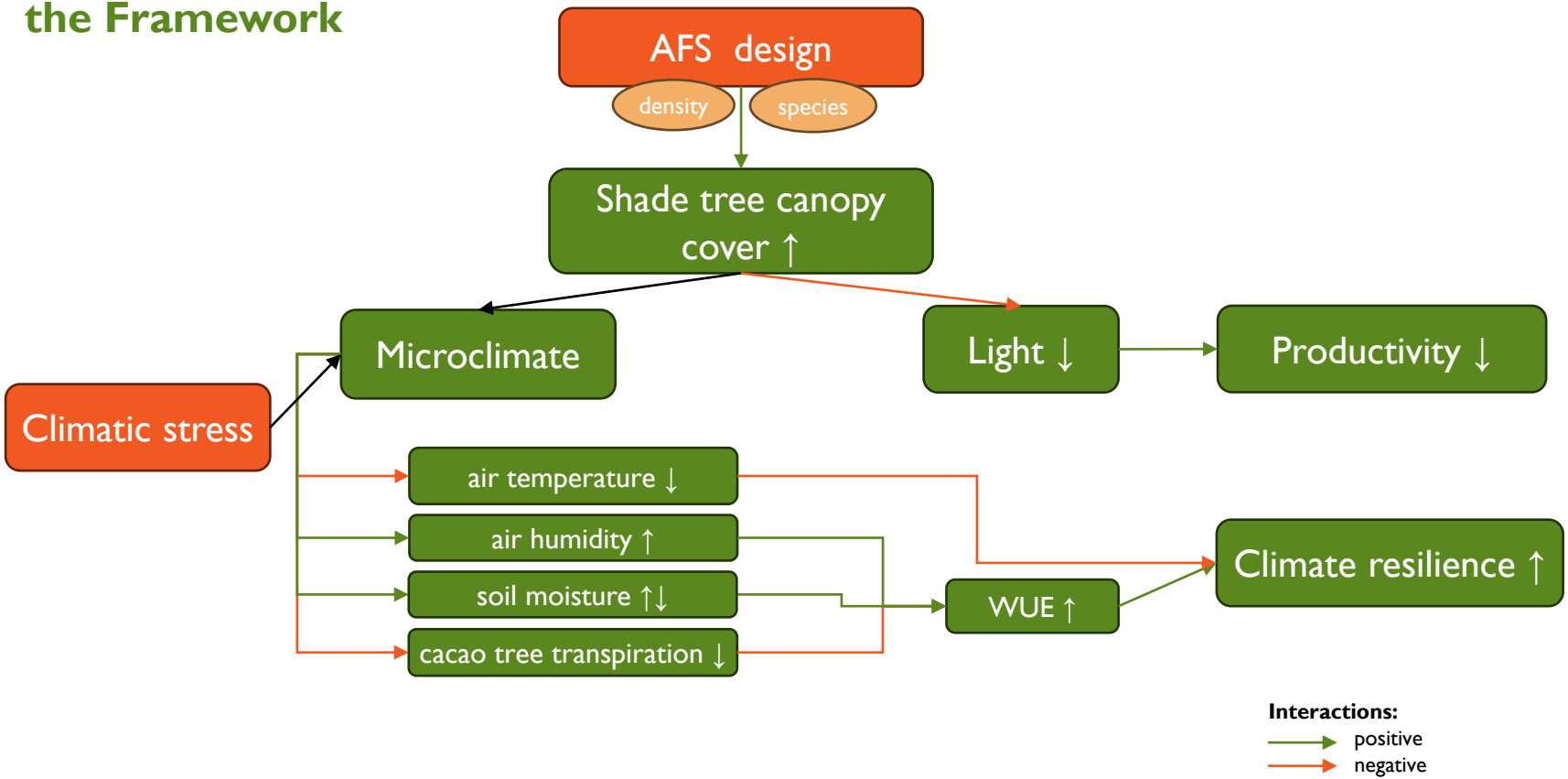

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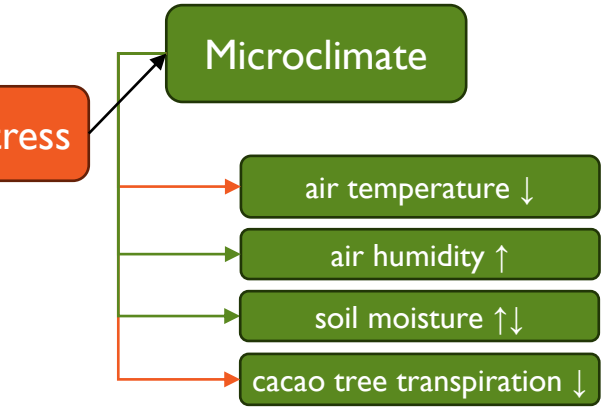
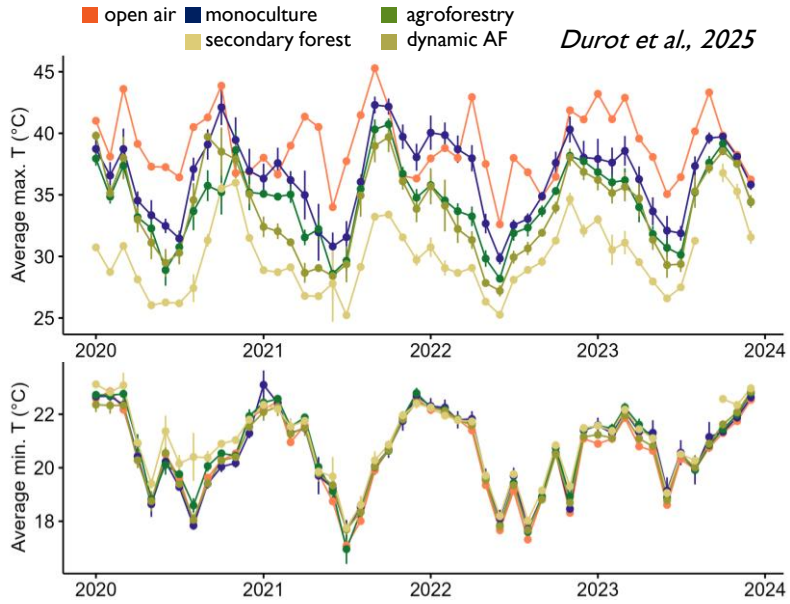
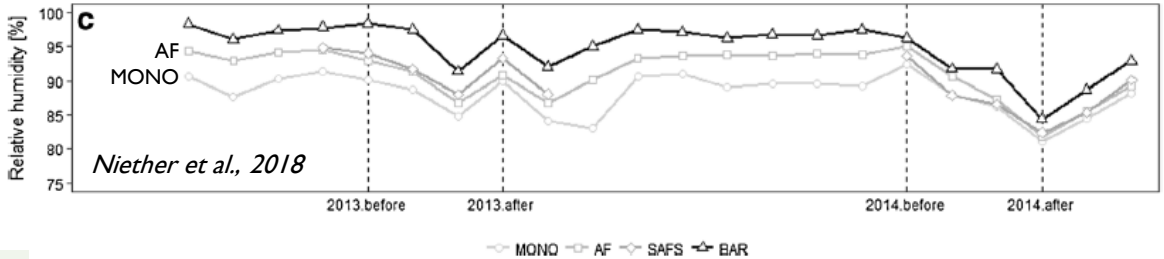


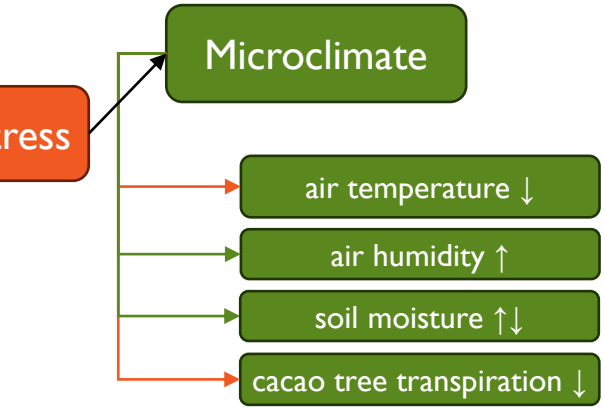


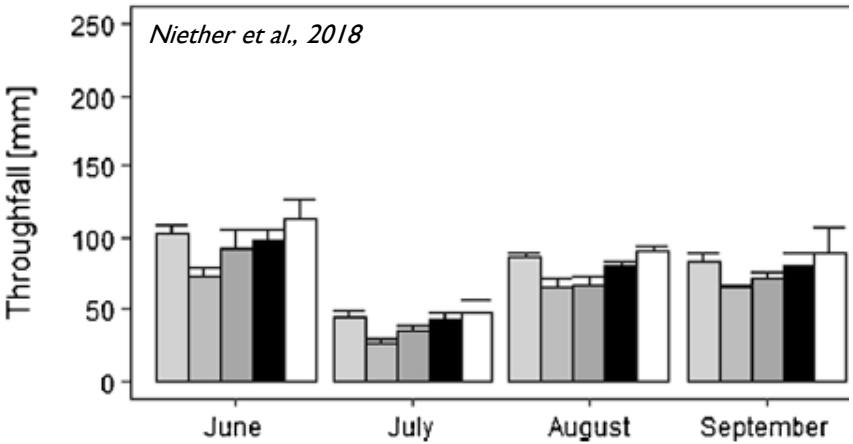


- compared to open air, daily max. T reduced by 4.6 °C (AF) to 5.1 °C (DAF)
- no buffering effect against low temperatures (*Durot et al., 2025*)

- mean annual T amplitude was lower in AF vs. MONO (-1.1 °C)
- RH was higher in AF (91 %) than in MONO (88 %) (*Niether et al., 2018*)

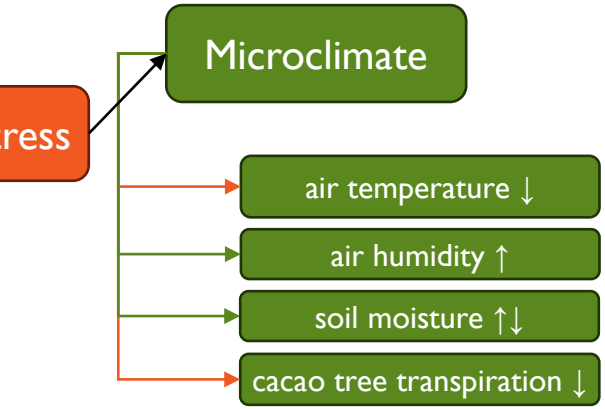
the Framework



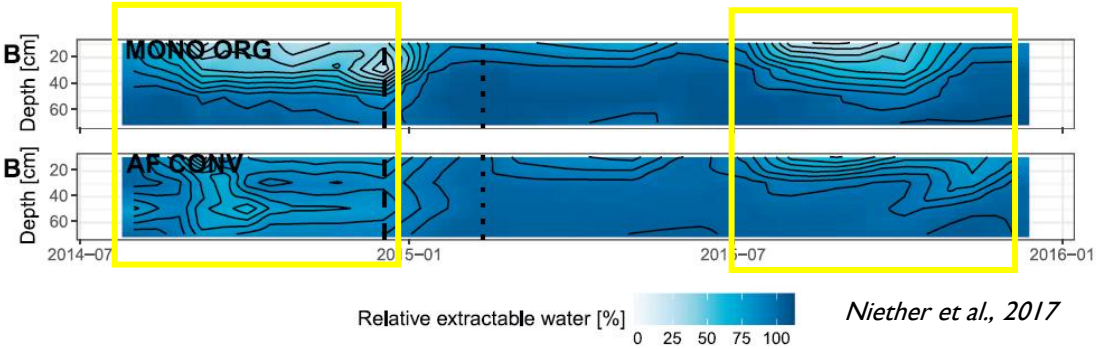


Throughfall rates
- MONO: 94.5 %
- AF: 54.8 %
- DAF: 74.7 %

the Framework

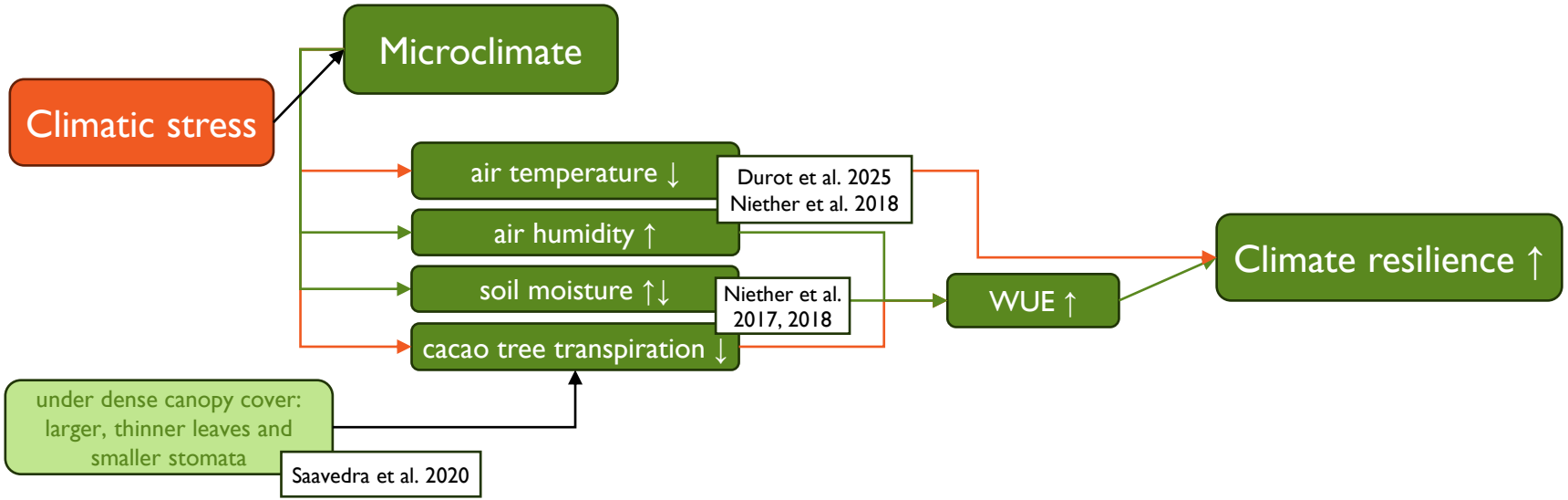


- evaporation & cacao transpiration: AF < DAF < MONO (*Niether et al., 2018*)
- less cacao tree transpiration → lower water demand → less soil water extraction



Niether et al., 2017

the Framework



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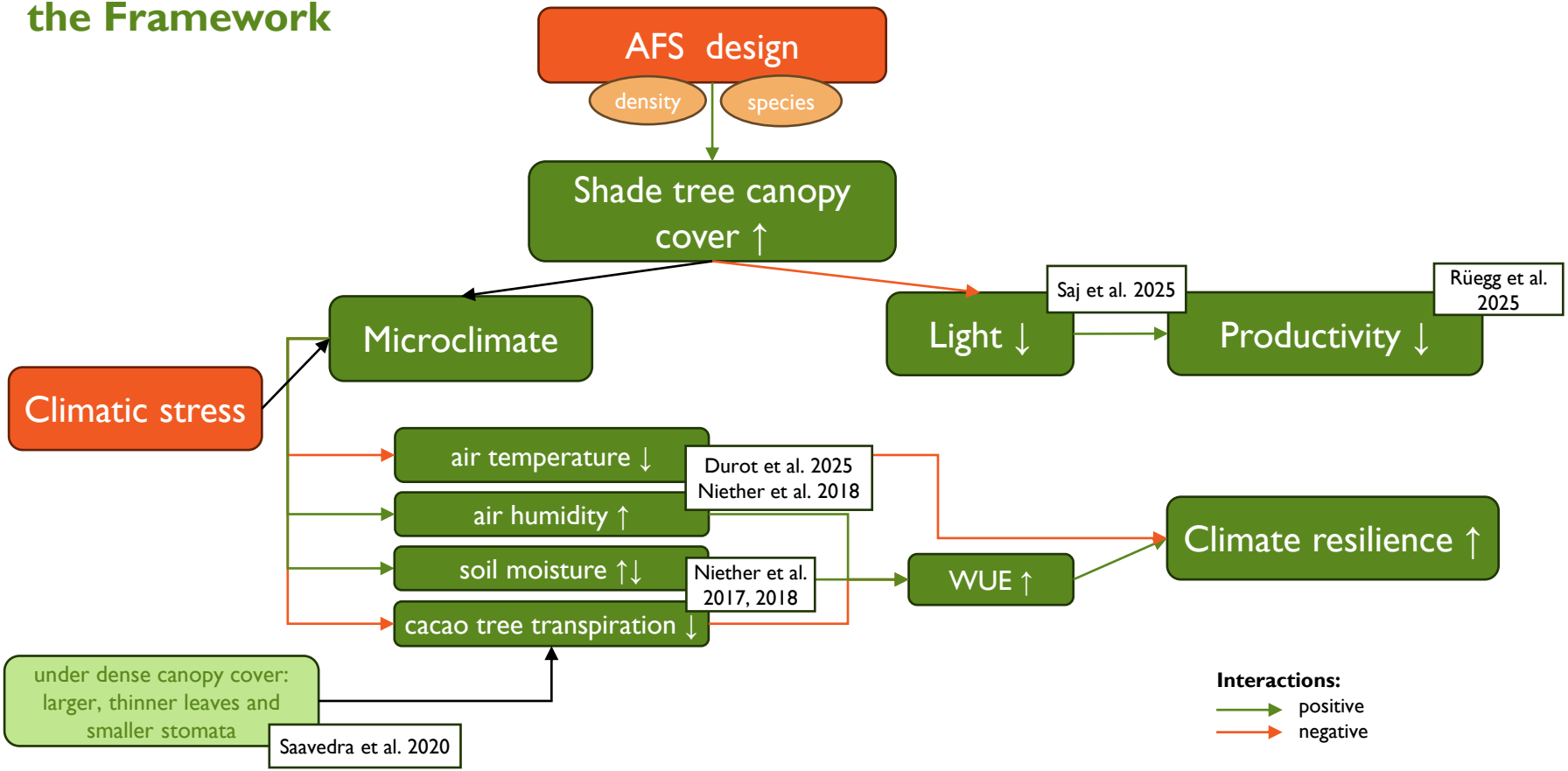

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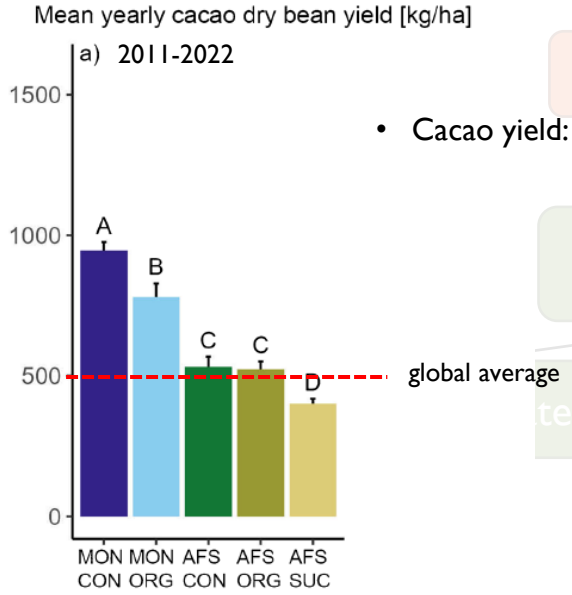


Rüegg et al., 2025

- Cacao yield: MONO > AF > DAF

AFS design

Shade tree canopy cover ↑

Light ↓

Saj et al. 2025

Productivity ↓

Rüegg et al. 2025

cacao | by-crops | biomass

Johanna Rüegg, 5 pm today (talk no. 313, session 4.2)

Krause et al. 2025

the Framework

- Cacao yield: MONO > AF > DAF
- exponential relationship between canopy cover and yield

AFS design

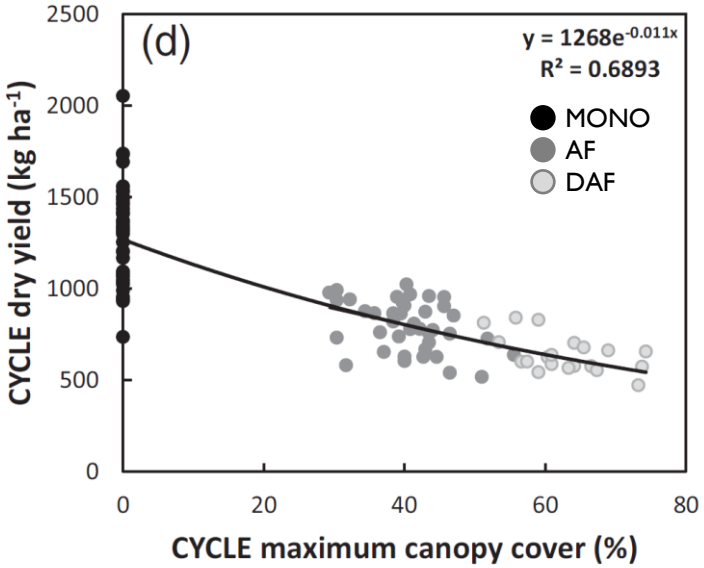
Saj et al. 2025
Esche et al. 2023
Niether et al. 2018

Canopy management

timing

intensity

Microclimate



Saj et al., 2025

Rüegg et al. 2025

Productivity ↓

the Framework

Saj et al. 2025
Esche et al. 2023
Niether et al. 2018

Canopy management

timing

intensity

AFS design

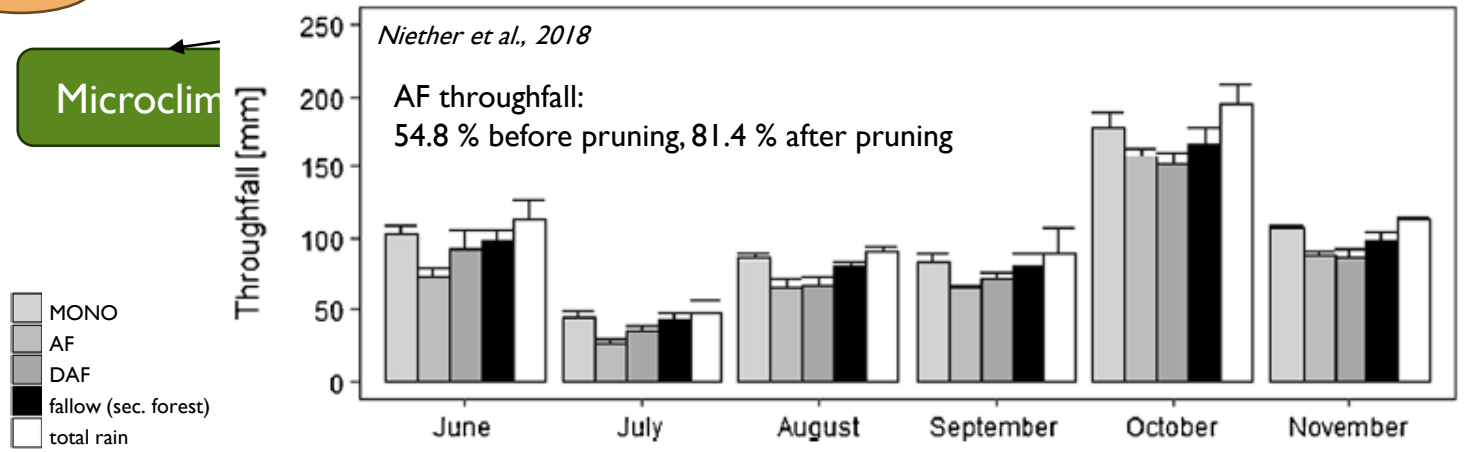
density

species

Shade tree canopy

Microclim

- Cacao yield: MONO > AF > DAF
- exponential relationship between canopy cover and yield
- Regrowth is faster during the rainy season
- Pruning increases throughfall



the Framework

Saj et al. 2025
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Canopy management

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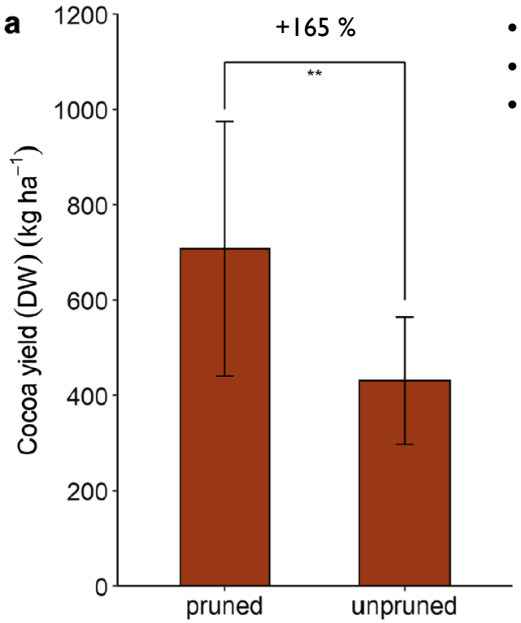
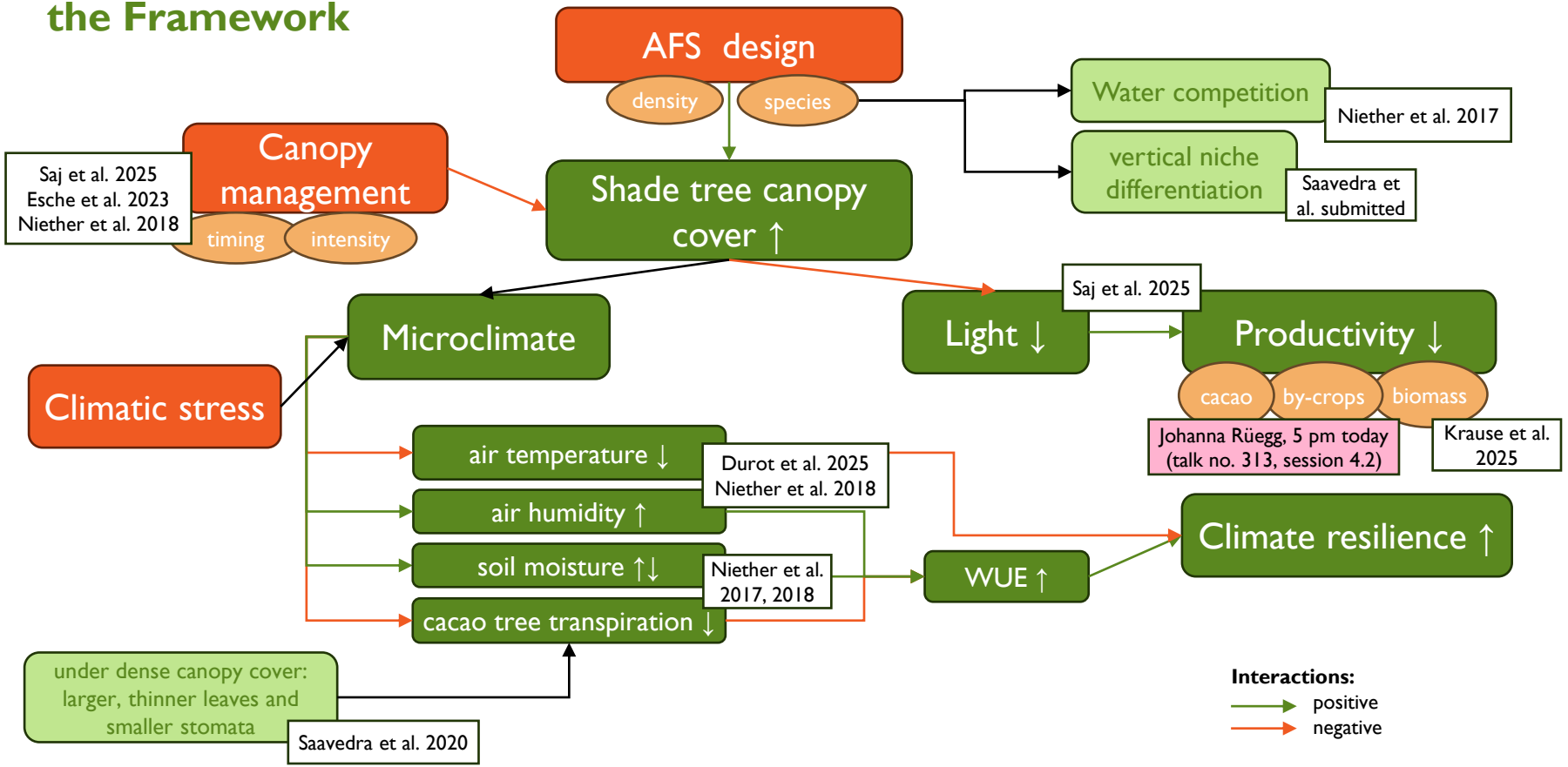
Microclima



Esche et al., 2022

- Cacao yield: MONO > AF > DAF
- exponential relationship between canopy cover and yield
- Regrowth is faster during the rainy season
- Pruning increases throughfall
- Pruning can improve cacao yield

the Framework



Take Aways for European Context

- Shade canopy buffers against high but not low temperatures in our case.
- Soil moisture is influenced by cover (throughfall, evaporation, transpiration) and likely tree rooting depth.
- Light availability management (pruning) at the right moment is key for cash crop productivity.

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This project is supported by the **Coop Sustainability Fund.**

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