

# The contribution of cocoa agroforestry on yields, soil, pests, biodiversity and climate change: a multi-dimensional meta-analysis

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# Meta-analysis: comparing cocoa...

AGROFORESTRY SYSTEMS

and

MONOCULTURES

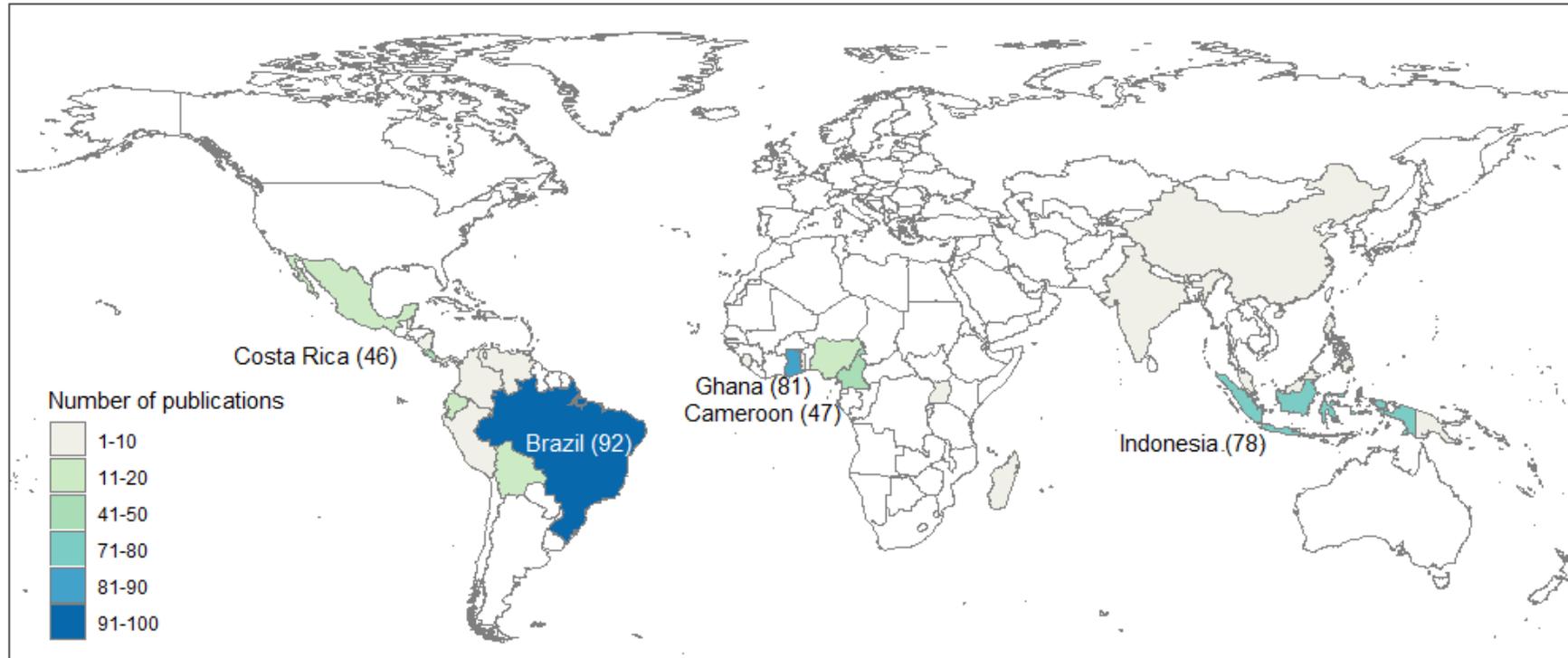


Cocoa agroforestry system (image: W. Niether)



Cocoa monoculture (image: J. Jacobi)

# Literature search



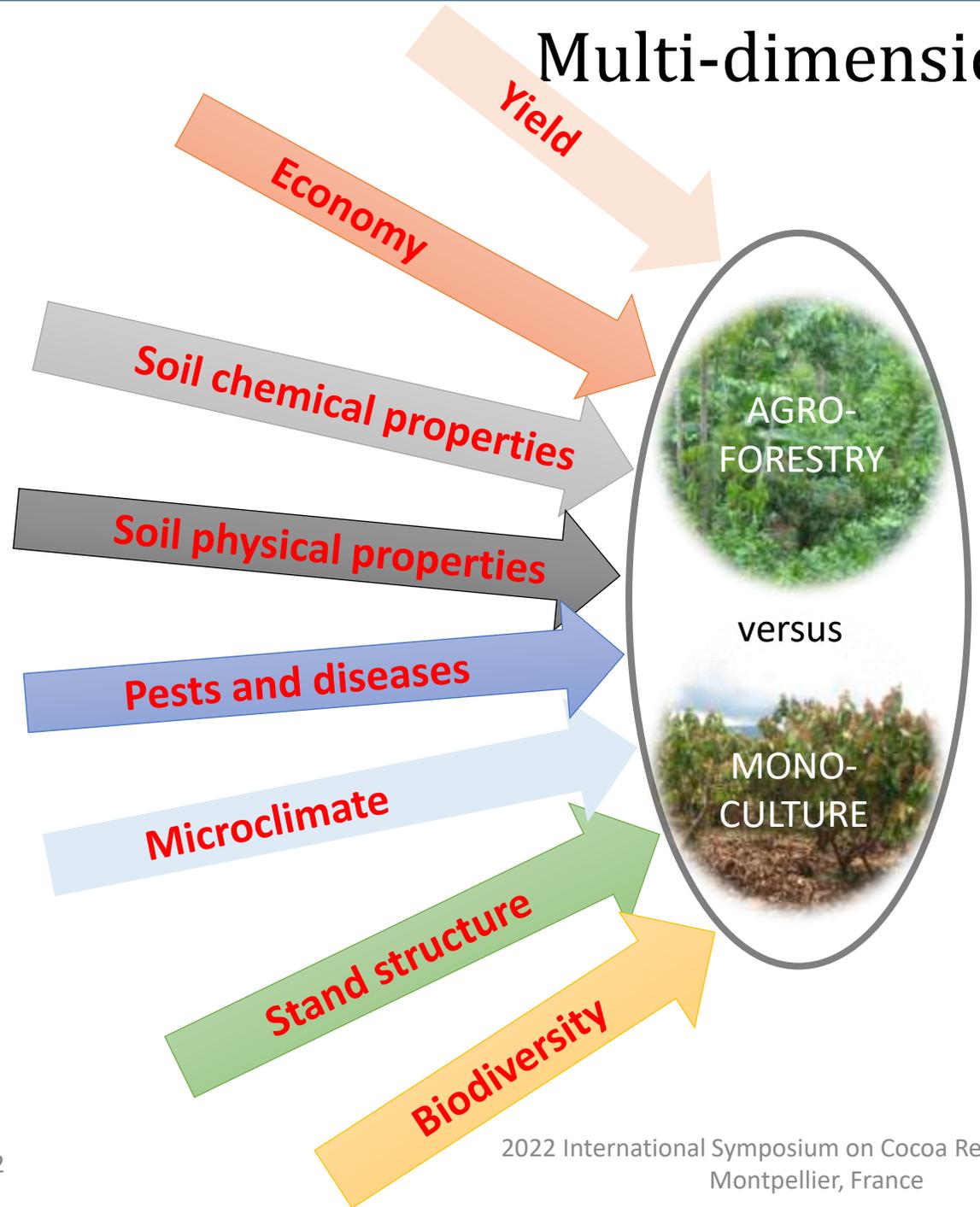
World map: research on cocoa agroforestry per country

→ **52 articles** with direct comparisons

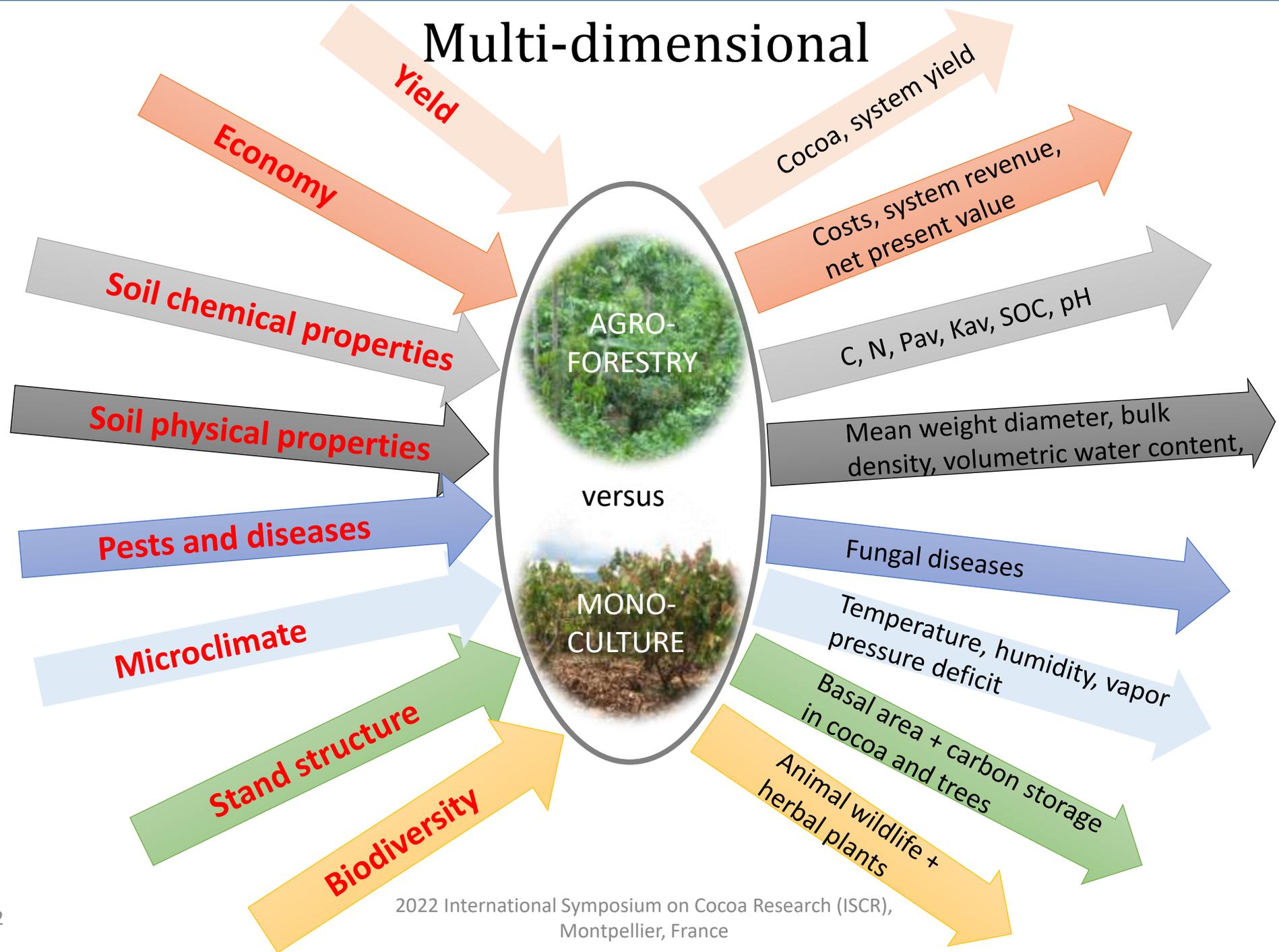
→ **144 sub-studies**

→ **93 data pairs** (independent pairwise comparisons)

# Multi-dimensional



# Multi-dimensional



## Results: Yield



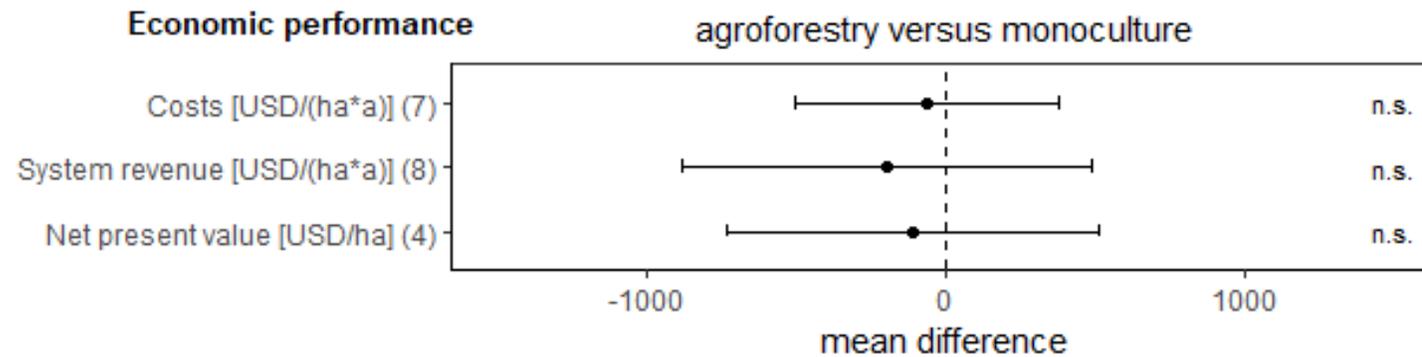
- Higher cocoa yield in monocultures
- Higher system yield in agroforestry systems

# AGROFORESTRY SYSTEM

# MONOCULTURE



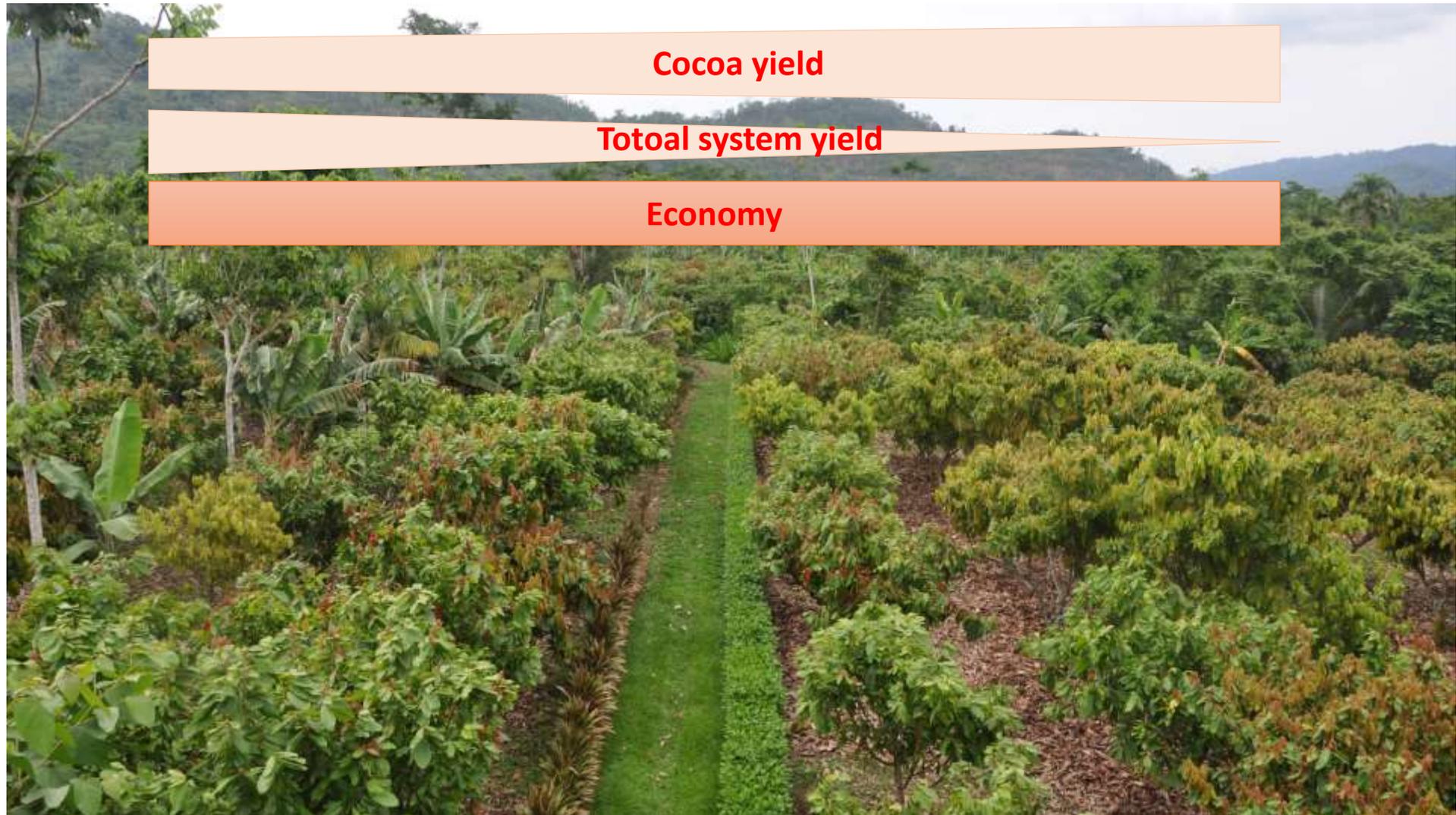
## Results: Economic performance



→ No significant differences between monocultures and agroforestry systems

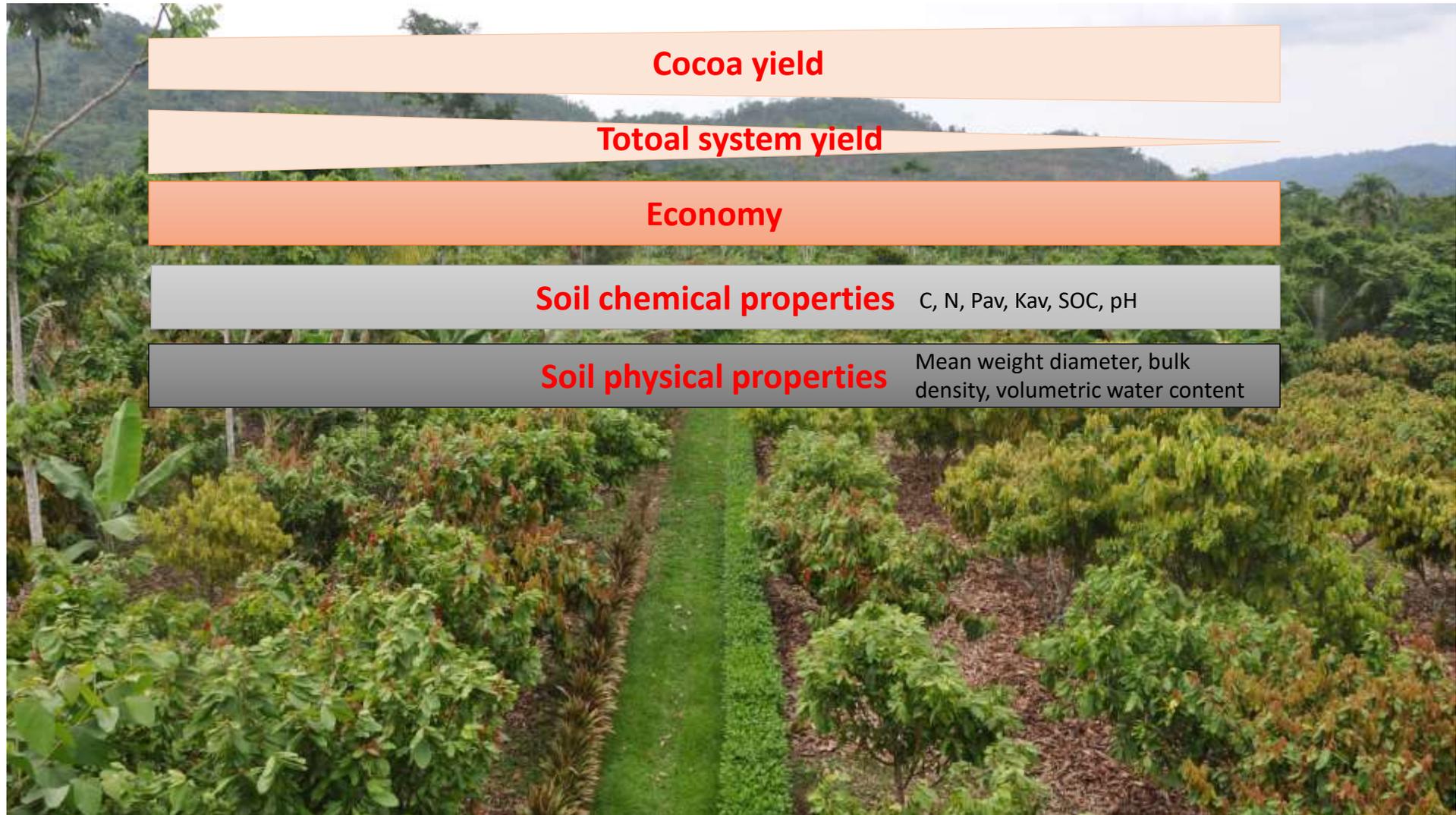
# AGROFORESTRY SYSTEM

# MONOCULTURE

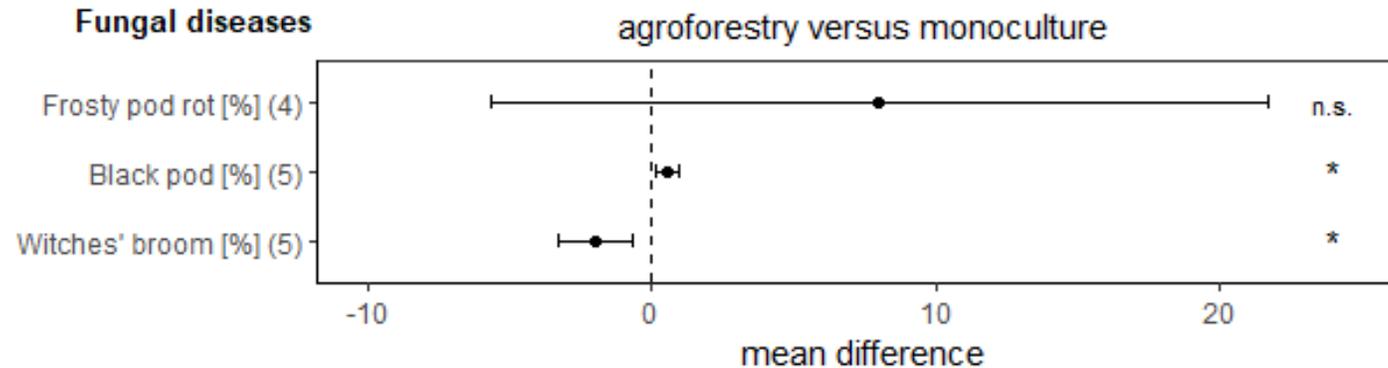


# AGROFORESTRY SYSTEM

# MONOCULTURE



## Results: Pests and diseases

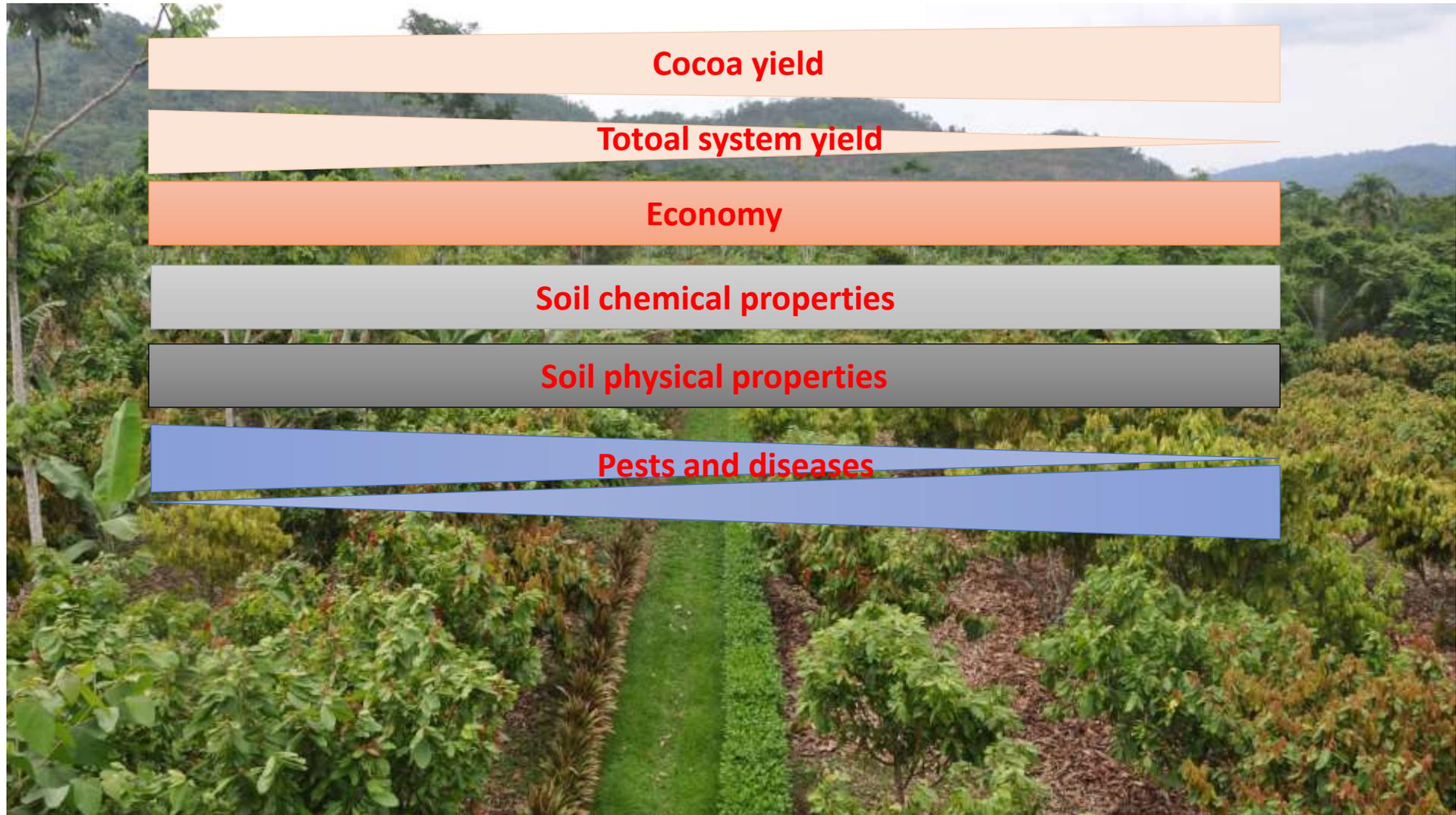


		Monoculture	Agroforestry sytem
Frosty Pod Rot	%	21.2 ± 16.0	28.8 ± 24.5
Black Pod	%	3.0 ± 2.0	3.4 ± 2.2
Witches' Broom	%	3.7 ± 2.4	1.9 ± 1.4

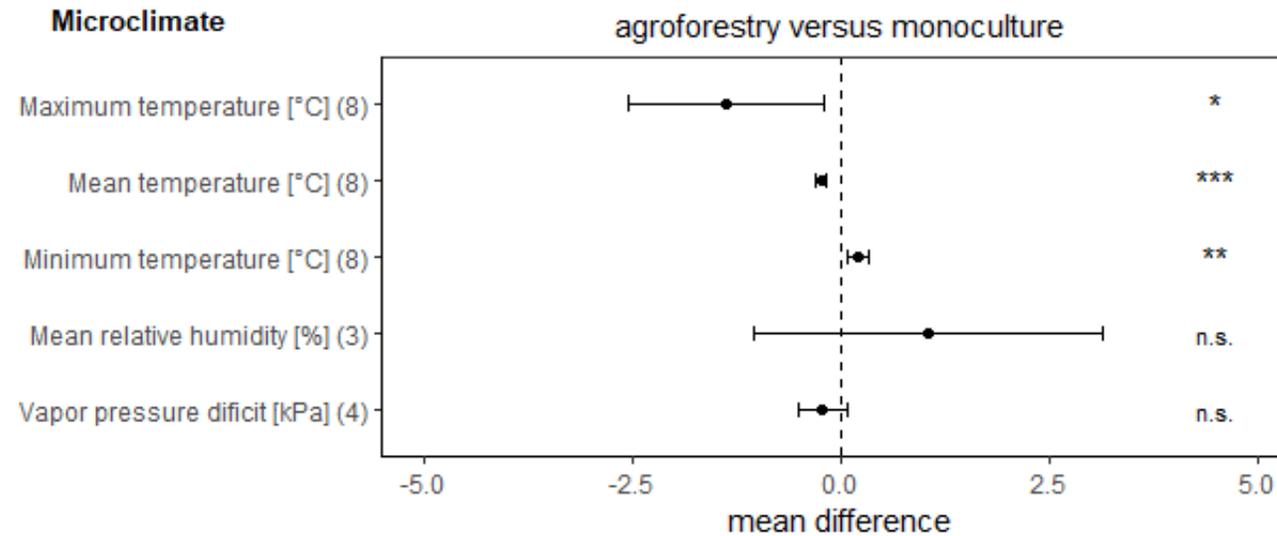
→ Effects depend on the nature of the disease

# AGROFORESTRY SYSTEM

# MONOCULTURE

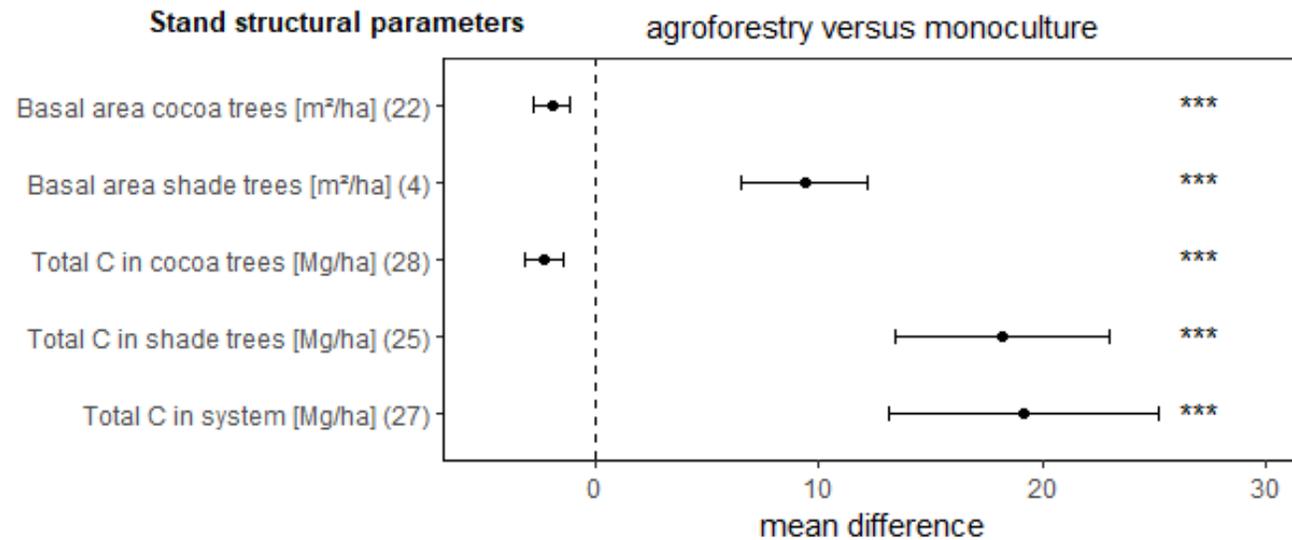


## Results: Microclimate



- Buffering of high temperature and low humidity under shade
- Climate change adaptation

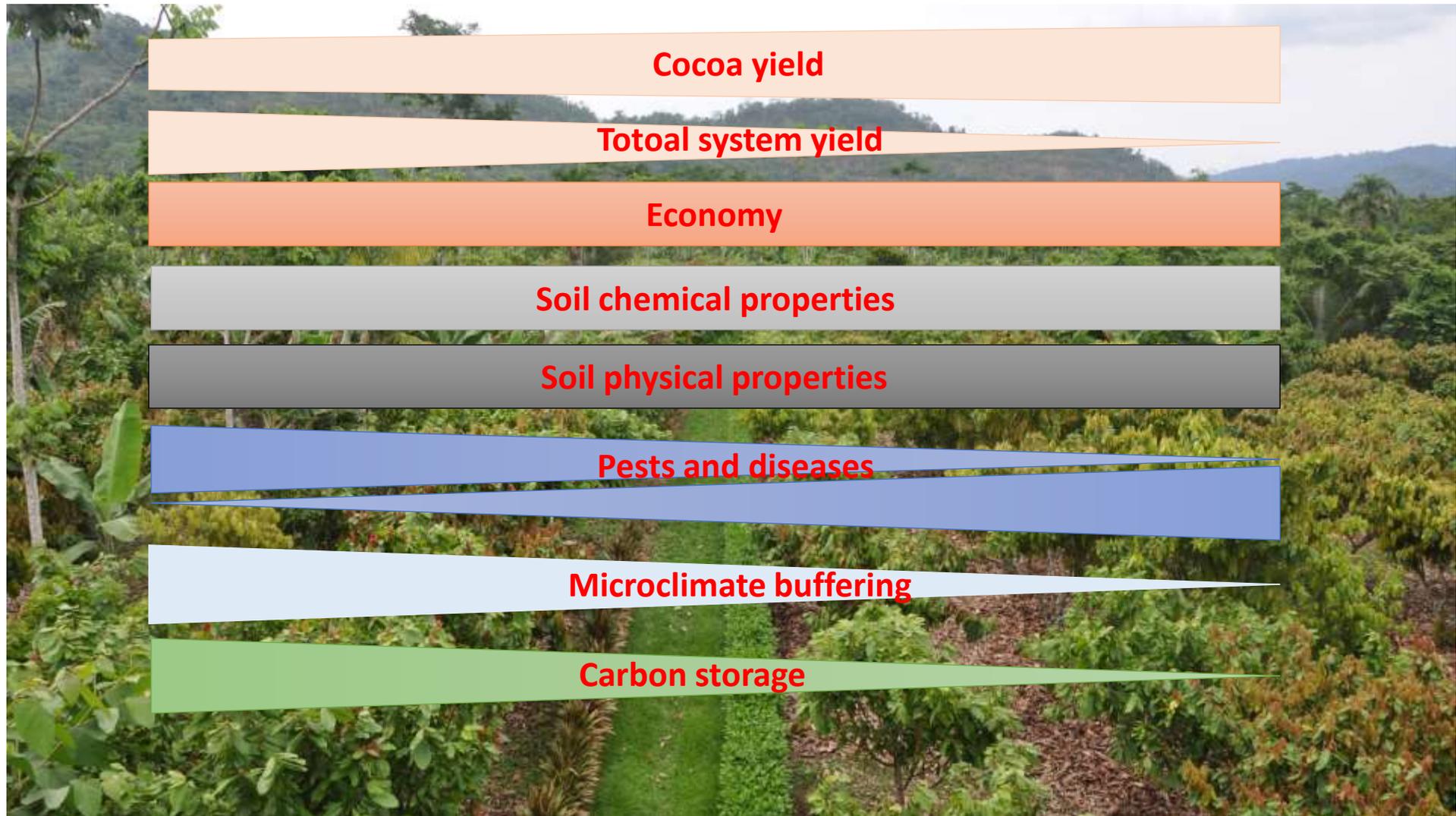
## Results: Stand structure and carbon storage



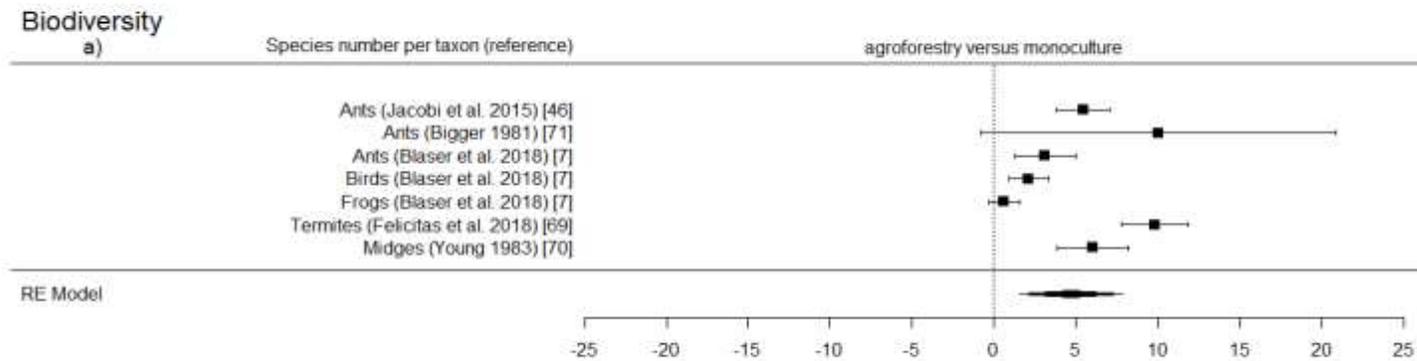
- More carbon storage above- and belowground in agroforestry
- Mitigation of climate change → Carbon sequestration
- Options for carbon offset?!

# AGROFORESTRY SYSTEM

# MONOCULTURE



## Results: Biodiversity



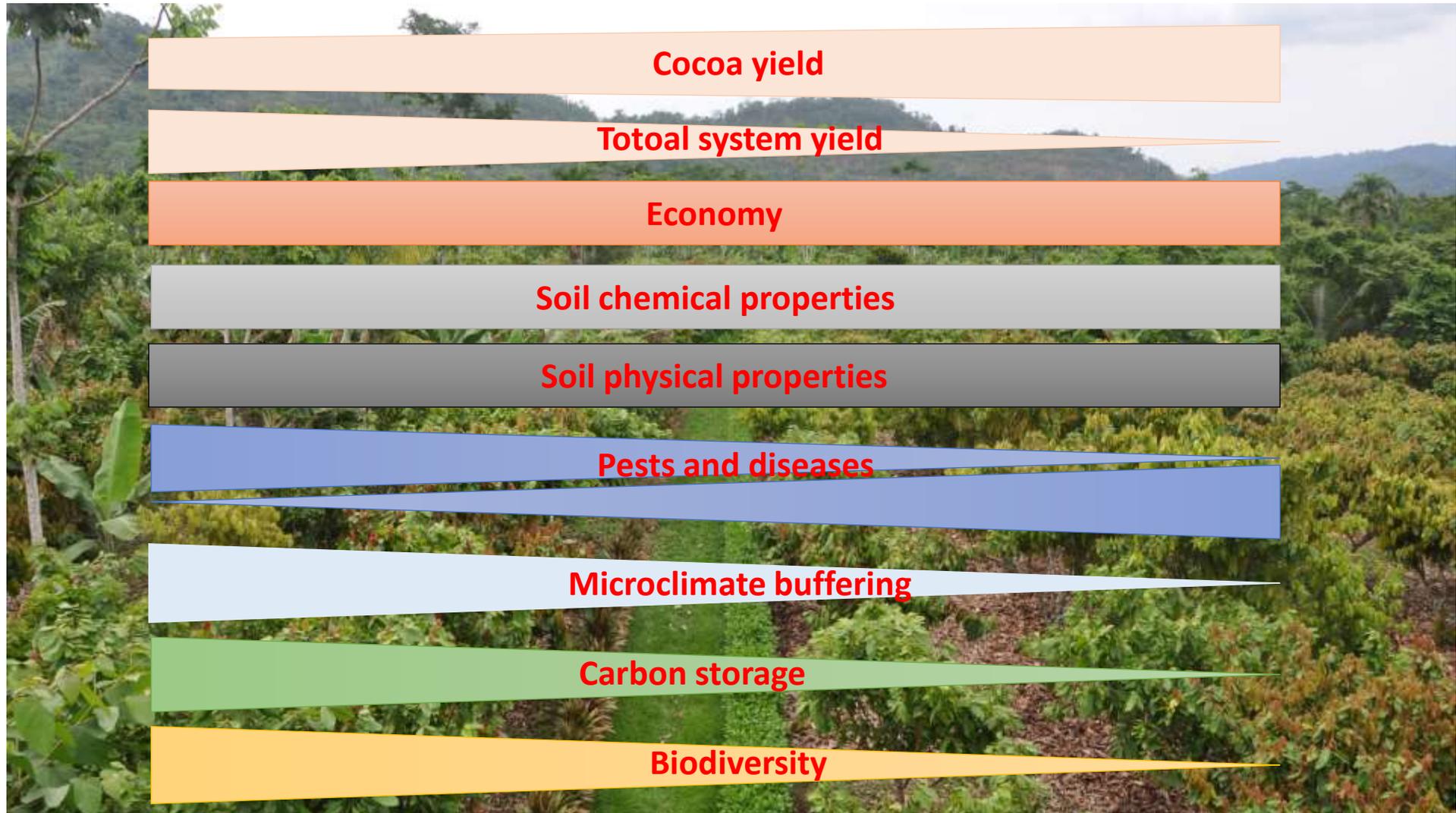
→ Higher species number in agroforestry systems

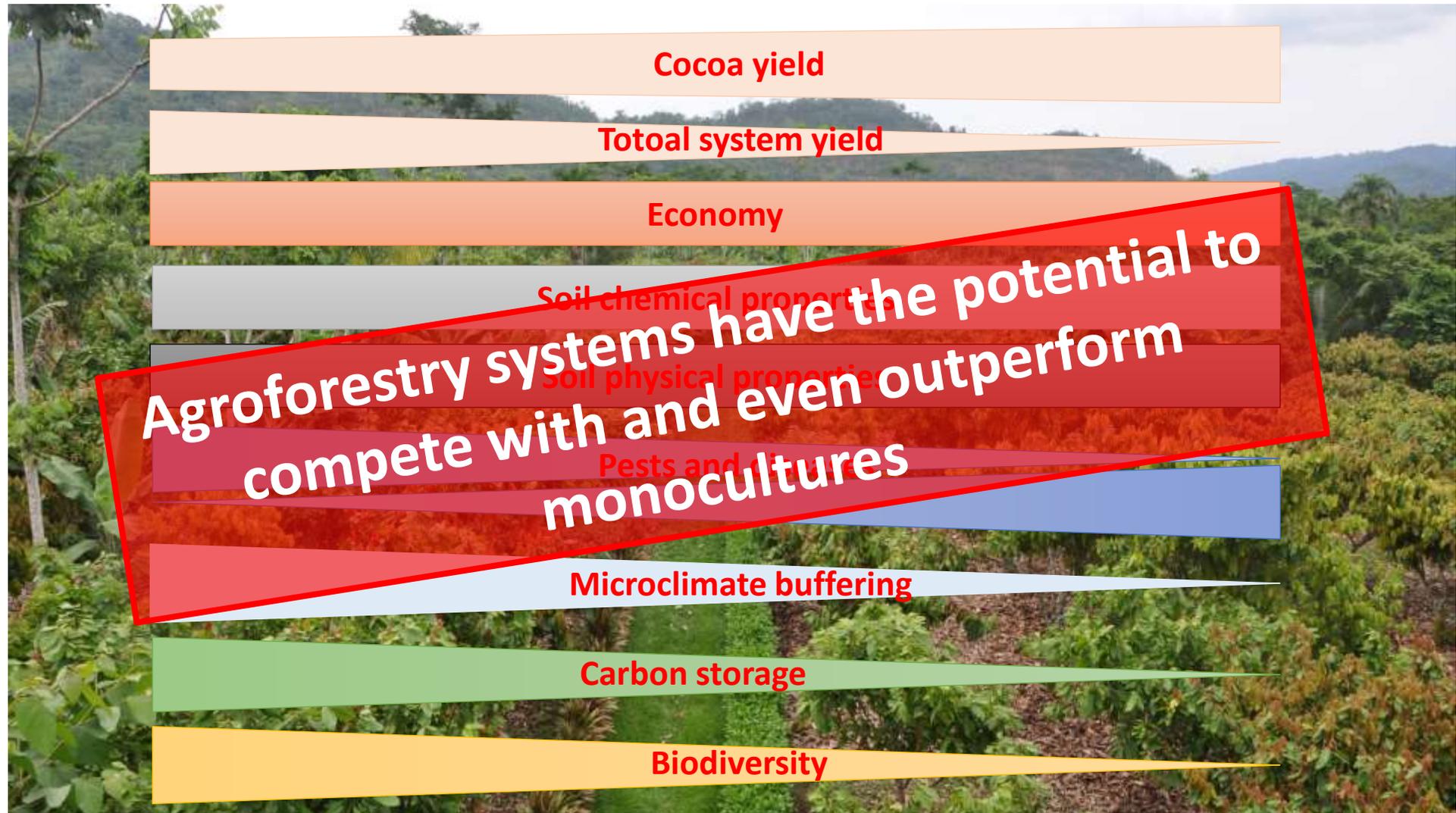
→ Number of herbal species depends rather on management (herbicides)

(Marconi and Armengot 2020)

# AGROFORESTRY SYSTEM

# MONOCULTURE





# Conclusions and implications (1)

- No definition of cocoa agroforestry beyond “inclusion of trees”
- A global recommendation for shade levels or shade tree species would not be accurate (high heterogeneity of environmental, climatic, soil and socio-cultural conditions)



Farmer-to-farmer field course, Bolivia (image: J. Jacobi)

# Conclusions and implications (1)

- No definition of cocoa agroforestry beyond “inclusion of trees”
- A global recommendation for shade levels or shade tree species would not be accurate (high heterogeneity of environmental, climatic, soil and socio-cultural conditions)
- But: Local and context-specific knowledge and recommendations for cocoa agroforestry design and management needed
- Knowledge gaps on species-specific information on shade trees, management strategies, pricing policies, livelihood aspects need to be addressed



Farmer-to-farmer field course, Bolivia (image: J. Jacobi)

# Conclusions and implications (2)

- Management is crucial, but pesticides can threaten human health and environmental benefits

→ Alternative management strategies



*Agroforestry system before pruning*



*Agroforestry system after pruning*

Pruning to manage microclimatic conditions (images: W. Niether)

# Conclusions and implications (3)

Even simple agroforestry systems can have positive effects. But they are not enough because:

- I. food security and
- II. environmental benefits need to be part of the calculation

→ social-ecological system approaches are necessary



Diversification of cocoa plots, El Ceibo, Bolivia (image: J. Jacobi)

# Conclusions and implications (3)

Even simple agroforestry systems can have positive effects. But they are not enough because:

- I. food security and
- II. environmental benefits need to be part of the calculation

→ social-ecological system approaches are necessary

- Building and enabling access to new alternative markets and value chains for agroforestry products

→ (Real) incentives for farmers to plant trees

**→ Deforestation for agroforestry is no option!**

(also no carbon offset)



Diversification of cocoa plots, El Ceibo, Bolivia (image: J. Jacobi)



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MERCI

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**Environmental Research Letters**

**LETTER**

**Cocoa agroforestry systems versus monocultures: a multi-dimensional meta-analysis**

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Supplementary material for this article is available [online](#)

**Abstract**  
Scientific knowledge, societal debates, and industry commitments around sustainable cocoa are increasing. Cocoa agroforestry systems are supposed to improve the sustainability of cocoa production. However, their combined agronomic, ecological, and socio-economic performance compared to monocultures is still largely unknown. Here we present a meta-analysis of 52 articles that directly compared cocoa agroforestry systems and monocultures. Using an inductive, multi-dimensional approach, we analyzed the differences in cocoa and total system yield, economic performance, soil chemical and physical properties, incidence of pests and diseases, potential for climate change mitigation and adaptation, and biodiversity conservation. Cocoa agroforestry systems outcompeted monocultures in most indicators. Cocoa yields in agroforestry systems were 25% lower than in monocultures, but total system yields were about ten times higher, contributing to food security and diversified incomes. This finding was supported by a similar profitability of