

CLIMATE-SMART
Agriculture
20**15**



Global Science Conference

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Le Corum, Montpellier France

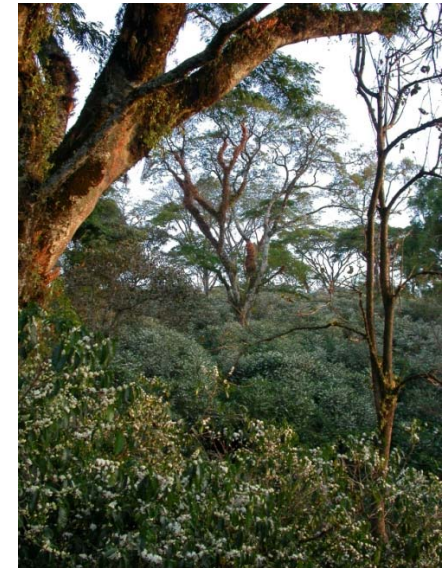
Smallholders' coffee and cocoa agroforestry systems; examples of climate-smart agriculture

Vaast P, Harmand JM, Charbonnier F, Roupsard O, Garcia C,
Kushalappa CG, Jassogne L, Sinclair F, Laderach P & Somarriba E.



Outline

- Key figures on cocoa & coffee
- Illustrations on how coffee & cocoa AFS are “perfect” examples of CSA
- Approach currently developed to intensify coffee & cocoa AFS while conserving their CSA nature





Some key figures



- Export values: 11 (coffee) and 12 (cocoa) billions \$ annually
 - 2.25 billions cups of coffee per day
 - 5-10 Kgs per person per year in EU
- Coffee: 15-20 M households
- Cocoa: 10-15 M households
- Global coffee area: 10.2 M ha
- Global cocoa area: 9.9 M ha

Coffee systems



- 40% of world coffee with no shade,
- 35% with “light - moderate” shade,
- and 25% with traditional diverse shade

- Global average yield: 550 kg /ha
- Vietnam (2000 kg ha⁻¹ Robusta)
- Brazil (1100 kg ha⁻¹ - Robusta & Arabica)



- Limiting factors: pests & diseases, susceptible plant material and low soil fertility

- Coffee responsible for 10-12 million ha of deforestation over 1-1.5 century

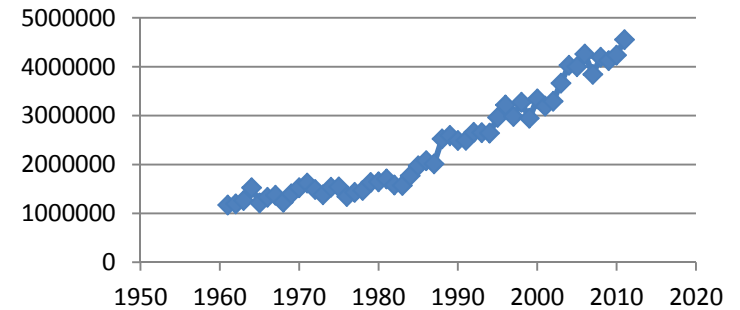


Cocoa systems

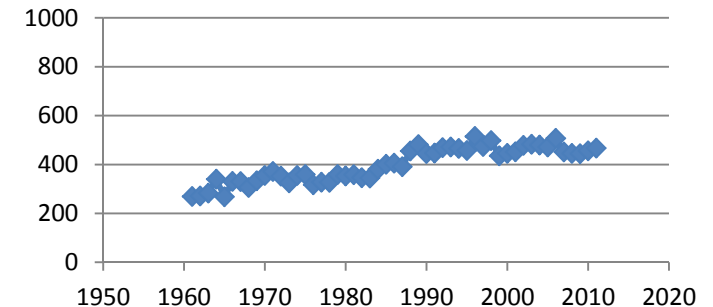
- 30% of world cocoa with no shade,
- 50% with “light - moderate” shade,
- And 20% with traditional diverse shade

- World cocoa prod. doubled in 20 years, low yield (FAO, 2013), 3 countries (~70%), :
Ghana (370 kg ha^{-1}); Côte d'Ivoire (630 kg ha^{-1}); Indonesia (670 kg ha^{-1})
- Yield potential: $1000 - 1200 \text{ kg ha}^{-1}$
- Limiting factors: high pests & diseases, low yielding and susceptible material, decreasing soil fertility
- Cocoa responsible for 6 M ha of deforestation over last 50 years

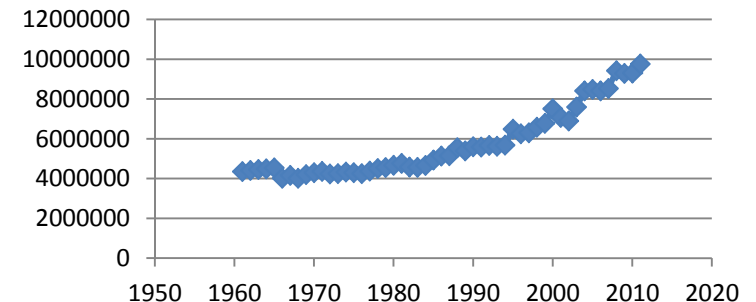
World (Production Tons)



World (Yield kg/Ha)

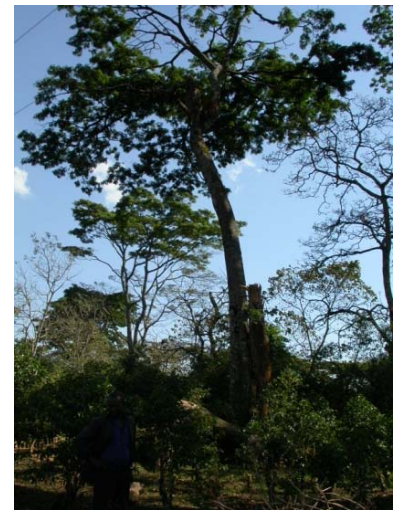


World (Area Ha)



Smallholders (80%) of world production for both coffee & cocoa

- Low in capital, hence low investment capacity in technical innovation
- highly exposed to price volatility
- Trends towards monoculture, but low intensification (Ruf 2011; Jah et al 2014)
- most vulnerable to CC (IPCC 2013)



COCOA

Models predict by 2050
T increase by $\sim 2^{\circ}\text{C}$, no
“drastic” decrease in rainfall

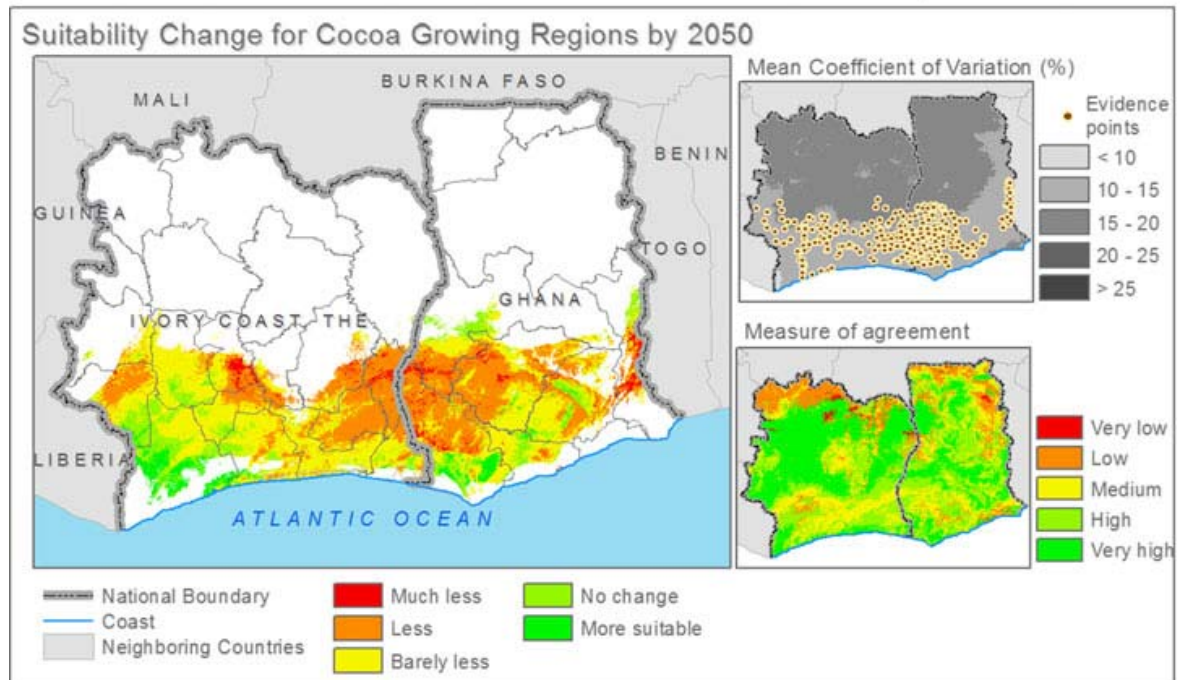
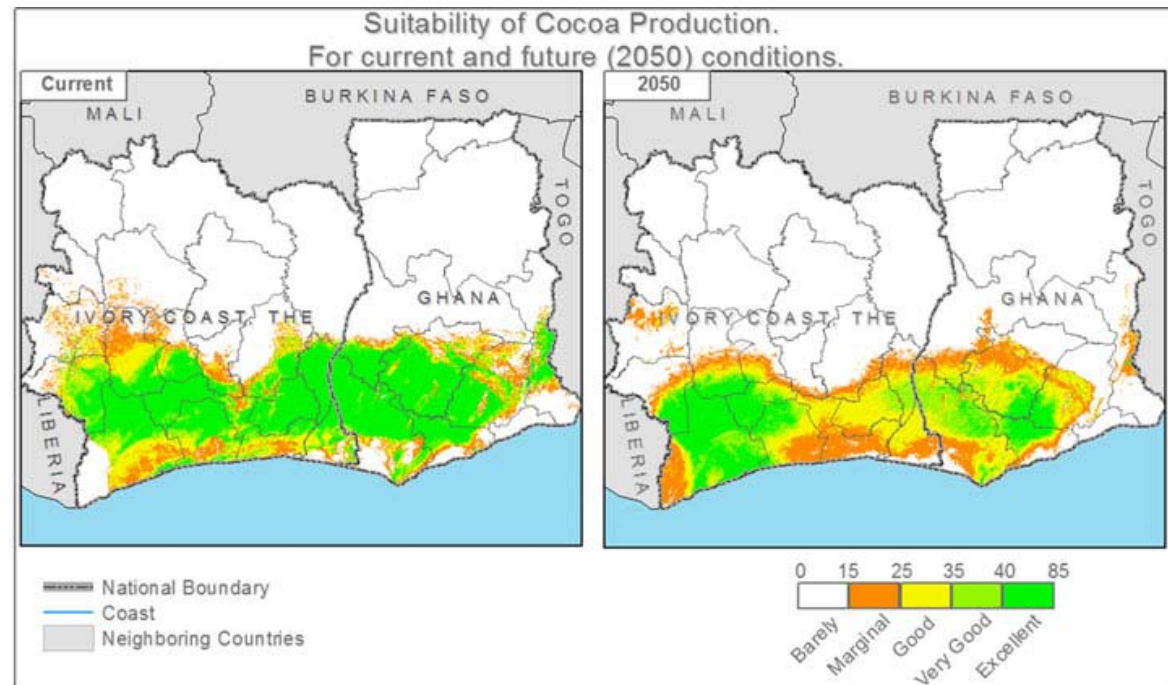
Low direct T effect on
cocoa (low T susceptible)

indirect via ETP increase,
decreased water availability

Reduction in “suitable
areas” mainly in already
“dry” marginal zones

Model not specific to
cocoa eco-physiology
Not taking into account:

- Effects on pests & diseases
- Farmers’ management adaptation



COFFEE

Models predict by 2050 :

- T increase by ~2-2.5 C
- Lower and more erratic annual rainfall (5-10%)

Strong direct T effect on Arabica (High T susceptible, faster berry ripening & lower quality)

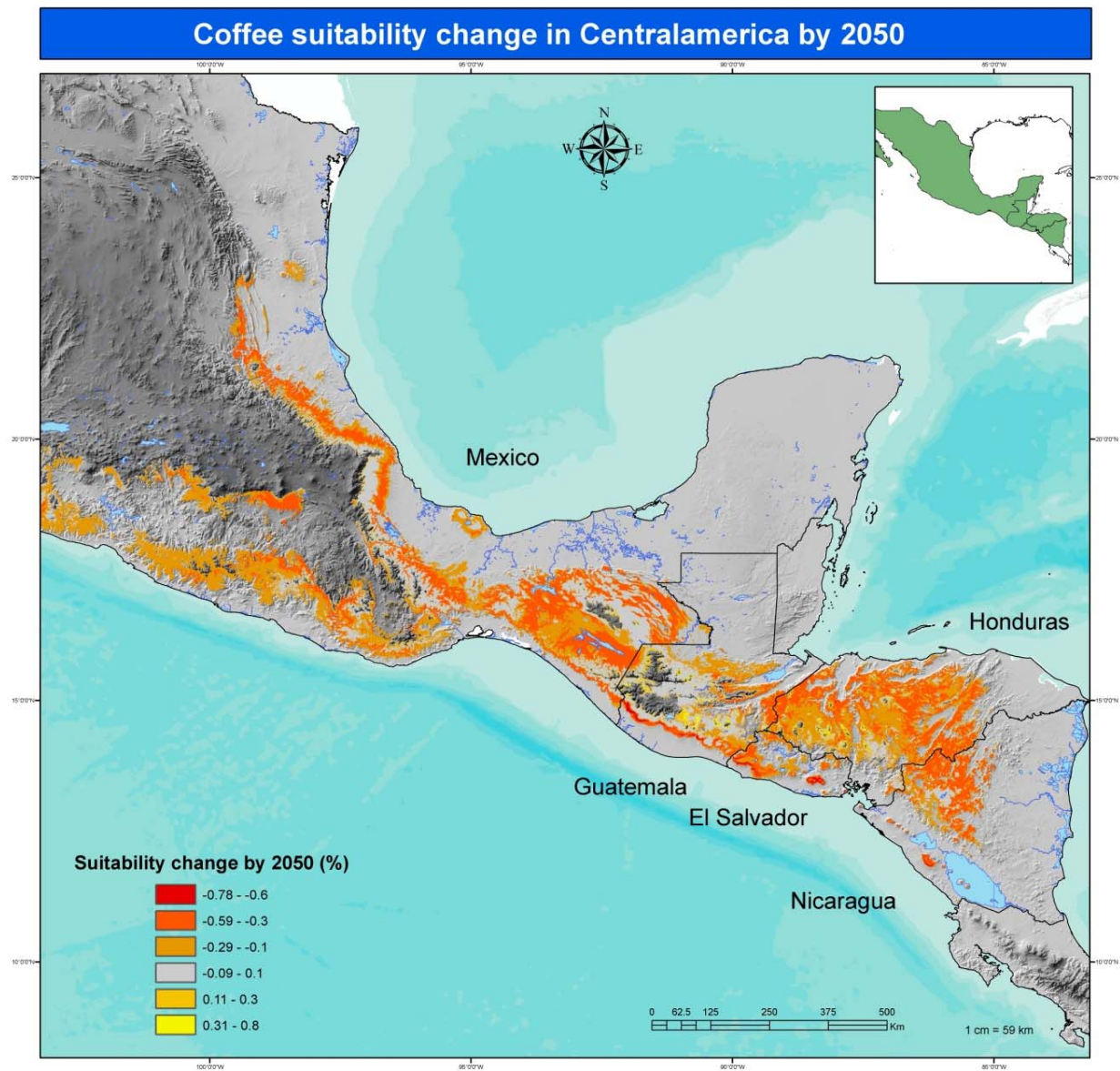
Strong direct rainfall effect on Arabica (flowering, fruit drop)

indirect via ETP increase ,
decreased soil water availability

Reduction in “suitable areas”
mainly in already “low altitude”
marginal zones

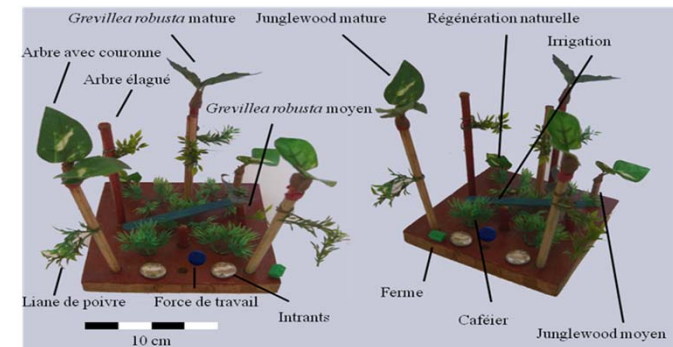
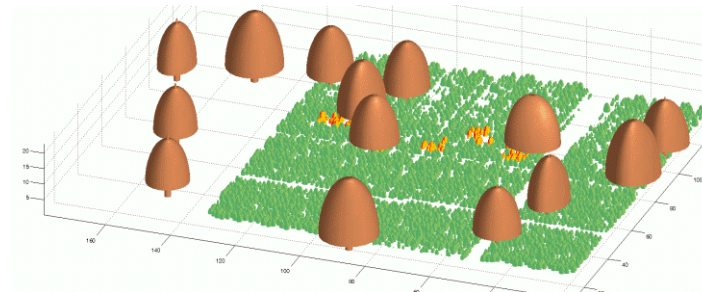
Models not taking into account:

- Cocoa eco-physiology
- Effects on pests & diseases
- Farmers' management adaptation



Agroforestry is climate smart

- Mitigation
- Adaptation
- Livelihood and food security
- Challenges
 - Intensive full sun vs Agroforestry
 - Ecological intensification around agroforestry practices



Mitigation

- Despite deforestation, cocoa & coffee AFS
 - sequester large amounts of C
 - **60-80 t C ha⁻¹** Aerial biomass cocoa AFS in Cameroon (Saj et al 2013)
 - **150-200 t C ha⁻¹** (soil and Abg) coffee AFS in India (Vaast et al 2011)
 - High rate of annual C accumulation
 - **3-5 t C ha⁻¹ yr⁻¹** in coffee AFS Costa Rica (Harmand et al 2007)
 - Lower GHG emission in coffee AFS than full sun:
 - **-7 t CO₂ eq ha⁻¹ yr⁻¹** (Hergoualc'h et al 2012)



Adaptation to climate extremes

- Well documented buffering effects of shade trees on coffee & cocoa heat and water stresses; Beneficial effects most cited by farmers
- Decrease air Temp. up to 2-3°C and leaf Temp. up to 6-7°C (Coffee, Siles et al 2010; Cocoa, Lin et al 2008)
- Reduce water stress during dry season (deep rooted shade tree species)
 - Cocoa & *Gliricidia sepium*, Sulawesi (Schwendenmann et al 2010)
 - Arabica coffee & *Inga densiflora*, Costa Rica (Cannavo et al 2011)

Livelihoods: diversification

To limit vulnerability to coffee/cocoa price volatility:

- Pepper in Western Ghats, India :
 - 20-50% of annual coffee revenue
- Timber in Costa Rica:
 - 30-40% of cumulated coffee revenue over 25 yrs
- Fruits, medicinal, banana and others in Central America:
 - 30-60% of annual cocoa revenue



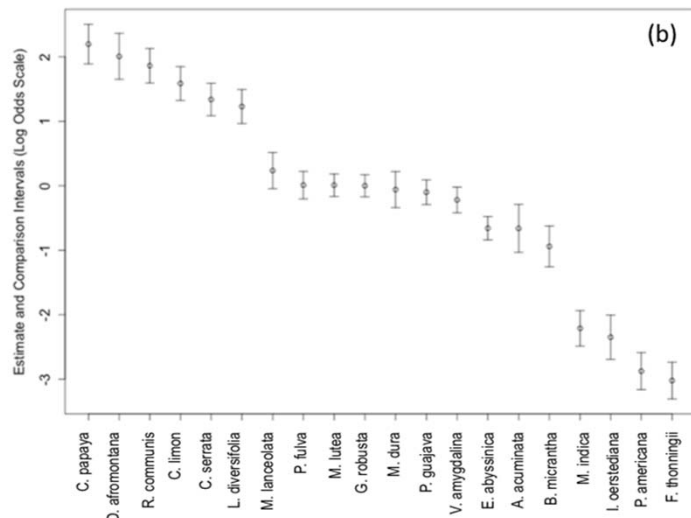
Challenges towards ecological intensification of cocoa and coffee AFS

- **Matching tree species** to specific ecological conditions/niches and social context, combined with management regimes (i.e. shade regulation) to **increase yield while enhancing provision of environmental services** at plot and landscape scales,
- Developing **integrated pests & diseases management options** where shade trees species are selected for their role as promoting functional biodiversity (natural enemies, barrier, connectivity...)
- Policy recommendations to enhance social assets and to **secure rights on trees and land of farmers**

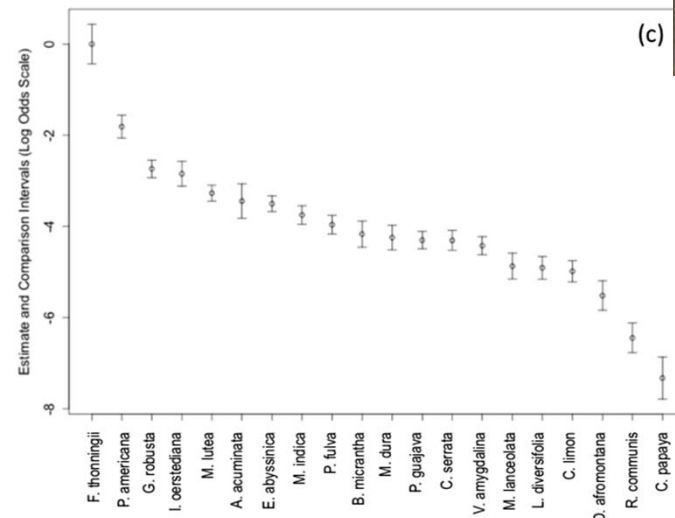


Combining research approaches

- Local AF Knowledge:
Ranking of tree traits & attributes



Crown density/shade

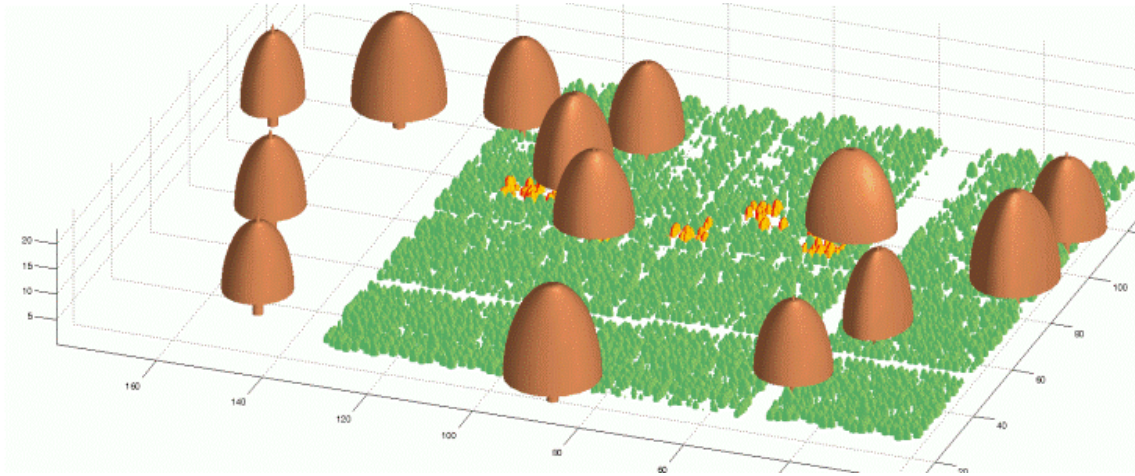


Root depth

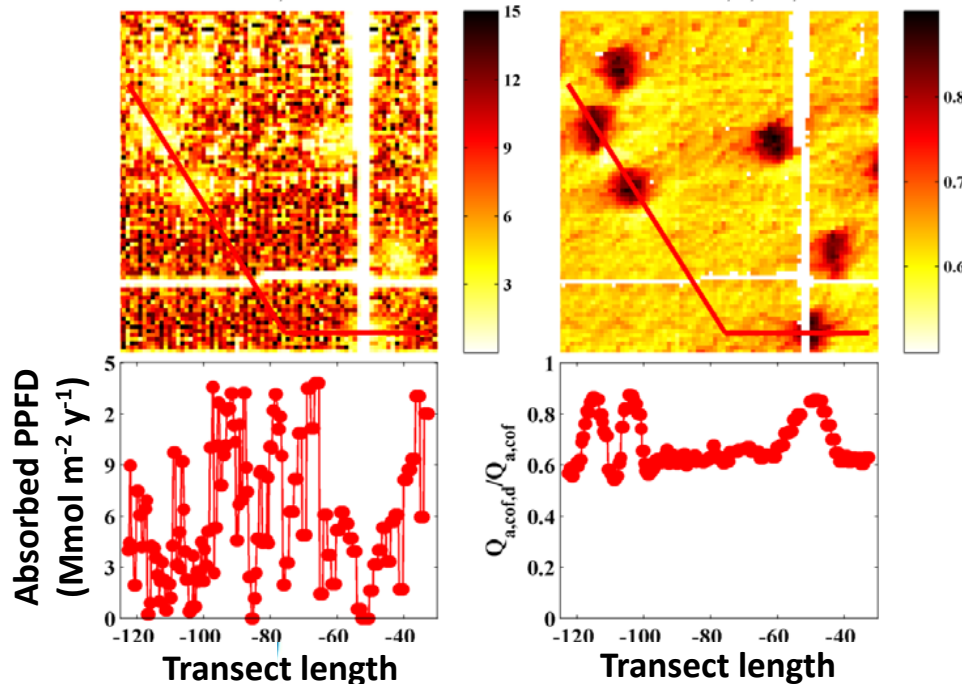
soil fertility, host to pests & diseases, timber quality,
fuelwood calorific value,etc



Modeling of interactions of coffee/cocoa and shade trees



Map of a virtual plot with shade trees and coffee plants as simulated with **MAESPA model** (Duursma and Medlyn, 2012). Source: Charbonnier et al. (2013).



a/: map of the amount of light (PPFD = P absorbed by the coffee layer, cumulated over one year (yellow spots below shade trees and red colors in full sun),

b/: variability of the absorbed light by the coffee layer along the red transect from a;

c/: fraction of diffuse light absorbed by coffee plants below shade trees (red spots, more diffuse light) and in full sun; **d/**: transect..

<http://macacc/>

Combined research approaches

Sessions of role playing with stakeholders of value chain and modeling of scenarios

