Agroforestry and climate change

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Agroforestry: well-known buffering and resilience effects

- Climate variability is well buffered by agroforestry because of permanent tree cover and varied ecological niches

- Resilience, or recovering after a disturbance (e.g. extreme weather events, or market failure) is well performed by agroforestry because of diversified temporal and spatial management options

Many references, e.g. Sanchez (1995), Huxley (1996), Torquebiau (1992), Garrity et al. (2010)

Examples of criteria for the sustainability attributes of agroforestry

- Permanent tree cover protects and improves the soil, while increasing soil carbon stocks
- Varied ecological niches allow for the presence of different crops, e.g. shade-tolerant and light-demanding
- Diversification of commodities allows for adjustment to market needs
- Management flexibility is compatible with shifts in labour supply
- Non-harvested components play an important protective role

Today's climate change context confirms the potential of agroforestry

- Climate-smart agriculture gives trees a large importance (see next slide)
- Conservation agriculture (no-till + cover crops) mimics the protective cover of trees (see next photo)
- Sustainability attributes of agroforestry are strong assets for climate change **adaptation**
- Carbon sequestration by trees contributes to climate change **mitigation**

Concept of climate smart agriculture by FAO:
Trees are a key component

http://www.fao.org/climatechange/climatesmart/en/

Conservation agriculture with cover crop

Conservation agriculture with trees
(also called evergreen agriculture)
is a form of agroforestry.
Ex: Maize and Faidherbia albida, West Africa

Photo: Dominique Loupe - CIRAD

The double potential of agroforestry to address climate change issues

- **Greenhouse gas–mitigation strategy** through carbon sequestration because of greater efficiency of integrated systems in resource (nutrients, light, and water) capture and utilization than single-species systems (Nair et al. 2009)

- **Sustainable adjustment to changing conditions** because agroforestry systems can be called perennial farming systems. They maintain and develop their root and woody biomass throughout seasons while providing food, fibre, energy and vegetative cover for soils.

Agroforestry has a high carbon sequestration potential on the long term (e.g. by the year 2040) not because it has a high carbon density (compared to forests) but because a lot of lands can potentially be turned into agroforestry

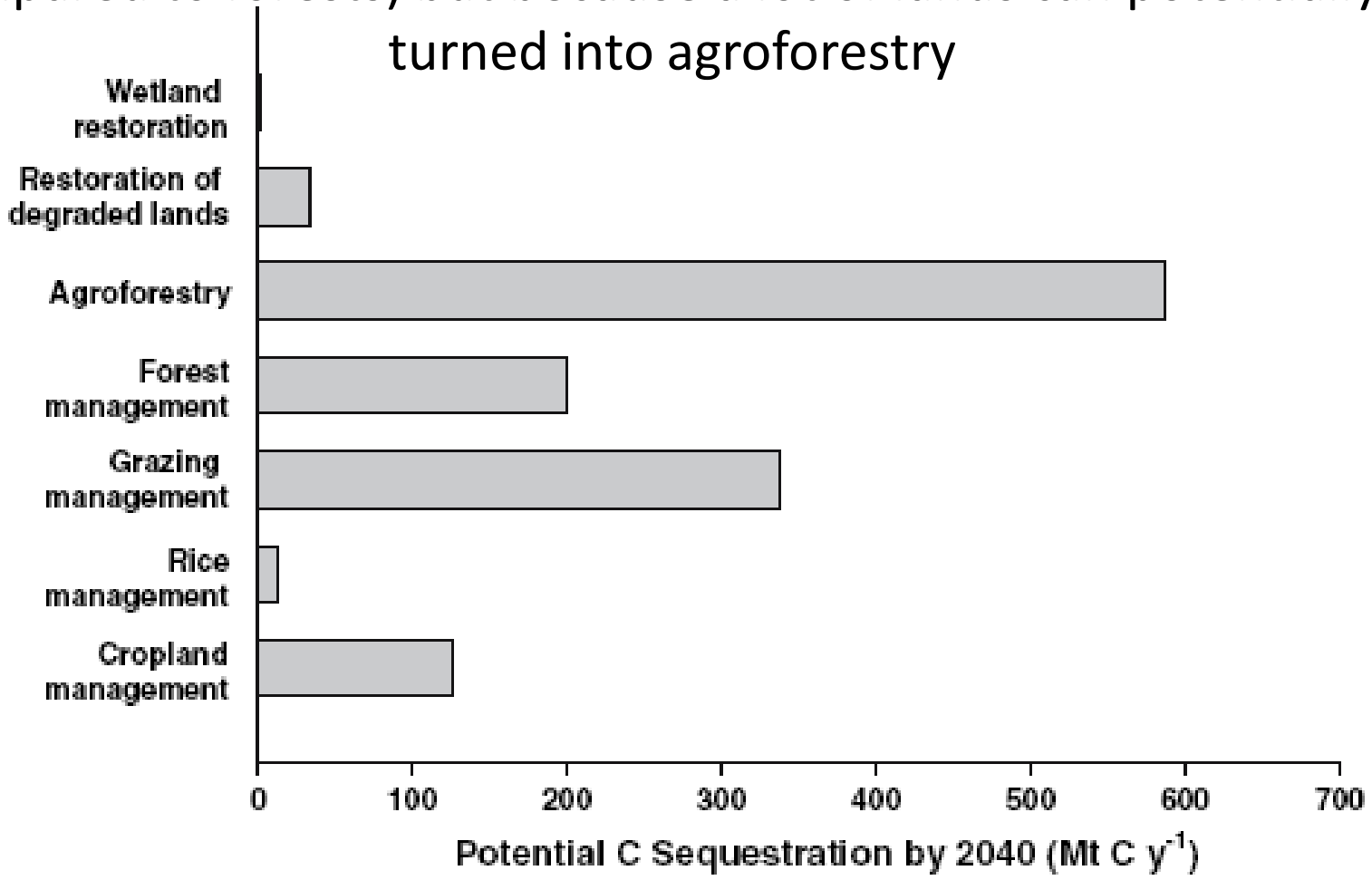
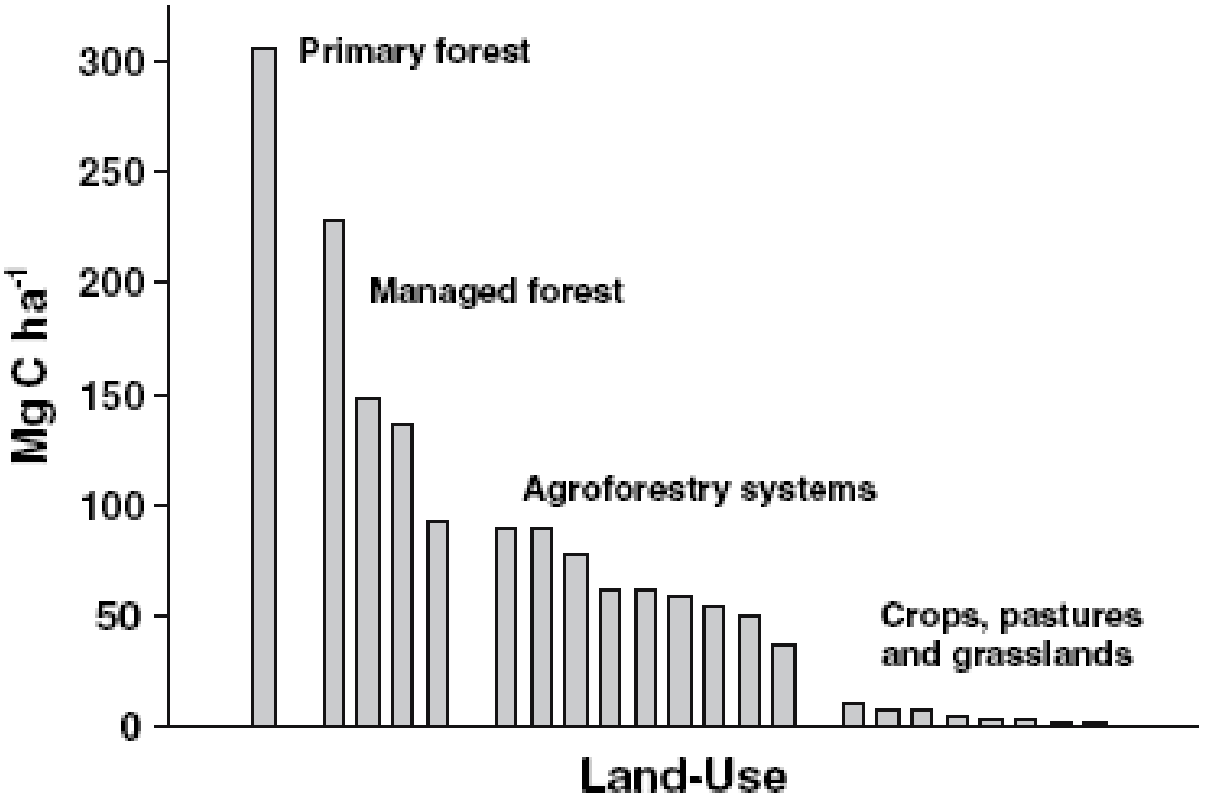


Fig. 1 Carbon sequestration potential of different land use and management options (adapted from IPCC 2000)

Verchot et al. Mitig Adapt Strat Glob Change (2007) 12:901–918

Agroforestry (humid tropics) can contain 50 to 75 Mg C ha^{-1}, i.e. far less than forests, but much more than annual crops

Fig. 2 Summary of C stocks at maturity in different ecosystems of the humid tropics. Data are from the benchmark sites of the Alternatives to Slash and Burn Programme of the Consultative Group for International Agricultural Research (CGIAR)



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Agroforestry can boost synergy between adapation to and mitigation of climate change

- **Mitigation** of climate change mainly takes the form of carbon sequestration, e.g. biomass, either above or below ground
- **Adaptation** to climate change is very much a function of soil organic matter content and diversified , multispecies cropping technologies
- Agroforestry perfoms well on the 2 above criteria and thus is a preferred approach to develop **synergies** between adaptation and mitigation
- High **biodiversity** and resulting **ecosystem services** in agroforestry also contribute to synergy between adaptation and mitigation
- Agroforestry improved fallows (see next slide) provide an example of such synergy

In agroforestry fallows with *Sesbania sesban*, decreased soil bulk density and improved water inflitration explain better early growth of the subsequent crop. Tree roots can reach 7 m deep in 2 years and represent 1.7 to 2.9 Mg ha^{-1} after 2 years, i.e. about 0.6 to 1 Mg C ha^{-1}

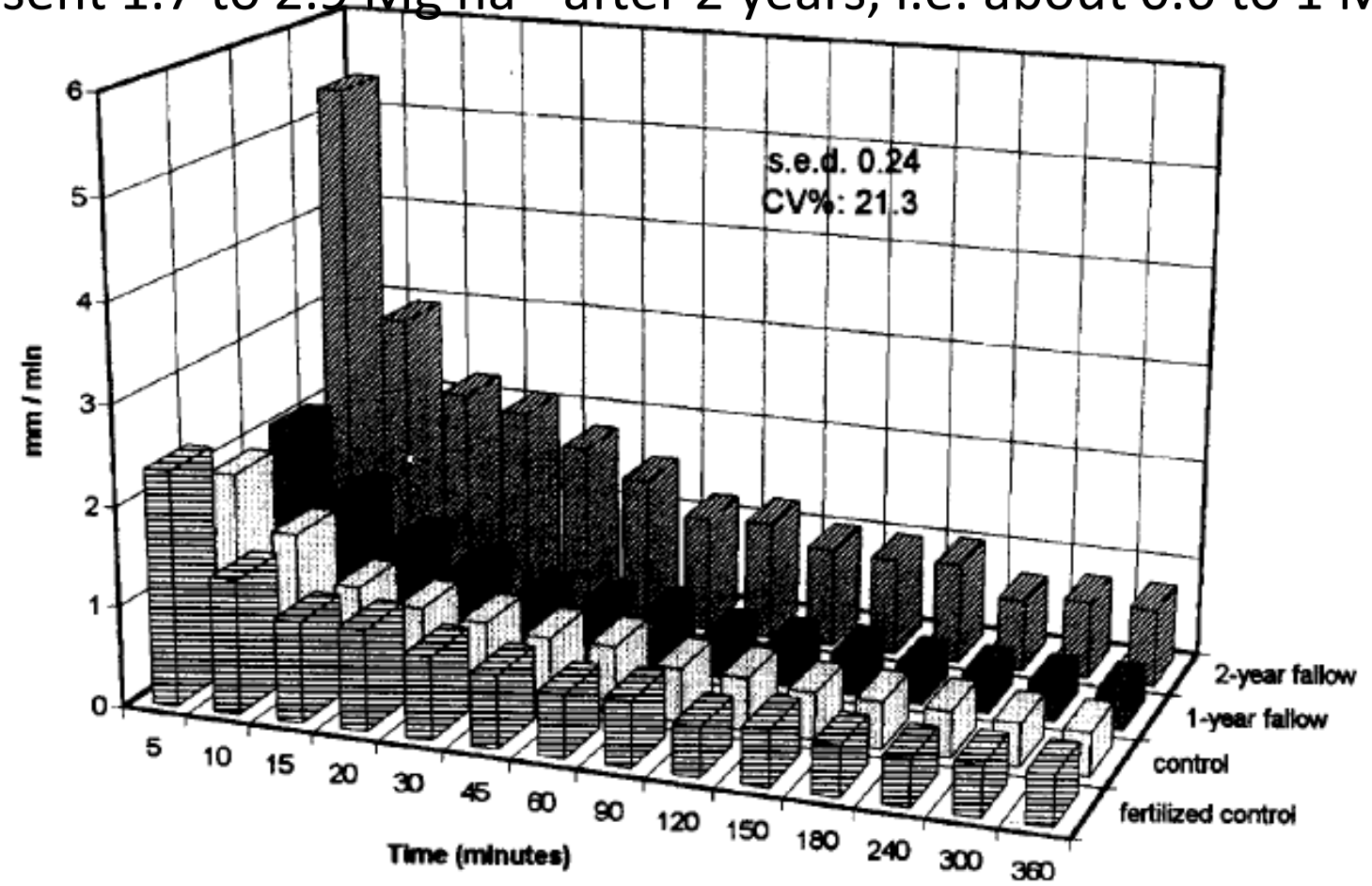


Figure 1. Water infiltration in the soil by the end of the fallow phase as a function of fallow length and controls at Chipata, Zambia, August 1993. Torquebiau and Kwesiga, 1996

Agroforestry is a landscape-scale approach, thus favours synergy between adaptation and mitigation

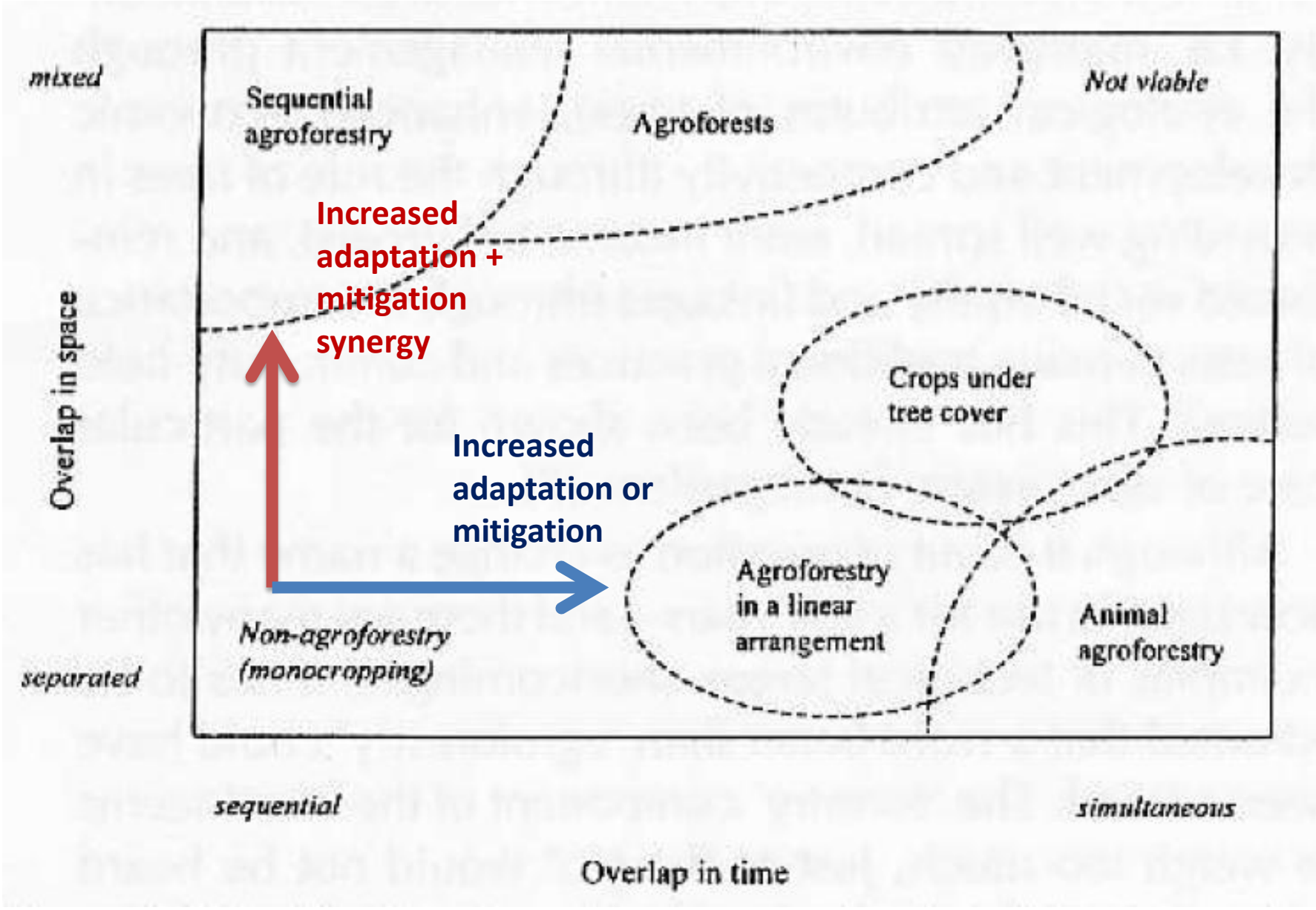
A typical agroforestry landscape in Haiti (Photo R. Torquebiau)

Table I. Classification of agroforestry in six structural categories.

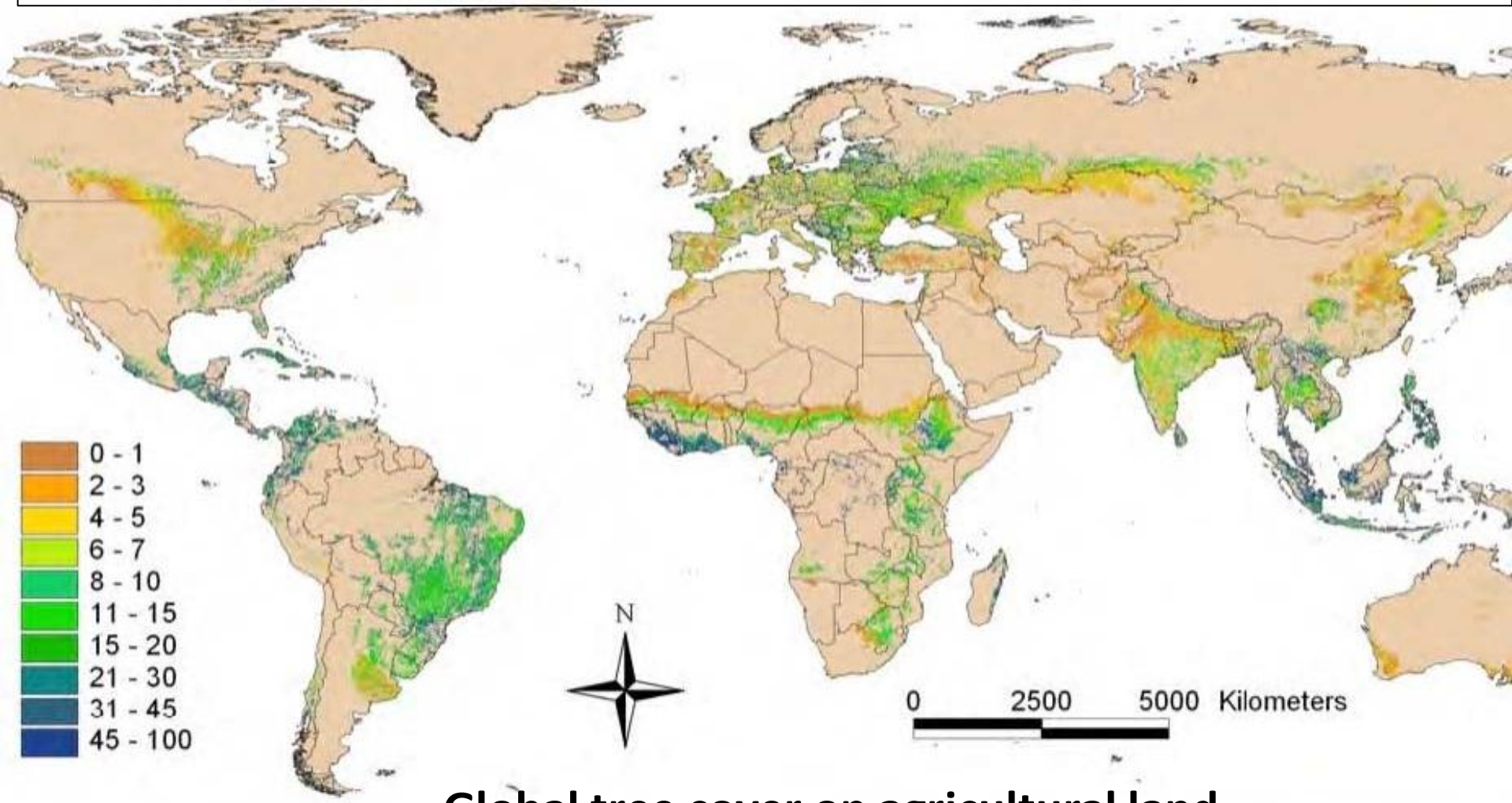
Crops under tree cover	scattered trees in cropland
	shade trees in plantation crops
	parklands
	crops in orchards
	plantation crops combinations
Agroforests	agroforestry homegardens
	village forest gardens
	mixed woodlots
	agroforestry buffer zones
Agroforestry in a linear arrangement	windbreaks and shelterbelts
	boundary planting
	live hedges
	living fences
	soil conservation hedgerows
	alley cropping
	roadside planting
	woody strips
Animal agroforestry	grazing or browsing in wooded or forested land
	tree planting in rangeland
	animal feeding with collected browse
	browse banks
Sequential agroforestry	shifting cultivation
	tree-improved fallows
	taungya
Minor agroforestry techniques	sericulture
	lac production
	apiculture with trees
	tree-based aquaculture

Torquebiau, 2000

Different categories of agroforestry have different climate change adaptation or mitigation potential (adapted from Torquebiau, 2000)



Trees on farms and agricultural landscapes must be included in the climate change talks about Reducing Emissions from Deforestation and Forest Degradation (REDD+)



Global tree cover on agricultural land

46% of agricultural land have more than 10% tree cover
27% of agricultural land have more than 20% tree cover
7.5% have more than 50% tree cover (Zomer et al, 2009)

A new paradigm is required for designing climate-smart agroforestry associations

- So far, agroforestry has mainly been a crop system and a tree system side by side
- A new agroforestry paradigm is required where trees and crops are selected and managed together
- Examples:
  - shade-tolerant crops adapted to particular tree species
  - Trees and crops with non-overlapping roots
  - Trees and crops with temporally differentiated ecological requirements (e.g. dry and wet season)
- Such innovative associations will be able to address food security and climate change issues in simultaneity

Warning!

- Agroforestry is not a recipe
- There are many possible tree / crop (and animal) associations
- Some work, some don't
- While the presence of perrenial plants (trees / woodiness) is key towards addressing climate change problems, care should be taken to select the right tree / crop association and management practices for different places
- See here: http://www.worldagroforestrycentre.org/

Useful references

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- Sanchez, P.A. 1995. Science in agroforestry. Agroforestry Systems 30: 5-55
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- Zomer, R. J., Trabucco, A., Coe, R., Place, F. (2009). Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry. Nairobi: World Agroforestry Centre, ICRAF: Working Paper No 89

For French speaking readers:

- Torquebiau, E. 2007. L'agroforesterie: Des arbres et des champs. Paris: L'Harmattan, 151 pp. (also available as e-book on http://www.editions-harmattan.fr/index.asp?navig=catalogue&obj=livre&no=23970