# Reassessing the role of remnant trees in tropical swidden systems

Ata Davatgar & Lindsey Norgrove
School of Agricultural, Forest and Food Sciences, Bern University of Applied Sciences,
Zollikofen, Switzerland. lindsey.norgrove@bfh.ch

Tropentag,
18-20 September, 2019,
Kassel, DE

Swidden farming, aka shifting cultivation, is common in the tropics (Fig 1). Farmers clear forest, dry the cut vegetation & burn it. After a short cropping phase, the plot is fallowed then the cycle is repeated.

Palm et al. (1999) based "time averaged carbon" calculations (Fig 2) on a clear-cut plot and thus aboveground carbon stock (AGC) at clearance is 0. Yet farmers retain "remnant trees" & these have not been accounted for.

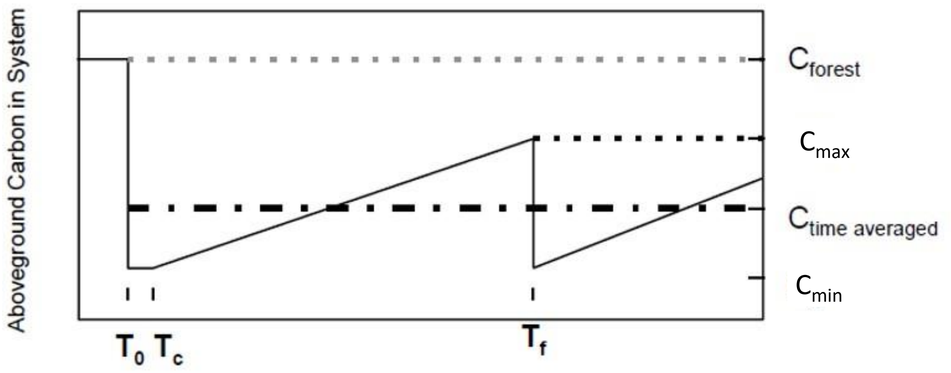



**Fig 2:** Time averaged carbon concept (after Palm et al 1999)
C accumulation rate = $I_c = (C_{max} - C_{min}) / (T_f - T_c)$.
$C_{time\ averaged} = (I_c \times T_f) / 2$.
$C_{max}$ = Maximum carbon accumulated in fallow
$C_{min}$ = carbon in crop assumed to be zero
$T_c$ = Length of time in crop phase
$T_f - T_c$ = Length of time in fallow phase

## Objectives

Why do farmers retain remnant trees in swiddens?

Which tree species are retained?

How much are AGC stocks in remnant trees?

How do these C stocks modify the $C_{time\ averaged}$ of Palm et al. (1999) & what is their contribution to the *missing terrestrial carbon sink* (sensu Houghton et al. 2018)?

## Methods

Systematic search in ISI Web of Science, limited to English yet without time limitation:

*("remnant trees" OR retain OR orphan OR remove OR fell OR clear*) AND ("shifting cultivation" OR swidden OR "slash and burn") AND ( biomass OR carbon)*

51 studies contained data on farmers' reasons (Fig 3). 31 contained data on diameter at breast height (DBH), density, biomass or carbon (C) data

Conversion from DBH to AGB using allometrics (Brown et al. 1989; Chave et al. 2005)

50% of total AGB assumed to be C (following Brown 1997). Wood densities after Brown (1997) and African Wood Density Database (2012)

$C_{time\ averaged}$ recalculated using the remnant tree ABG at t=0, rather than coding it as 0

Differences in TAC then combined with data from Silva et al. (2011) on the extent of swidden in those countries to estimate how much C in remnant trees is unaccounted for

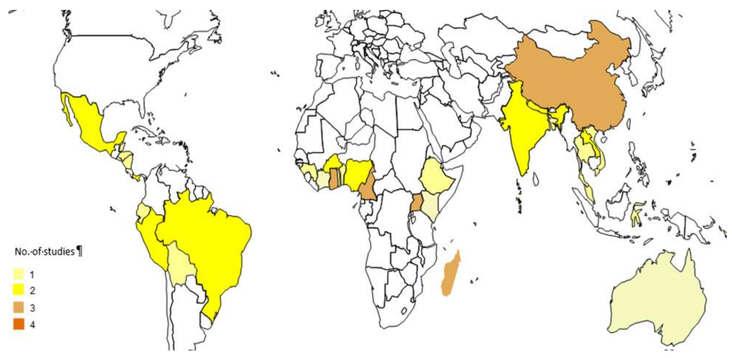
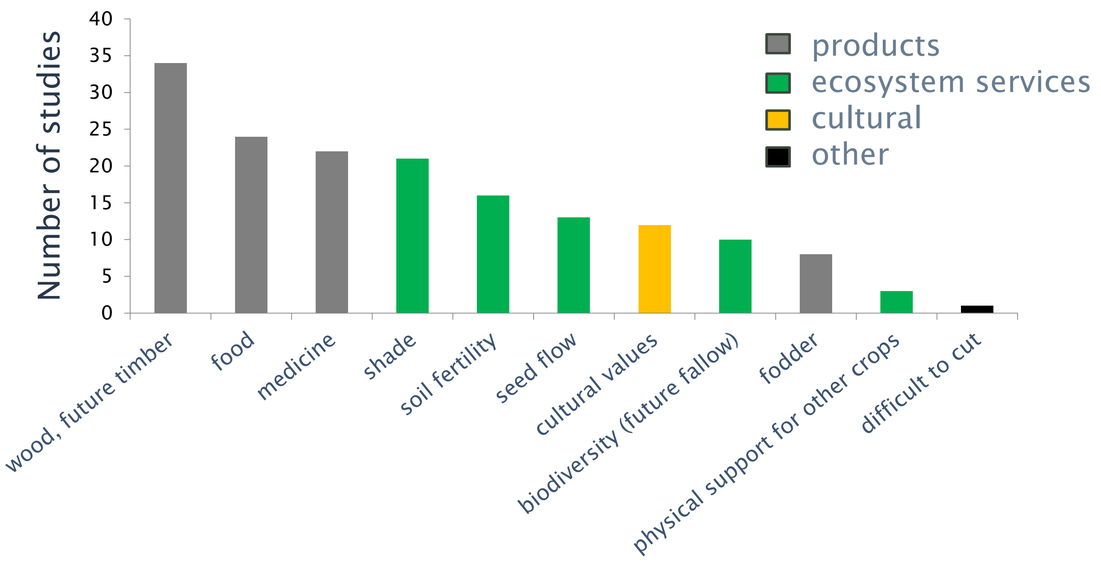



**Fig 3:** Studies reporting reasons for retaining remnant trees (n=51)

## Results

**Fig 4:** Reasons most cited by farmers for retaining trees in swiddens (n=51)




Most cited families were Moraceae (9), Fabaceae (7) and Malvaceae (6)

*Ficus* (Moraceae) most frequent genus (n=7). E.g. among the Iban community in Sarawak Malaysia cutting them is taboo and fruits are used as food (Horowitz 1998)

**Fig 5:** AGC in remnant trees in swiddens correlated with annual rainfall (n=30)

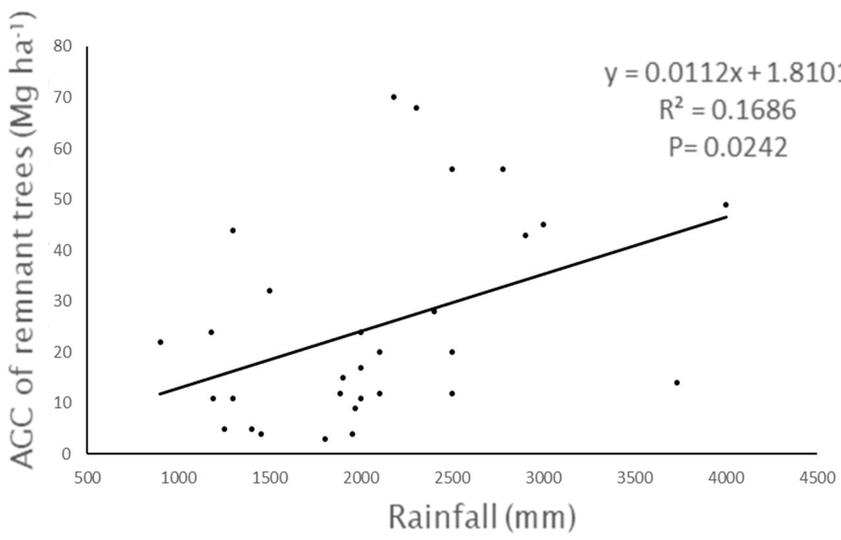



**Table 1:** AGC stock in remnant trees in different agroecozones (n=30)

| agroecozone | DBH range (cm) | Height range (m) | Tree density range (/ha) | C stock mean (Mg / ha) |
|---|---|---|---|---|
| tropical humid (n=17) | 20 - 143 | 20 - 45 | 1 - 160 | 32 |
| tropical dry (n=3) | 23 - 45 | - | 2 - 78 | 17 |
| tropical montane (n=14) | 18 - 63 | 8 - 15 | 13 - 25 | 18 |

Assuming the mean C stock per country (Table 1) and multiplying by the area of swidden per country (after Silva et al. 2011), AGC in remnant trees contributed 2.9 Pg C in 10 countries alone.

## Conclusions

- Remnant trees retained for products, providing ecosystem services and for cultural values
- AGC in remnant trees related to annual rainfall and agroecozone
- Remnant trees contributed 2.9 Pg C of the "*missing terrestrial carbon sink*" in ten countries alone

Bern University of Applied Sciences

**Fig 1:** Typical swidden system, Awae, Southern Cameroon

## References

African Wood Density Database 2012 http://old.worldagroforestry.org/treesandmarkets/wood/

Chave J, Andalo C, Brown S, Cairn MA, Chambers JQ, Eamus D, Fölster H, Fromard F, Higuchi N, Kira T, Lescure JP, Nelson BW, Ogawa H, Puig H, Riéra B, Yamakura T, 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia, 145, 87–99.

Brown S, 1997. Estimating Biomass and Biomass Change of Tropical Forests: a Primer. FAO FORESTRY PAPER134. FAO - Food and Agriculture Organization of the United Nations Rome, 1997.

Brown S, Gillespie A, Lugo AE, 1989. Biomass estimation methods for tropical forests with applications to forest inventory data. For Sci, 35,881–902.

Houghton RA, Baccini A, Walker WS, 2018. Where is the residual terrestrial carbon sink? Global Change Biology, 24, 3277-3279.

Palm CA, Woomer PL, Alegre J, Arevalo L, Castilla C, Cordeiro DG, Feigl B, Hairiah K, Kotto-Same J, Mendes A, Moukam A, Murdiyarso D, Njomgang R, Parton WJ, Ricse A, Rodrigues V, Sitompul SM, van Noordwijk M,1999. Carbon sequestration and trace gas emissions in slash and burn and alternative land uses in the humid tropics. Nairobi, Kenya, ASB Climate Change Working Group Final Report, Phase II, ASB Coordination Office, ICRAF.

Silva JMN, Carreiras JMB, Rosa I, Pereira JMC, 2011. Greenhouse gas emissions from shifting cultivation in the tropics, including uncertainty and sensitivity analysis. Geophysical research,116, D20304