How REDDy is African Agriculture?

Supplying Robust Carbon Estimates for Agricultural Landscape Mosaics in Western Kenya

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Rationale

Trees significantly stabilize or even increase **carbon sequestered** in many agriculturally dominated landscapes of Sub-Saharan Africa (87% have tree cover >10%; *Zomer et al. 2009*). Robust and viable methods are needed to **assess biomass carbon** especially in such heterogeneous agro-landscapes.

The international debate on climate change mitigation has **recognized REDD+** and currently discusses REDD++ approaches that create opportunities for **rural farmers** in the tropics to **participate** in coupling mitigation with adaptation actions. Reducing carbon emissions from deforestation and degradation can combat **climate change**, conserve **biodiversity** and enhance agricultural **production** and can ultimately lead to more resilient hence **food-secure** cropping systems.

Assessing biomass carbon in highly heterogeneous agricultural landscape mosaics requires robust and viable methods. The aim of this study is i) to develop a **generic allometry** covering the tree biodiversity of the study region in Western Kenya through empirical, destructive measurements and ii) to collect calibration data for modeling approaches that can eventually **replace destructive sampling** (e.g. *Santos et al. 2010*).

Methods

In the first half of 2010, **72 trees** were randomly selected for harvest across the landscape (Fig. 1) to equally cover all 6 diameter classes and natural species abundance (Fig. 3) for which the Middle Yala block contributed trees at 50% and the lower and upper blocks 25% each. An additional 25 trees were harvested for validation of the equations.

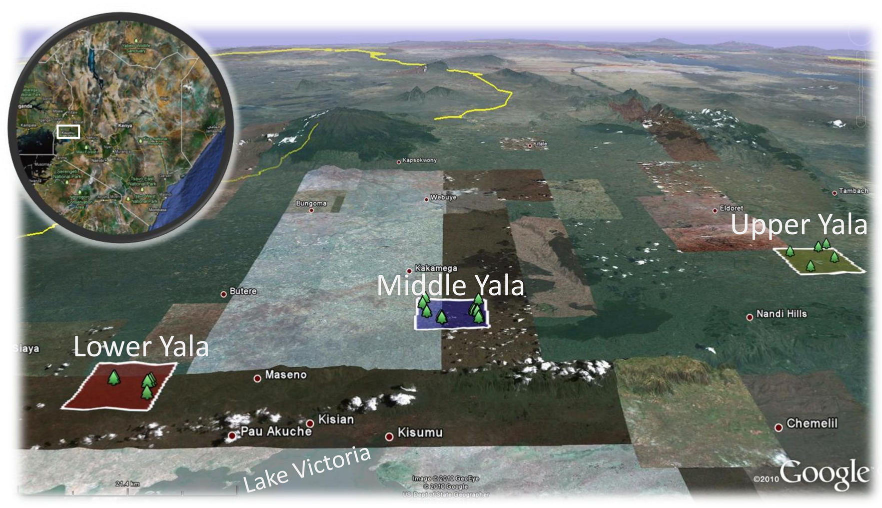
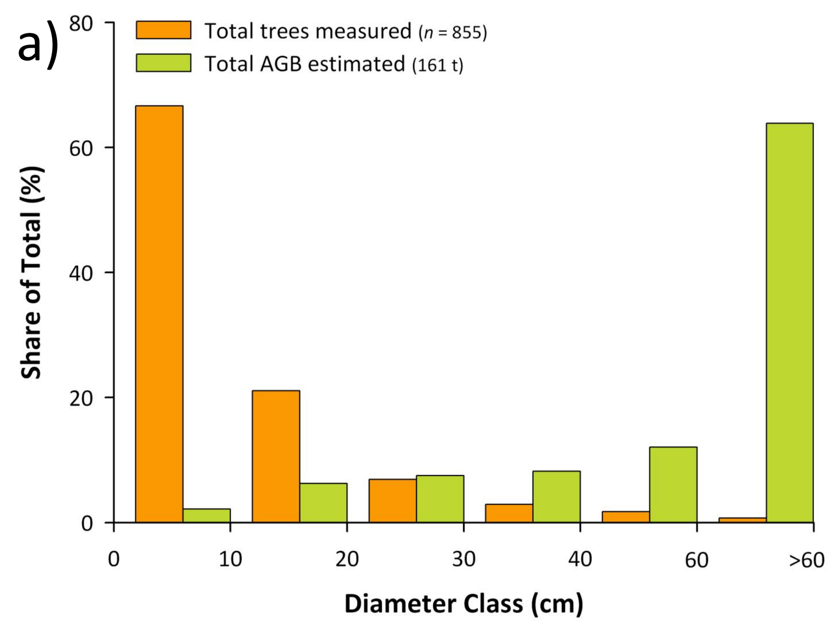


Fig. 1: The location of the three 10x10 km study blocks in the Yala catchment of Western Kenya along an altitudinal gradient from 1200m (Lower) to 2200 m (Upper).

- Diameter, height, crown dimension and management effects on crown were recorded for all harvested and non-harvested trees
- Harvested trees were separated into components (leaves, branches and stem) and weighed in the field on a 300 kg scale (Fig.2)
- Component subsamples fresh weights were measured in the field on a 3 kg scale and their respective dry weights determined after oven-drying at 105°C for 24 hours
- Wood density was determined by coring and displacement methods
- Losses from chain sawing were calculated from fresh wood density
- Link lengths and diameters were measured to provide modeling data for non-destructive approaches

Fig. 2 a) Removal of leaves from branches for weighing (Upper Yala) and **b)** weighing a sectioned trunk piece < 300kg (Middle Yala), June 2010.

Results & Discussion



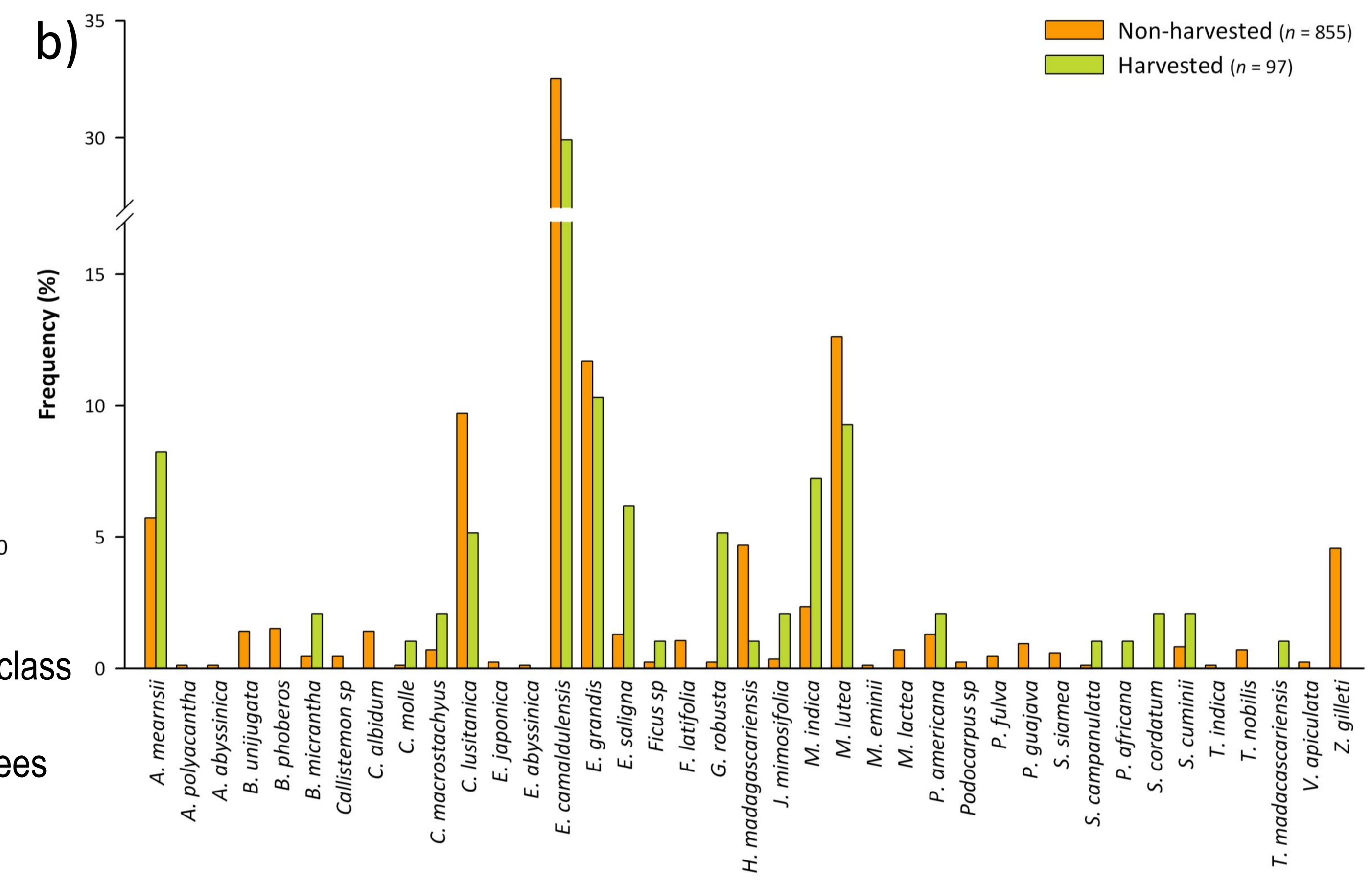
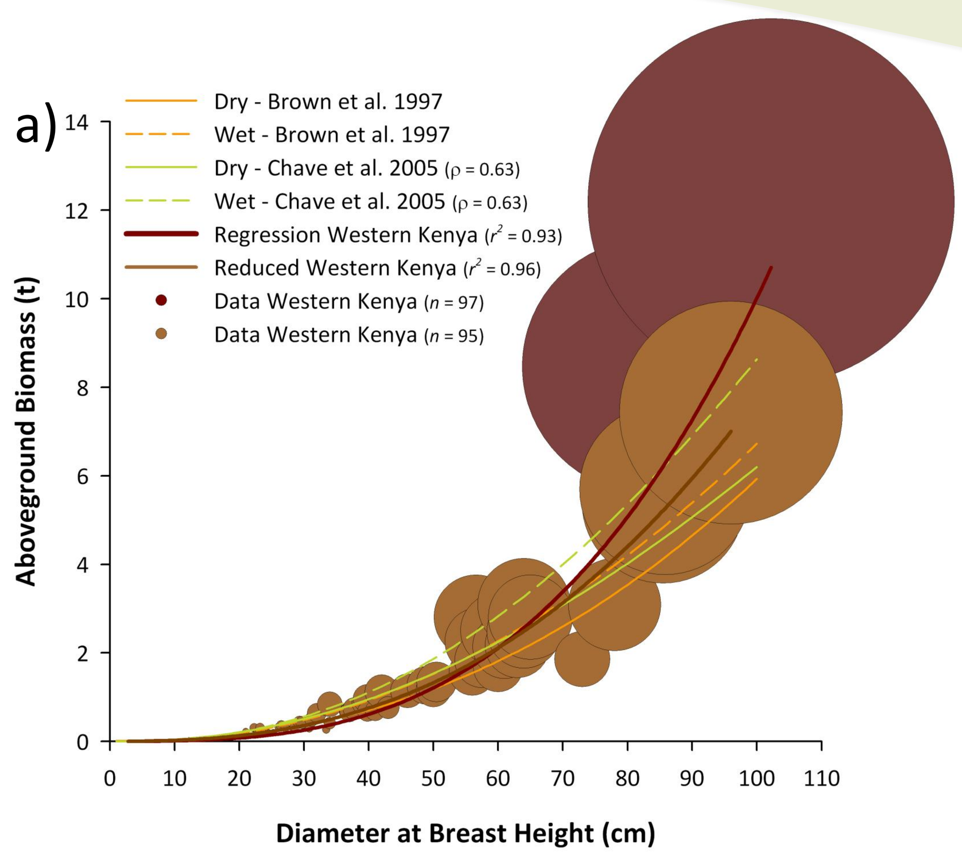


Fig. 3 a) Distribution of trees measured per diameter class and their estimated biomass; and **b)** Species distribution for harvested and non-harvested trees

- Most of the trees measured had a diameter at breast height (DBH) <10 cm indicating a renewed effort in planting trees in the area.
- 75% of the estimated non-harvested biomass was accounted for by the largest 2.5% of the trees (Fig. 3a and 4a).
- *Markhamia lutea*, *Eucalyptus* spp. and *Acacia mearnsii* are dominant in the lower, middle and upper Yala blocks respectively.
- The harvested species reflect well the overall species distribution (Fig 3b).
- Most of the trees (>80%) measured are not native to East Africa (Fig. 3b).
- Management in Middle Yala differed from the other blocks (Table 1).
- Overall management effects by pruning were low (12%), but the use of trees for boundary planting and woodlots resulted in high crown restriction (83%).

Tab. 1. Management effect observed on harvested and non-harvested trees in terms of pruning and crown restriction in each blocks

	Crown restriction (%)		Pruning (%)	
Block	restricted	not restricted	pruned	not pruned
Lower	95	5	10	90
Middle	33	67	11	8
Upper	80	20	32	68



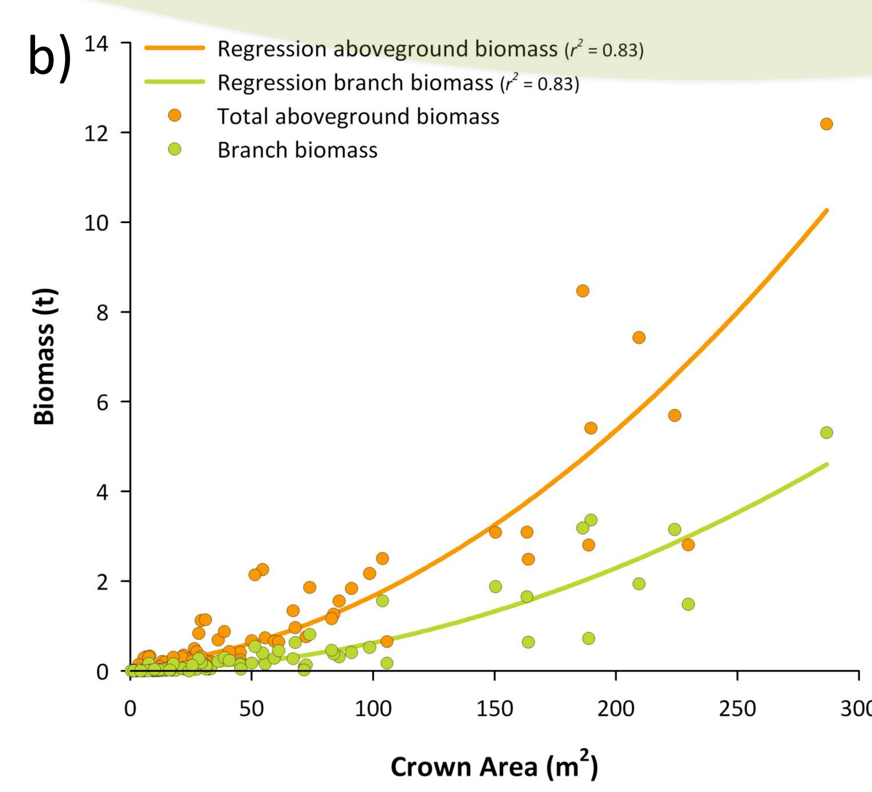


Fig. 4 a) AGB prediction by DBH compared to two relevant global studies and regressions of a dataset reduced by the two largest trees and all trees (circles are proportional to biomass) and **b)** total above-ground and branch biomass predicted by crown area.

- The regression concurs with widely recognized global biomass equations at lower DBH (<60 cm). The global equations tested tend to underestimate AGB significantly at DBH > 60. Even excluding the two largest trees from the regression yields significant underestimations (Fig. 4a).
- The predictive power of canopy area for AGB and branches is encouraging despite large variation at >100 m². Its application for remote sensing based upscaling should consider crown interactions with competing or co-existing neighboring trees (Fig. 4b).

Conclusions

- A regionally valid generic biomass equation for aboveground biomass of trees in complex agricultural landscape mosaics was produced successfully (r^2 >0.9) with random sampling that is similar yet superior to global equations.
- Most biomass is held by very few large trees emphasizing the imperative to focus on these trees in the (destructive) sampling scheme.
- Further studies are required to determine the applicability and specificity of the equation developed for a wide range of agricultural landscapes.

References:

Brown et al. (1997) FAO Forestry Paper 134

Chave et al. (2005) Oecologia 145: 87-99

Santos et al. (2010) Agroforestry Systems 87(3):193-202

Zomer et al. (2009) ICRAF working Paper No. 89

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