Carbon Sequestration in Tropical Tree Crop Systems – especially in Rubber Plantations (Hevea brasiliensis)

Kongsager, Rico

Publication date: 2013

Carbon Sequestration in Tropical Tree Crop Systems – especially in Rubber Plantations (*Hevea brasiliensis*)

International Rubber Research & Development Board
International Rubber Conference
London 24-26 June 2013

Rico Kongsager – PhD Candidate
UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC)
Technical University of Denmark
Outline

• Introduction
• Case Study from Ghana
• Research conducted
• REDD+ and rubber plantations
• Examples of rubber plantation projects
• Summary

Langkawi, Malaysia - Photo: R. Kongsager 2009
Introduction

- Land-use and land-cover change has contributed about 33% of global carbon emissions over the past 150 years.
- However, the current relative contribution has declined to 10-13% annually (Houghton et al. 2012).
- A growing interest in lowering the emissions of greenhouse gases from different types of land-use.
- Compared to other tropical agricultural crops.
- Potential to increase sustainable development if projects are implemented in the right way.
- REDD+ (payment scheme).

- Question: Are rubber plantations a good climate change mitigation option?
WHERE DOES CARBON GO?
CARBON STORAGE IN A GREAT LAKES FOREST

LEAVES 1%

NET PHOTOSYNTHESIS 2.9 tons of carbon/acre yearly

TRUNK & BRANCHES 40%

SOIL RESPIRATION 2.2 tons of carbon/acre yearly

WOODY DEBRIS 1%

CARBON STORED 0.7 tons of carbon/acre yearly

TOTAL ECOSYSTEM CARBON 80 tons/acre

TREE ROOTS 13%

SOIL ORGANIC MATTER 45%

“Carbon Sequestration in Tropical Tree Crop Systems”
Rico Kongsager
Case Study

“Carbon Sequestration in Tropical Tree Crop Systems”
Rico Kongsager
Figure 6: Map of ARC-Kade. 1: Primary forest (> 100 years). 2: Orange plantation (15 years). 3: Oil palm plantation (16 years). 4: Oil palm plantation (23 years). 5: Oil palm plantation (7 years) 6: Rubber plantation (44 years). 7: Cacao plantation (21 years). 8: Rubber plantation (12 years) 25 km south of Kade. Red lines indicate transects, white circles indicate primary forest plots, and red squares in 6 and 8 indicate rubber plots.
Climate

Note: compared to Malaysia: temp the same, but precipitation is around 1000mm higher in Malaysia
### Table 1 Specifications of the plantation measurements

<table>
<thead>
<tr>
<th></th>
<th>Cocoa</th>
<th>Oil palm</th>
<th>Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable measured</td>
<td>Diameter at breast height</td>
<td>Height</td>
<td>Diameter at breast height</td>
</tr>
<tr>
<td>Total number of trees/stems measured</td>
<td>246</td>
<td>360 (120 from each year)</td>
<td>442 (178 from 1967 and 264 from 1999)</td>
</tr>
<tr>
<td>Number of plantations measured</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Age</td>
<td>21 years old (planted in 1990), Shade trees 40 years old</td>
<td>7 years old (planted in 2004), 16 years old (planted in 1995) and 23 years old (planted in 1988)</td>
<td>12 years old (planted in 1999) and 44 years old (planted in 1967)</td>
</tr>
<tr>
<td>Total size of area</td>
<td>13.9 ha</td>
<td>50.04 ha (2004), 13.9 ha (1995), and 30.58 ha (1988)</td>
<td>55.6 ha (1999) and 38.92 ha (1967)</td>
</tr>
<tr>
<td>Planting density</td>
<td>1,097.39 stands/ha</td>
<td>144 stands/ha</td>
<td>Unknown</td>
</tr>
<tr>
<td>Species</td>
<td>Theobroma cacao</td>
<td>Elaeis guineensis (Tenera)</td>
<td>Hevea brasiliensis</td>
</tr>
<tr>
<td>Type of plot</td>
<td>Since distinct rows of cocoa trees were absent, circular plots with a radius of 20 m were chosen.</td>
<td>Since no palms were missing in the rows, the oil palm plantations were measured in rows equivalent to two acres (0.4047 ha) as transects through each plantation.</td>
<td>Because of incomplete rows, we measured in 60×60 m squared plots instead of only equivalent rows. Trees were missing since no replanting took place if a tree died, as the older trees would shade the younger trees too much.</td>
</tr>
<tr>
<td>Plots</td>
<td>5 plots of 314.15 m²=0.16 ha=4 % of the total population.</td>
<td>1 transect of 120 trees in each plantation=0.81 ha=6 % (2004), 20 % (1995) and 9 % (1988) of the total population.</td>
<td>2 plots of 3,600 m² (in both plantations)=0.72 ha=4.5 % (1999) and 16 % (1967) of the total population.</td>
</tr>
</tbody>
</table>

Orange

<table>
<thead>
<tr>
<th></th>
<th>Basal area</th>
<th>108 (94 alive and 14 dead/missing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>25 years old (planted in 1986)</td>
<td></td>
</tr>
<tr>
<td>Total size of area</td>
<td>20.71 ha</td>
<td></td>
</tr>
<tr>
<td>Planting density</td>
<td>266.93 stands/ha</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Citrus sinensis (Late valencia)</td>
<td></td>
</tr>
<tr>
<td>Type of plot</td>
<td>The plantation was measured in equivalent rows.</td>
<td></td>
</tr>
</tbody>
</table>

---

“Carbon Sequestration in Tropical Tree Crop Systems”

Rico Kongsager
Results

Table 2  Carbon content in plantations

<table>
<thead>
<tr>
<th>Type</th>
<th>Age [years]</th>
<th>Aboveground [tC/ha]</th>
<th>Accumulation [tC/ha/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa</td>
<td>21</td>
<td>65.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Oil Palm</td>
<td>7</td>
<td>21.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Oil Palm</td>
<td>16</td>
<td>28.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Oil Palm</td>
<td>23</td>
<td>45.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Rubber</td>
<td>12</td>
<td>61.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Rubber</td>
<td>44</td>
<td>213.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Orange</td>
<td>25</td>
<td>76.3</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Time-averaged carbon content (30 year rotation)

<table>
<thead>
<tr>
<th>Type</th>
<th>Accumulation [tC/ha/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa</td>
<td>46</td>
</tr>
<tr>
<td>Oil Palm</td>
<td>30</td>
</tr>
<tr>
<td>Oil Palm</td>
<td>75</td>
</tr>
<tr>
<td>Orange</td>
<td>46</td>
</tr>
</tbody>
</table>

In comparison was the carbon content in the unmanaged natural forest (> 100 years) at the research station measured to be 130.2 tC/ha (permanent content – no rotation)
Rubber plantation 44 years, ARC-Kade, Ghana - Photo: J. Napier 2011
### Other Case Studies

<table>
<thead>
<tr>
<th>Average carbon content in aboveground biomass</th>
<th>Comment</th>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 ton C/ha</td>
<td>with a 30 year rotation period</td>
<td>Ghana</td>
<td>Kongsager et al. 2012</td>
</tr>
<tr>
<td>90 ton C/ha</td>
<td>permanent agroforest</td>
<td>Indonesia</td>
<td>Palm et al. 2005</td>
</tr>
<tr>
<td>50 ton C/ha</td>
<td>intensively managed</td>
<td>Indonesia</td>
<td>Palm et al. 2005</td>
</tr>
<tr>
<td>93 ton C/ha</td>
<td>38-year chronosequence</td>
<td>China</td>
<td>Yang et al. 2005</td>
</tr>
<tr>
<td>76 ton C/ha</td>
<td>14-year-old stands</td>
<td>Ghana</td>
<td>Wauters et al. 2008</td>
</tr>
<tr>
<td>42 ton C/ha</td>
<td>14-year-old stands</td>
<td>Brazil</td>
<td>Wauters et al. 2008</td>
</tr>
</tbody>
</table>

Average carbon content of natural forests for all tropics: 94 tC/ha (Houghton 2005)
## Carbon in Oil Palm

<table>
<thead>
<tr>
<th>Average carbon content in aboveground biomass</th>
<th>Comment</th>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ton C/ha with a 30 year rotation period</td>
<td>Ghana</td>
<td>Kongsager et al. 2012</td>
<td></td>
</tr>
<tr>
<td>48 ton C/ha rotation times of 25 years</td>
<td>Indonesia</td>
<td>Palm et al. 2005</td>
<td></td>
</tr>
<tr>
<td>91 ton C/ha 20 year rotation time</td>
<td>Indonesia</td>
<td>Murdiyarso 2002</td>
<td></td>
</tr>
<tr>
<td>36 ton C/ha</td>
<td>Malaysia</td>
<td>Henson 2003</td>
<td></td>
</tr>
<tr>
<td>30 ton C/ha 51 oil palm plantations taken from several studies</td>
<td>Global</td>
<td>Germer and Sauerborn 2008</td>
<td></td>
</tr>
</tbody>
</table>
Agroforestry in General

• Carbon sequestration potential greater than crop or pasture systems

• Lower GHG emissions compared to cropping systems

• Agroforestry systems can regain 35% of the carbon stock and store soil carbon at a rate of 80–100% that of forest, compared to 12% and 50 % respectively on crop or pastureland
  Palm et al. 2004; Watson et al. 2000

• However, systems vary considerably and sequestration potential depends on practices used
  Albrecht and Kandji 2003; Current et al. 1995; Mutuo et al. 2005

Main source: Anderson and Zerriffi 2012
REDD+

- REDD+ is a payment scheme
- Negotiations are in progress, but the guidelines will most likely not be stricter than the ones in the Kyoto P. (CDM)
  - Crown cover: 10-30%
  - Area: 0.5-1.0 ha
  - Height: 2-5 m
- Scenarios
  - From agriculture to rubber plantation = reforestation/afforestation
  - From forest to rubber plantation = forest degradation
- Rubber vs Oil Palm

Source: Personal communication: Peter Aarup Iversen, UN-REDD Technical Specialist, UNDP Cambodia
Examples of rubber projects

- Promoting Sustainable Development through Natural Rubber Tree Plantations in Guatemala
- VCS (Voluntary Carbon Standard) – applying the A/R CDM methodology
- 3,900,439 tCO$_2$ over 42 years through the reforestation of 2,366.16 ha with rubber trees.
- Establish in degraded and degrading lands
- Traditional use: cattle grazing
- Smallholders on privat land
- Timber will be certified under the Forest Stewardship Council (FSC)
- Carbon credit revenue is spend on project activities

“Carbon Sequestration in Tropical Tree Crop Systems”
Rico Kongsager
Examples of a… (cont)

• Baseline study to show eligibility (not forested on December 31st 1989 + no forest in the last 22 years)
• Additionality: compared to Business As Usual and four other alternative land use scenarios
• Measurements: Aboveground (Diameter at breast height) + Belowground (ratio of aboveground)
• Leakage: Grazing animals were transferred to identified grasslands or slaughtered
Examples of a… (cont)

- The productive life is approximately 40 years
- Productivity declines after ca 20 years
- Rubber will be extracted starting in year six continuing for a minimum of 30 years
- Harvested for timber (FSC)
- Plantation will be replanted
- Environmental Impacts
- Social impacts

Source: http://www.rainforest-alliance.org/climate/projects/pica-project

“Carbon Sequestration in Tropical Tree Crop Systems”
Rico Kongsager
Examples of a… (cont)

Colombia (78,160 tCO₂)
• Establishing 4,109 ha of rubber plantations on cattle pastures

Lao People's Democratic Republic (40,672 tCO₂)
• Establishing 1,046 ha of rubber plantations on degraded and abandoned grasslands
• Main aims are:
  • poverty alleviation and wealth creation in rural areas
  • communities empowerment through active participation in all stages of the project
  • improvement of basic infrastructure for rural communities
• Technical and investment barrier for small-farmers

Source: http://cdm.unfccc.int/Projects/Validation
Summary

Are rubber plantations a good idea in regard to climate change mitigation?

• Suitable location in regard to sequestration
• Level of intensity
• Established on land with modest carbon content, such as degraded forest or agricultural land

A good idea in regard to Sustainable Development?

• Impact on Local livelihood and Biodiversity
References


“Carbon Sequestration in Tropical Tree Crop Systems”
Rico Kongsager
References (cont)

Thank you for your attention…

Rico Kongsager

UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC)
www.uneprisoe.org

Technical University of Denmark

Direct: +45 46775192
Mobile: +45 61690468
Skype: rico.kongsager
Email: rick@dtu.dk

Kade, Ghana - Photo: J. Napier 2011