Carbon Sequestration Rate of Tea Plantations

by

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Introduction and Focus

• Environmental issues – Climate Change (CC) increasingly important.

• CC influences many sectors of the Sri Lankan economy including plantation agriculture

→ Extreme weather events.
Heavy rainfall
Severe droughts
• Greenhouse gases (GHGs) in the atmosphere, mainly CO$_2$, is the principal cause of global warming and CC.

• Solving CC problem
  → reducing and stabilizing GHGs to a level that prevents dangerous anthropogenic interference with the climate system

• Reducing GHGs in atmosphere →
  • one of the fastest,
  • most significant
  • and cost-effective options for slowing down CC
Carbon sequestration:

• The removal and storage of carbon from the atmosphere in carbon sinks (such as oceans, forests or soils) through physical or biological processes

• $\text{CO}_2$ concentration in atmosphere $\rightarrow$ reduced

  ↓

  Adverse impacts of CC would be minimized
Types of C Sequestration:

1. Geologic Sequestration:
2. Ocean Sequestration:
3. Terrestrial Sequestration

Significant opportunity to reduce CO$_2$ and obtain additional benefits
Geologic Sequestration

- Underground in rock formations

- Involves injecting carbon dioxide deep underground
Ocean Sequestration

Largest potential sink

- Solubility
- Biological → algae
- Man made
Terrestrial sequestration

a. Biosphere
b. Soil

Green C
Current Trend

- Information on carbon sequestration → already generated for several land use types and plant species.

- Such experiments continue to gain more attention & high priority among the other areas of research due to the urge of the global trend.
## C Sequestration of different plants

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>C sequestration (Mg of C ha(^{-1})yr(^{-1}))</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teak</td>
<td>1.1 - 466.4</td>
<td>Abayasiri &amp; Ranasinghe, 2000</td>
</tr>
<tr>
<td>Mesic Savannas</td>
<td>2.8</td>
<td>Williams et. al., 2004</td>
</tr>
<tr>
<td>Silver oak</td>
<td>2.09</td>
<td>Niranjana &amp; Viswanath, 2005</td>
</tr>
<tr>
<td>Rubber plantations</td>
<td>7.69</td>
<td>Tillekeratne, 2007</td>
</tr>
<tr>
<td>Smallholder Agroforestry Systems</td>
<td>1.5 - 3.5</td>
<td><a href="http://www.coffeehabitat.com">http://www.coffeehabitat.com</a>, 2008</td>
</tr>
<tr>
<td>Coconut plantations</td>
<td>4.8 – 22.8</td>
<td>Ranasinghe and Thimothias, 2012</td>
</tr>
</tbody>
</table>
• Tea industry contributes a major share to the Sri Lankan economy,

In year 2013 contributed 0.9% of GDP
annual production around 340 million kilograms
US dollars 1.5 billion foreign exchange earning

it is important to estimate the impacts of climate change
and take precautions to minimize its adverse effects.

• Also it is necessary to find way forward for a greener industry.
Payments for Environmental Services (PES)

PES is designed to provide economic compensation for the services supply to society including: carbon sequestration, biodiversity conservation, scenic beauty, and watershed protection etc.

Carbon sequestration is an environmental service which helps to minimize the environmental risks while leading to sustainable development.
Worthwhile to investigate the C sequestration capacity &
Generate the baseline data

Proper documentation in REDD+
(i.e. efforts to Reduce Emissions from Deforestation and forest Degradation, and promote conservation, sustainable management of forests, and enhancement of forest carbon stocks) &
GHG Inventory

Additional income for Environmental Services of Tea Plantations
Tea Plantations

- High Shade
- Medium Shade
- Tea plants
- Community of tea plantations
- Ecosystem

+ External Environment
The magnitude of the C sequestration depends on:

- **Plant physiological characteristics**
  - rate of growth,
  - growth stage,
  - age etc.

- **Environmental parameters**
  - availability of soil moisture and nutrients,
  - temperature (both atmospheric as well as soil),
  - solar radiation,
  - rainfall

- **Managerial aspects**
  - planting density,
  - pruning, coppicing and pollarding etc.
C sequestration of tea plantations

- Less compared to natural forest species
Way forward

- Tea plantations as a community

- Resemble natural forests:
  - Tea plants
  - Shade trees
  - Wind belts, weeds etc

- Contribution of these species to store atmospheric CO\(_2\): Great importance to mitigate global climate change

- Very little reliable information on C sequestration of tea and these tree species
Case study in Sri Lanka

Site selection

Representative samples:

- **tea growing region**
  - LC
  - MC
  - UC

- **Genotype**
  - Seedling
  - VP

Stratified Random Sampling

IPCC Stock Change Method, 2000

- Initial sampling in 2009
- Final sampling in 2012

Community of tea Plantations
- tea + high shade + medium shade
C sequestration of tea plants
### C sequestration of shade trees

Allometric equations using CBH

\[
C \text{ content} = \text{Biomass content} \times 50%
\]

(De Costa et al., 2008)

<table>
<thead>
<tr>
<th>Shade tree species</th>
<th>Allometric equation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grevillea robusta</strong></td>
<td>[\log_{10} Y = -1.9583 + 1.9585 \log_{10} X]</td>
<td>Jangra et al., 2010</td>
</tr>
<tr>
<td>Branches</td>
<td>[\log_{10} Y = -0.2055 + 1.221 \log_{10} X]</td>
<td></td>
</tr>
<tr>
<td>Bole</td>
<td>[\log_{10} Y = -0.5337 + 1.2607 \log_{10} X]</td>
<td></td>
</tr>
<tr>
<td>Roots</td>
<td>[\log_{10} Y = -0.5337 + 1.2607 \log_{10} X]</td>
<td></td>
</tr>
<tr>
<td><strong>Albizia moluccana</strong></td>
<td>[Y = \exp\left{[2.591 \ln D] - 3.003\right}]</td>
<td>Dharmaparakrama, 2006</td>
</tr>
<tr>
<td><strong>Gliricidia sepium</strong></td>
<td>[Y = 5.079 e^{0.151D}]</td>
<td>Dharmaparakrama, 2006</td>
</tr>
<tr>
<td><strong>Erythrina lithosperma</strong></td>
<td>[Y = 8.8087 e^{0.1087D}]</td>
<td>Dharmaparakrama, 2006</td>
</tr>
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</table>

Data Analysis:
SAS v9
ANOVA
DNMRT
## Calculation of C sequestration potential

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camellia sinensis</td>
<td>Recommended practices of the TRISL</td>
</tr>
<tr>
<td>Grevillea robusta</td>
<td></td>
</tr>
<tr>
<td>Albizia moluccana</td>
<td></td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td></td>
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<td>Erythrina lithosperma</td>
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</table>
High Shade: Albizia

12 years
High Shade: Grevillea
30 years
Medium Shade: *Gliricidia* 20 years
Medium Shade: Erythrina

20 years
Results
RGR followed the same pattern of variation

Differences in biomass partitioning between SD and VP tea
## C sequestration potential of tea without shade trees

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of tea</th>
<th>Bush densities (# of bushes ha(^{-1}))</th>
<th>Adjusted C gain Rate (g bush(^{-1}) yr(^{-1}))</th>
<th>C sequestration (kg ha(^{-1}) yr(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC</td>
<td>SD</td>
<td>8000</td>
<td>213.6</td>
<td>1708.8</td>
</tr>
<tr>
<td>LC</td>
<td>VP</td>
<td>12500</td>
<td>159.3</td>
<td>1991.3</td>
</tr>
<tr>
<td>MC</td>
<td>SD</td>
<td>8000</td>
<td>96.9</td>
<td>775.2</td>
</tr>
<tr>
<td>MC</td>
<td>VP</td>
<td>12500</td>
<td>81.6</td>
<td>1020.0</td>
</tr>
<tr>
<td>UC</td>
<td>SD</td>
<td>8000</td>
<td>32.4</td>
<td>259.2</td>
</tr>
<tr>
<td>UC</td>
<td>VP</td>
<td>12500</td>
<td>21.6</td>
<td>270.0</td>
</tr>
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</table>
### Calculation of C sequestration potential

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Plant density (No. of plants ha(^{-1}))</th>
<th>Region used for the calculation</th>
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<tr>
<td><em>Camellia sinensis</em></td>
<td>SD 8000 / VP 12500</td>
<td>LC, MC and UC</td>
</tr>
<tr>
<td><em>Grevillea robusta</em></td>
<td>62</td>
<td>MC and UC</td>
</tr>
<tr>
<td><em>Albizia moluccana</em></td>
<td>62</td>
<td>LC</td>
</tr>
<tr>
<td><em>Gliricidia sepium</em></td>
<td>208</td>
<td>LC and MC</td>
</tr>
<tr>
<td><em>Erythrina lithosperma</em></td>
<td>208</td>
<td>UC</td>
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Carbon sequestration potential of different trees in a tea plantation community

Tea growing region

Carbon sequestration potential (kg of C ha\(^{-1}\) yr\(^{-1}\))

- LC
- MC
- UC

Different species:
- Tea
- Albizia
- Grevillea
- Gliricidia
- Erythrina

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C sequestration potential of tea lands with varying density of shade trees

Tea Growing Region

- 100%tea+100%HS+100%MS
- 100%tea+50%HS+50%MS
- 100%tea+0%HS+0%MS
Future scenario

Crop simulation model predictions

LC tea yields → negatively affected

Obtaining additional income for C sequestration via PES

Will help to compensate the yield lose

Tea industry remain as a profitable venture
Tea plants accumulate less biomass carbon than the other C3 crops, when considering as a community; based on their management, the extent of cultivation & the duration of the availability in the field, the C sequestration ability of tea plantations → considerable importance in a greener economy.
THANK YOU!!!