**DESCRIPTION**

Agroforestry system of cacao crop under gallery forest shadow as family agriculture. It is located at the foothill ecosystem of the Andes, in the Cusiana River, Orinoco Watershed, Colombia.

The agroforestry system of cacao crop planted under gallery forest is a private farmer initiative for family agriculture. The Crop is located in the gallery forest of Pozetas Stream, in the Cusiana River Basin. It is in the Foothill Ecosystem (300m a.s.l.), between the Andean Mountains and the Orinoco Floodable Savanas. Municipality of Tauramena (Casanare), Colombia.

The cacao grows in an area of 4 hectares, being considered small farming, according to the Orinoco Region scales. The cacao density is 1080 plants/hectare and the distance between plants is 3m. In this area, after tree thinning, the forest occupies 30% approximately. Some of the common tree species are Cedrus spp., Ficus spp. and Anadenanthera peregrina, among others.

The purpose of the technology is to use the gallery forest land in a productive way to generate income for the family, while keeping part of the forest and integrate it in the agroforestry as cacao needs some shadow, specially in early growth stage.

Seed germination and seedling preparation, forest thinning and soil improvement with lime and organic fertilizer (rice husk), and finally planting, are the main establishment activities. Then the maintenance activities include cutting weeds, trimming cacao trees and fertilization every 2-3 months.

The cacao crop has produced fruits since the sixth year of being planted (2016) and is harvested every two weeks. It presents two yield peaks, the first one is in May-June and the second one in October-November. However it produces fruits along the year.

This technology provides additional income to the family, while conserving part of the original gallery forest. The more complex and diverse production system might favored pollination and crop health. The technology compared with other land uses around it such as oil palm tree and rice is more sustainable and it is something land users prefer. They also like the value added to the cacao beans by processing their self the cacao beans to produce hand made 100% cacao bars for drinking chocolate.

**LOCATION**

Location: Municipality of Tauramena, Rural District of Iquia, Casanare, Colombia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- -72.79953, 5.0246
- -72.60177, 4.92761

Spread of the Technology: evenly spread over an area (0.04 km²)

In a permanently protected area?: No

Date of implementation: 2010

Type of introduction
- ✓ through land users' innovation
- as part of a traditional system (> 50 years)
- during experiments/ research
- through projects/ external interventions
Cacao fruits collection (Ana Silvia Martinez)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
- improve production
- ✓ reduce, prevent, restore land degradation
- conserve ecosystem
- protect a watershed/ downstream areas – in combination with other Technologies
- preserve/ improve biodiversity
- reduce risk of disasters
- adapt to climate change/ extremes and its impacts
- mitigate climate change and its impacts
- ✓ create beneficial economic impact
- create beneficial social impact

Land use
- Land use mixed within the same land unit: Yes - Agroforestry

Cropland
- Tree and shrub cropping: cacao
- Is intercropping practiced? No
- Is crop rotation practiced? No

Forest/ woodlands
- (Semi-)natural forests/ woodlands. Management: Selective felling
- Tree types (evergreen): Cedrus species, Anadenanthera peregrina, Ficus spp.,
- Products and services: Fuelwood, Protection against natural hazards, shadow

Water supply
- rainfed
- ✓ mixed rainfed-irrigated
- full irrigation

Purpose related to land degradation
- ✓ prevent land degradation
- reduce land degradation
- restore/ rehabilitate severely degraded land
- adapt to land degradation
- not applicable

Degradation addressed
- ✓ biological degradation - Bh: loss of habitats, Bq: quantity/ biomass decline

SLM group
- ✓ agroforestry

SLM measures
- management measures - M1: Change of land use type,
- M5: Control/ change of species composition

TECHNICAL DRAWING

Technical specifications
In the agroforestry system of cacao and gallery forest, the cacao trees are planted, having 3 m distance between them. The native forest occupies 30% of the system and provides shadow to the cacao trees. Shadow is important for the good development of cacao, especially in early stages. Additionally the forest increases system complexity, diversity and balance, it increases crop pollination and health. The leaf litter from the cacao and the forest are also an important source of organic matter for soil.
**ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS**

**Calculation of inputs and costs**
- Costs are calculated: per Technology area (size and area unit: 4 hectares)
- Currency used for cost calculation: Colombian Pesos
- Exchange rate (to USD): 1 USD = 3750.0 Colombian Pesos
- Average wage cost of hired labour per day: 45000

**Most important factors affecting the costs**
The plant material from seeds to seedlings are the highest costs for the technology establishment. Then the fertilization is an important maintenance cost.

**Establishment activities**
1. Seed germination (Timing/ frequency: Enero)
2. Plant nursery establishment (Timing/ frequency: Febrero)
3. Clear felling of 70% of native forest in the area (Timing/ frequency: Febrero)
4. Sow hole digging (Timing/ frequency: April-May (beginning of rainy season))
5. Addition of lime and rice husk to the sow hole (Timing/ frequency: April-May (beginning of rainy season))
6. Cacao seedling planting in field (Timing/ frequency: April-May (beginning of rainy season))

**Establishment inputs and costs (per 4 hectares)**

<table>
<thead>
<tr>
<th>Specify input</th>
<th>Unit</th>
<th>Quantity</th>
<th>Costs per Unit (Colombian Pesos)</th>
<th>Total costs per input (Colombian Pesos)</th>
<th>% of costs borne by land users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest thinning to open cropland</td>
<td>ha</td>
<td>4.0</td>
<td>150000.0</td>
<td>600000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Sow hole preparation and seedling planting</td>
<td>ha</td>
<td>4.0</td>
<td>575000.0</td>
<td>2300000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Plant material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cacao seeds</td>
<td>seed</td>
<td>5400.0</td>
<td>25.0</td>
<td>135000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Cacao seedlings</td>
<td>seedling</td>
<td>5000.0</td>
<td>500.0</td>
<td>2500000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Fertilizers and biocides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime sack</td>
<td>50 kg</td>
<td>10.0</td>
<td>12000.0</td>
<td>120000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Rice husk</td>
<td>container</td>
<td>1.0</td>
<td>400000.0</td>
<td>400000.0</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Total costs for establishment of the Technology</strong></td>
<td></td>
<td></td>
<td><strong>6'055'000.0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total costs for establishment of the Technology in USD</strong></td>
<td></td>
<td></td>
<td><strong>1'614.67</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Maintenance activities**
1. Cutting of weeds, specially around each cacao tree (Timing/ frequency: Every 2 months)
2. Cacao tree trimming (Timing/ frequency: Every 2 months)
3. Fertilization (Timing/ frequency: Every 2-3 months)
4. Harvesting (Timing/ frequency: Every 2 weeks)

**Maintenance inputs and costs (per 4 hectares)**
### Sedentary or nomadic
- Sedentary
- Semi-nomadic
- Nomadic

### Market orientation
- Subsistence (self-supply)
- Mixed (subsistence/commercial)
- Commercial/market

### Species diversity
- High
- Medium
- Low

### Habitat diversity
- High
- Medium
- Low

### Soil depth
- Very shallow (0-20 cm)
- Shallow (21-50 cm)
- Moderately deep (51-80 cm)
- Deep (81-120 cm)
- Very deep (>120 cm)

### Groundwater table
- On surface
  - < 5 m
  - 5-50 m
  - > 50 m

### Soil type
- Coarse/light (sandy)
- Medium (loamy, silty)
- Fine/heavy (clay)

### Topsoil organic matter content
- Low (<1%)
- Medium (1-3%)
- High (>3%)

### Water quality
- Good drinking water
- Poor drinking water (treatment required)
- For agricultural use only (irrigation)
- Unusable

### Occurrence of flooding
- Yes
- No

### Level of mechanization
- Manual work
- Animal traction
- Mechanized/motorized

### Gender
- Women
- Men

### Age
- Children
- Youth
- Middle-aged
- Elderly

### Average annual rainfall
- < 250 mm
- 251-500 mm
- 501-750 mm
- 751-1000 mm
- 1001-1500 mm
- 1501-2000 mm
- 2001-3000 mm
- 3001-4000 mm
- 4001-5000 mm

### Agro-climatic zone
- Sub-humid
- Semi-arid
- Arid

### Altitude
- < 100 m a.s.l.
- 101-300 m a.s.l.
- 301-500 m a.s.l.
- 501-1000 m a.s.l.
- 1001-1500 m a.s.l.
- 1501-2000 m a.s.l.
- 2001-2500 m a.s.l.
- 2501-3000 m a.s.l.
- 3001-4000 m a.s.l.
- > 4000 m a.s.l.

### Technology is applied in
- Convex situations
- Concave situations
- Not relevant

### Total costs for maintenance of the Technology
- Total costs for maintenance of the Technology in USD
- 6'975.150.0
- Total costs for maintenance of the Technology in USD
- 1'860.04

### Fertilizers and pesticides
- Lime sack
- 50 Kg
- 10.0
- 12000.0
- 100.0
- Fertilizer sack
- 50 Kg
- 40.0
- 384000.0
- 100.0

### NATURAL ENVIRONMENT

<table>
<thead>
<tr>
<th>CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market orientation</strong></td>
</tr>
<tr>
<td>- Subsistence (self-supply)</td>
</tr>
<tr>
<td>- Mixed (subsistence/commercial)</td>
</tr>
<tr>
<td>- Commercial/market</td>
</tr>
<tr>
<td><strong>Species diversity</strong></td>
</tr>
<tr>
<td>- High</td>
</tr>
<tr>
<td>- Medium</td>
</tr>
<tr>
<td>- Low</td>
</tr>
<tr>
<td><strong>Habitat diversity</strong></td>
</tr>
<tr>
<td>- High</td>
</tr>
<tr>
<td>- Medium</td>
</tr>
<tr>
<td>- Low</td>
</tr>
<tr>
<td><strong>Soil depth</strong></td>
</tr>
<tr>
<td>- Very shallow (0-20 cm)</td>
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<tr>
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<tr>
<td>- Deep (81-120 cm)</td>
</tr>
<tr>
<td>- Very deep (&gt;120 cm)</td>
</tr>
<tr>
<td><strong>Groundwater table</strong></td>
</tr>
<tr>
<td>- On surface</td>
</tr>
<tr>
<td>- &lt; 5 m</td>
</tr>
<tr>
<td>- 5-50 m</td>
</tr>
<tr>
<td>- &gt; 50 m</td>
</tr>
</tbody>
</table>

### Agroforestry system of cacao and gallery forest

### Specified input

<table>
<thead>
<tr>
<th>Specify input</th>
<th>Unit</th>
<th>Quantity</th>
<th>Costs per Unit ( Colombian Pesos)</th>
<th>Total costs per input ( Colombian Pesos)</th>
<th>% of costs borne by land users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting of weeds, specially around each cacao tree</td>
<td>day</td>
<td>18.0</td>
<td>45000.0</td>
<td>810000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Cacao tree trimming</td>
<td>day</td>
<td>12.0</td>
<td>45000.0</td>
<td>540000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Fertilization and soil amendment with lime</td>
<td>day</td>
<td>13.0</td>
<td>45000.0</td>
<td>585000.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Harvesting</td>
<td>day</td>
<td>24.0</td>
<td>45000.0</td>
<td>1080000.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Equipment

- Manual tools (e.g. machete, trimmer, shovel)

### Total costs for maintenance of the Technology
- Total costs for maintenance of the Technology in USD
- 6'975.150.0
- Total costs for maintenance of the Technology in USD
- 1'860.04

### Technology is located between 2000-2200 mm isohyets. The rain season occurs from April to November and dry season from December to March.

Name of the meteorological station: Precipitation map of the Municipality of Tauramena (2015)
## Area used per household

- ✓ < 0.5 ha
- 0.5-1 ha
- 1-2 ha
- 2-5 ha
- 5-15 ha
- 15-50 ha
- 50-100 ha
- 100-500 ha
- 500-1000 ha
- 1,000-10,000 ha
- > 10,000 ha

## Scale

- ✓ small-scale
- medium-scale
- large-scale

## Land ownership

- state
- company
- communal/ village group
- individual, not titled
- ✓ individual, titled

## Land use rights

- open access (unorganized)
- leased
- ✓ individual

## Access to services and infrastructure

<table>
<thead>
<tr>
<th>Service</th>
<th>Poor</th>
<th>✓ Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
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<tr>
<td>Technical assistance</td>
<td></td>
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<tr>
<td>Markets</td>
<td></td>
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<tr>
<td>Energy</td>
<td></td>
<td></td>
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<tr>
<td>Roads and transport</td>
<td></td>
<td></td>
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<tr>
<td>Drinking water and sanitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## IMPACTS

### Socio-economic impacts

- **Crop production**
  - decreased ✓ increased
  - There was not crop production before the SLM
- **Production area (new land under cultivation/use)**
  - decreased ✓ increased
  - There was not a production area before SLM
- **Farm income**
  - decreased ✓ increased
  - The main income sources are expensive livestock and cacao bars
- **Diversity of income sources**
  - decreased ✓ increased

### Socio-cultural impacts

- **SLM/land degradation knowledge**
  - reduced ✓ improved

### Ecological impacts

- **Soil organic matter/below ground C**
  - decreased ✓ increased
  - It has not been tested, however it is assumed a soil organic matter increase you to the increased leaf litter added by the cacao trees.

### Off-site impacts

- **Downstream flooding (undesired)**
  - increased ✓ reduced
  - The different levels of the agroforestry system and the cacao tree density might increase water retention and infiltration. It contributes to reduce down stream flooding during rainy season.

## COST-BENEFIT ANALYSIS

### Benefits compared with establishment costs

- **Short-term returns**
  - very negative ✓ very positive
- **Long-term returns**
  - very negative ✓ very positive

### Benefits compared with maintenance costs

- **Short-term returns**
  - very negative ✓ very positive
- **Long-term returns**
  - very negative ✓ very positive

## CLIMATE CHANGE

### Gradual climate change

- Seasonal temperature increase
  - not well at all ✓ very well

## ADOPTION AND ADAPTATION

- **Percentage of land users in the area who have adopted the Technology**
  - ✓ single cases/experimental
  - 1-10%
- **Of all those who have adopted the Technology, how many have done so without receiving material incentives?**
  - ✓ 0-10%
  - 11-50%
Has the Technology been modified recently to adapt to changing conditions?

- Yes
- No

To which changing conditions?

- climatic change/ extremes
- changing markets
- labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user’s view
- The technology generates income along the year and keep us busy.
- It is a way of having a crop and the gallery forest together.

Strengths: compiler’s or other key resource person’s view
- The more complex and diverse production system might favored pollination and crop health.
- The technology compared with other land uses around it such as oil palm tree and rice is more sustainable.

Weaknesses/ disadvantages/ risks: land user’s view → how to overcome
- It takes 6 years to begin to produce, but during the first years it is still requirement all maintenance activities → Planting cacao varieties, which produce fruits in less than 6 years.
- There is little support for small farmers an entrepreneur initiatives, from public and private institutions, when then do not belong to any project. → By planning the potential occurrence of technologies/initiatives, FF that is worth to give support, especially from public institutions and plan some resources for it.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s view → how to overcome
- Gallery forest thinning to open cropland is about 70%, which is a high portion of forest. The more gallery forest is protected, the better buffering for extreme climatic events → Using cacao tree varieties with more shadow tolerance, which let leave more forest percent in the agroforestry system

REFERENCES

Compiler
Luisa F. Vega

Date of documentation: April 26, 2020

Reviewer
Hanspeter Liniger

Last update: July 1, 2020

Resource persons
Ana Silvia Martinez - land user
Rafael Medina - land user

Full description in the WOCAT database

Linked SLM data
n.a.

Documentation was facilitated by
Institution
n.a.
Project
n.a.