

# Closing the Loops: Emerging Models of Sustainable Agriculture in the Tropics

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## Introduction

Researchers across disciplines have been seeking solutions to unsustainable land use and agricultural techniques for communities in the Amazon rainforest (Hiraoka and Yamamoto 1980; Pichon 1997; Ryder and Brown 2000). Increased settlement and extensive use of land for commercial crops such as coffee and cacao are not well suited to the fragile rainforest ecosystem (Hiraoka and Yamamoto 1980).

In the Rio Napo region, where the colegio Tecnico Yachana is situated, the majority of land is tied up in cacao production. Most families are growing cacao as a commercial crop and many have abandoned basic subsistence crops. As a result, most of the food consumed in their homes is purchased through the market. Market goods consumed in the Rio Napo region are imported to the lowland from the Ecuadorian highlands. Various socioeconomic and historical factors at both the micro and macro levels have contributed to the move from subsistence agriculture to commercial production, however these will not be discussed here (see (Bronzizio 2004)).

Over the last few years, the students at the colegio Tecnico Yachana have worked to develop agricultural methods that are step toward the elimination of linear system of production and towards a regenerative intensive system. The intentions of this poster is to discuss the techniques and methods being introduced at the school and their implementation. Key questions include:

*What are the goals of intensification and sustainable agriculture at the colegio? What are the models that are being employed as a step toward achieving sustainability?*

## Sustainable Agriculture

The terms sustainability and sustainable agriculture are often operationalized and therefore have various definitions (Rogers, et al. 2006; Sandrine 2000). Broadly, sustainability incorporates economic, environmental, and social components (Rogers et al. 2006). Definitions can emphasize any of these components depending on the paradigm from which it approached. However, in all approaches accounting of returns and impacts is an important factor (Rogers et al. 2006; Sandrine 2000).

Focusing on agricultural production can be useful for understanding how input and output accounting can work (Sandrine 2000). Agriculture is sustained through the internalization of productivity into the biophysical and social context in which it takes place (Sandrine 2000). According to Sandrine (2006):

*"The general principle of sustainable production process is that it functions as a never ending and self-generating loop. Products and by-products are 'final commodities'; they satisfy needs, but also make the loop regenerate itself. If some by-products are not re-used in the loop, they should be used in another loop."* (110).

The agriculture system at the colegio will be discussed in terms of the internalization agricultural productivity and the self-generating loops that have been identified.

## Goals of Sustainable Agriculture At The Colegio

want to create resource loops that operate on both macro and micro levels and take into consideration natural, economic and social aspects of the whole system.

Environmental accounting at the colegio will limit resource depletion and environmental damage in terms of inputs and outputs. They are looking at ways to utilize agriculture practices that allow for sustainability of both internal and external loops.

## Models of Sustainable Agriculture

The students have chosen intensification as a method to increase crop yields by maximizing resources and labor without extending agricultural land. The students have implemented the following methods of intensification:

- Raised Beds and Mandalas
- Crop Rotation
- Crop Interplanting



Figure 1. Mandalas, raised beds, and a tomato house are being used for intensification at the colegio.

## Models of Sustainable Agriculture Continued

### Crop Rotation

Represents periods of time that allow for maximized crop productivity. There are two major cycles utilized at the colegio: temporal cycles and nitrogen cycles.

#### Temporal cycle.

- Time required for productive maturity of crops.
- Crops are planted according to moon cycles.
  - Full moon is considered the most optimal for planting crops.
  - Crops are not planted while the moon is in a thin quarter, a period when flies lay eggs in new plants.

#### Nitrogen cycles

- Nutrient cycling is accomplished through crop rotation.
- Nitrogen fixing legumes are particularly useful for restoring nutrients back into the soil. See figure 2.

**Table 1.**  
Crops are grown at the colegio. Many of these plants have qualities that allow them to be inter-planted or rotated with other crops.

Crop	Planting	Harvest	Notes
Maize	Full Moon	Thin Quarter	Inter-plant with peanuts and rice
Rice	Thin Quarter	Full Moon	Inter-plant with peanuts and maize
Peanuts	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Beans	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Peas	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Carrots	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Spinach	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Tomatoes	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Onions	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Garlic	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Chili	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Peppers	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Avocado	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Mango	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Pineapple	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Watermelon	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Cantaloupe	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Strawberry	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Blueberry	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Raspberries	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Blackberries	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Straw	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Hay	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Compost	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Manure	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Urine	Thin Quarter	Thin Quarter	Inter-plant with rice and maize
Sugar	Thin Quarter	Thin Quarter	Inter-plant with rice and maize

### Inter-planting

- Inter-planting allows for the stratification of perennial tall crops with short fast growing plants.
  - Tree crops can accommodate shorter partners.
  - Plants with different rooting depths can be inter-planted.
  - Strong smelling plants planted in close proximity to other plants in order to repel insects.
- See Table 1 for details on crops that can be planted together.

## Closed Resource Systems



Figure 3 All pig feed is produced within the agricultural system at the colegio. Coupled with the fertilizer and energy production the pigs provide, they are part of an efficient loop.

Crop rotation and interplanting are part of larger system of loops.
 

- Not all bigger loops can be closed, the students strive to maximize the potential of all products, by-products and waste as a way to minimize inputs and outputs.

### Fertilizers

- The colegio uses organic fertilizers to provide natural nutrient sources for plants and soil.
- Compost is made from all organic waste material
  - Processed manure from pig digester.
  - Human urine is collected by students and then fermented with sugar.



Figure 4. Students preparing organic material for compost heap.

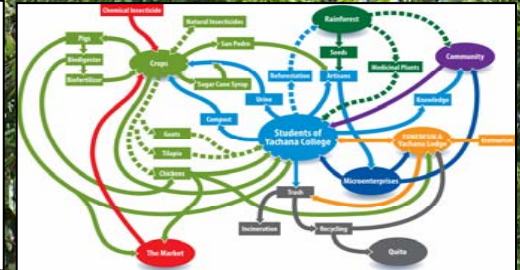


Figure 5. This represents all of the internal and external loops that are part of the agricultural system at the colegio. Inputs and outputs are also identified.

## Closed Resource Systems Continued

### Natural Pesticides

Students are developing natural pesticides.

- Free range chickens roaming amongst crops.
- Mixtures of natural ingredients: eg. *barbasco* and *ahi*.



Figure 6. Hydro-wheel constructed out of soup ladles, a bicycle wheel, and solar panels for energy.

### Energy

- Methane released during decomposition of pig manure in bio-digester is captured in plastic piping and utilized to heat the chicken house.

## Inputs and Outputs

The agricultural system at the colegio is not a completely closed and self generating loop. Some of these inputs cannot be easily eliminated.

- Due to infrastructural limitations in Ecuador, disposal of non-organic trash has to be done at the colegio.
  - glass recycled as aggregate for concrete
  - plastics are placed in a one meter deep trash hole, burned, and covered with dirt and palms. Tilapia ponds are being installed and will create a much needed protein source for the students.
- The school does not have its own seed bank and hybrid seeds are bought for all agricultural production.

The colegio is working on eliminating other inputs:

- Chemical pesticides are currently used.
- Students developing natural insecticide methods.
- The majority of chicken feed is commercially produced.
  - Eventually laying chickens will be allowed to forage among crops.
- 30% of food consumed at the colegio, mostly protein, is purchased at the market.
  - Tilapia ponds are being installed and will create a much needed protein source for the students.

## Future Research questions

1. The colegio is working on transferring sustainable agriculture into the community. They are developing an intensive cacao variety that can be introduced to local farmers. Students are also working on individual agricultural projects that they will implement in their own communities. The success of these technology transfers can be monitored.
2. How successful are the attempts to reduce inputs and outputs?