

# Integrated farming system for the foothill-regions of Colombia – Ariporo System (A.S.)

## Un sistema de agricultura integral para la región del piedemonte Colombiano-Sistema Ariporo (S.A.)

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### Abstract



Abundance of sun, wind and water (provided by equatorial regions) causes agriculture, energy and carbon sequestration to be unique in terms of Productive conditions in Colombia. This natural productivity yieldsland areas rich in biodiversity due to the high rates of efficient solar energy conversion and water, feeding macro and micro organisms, fauna and flora. This potential is wasted through the current use of extensive livestock production, which is inefficient in the conversion of solar energy into biomass. This article presents an adaptation of farming techniques applied to the seasons as well as to the foothill ecosystems of Colombia in order to exploit such natural resources without negative impact to the environment including the conservation of an endangered animal species.

**Keywords:** Agricultural engineering, Biological systems, Solar energy harvesting.

### Resumen



La abundancia de sol, viento y agua (proporcionado por regiones ecuatoriales) hace que la agricultura, la energía y el secuestro de carbono sean únicos y competitivos a nivel mundial para Colombia. Estos espacios naturales, tierras productivas ricas en biodiversidad debido a las altas tasas de conversión de energía solar en biomasa, alimentando macro y micro organismos, fauna y flora. Este potencial se desperdicia a través de la utilización actual de la ganadería extensiva, que es ineficiente en la conversión de energía solar en biomasa. En este artículo se presenta una adaptación de las mejores técnicas de cultivo aplicadas a las estaciones tomando como ejemplo un proyecto en los llanos Orientales (Casanare), con la posibilidad de aplicarse a todas las regiones de Colombia con el fin de explotar esos recursos naturales y sin efectos negativos para el medio ambiente, incluyendo la conservación de una especie animal en peligro de extinción.

**Palabras clave:** Técnica agrícola, Sistemas biológicos, Aprovechamiento de la energía Solar.

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## Introduction

Efficient exploitation of land is a challenging area of modern agriculture since geographical locations constrain the production rate of a specific region. In Colombia, there is a particular interest in conducting studies on efficient land use in order to help farmers increase their cash flow by taking advantage of Colombia's carbon sequestration and biodiversity. This is essential to reduce unemployment in rural areas. An increase in farm productivity requires more people working – agriculture needs more work-force than a cattle ranch. Moreover, higher farm productivity levels lead to better ecosystem conditions for native animals and plants, resulting in decreased greenhouse effects, sustainable employment, and a stable food supply in the country.

In the 1970s, industrial agriculture began to be developed. This worldwide trend was named the “green revolution” and it was basically an industrial system of agriculture based on chemical products mainly promoted by some countries. However, at the same time, these countries kept working on organic and natural production so as to obtain food without using any chemical substances.

As the green revolution spread, other countries began to work on land at an industrial scale but using a different paradigm. In the southern regions of Brazil, thousands of producers started a new agricultural movement aimed at discouraging the chemical-based production promoted by the “green revolution”. These people started by establishing good practices of organic-farmer agriculture according to two fundamental principles, namely respect for the environment and preservation of human health; rejecting the use of artificial chemical substances in agriculture production. Meanwhile, studies conducted by Persival Alfred Yeomans in Australia suggested that the soil conservancy model promoted as “green revolution” seemed to be intended not to preserve soil but to destroy it, leading to erosion and also to a permanent loss of minerals, fertility and biodiversity. On the basis of his findings, Dr. Yeomans developed a hydrologic management strategy for landscapes. Such a strategy was called “Key Line”, and consisted in successfully capturing, distributing and storing water so as to provide proper water absorption on rich soils; increasing the importance of having a living soil that enhances microorganism activity and increases the proportion of

organic material and minerals. This type of organic soil technique was then referred to as generating soil.

Although generating soils represent a suitable model for environmentally-sustainable farm production, in some countries, implementations of such a model are still scarce. In Colombia, for example, only a few (and small-scale) farms; located in regions like Cundinamarca, Medellin and Cali; actually implement Key-Line strategies. In spite of being a large country with rich soils and favorable weather conditions (all year long), what seems to hamper proper agricultural development is the reduced number of universities that deal with these topics. Moreover, once knowledge is acquired, it is difficult to make information reach every single farmer so that they become fully aware of the possibilities to start a transition process towards transforming an inefficient production system into an efficient one.

The present paper addresses the problems of Colombian cattle extensive farms, provided the country has a lot of land with unsustainable system without taking advantage of their real natural productivity in terms of carbon sequestration and biodiversity. In particular, the proposal deals with a productive system “Aripóro System” that exploits the environmental advantages of Colombian by adapting some techniques currently in use in other strong farm countries like Australia and Vietnam, but using Colombian species to preserve it. The purpose is to start with a new natural agro-business transformation in Colombian areas with unique productivity conditions. In this study, we analyze a cattle-extensive farm called Mataredonda in Hato Corozal Casanare located in the foothills region of the eastern mountains of Colombia, near Ariporo river, which is due the name “Ariporo System”. We found the best way to solve this productivity problem through organized activities, cost planning and evaluation. The results are taken from in-situ experience working on 210 Ha of land applying the Key-Line technique. In this theoretical study we simultaneously adapt two techniques (namely “key line” and the “VAC systems of Vietnam”) to the reality of rain and dry seasons and animal species of Mataredonda ranch increasing productiveness. The net result is a change in productivity, from 200 kg/meat/Ha/year, to 20.000 kg/products/Ha/year, according to the previous experience in Vietnam with a Fish-Duck VAC system applied in northern regions of Vietnam, but changing the species by some

natives from Colombia (catfish, fish, mammal, poultry, trees and shrubs for food) to produce and conserve Colombian biodiversity at the same time.

The general objective is to design a farming system of organic products, adopting techniques that enhance the characteristics of the Colombian ecosystem and culture, without producing harmful emissions and preserving health care for the people involved. The system produces native crops, fish, ducks, fruits, timber and vegetables together. The whole setup is strategically located according to water flow and water availability in the ground and also considers the needs and working routes per day, including natural source inputs to meet the needs of the system, namely restoring ecosystems, increasing natural resources and promoting the sustainability and ecological functionality. Built agro-tourism packages with sustainable activities (horseback riding, hiking, safari, bird watching, agricultural interaction and cultural traditions) are also part of this proposal, where native healthy food rich in minerals is regarded as part of an integrated and sustainable farming system.

## Background

The study area is located in South America, Colombia, in the region of Orinoco, Foothills of (Hato Corozal), in

the Lower hence of Ariporo river, into an area with more than four tons of carbon sequestration per year, potential wasted by the current use of extensive livestock production in terms of conversion of solar energy to biomass (200kg/meat/Ha/Year). *“To produce 1 calorie of meat requires 7 calories to get it”<sup>1</sup>.*

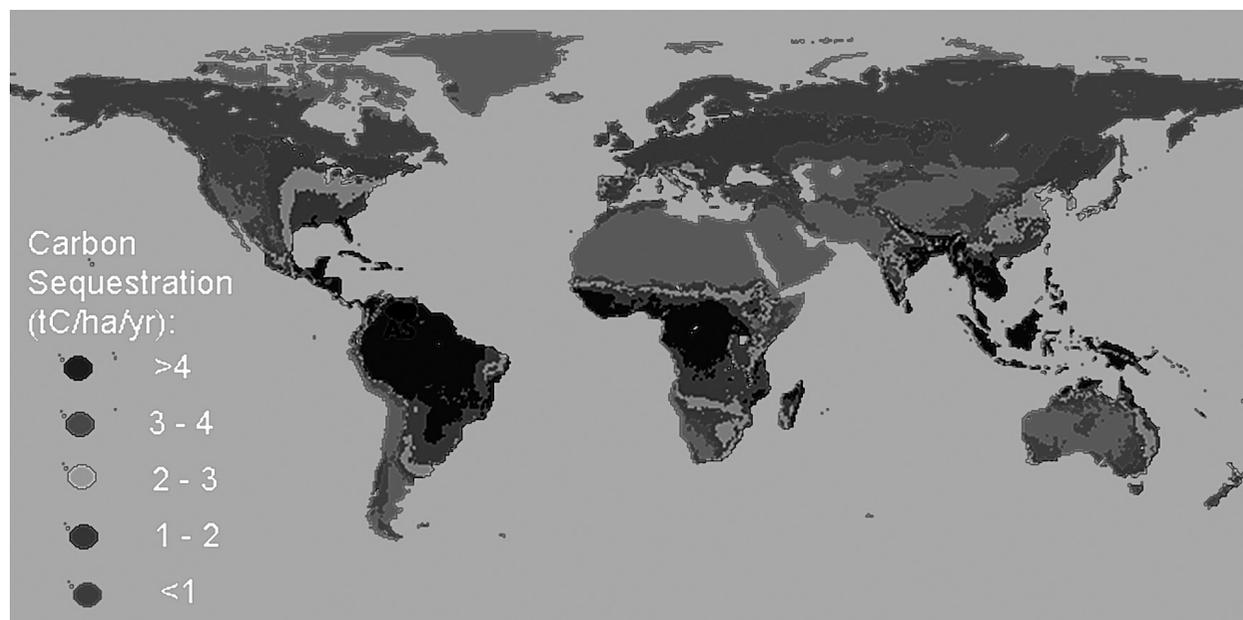
Extensive livestock system causes:

- Loss of natural ecosystems and biodiversity.
- Slow cash flow.
- Destroy the vertical flux of minerals from deep soil horizons to the surface through the roots of the trees.
- Increase the temperature of the ecosystem.
- Less carbon dioxide sequestration.
- Fewer jobs.
- Less humidity and texture of the soil
- High mineral loss caused of a soil exposed directly to rainfall.

All of these problems caused for the change of land use to facilitate livestock management, from an equatorial jungle to a savanna. For these problems, this current system needs to be adapted with techniques to find a new one to:

1. Professor Thomas Berthold.

Figura 1. Carbon sequestration (>4 Tons of Carbon/Hectare/year).(AS) Studied area in Colombia [1].



- Increase biodiversity and employment.
- Increase solar energy transformation and carbon sequestration.
- Minimize the greenhouse effect.
- Educate the community on sustainable development processes.
- Increase sustainable activities to offer more products in shorter harvest times and in a smaller area than the extensive livestock system.
- Make viable a continuous cash flow faster than livestock production, improving the live conditions of the community.

**Table 1.** Unsustainable livestock production in worldwide [3]

Tropical America	Worldwide	Water impact	Biodiversity impact
<p>over 50% of the pasture area is in stage of degradation. Causes of pasture degradation:</p> <p>Unadapted germplasm used. Overgrazing. Uncontrolled fires. Inappropriate tillage practices (dredge). No cover crops and soil conservation methods. Ineffective management of soil fertility. The exploitation of the land generates a cash flow directed to the self-sustaining, with low employment opportunities and a high impact on the natural ecosystem. [2]</p>	<p>Livestock production occupies 70 percent of all agricultural land and 30 percent of the Earth's land surface.</p> <p>Approximately 20 percent of the world's grasslands, with 73 percent of land use in different drylands are already degraded, mainly by overgrazing, compaction and erosion created by livestock action.</p> <p>The livestock sector is responsible for 18 percent of greenhouse gas emissions measured in CO<sub>2</sub> equivalent, a higher share than transport</p>	<p>Use more than 8 percent of drinking global water, for irrigation of food production.</p> <p>In the United States, livestock is responsible for about 55 percent of erosion and sedimentation, the percent 37por pesticide use, 50 percent of antibiotic use, and a third of the nitrogen and phosphorus loads in freshwater resources.</p> <p>Affects freshwater cycle, soil compaction reduces water infiltration, degrading the channel banks, floodplains drying and falling groundwater.</p>	<p>Livestock production is responsible for about 20 percent of the total terrestrial animal biomass, and 30 percent of the land area of the world that was previously wildlife.</p>

Impact of livestock in the air		
Greenhouse gases (GHG)	Share of livestock in total anthropogenic	Main Cause
Carbon dioxide CO <sub>2</sub>	9%	Deforestation of natural forests for livestock and agriculture.
Methane CH <sub>4</sub> (with 23 times the global warming potential (GWP) of CO <sub>2</sub> )	35-40%	Cellulose fermentation in the rumen protozoa, 80%. 280liters/methane/cow/day. Fermentation of starch produces less methane fermentation of cellulose.
Nitrous oxide (N <sub>2</sub> O) (with 296 times the GWP of CO <sub>2</sub> )	65%	Storage and application of organic manures.
Ammonia (NH <sub>3</sub> ) acid rain and acidification of ecosystems	64%	Manure storage and application of liquid and solid.

Diversification of sustainable farm products into an organized system as a suitable opportunity to change to an efficient and organized farming system.

**Figura 2.** Diversification of sustainable farm processes of (A.S.), Gonzalo Forero and Jaime Romero (2010).



## Methodology

### Process of creative examination:

A problem is solved clearly, when we look for a viable way to make smaller the gap between the unsatisfactory and ideal situation that you want to reach. For this you have to define this scenarios. [4]

- **Unsatisfactory scenario:** The traditional extensive livestock farming system is unsustainable in (social, economic and environmental) aspects.
- **Ideal scenario:** Offer and sell in the local and international value chain, organic farm products with environmental and quality processes, preserving the native species extolling it's beauty through sustainable tourism, generating (Employment, value added, increasing natural ecosystem areas, sustainable ancestral culture and more opportunities for the community).
- **Problem:** There should be a technical-organizational-logistical and commercial system, with economic and financial needs met, to integrate the different productive subsystems without use of synthetic chemicals, with sustainable tourism activities and clean processing farm products, to be viable cash flow and have an expected return to the system sufficiency, than they recover in value of land letting, without negative impact to the environment, benefiting owners, indigenous communities and local families.

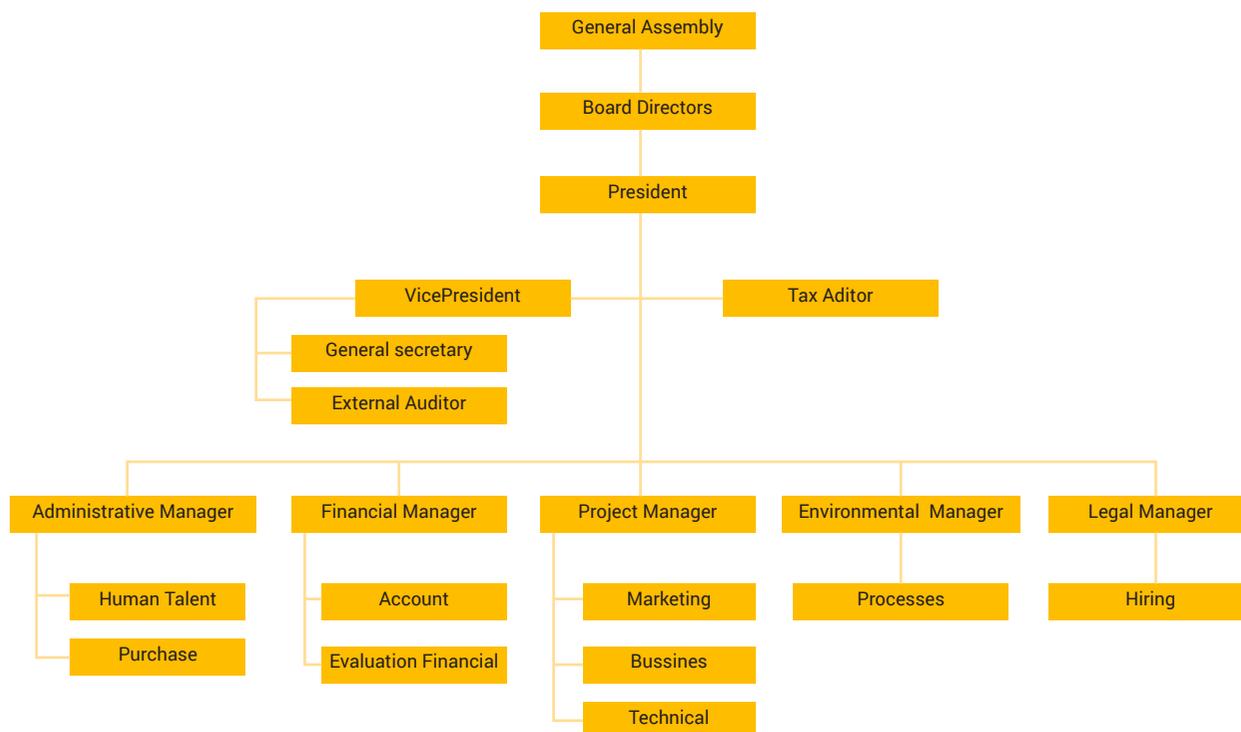
### Analysis with the systemic approach for organizations [5], using these components:

**a. Reason for being (mission, values and goals).**

The tools and production techniques with natural inputs using gravitational energy to assurance slow water flow in all ground adapting production to the natural ground conditions, through a Key line design, adding ancestral traditions with sustainable and responsible production systems. Integration of work communities providing the knowledge to be appropriated, improvement and multiplied, to prevent migration of the rural population to the city [6], with the incorporation of healthy systems and economic like the VAC duck-fish farming system using native Colombian species to preserve it.

**b. Structure (regular lines). Administration system.**

Figura 3. Communication and regular lines,(Gonzalo Forero, Jaime Romero, Kenneth Ochoa).



**c. Psychosocial (cultural and individual paradigm).**

Agricultural chemicals with high economic value and harmful to human health, are the only option today because to the absence of technological options available to farmers [7].

The development of the “(AS) Aripóro System” is an option without abuse to the rural community health and their ecosystems, allowing the preservation of native species, the most persecuted for their quality: Lapa (*Agouti paca*) (Mammal), Yaque (*Leiorius marmoratus*) (Catfish), Yaguazo (*Dendrocygna atumnalis*) (Duck), cedro amargo (*Cedrela odorata*) (Timber), Cashew nuts (*Anacardium occidentale*) (Fruit) and orange fruit (*Citrus sinensis*). The system is susceptible to change any species that farmer want to produce and preserve the same time.

**d. Technology (equipment and infrastructure).**

The methodology of the strategic program will be Technology-Organization-Design-Participation-feedback. Organic production (without artificial synthetic chemicals with natural minerals) will be added to key line design (To achieve slow water rain flow distributed throughout the ground, water with minerals capitalized on trees and shrubs exploiting the abundant solar energy to provide healthy food to the system, taking advantage of the three months of intense precipitation on the area guiding them through canals to take advantage of it with slow flow trough all land to irrigate crops and trees increasing natural productivity of soil taking advantage of them during the dry seasons, carry the water to take advantage into a VAC duck-fish farming system promoted by FAO) [8], but with Colombian native species. Feedback by farmers experimenting with these natural technologies in their hands, appropriate it and improve sustainable agricultural production inputs and available resources in the region [9], mixing this techniques and use according to the seasons of Colombia, changing from produce 200Kg/meat/year/Hectare in the extensive livestock system, to produce as in Vietnam 20.000 kg/products/Hectare [10]).

**e. Management (decision making, supplier-customer relationship).**

The administration, auditing and traceability system will be connected to ensure correct operation, paying weekly reports to the Financial Chief and Administrative Manager.

All contracts will be reviewed by the legal counsel who will adjust to avoid problems regarding compliance with regulations and contractual regulations or inter-trade agreements that are required to operate the system.

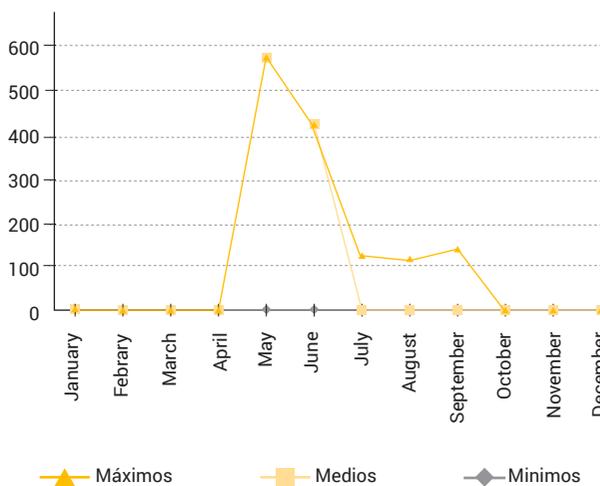
There will be a control on the outputs of the system connected to the inputs, the control is to make informed decisions and obtain the global flow of the system processes.

**f. Macro and micro environment (environmental, social, economic, political).**

The project start in Colombia, Hato Corozal, in the foothills of the Cocuy mountain, with a bh-T a warm humid climate (CH) as classified by Holdridge climate with an average annual temperature of 26 degrees Celsius, annual precipitation of 2934 mm. with the lowest relative humidity (60-70%) in (January and February) and highest (80-90%) in (May, June and July) [11].

Millimeters of rainfall per month since (1995-2011).

**Figura 4.** Taked on 2012/03/30 of IDEAM Meteorological station number 36015010 in Paz de Ariporo, Casanare, Colombia.



## Proposal

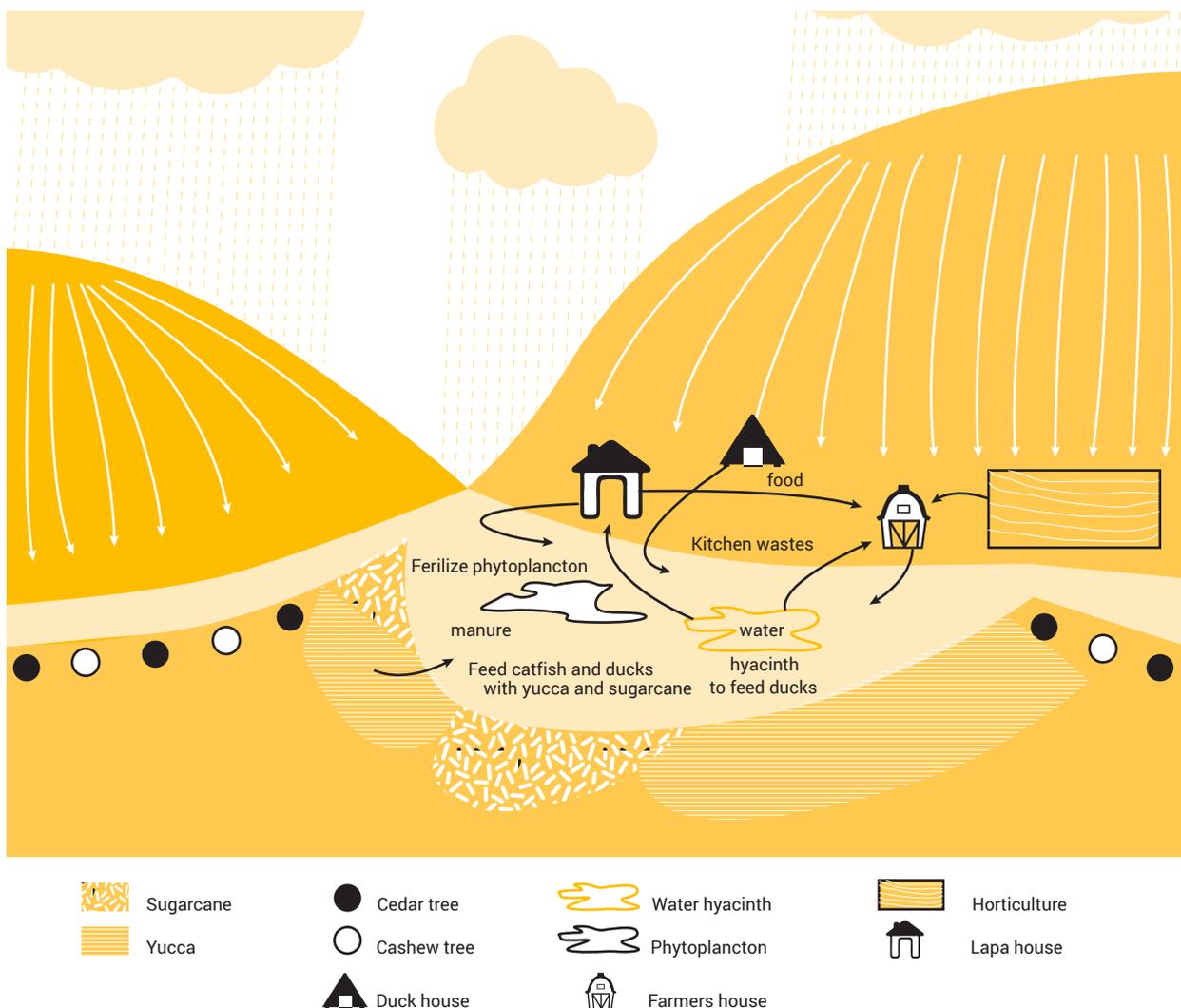
This proposal is flexible to change, we can choose production species of the great Colombian biodiversity always respecting the environmental laws and the natural requirements of the selected specie at their natural ecosystems. We can be creative to approach this characteristics with the natural soil regeneration with Key line design that increase minerals, water available to microorganism activity in all seasons, organic material and more than 3 products in the same area increasing the production per area with the VAC systems, This proposal, is the best option to produce natural and economic farm products in order to preserve and exploit native species without negative impact to the environment.

The Manure of animals feed phytoplankton, phytoplankton feeds zooplankton. Zooplankton feed the fishes with agriculture (yucca, sugar cane and corn). On the water grows water hyacinth, we chooped this plant to feed ducks mixed with kitchen wastes. Behind the channels of water, we can grow trees, is flexible specie, it depends of the bussiness plan and the natural conditions of the specie, with this system we can control the water flow for all the landscape and let it go where the system needs.

## Schedule of activities

The schedule of activities is an important part of the proposal because when the activities are organized as a part of a project is easier to be effective to achieve the objectives expected.

Figura 5. Duck fish system working with key line design Taked of Eugenio Grass 2009 and adapted by Gonzalo Forero 2012.



**Table 2.** Schedule of Activities

Sub	Activity	Task	SCHEDULE
Project		Year (Month) January-November	
1. Project plan	1.1. Gather the necessary information to carry out the project.	1.1.1 Do the Costs study of the project	Jan, Feb, Mar
	1.1.2 Get historical Rainfalls		
	1.1.3. Perform the topographic study and design productive areas		
	1.1.4. Gather legal requirements, Involve the right personnel in the project		Oct, Nov
	1.1.5. Make the market study		
	1.1.6. Gather information about value added of products		Apr, May, Jun
	1.1.7. Make the environmental study of the project		
	1.1.8. Perform the risk management plan within the project		Jul, Aug
	1.1.9. Collect all the costs of the project and compare to the budget availability.		Sep, Oct
	1.1.10. Review with an expert, to do the amendments before the final project version.		Nov, Dec
<b>Review of documents by a skilled person (deliverables to proceed to the following phase revision during the month of december (resource approval).</b>			
2. Implementation of the plan project.	2.1. Gather the financial, human, technical and technological indispensable to do the project.	2.1.1. Make a proper acquisitions	Jan, Feb, Mar, Apr, May, Jun
		2.2.2. To establish a system of Communications and internal decision-making involving all departments	
	2.2 Design a strategy to generate and maintain the marketplace of products.	2.2.3. Select and contract the most qualified personnel to work within productive system	Jan, Feb, Mar, Apr, May, Jun
<b>Review of documents by an expert deliverables to proceed to the next phase in the month of july (approval of resources).</b>			

## Evaluation Methods

- Results will be measured on productivity in terms of carbon sequestration and efficiency in the use of solar energy compared to the extensive cattle raising system in kg of biomass as products / time unit/Hectares, and number of species and released to the wild.
- The change between the extensive livestock the productive system and the new production process reflected in the balance sheet and ecological footprint examined from each one of the components involved (energy, water, greenhouse effect).
- Evaluate the change in cash flow and employment before and after the establishment of the productive system.
- Measure the acceptance and multiplication of production techniques adopted by the community in their parcels using surveys and interviews.

## Costs per hectare per year of the system

**Table 3.** COSTS/ Ha/Year

Cost of	Colombian pesos
1. Channels and ponds	2'000.000
2. Fence	600.000
3. Construction houses	600.000
4. Ducks	300.000
5. Fishes	200.000
6. Seeds	300.000
7. Nursery needs	300.000
8. Fertilizer	300.000
9. Workmanship	14'400.000
Total	16'400.000
Return expected	30'000.000

## Discussion and Conclusions

(Summary) We have analyzed the production problems that have all the landscapes, drought at the dry seasons and flooding at rainy seasons, this condition don´t allow microorganism to work because they need water but not in excess (absence of oxigen), they need oxygen to mineralize the nutrients for the plants. Key line technique controls water flow system in the landscape, decrease water soil erosion, increase water flow through all the land in open channels. This soil management mixed with the VAC systems of production (agriculture, fish pond, poultry or pigs) was put forward so as to solve problems as land productivity caused of the time of production and the slow rate of solar transformation into meat in an extensive cattle ranch.

The findings suggest that this is the way to produce at the farms in Colombia solving problems as employment, slow cash flow, decrease of natural ecosystems, competitiveness at the agro business market around the world and food safety of the country.

## Reflections, implications

Colombia has great conditions due to the location and productively lands, we have to approach these conditions with better productive systems producing food faster than the current extensive cattle ranch systems increasing the tons of food per year, being carefully with environment and biodiversity.

Future work should address the implementation of such proposals as experiment with different options of crop and VAC systems adapted to all areas in Colombia preserving biodiversity and soil, adapting the production to the natural ecosystem to increase productively areas in to a unique and competitive products offering it to all the world.

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## El Autor



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(Bogota, January 31 of 1987) Environmental Engineer, El Bosque University, Bogota, Colombia 2009. Master in Environmental (ISO 14001) and Quality (ISO 9000) Management for Enterprises, Escuela Europea de Dirección y Empresa, Madrid, Spain 2012.

(F). One of the Colombians Permaculture and Key line Pioneers, experienced designing farms since 2009 with six farms designed in Colombia. Student of Eugenio Grass, one of the bests farm designers in the world with the world famous Darren Doherty certified in 2010. Student of Dr. Jaime Romero, Civil Engineer professional experienced solving complex engineering problems and systemic administration learned on his Doctorate Master´s degrees at Québec University of Canada and Politecnico Di Milano in Italia.

Gonzalo worked in a rubber nursery at Paratebueno Cundinamarca as a designer of a strategy of clean rubber plants production cauchopar (2009), designer of an organic coffee farm at “el tigre” in medellin (2010), rubber farm designer of “las brisas” in hato corozal casanare (2010), designer of water supply strategy of “el atardecer” farm in pandi Cundinamarca (2011), auditor of the environmental licence of mineral minning for asphalt production in concrepav Ltda, Flandes Espinal Tolima (2011), key line design of mataredonda and san miguel ranch in hato Corozal Casanare (2011-2012).

Mr. Forero is member of Choc Izone, research group of clean production for Colombia since 2009 International youth representative of Servas International, United nations NGO and has a specialized couse in Hydraulic control structures for engineering.