The Cuban experience in integrated crop-livestock-tree farming

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For nearly 25 years agriculture in Cuba strongly depended on trade with socialist countries in Europe and the Far East. A few export products (sugar cane, citrus, coffee and tobacco) were exchanged for, among others, modern inputs to sustain the farming and ranching activities.

In 1990, this advantageous trading system collapsed. As trade was blocked also with the USA and other Western countries, import of inputs was not possible anymore. The ensuing economic crisis demonstrated the vulnerability of agriculture strongly dependent on imported external inputs. But agriculture in Cuba proved to be unsustainable, also due to the ecological and environmental problems it had created: soil degradation, deforestation, water pollution and loss of biological diversity.

The challenge to transform agriculture

This crisis challenged Cuban farmers and the government to transform their export-oriented, large-scale, specialised production systems into diversified, integrated, self-sufficient, small-scale systems. Agricultural research started to experiment, among others, with local cattle and the development of integrated systems and management practices, and more sustainable feeding methods. Conversion of ranching systems into integrated crop-livestock-tree systems to reverse the economic and environmental crisis and to provide income and food security for producers was the focus, with efficiency as a key factor for success.

In 1994, the Cuban Grass and Forage Research Institute started a project to study, develop and promote integrated small and medium-scale crop-livestock-tree systems. The work included research on 14 experimental farms and a large outreach programme in the provinces of Havana, Sancti Spiritus, Camaguey and Las Tunas based on participatory extension for spreading the lessons (Monzote and Funes-Monzote, 2000).

Six years later, the project has shown that integrated crop-livestock-tree systems can be sustainable, efficient and productive alternatives to specialised, external-input dependent dairy farming. Researchers and farmers show that combining the components into a consistent whole brings better results in terms of total production, energy efficiency, recycling of organic matter and the use of available natural resources.

The experimental farms

The project converted 14 ranches into integrated farms. These farms cover a wide range of soils (alfisoles, mollisoles and inseptisoles) and climates (1000 to 1400 mm rainfall, nearly 80% during the rainy season). These rainfed farms, ranging from 1 to 20 ha. in size, had not used agrochemicals or imported animal feed in the four years before the project began. Eight of them were specialised ranching systems dedicated to pasture and milk production.

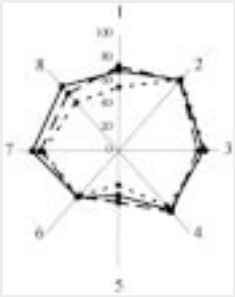


Figure 1. Evaluation of a farm through weighted indicators (% satisfaction) represented in a spider web

..... 1st year after the redesign process started
- - - - 2nd year
____ 3rd year

Each experimental integrated farm has its own unique combination of crops, livestock and trees (with 25 to 50% of crops integrated in the livestock system) which suits the local conditions: soils, topography, climate, natural vegetation, wildlife and farmer preference. Each farm has a crop production sub-system (areas of arable crops, perennial crops and vegetable garden) and an animal production sub-system (forest ranch land, pastures with a mixture of gramineous and leguminous species, fodder banks with e.g. Pennisetum, sugar cane, protein banks with leguminous fodder crops and trees such as glycine, kudzu, leucaena, and areas for small animals). Medicinal plants and fruit trees are distributed throughout the farms.

Each farm manager defined the process of redesigning the farm. Self-sufficiency in food, fodder and organic fertilisers, high production of biomass, diversification and integration were the leading principles. Strategies like the use of crop residues for animal feeding, functional biodiversity, reforestation of grazing areas, recycling of manure, composting of organic waste, soil regeneration and conservation were followed.

Evaluation of performance

Spider web diagrams (figure 1) were used to show the results of a large number of tests used to interpret the performance of the farms. Eight agroecological indicators were selected to evaluate the performance and sustainability of the integrated crop-livestock-tree systems. In milk specialised systems in Cuba the average yield is about 1 to 1.5 tons of milk per ha. Some of the integrated farms achieved 3 tons of milk and 6.1 tons in terms of total food production from crop and livestock (Tabel 1).

Diversification of production

The biodiversity in the redesigned farms had increased considerably in the three years. The number of trees per hectare had increased by 26 – 50% a year and the average number of food crops had

Table 1: Scores of the sustainability indicators in the experimental farms

Indicator	Range*
1 Milk production (tons/hectare)	1-3
2 Food production (tons/hectare)	1-9-6-1
3 Reforestation level (number of trees/hectare)	53-277
4 Diversity of wildlife (total number of species)	46-78
5 Food products (Number of edible products)	11-20
6 Production of organic fertilisers (tons/hectare)	1-2-8
7 Intensity of work (hours/day/hectare)	0.8-4.5
8 Energy efficiency (calories produced / calories invested)	4-5-10.6

** as a mean result of the 14 farms during six year*

increased from 14 to 17 to 20. The total biodiversity of wildlife had increased from 46 to 78 species per hectare, in addition to the increase in the diversity of soil life.

Reforestation is an essential activity in the transformation to integrated systems. But securing the survival of planted tress is a complex task on farms with livestock. Therefore, for each sub-system several strategies (see Table 2) were defined:

Table 2. Reforestation strategies

Reforestation	
Crop production sub-system	***Animal production sub-system***
• *Around the fields*	• *Within the pastureland (with protection)*
• *Within the cropping land (in strips)*	• *Forest patches (segregation)*
	• *Fences (hedges)*
	• *Use of species that are not palatable for cattle*

Organic fertilisers

A crucial question is where to obtain the organic matter and nutrients. One option is to import them from another farm, which is usually the case in market-oriented organic production. The other option is to produce them on-farm. In this respect, Jeavons (1991) dismisses the former and stresses that organic fertilisers must be produced on the farm itself, recycling nutrients and maintaining the fertility of the soil by proper management. In balancing nutrient flows, long-term, nutrient losses by soil erosion, leaching, etc. have to be minimised and export of nutrients to the market has to be compensated by import of nutrients, e.g. as fertiliser or feed. The advantage of having cattle is that they produce considerable quantities of manure, which makes recycling of nutrients and organic matter easier.

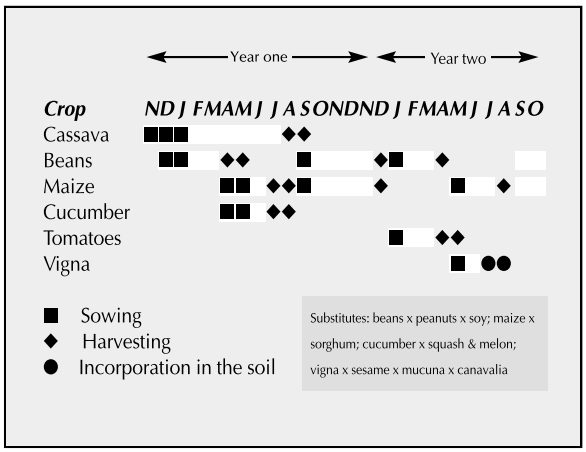
The evaluation showed that it is possible to produce enough good quality organic fertiliser from the by-products available in the farms to fertilise both the ranch and crop areas at a rate of 2 - 6 tons per ha., depending on the design of the farm.

In addition, worm humus is produced in smaller quantities and green manure crops at a large scale. In this way the degraded soils are being regenerated into biologically active and nutrient- rich soils. Nevertheless, there may be a nett outflow of nutrients, which has to be compensated for on the long-term.

Multiple cropping

Designs for multiple cropping systems were made that are well adapted to the local conditions and with crops commonly used in Cuba: cassava, beans, groundnuts, soy beans, sesame, maize, sorghum, squash, melon, tomatoes, cucumbers and *vigna, mucuna* and *canavalia* etc. (as green manure) (see Figure 2). These systems resulted in high land use rates (LUR), proving the vast potential of multiple cropping for intensive land use.

Figure 2. Sequence of rain-fed crops for 2 years



Biomass production and energy efficiency

The evaluation revealed the high productivity of these farms. The total biomass production was 3-9 tons of dry matter/ hectare/year, of which 1-3 tons/hectare/ year relates to the livestock system and the rest to crops, which corresponds with 3,000 - 10,000 Mcal/hectare of protein. The number of persons that can live from each farm varied from 4 - 10 persons and the sources of protein and energy are diverse (see Table 3). This shows the potential of integrated farms to produce a complete diet, food security for the family and a market surplus.

The energy balance of 4 - 10 calories produced for each calorie invested, shows the biological benefit and efficiency of these systems. In conventional livestock systems applied in Cuba during the '70s and '80s, this is normally in the order of 5 calories invested for 1 calorie produced (Funes-Monzote, 1998).

Final comments

This study showed the high potential in terms of production, sustainability and environmental care of integrated crop-livestock-tree farming built on agroecological principles. The practical evaluation methodology based on selected sustainability indicators is appropriate for further defining of strategies, planning and research. The redesigned farms attracted a lot of attention from farmers, technicians, researchers and teachers; they provided training opportunities and led to the adoption of the approach by other farmers.

The agroecological concepts stimulate the creativity and enthusiasm of farmers, which leads to better decision making and performance of the farm. By incorporating crops and trees in their farming system, ranchers can become self-sufficient in food products and increase the amount of by-products available for animal feed and income. Recycling of manure, green manure crops and trees help to take care of the environment, whilst adding value to the production unit.

Promotion of crop-livestock-tree integration is important to change the farming mentality and to develop more efficient production practices based on the optimal use of locally-available resources and a fair and sustainable balance between nature and human beings.

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Table 3. Number of persons sustained on the monitored farms

Indicators	*Range**
• *People fed per hectare*	*4-10*
• *Sources of energy*	*4-9*
• *Sources of vegetal protein*	*3-10*
• *Sources of animal protein*	*5-12*

** as mean result of the 14 farms during six years*

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