New Caledonia: can agriculture protect "the Island nearest to Paradise" ?

T. Mennesson *et al.*[*]

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This communication deals with the links between agriculture and the environment in New Caledonia, firstly through a general presentation of economic activities in the archipelago, then as a description of research undertaken to promote forms of agriculture that harmonize with the environment in overall accordance with the sustainability of agricultural systems.

New Caledonia is situated at the far south of the Melanesian arc, between 19° and 23° south and 163° and 168° longitude. The archipelago has a surface of 18,575 km^2, and comprises

- The main island (about 400 km x 40 km) oriented on a south-east/north-west axis,
- The Isle of Pines in the south and the Belep Archipelago in the north,
- The Loyalty Islands (Lifou, Maré, Ouvéa and Tiga) in the east, on an axis parallel to that of the main island.
- Numerous secondary islands, either occasionally inhabited or uninhabited, which bring the exclusive economic zone to 1,450,000 km^2.

Approximately 70 million years ago, New Caledonia separated from Australia and now presents a general topography of low mountains covering more than 80% of its surface. The west and the east are asymmetrical; a narrow corridor separates the mountain ranges from the sea in the east, whereas the plains are wider and better suited to agricultural in the West. The Loyalty Islands are former atolls that have risen and tipped over. They have a flat topography, calcareous and filtering soils, and are lined with sandy white beaches. Streams are non-existent in these islands, and those on the main island are small and tend to run dry, except in the rainy season. They descend transversely from the mountain ranges, with the exception of the longest, the Diahot, in the north of the island, which runs lengthwise for about 100 km.

Around the main island, the width of the lagoon varies from 2 to 20 km, with an average depth of 15-20 metres, and is protected by a coral reef barrier. These coral reefs are interrupted with *passes* directly opposite the rivers' mouths.

Temperatures are relatively homogeneous over the whole territory, with an annual average temperature of 23° but extreme values such as 47° and 37° have been recorded. The climate is tropical, with a hot and humid period from November to March and a cool and dryer period from June to August. It is highly moderated by the oceanic influence and a pattern of trade winds that blow more than 300 days (between 15 and 35 km/h) per year, mitigating the effects of a relative humidity close to 80%.

Rain gauge data shows a strong temporal and spatial heterogeneousness of rainfall patterns. Averaged over 30 years, the annual rainfall is 4 times greater in February than in September (221 mm against 54 mm),

* Thierry Mennesson, Master in Public Law
General Manager of the "Institut Agronomique néo-Calédonien" (IAC)
Graduated in Law and Political Sciences at Pau and Bordeaux Universities, France.
Lecturer at the University of New Caledonia.
IAC's General Manager since 2000. Secretary General of the Northern Province of New Caledonia from 1993 to 2000; Specialized in local issues and in the application of land tax policies in New Caledonia.

and the annual average exceeds 3,000 mm on the North/East, 3 times greater than on the West coast. Cyclic droughts and cyclones disrupt the cycles of the harvests.

The variety of plant species and its exceptionally high endemic rate are a result of the long period of isolation of the archipelago and the great geological variety of the soils, which are based on peridotite, schist, basalts, alluviums, and silica. Four main ecosystems cover the territory, with rich and original characteristics (mangrove, forest, savannah and scrub).

The richness of the flora is matched by the endemic land fauna, characterized by the minimal presence of land mammals.

Human colonization occurred in successive stages, with oldest proof of human presence going back 4000 years, from migratory movements originating in Southeast Asia. Europeans discovered New Caledonia in 1774 and France took possession of it in 1854 for use as a penal colony. The archipelago today has a population of 230,000 inhabitants, giving a density of 12 persons/km^2.

New Caledonia has a high standard of living, with an average Gross Domestic Product per inhabitant of $14,000 per year in 2002, close to 20th worldwide. The main constituents of this GDP are: public sector (26%), consumer services, trade, building and public works (roads, bridges, etc.,) with 8% accounted for by nickel extraction and metallurgy. With 13% of world's known reserves of nickel, this activity has a strong influence on the economic sector, and the nickel industry has in the past had an important impact on demography (immigration from France and other Pacific French Territories) and development. Nickel, the main locomotive of Caledonian development, accounts for 90% of the value of the archipelago's exports. Three important metallurgic projects that are soon to be launched (Goro Nickel in the South; Falconbridge in the North; enhancement of SLN capacities) will clearly change the profile of Caledonian society and have a major impact on the economy as a whole.

Concerning GDP, the Agricultural Production Haggle (Commerce) (APH), having accounted for 10% of New Caledonian Gross Domestic Product (GDP) in the '60s, now represents only 2-3% of GDP, compared with 60% for commerce and services, even though production continues to rise in volume and has doubled in the last 15 years.

New Caledonian agriculture is characterized by an important dualism between trade agriculture (extensive cattle farming, market-gardening) and traditional self-sufficient agriculture, mainly engaged in by Kanak people on traditional lands (Tuyenon, 2003), based on a system that mimics biodiversity and which involves the vegetative multiplication of yams, taro and sweet potatoes at a level unknown in the rest of the world (Walter et Lebot, 2003).

The most important agricultural products are fruit and vegetables, bovine products (essentially meat), poultry farming, porcine production and horticulture. Because the statistics take into account only those quantities which count as commercial exchanges, they unfortunately do not include self-grown and -consumed products or those customarily traded within the Kanak population.

2003	Value (euro)	Percentage of the total value
Cattle (meat and milk)	1662.3	21.1
Poultry	1364.9	17.3
Pork	779.4	9.9
Other small ruminants	98.4	1.2
Horses	29	0.4
Bee-keeping	46.3	0.6
Fruit and vegetables	2510.5	31.9
Horticulture	700	8.9
Forestry	420.1	5.3
Coffee	7.2	0.1
Coconuts	13.7	0.2
Vanilla	7	0.1
Cereals	237.1	3.0
Total	7875.9	100

In New Caledonia the agriculture stakes are related to the following:

- the population's food security in a context which is not usually that of a risk of shortages,
- the maintenance of the operational system's economic performance by taking into account traditional agriculture, whose role in household incomes remains inaccurately estimated.
- the assets and potentialities connected to export to nearby temperate countries,
- the conservation of natural resources in a vulnerable environment: the biodiversity of the islands' natural environment is known to be particularly fragile.

For the agricultural activity it is therefore a matter of:

- Maintaining resources (environment, soil, water, varieties of cultivated plants),
- Protection against biological invasions,
- Reducing emissions of toxic substances (hormones, chemicals, etc.),

The risks which agriculture places on the environment are connected to the impoverishment of biodiversity resulting from deforestation or the collecting of species for sale; to pollution of the environment through the use of pesticides or the irrational use of fertilizers, but also the risk of pollution of actual farm produce by the residues of these pesticides (health risks). They are not the same, depending on the field of production, and some are more exposed than others. Consideration of the impact of pollution must also take into account the environment in question itself. Thus, coral islands with their draining grounds are particularly threatened by bad management of these chemical and biological inputs.

Impoverishment of Biodiversity

The natural resources of islands are known to be particularly fragile (Blondel, 1995; Barnaud et Chapuis,1997). Demographic pressures and the food needs of the population, often concentrated around urban centres, will force agriculture to become specialized and to look for increased returns from ever smaller areas.

In addition, in terms of bovine breeding, the local agroclimatic conditions of marked drought leads developers to favour courses of breeding that are extensive or semi-extensive. Their need for cultivated land area results in encroachment on the natural environment of primary forests or of very specialized dry forest environments, leading to the destruction of certain species' environments and risking their extinction.

In horticulture, collection from the natural environment by collectors or florists for the horticultural industry in search of foliage has established a potential threat. The population's recent awareness of the need for environmental protection, however, seems to have led to a decrease in these practises.

The introduction of new species to systems different to those of their origin has led to numerous cases of invasions, an important problem which concerns animals as well as plants. In New Caledonia, the introduction of a deer species (*Cervus rusa*) from Indonesia and of pigs, which have now become wild, present real threats to the environment. Attempts to set up regulation of these populations take time and their results are uncertain. Also, the recommendation of shrubbery vegetables for fodder crop purposes, such as the mimosa (*Leucaena leucocephala*) or the "Sweet Acacia" (*Acacia farnesiana*) has led to their distribution over the whole area of New Caledonia, where they compete with native species.

Whether it may be a clearing practice for fields or hunting paths, the resort to fire, very widespread on the island, is a recurring and annual plague in the warm and dry season.

The irrational use of pesticides and fertilizers

Listed in ascending order of gravity

- Persistent contamination with long-term effects on the soil

- Pollution resulting from the inappropriate use of pesticides (choice of molecules, doses, application during unfavourable periods–for example, just before heavy rain). These products which penetrate the soil then follow several paths:

Some can be degraded by micro-organisms into by-products that are harmless to the environment;

Others remain semi-permanently in the ground and can destabilize the micro flora, which have a regulatory role in the soil, by their toxicity.

Some are leached downwards until they reach phreatic groundwater and pollute drinking water springs,

Others finally are partially degraded, but their by-products also turn out toxic to aquatic or to the soil (whether they are permanent or washed away)

- The contamination of waters (creeks, rivers, maritime coastal ecosystems, phreatic groundwater)

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By pesticides that are leached out during floods or strong rains. This is the case for both plant and animal production channels.

Through fertilizers (on the ground or in lost nutrient solutions), brought in overlarge quantities and/or not broken down, with nitrates as a "key" example,

Through inadequate use of organic matter (pig manure and hen droppings, which are very rich in nitrogen and minerals: used in heavy doses for preparation of the soil, without any cultures to value them; and this nitrogen is most probably lost to the plant but unfortunately not for the environment). This particularly concerns coral reef islands,

- and farm products intended for human consumption

Pollution through pesticide residues (doses and/or Delay Before Harvest not respected)

Even if we do not possess reliable data to back up these reports, the risks, however seem real to us, and the networks of exchanges established with the producers show us clearly that their use of preventive sprays at a rate of "too much rather than not enough" are not without risk to the environment and to consumers. To have at our disposal means for making reliable measurements will be important to assess the real risks.

Contribution of research to the development of a sustainable agriculture: an example of integrated protection

Integrated protection has been the object of considerable research effort. We list below some examples which illustrate how research contributions, though, are now declining.

3.1 Towards integrated protection of agricultural production

First let us define the term "integrated protection", which is a protection process towards cultures and breeding animals operating at different levels to repel different lines of attack and in opposition to bio-aggressors. The term comes from a report on the over-use of biocides, of which we know the fatal effects on both environment and health; it is different from the conventional concept of direct treatment of aggressors.

It repositions itself on wide levels of organization, returning the problem to vaster scales of space and time, taking into account widespread agro-ecological processes. The intermediate stages between the conventional chemical control and the integrated protection are rational control and followed by integrated control.

3.2 Cases of agricultural plant zoning

The first component of integrated protection consists of establishing an agricultural enterprise in a bio-climatic environment that suits it. In line with this process, in New Caledonia, zoning of mango trees has reduced parasitic attacks and in turn reduced dependence on phytosanitary treatments (Kagy *et al.*, in 2003). The impact of this measure is all the greater by being accompanied by additional measures that make it possible to decrease even further the need to use chemical treatments, such as for example employing mulching instead of weedkillers.

3.3 Choices of animal varieties and vegetable varieties that are tolerant to bio-aggressors

One example is provided by bovine species with respect to the problem of ticks, which is the main constraint on New Caledonian bovine breeding. European cattle seem very sensitive to the tick *Boophilus microplus*, but this is not the case with zebus, including the Brahman. Experiments have showed that some Brahman were 100 times less infested than Charolais maintained on the same plots of land. Use of this race and its crossbreeds would limit the usage of acaricide, currently applied to cattle a dozen times a year, and which generates problems with residues and pollution, but also problems of increased resistance on the part of the ticks.

3.4 Integrated control of truck farming

Truck farming is also a good example of integrated protection, involving for example the protection of cabbages in New Caledonia against a defoliant caterpillar (*Crocidolomia binotalis*). Specific ways of using insecticides were worked out to decrease their use while increasing their efficacy and preventing the development of resistance. Alternatives to chemical treatments were also tested, such as pheromones or trap plants, or through resorting to auxiliaries in the fight against crop destruction.

3.5 Effects of cultural practices on the development of weeds

In New Caledonia, the role of cultural practices on *Cyperus rotundus* (Umbrella sedge) infestations, one of the worst weeds in the world, was estimated using an experimental model. It appears that the use of rotavators, which cut through the rhizomes, simply encourages the reproduction of this weed. On the other hand, circular spikes bring the tubers to the surface, considerably reducing the chances of their regrowth. Additionally, use of crop rotation systems with covering cultures is particularly recommended. In this last case, a pre-emergence weedkiller such as halosulfuron methyl can then be used between the preparation of the ground and the installation of the covering culture (Ratiarson, 2004).

Conclusion

This overview of current conditions faced by New Caledonian agriculture and of the chances of contributions by research, makes it possible to formulate propositions.

4.1 Traditional agriculture appears to be closely adapted to local environmental conditions

This traditional agriculture, which is a small consumer of inputs, and thus not particularly harmful to the environment, appears to be particularly resilient and adapted to the environment's local conditions. Let us remember that it is deeply rooted and with a long history: vegeculture (culture of plants by means of vegetative reproduction) was already practised 20,000 years ago on the Sahul Plateau. This agriculture

is presumably very rich in lessons but nevertheless constitutes a knowledge base that is undervalued by conventional agriculture.

4.2 A necessary capacity for integrated reaction aimed at biological invasions

For the previous-given reasons, but also because of the extreme sensitivity to invasions of the island's environment, it is necessary to adopt a highly integrated setup to handle this serious problem, both to prevent new introductions and to control the most harmful naturalized species. The threat, not only to agriculture, of biological invasions but also to the entire land and marine environment, is all the more relevant with exchanges between continents and island areas continuing to increase significantly.

4.3 Which research areas to prioritize?

The research priorities outlined at the end of this analysis are the following.

- to strengthen the preservation of soil, aquatic and biological resources;
- to value the biological fertility of the soil (organic matter, microbiology, biogeochemical cycles);
- to replace chemical control of pests, diseases and weeds with integrated protection;
- to support more diverse agricultural production and favour more resilient systems;
- to combine the objectives of production for trade with the resilience of multifunctional domestic agriculture under the common perspective of sustainable development.

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