

## **Chicken manure in the cocoa plantations of Côte d'Ivoire**

*An agro-ecological and social revolution*

*A 'frugal' village innovation*

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In *Showdown*, the novel by Brazilian author Jorge Amado, a cocoa planter mocks the agronomist from the city for recommending the use of fertilizers. After all, his cocoa trees in the cleared forest plot will not need fertilizer for a long time. In the 19th century, cocoa cultivation was still a predominantly South American pursuit, mainly Brazilian. But within a few decades at the end of 19th century and the beginning of the 20th, West Africa took over the mantle of the world's primary cocoa cultivation region, a result of powerful waves of migration: poor villagers came down from the savannah and the Sahel to clear tropical forests, first, of southern Ghana and Nigeria and, later, of Côte d'Ivoire. For a hundred years, cocoa production grew exponentially due to continued forest clearing, mainly by migrants. As in Brazil in the 19th century, for several decades, African farmers did not use any fertilizer. Fertility was provided by the cutting down and burning of the woody mass accumulated in tropical forests. But over time, continued cultivation of cocoa slowly depleted these soils.

In Côte d'Ivoire, fertilizer first made an appearance on cocoa farms in the early 1980s, in Soubré region. A few Baule migrant farmers (from central Côte d'Ivoire) became concerned about the early mortality of their cocoa trees on the region's poor soils. They sought a solution and found it – on their own – in chemical fertilizers. A pioneering group of farmers travelled to Abidjan to buy a few bags. It then took some 20 years for the process of learning and imitation between farmers to make fertilizer use more widespread and for retailers to get interested in selling it to them. During this period, the market grew from a few hundred kilograms to 12,000 tonnes in 1997, and nearly 80,000 tonnes in 2003, thanks to the peaking of world cocoa prices (1). Then, from 2004 to 2011, adoption of fertilizer declined, falling to less than 20,000 tonnes annually, caught between falling cocoa prices and the sharp rise in fertilizer prices (2). Nevertheless, this first cycle of fertilizer adoption remains a wonderful example of Ivorian farmers' ability to innovate. Their entrepreneurial initiatives and rationales can even provide lessons to those mandated to provide support and help to them. Over the 1983-1995 period, public agricultural extension collapsed for lack of funds. During the 1995-2010 period, the private sector in the form of the chocolate industry, worried about its cocoa supplies, and not having yet understood the importance of fertilization, focused instead on recommending good manual agricultural practices – which the smallholders, for the most part, did not adopt. However, since 2011, part of industry, driven by IDH (Dutch parapublic organization for sustainable trade

initiatives whose mission is to optimize the joint efforts of the public and private sectors across different supply chains), has concentrated increasingly on fertilizers and the specifics of their use (Which fertilizer to use on which soils? What modes of application?). But this focus of the chocolate multinationals on fertilizers has lagged well behind the pioneering smallholders of Côte d'Ivoire's 'cocoa belt' in Soubré.

But just when industry started to advocate the use of chemical fertilizers, family farmers began to diversify their fertilization strategies, increasingly turning towards more organic inputs. A particular innovation emerged in the 2000s and has been taking considerable hold in the 2010s: the fertilization of cocoa trees by the application of chicken manure, the birth of a truly new sector.

Why this innovation? Why did it emerge in the 2000s and grow exponentially in the 2010s? We will empirically test four interconnected hypotheses. The first is that of the 'frugal innovation': the farmers would prefer to use chemical fertilizers but financial constraints compel them to fall back on a cheaper organic fertilizer: chicken manure. Second, going beyond the financial aspect, some farmers hope to do better with this 'lesser' fertilizer (3), which not only reinforces the idea of frugal innovation but also introduces a concurrent hypothesis, that of an agro-ecological invention or revolution: under certain conditions, farmers hope to discover and disseminate an agro-ecological intensification technique that is more effective and sustainable than the chemical-based solution of mineral fertilizers (4), (5). The third hypothesis is that of a network of migrant farmers who play a major role in innovation mainly because they have privileged access to information from several economic spaces and to very effective networks to disseminate information (6), (7). Finally, in Côte d'Ivoire's current political context, with its economy returning to growth and with the chocolate industry becoming increasingly involved with farmers and cooperatives, is a fourth hypothesis, that of a direct or indirect impact of public policies and/or the private sector.

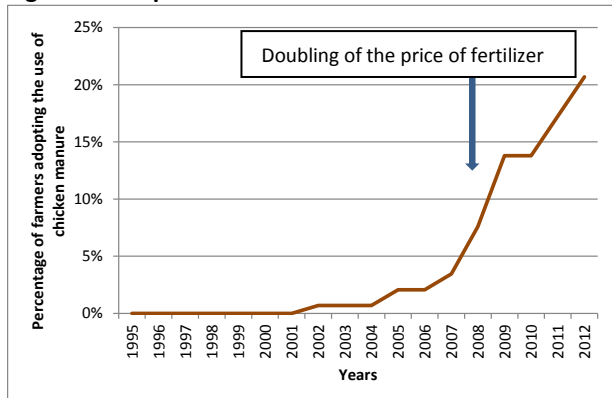
Our analysis is based on several surveys: in 2007 (800 cocoa farms in a study on behalf of the European Union), in 2012 on 145 farms, specifically on the fertilization of cocoa trees, and a follow-up of farms since 2013 (140 farms in a 'fertilizer initiative' joint programme with IDH), all complemented by more local observations in various regions of Côte d'Ivoire. These surveys and follow-ups over the long term help us reconstruct the context and history of this innovation. Finally, a first survey specifically on the adoption of chicken manure was conducted with 60 farmers in January 2015. We start by exploring the extent of the innovation process, along with initial explanations.

## **1. The extent of the innovation**

### *Regional approach in 2012*

A survey conducted in 2012 of 145 farms, mainly west of the Bandama River (Gagnoa, Daloa, Duékoué, and the Soubré-Meagui-San Pedro axis), revealed a growing adoption of chicken manure from 2001 to 2004, followed by the first rapid increases from 2005 to 2007 and a veritable exponential-growth phase in 2008 to reach an adoption level of 20% in 2012. While this looks like a classic diffusionist model (8), with considerable extent, it remained largely unrecognized in 2012.

**Figure 1. Adoption of chicken manure in 145 cocoa farms in Côte d'Ivoire**



Source: Author surveys, 2012.

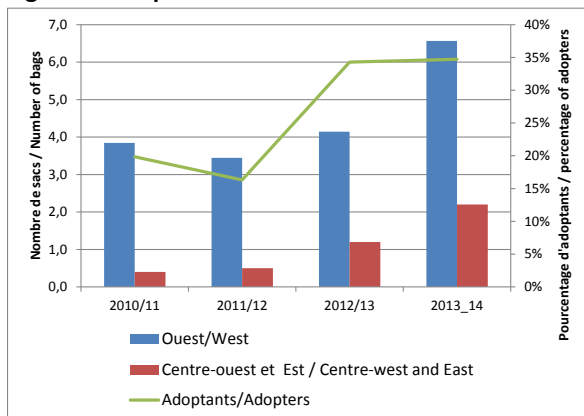
The most striking fact is the exponential-growth phase in 2008/09, corresponding to the period of the doubling of fertilizer prices on the Ivorian market, from between 12,000 and 13,000 FCFA to between 20,000 and 24,000 FCFA. It seemed as though the smallholders were seeking an alternative to chemical fertilizers which had become too expensive: the beginnings of a frugal innovation.

#### National approach in 2014

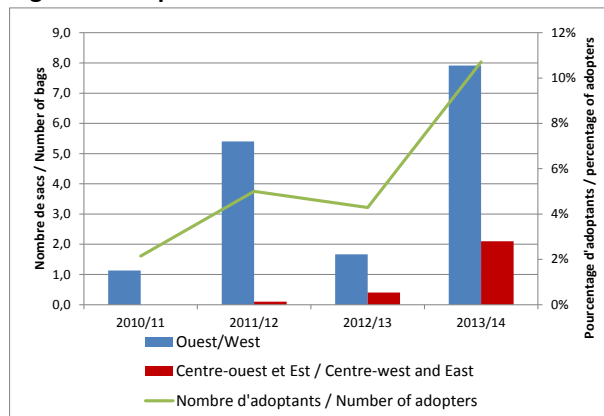
In 2013/14, the monitoring of 140 farms – spread over 14 villages across the country’s cocoa cultivation zone – through the ‘Fertilizer Initiative’ programme launched in 2013 by IDH showed a more haphazard adoption of chicken manure (Figures 2 and 3). The recovery and stabilization of the price of cocoa from 2012/13, together with the beginnings of a reduction in the price of chemical fertilizers led their use to grow in 2013, while the use of chicken manure did not show any growth at the farms surveyed: In 2014, 35% of farmers applied fertilizer, whereas only 11% used chicken manure.

Both types of fertilizers had one aspect in common: they were both adopted earlier in the country’s western regions than in its eastern ones. This phenomenon can be explained in part by the poorer soils found in the west, hence the compulsion to use fertilizing inputs, as well as by a very high proportion of migrants in the west, more likely than autochthons to buy inputs since their farms are bigger and their budgets are not as stretched.

**Figure 2. Adoption of chemical fertilizers 2010-2014**



**Figure 3. Adoption of chicken manure 2010-2014**



Sources: ‘Fertilizer Initiative’ follow-up, CIRAD/ALP surveys (140 farms in Côte d'Ivoire’s cocoa-cultivation zone)

The growth in use of chicken manure did not therefore take place at the expense of chemical fertilizers; both saw growth in usage. Nevertheless, these figures need explanation because of the skewed sampling. The 140 farms were selected under the 'Fertilizer initiative' programme, promoted by IDH in partnership with the public and private sectors. Several cocoa processing and trading companies work with cooperatives, usually located along roads and tracks, at least along the major ones. Some of the many factors that point to a higher chemical fertilizer consumption in this sample as compared to the national average are the proximity of roads which facilitates the stocking of fertilizer in private sales warehouses in villages, organization of smallholders into cooperatives which facilitates access to credit for purchasing fertilizer, and support of NGOs working in partnership with industry.

In contrast, in this sample, only one chocolate company was interested in chicken manure. It was also involved marginally in a complicated compost experiment with multiple ingredients: a novel approach deserving encouragement but without much scope for expansion as yet. Other companies and cooperatives have also tried to introduce compost based on waste pods but are not involved with chicken manure in any way. This suggests that the consumption of chicken manure is not overestimated in this sample compared to the national level. It may even be underestimated. Indeed, the profit margins of fertilizer dealers are diminishing with increasing competition and thus they tend not to venture out to the remoter settlements. The margins of chicken manure dealers, as we shall see, are still very comfortable, allowing them to sell to the least accessible consumers (9).

These figures are available only up to the 2013/14 season, i.e., the period from September 2013 to August 2014. However, two changes have since taken place that affect cocoa farmers.

On the one hand, the increase in the price of cocoa, from 750 to 850 FCFA/kg in October 2014, not only encouraged fertilizer purchases but also provided a fillip to the manure sector in a highly visible way: stocks of manure bags were stored in large numbers at the entrances of villages between San Pedro and Grand Bereby (Photo 6). Chicken manure dealers did not seem to be afraid of thefts. Obviously, a bag of manure at 3000 FCFA is less tempting to a thief than a bag of chemical fertilizer at 17,000 FCFA – and the smell of manure bags can betray a thief very quickly. This visibility of the product has certainly played a role in boosting village demand.

On the other hand, repairs and renovation of Côte d'Ivoire's road system that began in 2013 have favoured business initiatives in general but the transport of chicken manure in particular, since very large tonnages are required. Given prices and their production targets, cocoa farmers can apply two to three times more bags of chicken manure than of fertilizer. The relaying of roads and tracks has allowed stocks to be deposited along major tracks, much more to the interior than in previous years.

In anticipation of the latest data, we can already say that chicken manure purchases continue to grow exponentially in the 2014/15 season, starting in August/September 2014. We shall now see what light can be shed on the topic by local stories of innovation.

## 2. The story of an agro-ecological innovation through the market and migrants' networks

### *Emergence of the Agnibilékrou-Duékué supply chain*

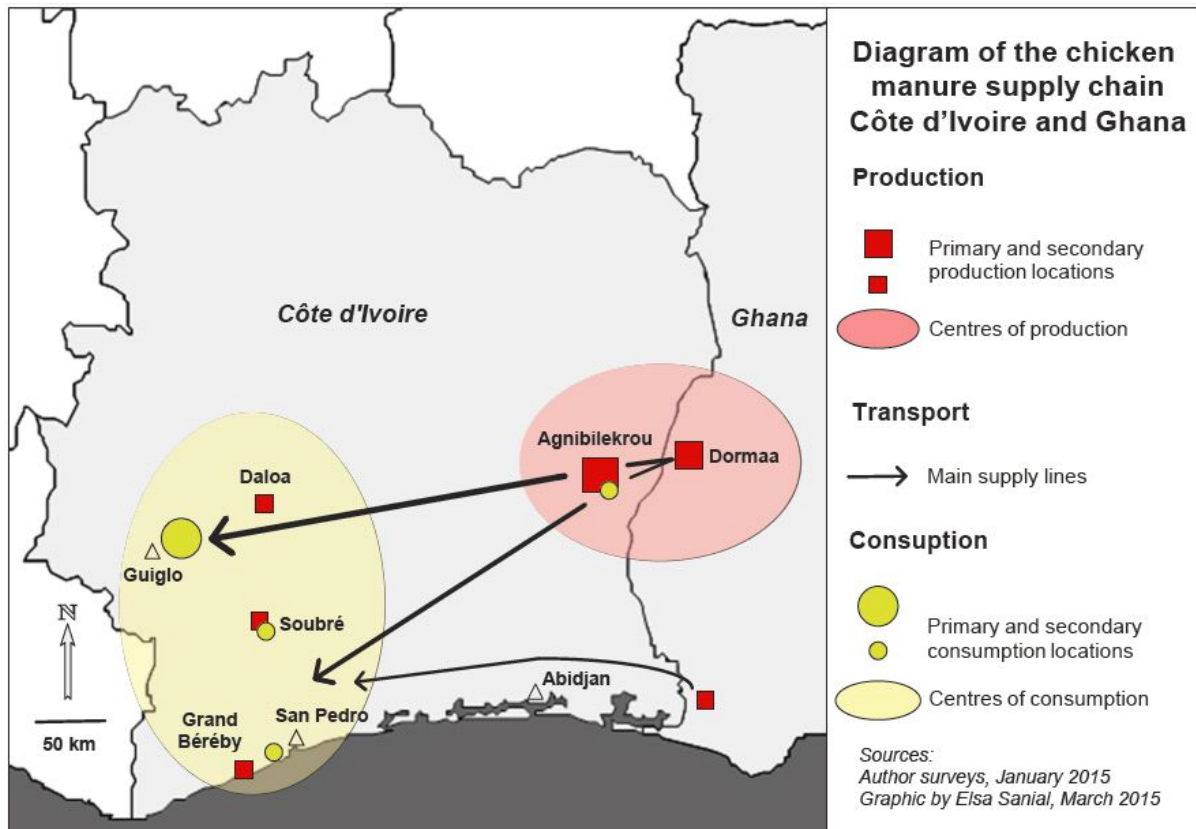
Chicken manure was first adopted in Côte d'Ivoire in 2001/02 (Figure 1). Initially, its use was concentrated in the region of Duékué and Guiglo, in the west of the country. The price of a 50-kg bag was between 1500 and 2000 FCFA at the time. Farmer interest in chicken manure started to grow from 2005. Due to demand pressures in this region, the price of a bag gradually increased to between 3500 and 4500 FCFA in the late 2000s. Another study conducted in 2007 on 800 cocoa farms confirmed these results: while only 2.3% of farmers nationally used chicken manure, in the Duékué/Guiglo region this figure was 17%.

Why this area in particular? It is far from Abidjan, near the Liberian and Guinean borders, and among the most affected by the politico-military conflicts that began in September 2002. The first reason is the poor soil quality. Without fertilization, cocoa trees die more quickly than in Soubré. The second reason was the difficulty of obtaining fertilizer bags from Abidjan and the costs involved. The price of a bag of mineral fertilizer had almost doubled, from 12,000-13,000 FCFA to 20,000-23,000 FCFA. This increase was the result not only of soaring world fertilizer prices but also of increasing distributor margins. Indeed, fertilizer companies stopped distributing their products directly and began relying on intermediary dealers. During the same period, in the late 2000s, the quality of the roads deteriorated and the number of roadblocks set up by various 'law enforcement' forces increased, with each such group demanding its 'toll'. The fertilizer market became risky.

At that time, chicken manure was a waste product of no value to industrial poultry farms. The 'chicken manure for cocoa farms' innovation came about because an arbitrage opportunity was identified between a by-product that was worthless at farm gates in the country's east and one that increasingly gained value as it reached the cocoa farms of the west. The margins on chicken manure are therefore much higher and help overcome the associated costs and risks. In 2008, despite uncertainties about availability (How many chicken farms in the country? What transportation options?), the 'chicken manure' innovation already seemed to hold a bright future. In 2012, demand continued to grow. We estimate that, at that time, at least 50% of farmers in the Duékué/Guiglo region used chicken manure. In 2015, we estimate this proportion at 77%. There seems to be ample availability since prices in 2015 appear to be stabilizing around 4000 FCFA per bag originating from Agnibilékrou, but local poultries are beginning to occasionally offer bags at lower prices.

In fact, a real supply chain has come up between Agnibilékrou in the east, still the country's largest centre for poultries and production of manure, and Duékué in the west, which has become one of the country's biggest manure consumption areas. In the villages surveyed around Duékué, we identified two large farmers of Burkinabe and Senufo origin as the innovators. They have contacts with the Agni who migrated to Duékué, with the latter still maintaining contacts with their parents in Agnibilékrou. The farmer who buy chicken manure are mainly migrants from Burkina Faso.

Chicken manure is transported across Côte d'Ivoire, from east to west, in 35-tonne articulated lorries (Photo 5), with the loads then often being transferred to small 6-tonne trucks for distribution to less connected villages. All this does not cost the State or the cocoa industry a single FCFA.



This is therefore a major innovation on at least two levels. On the one hand, until the 2000s, organic manure was almost unknown and non-existent, except for chickens running around on cocoa farms, very useful but whose use was limited by the risk of theft (10). On the other hand, one would have thought that manure would be self-produced on cocoa farms. This process exists but is largely overshadowed by external supply, through the market with the introduction of a new supply chain. Individuals engaging in this commercial activity are true entrepreneurs. This entire network of actors or innovation system, which relies on the combined initiatives of poultry farmers, cocoa farmers, traders and transporters, has been built while the country is in the throes of a major socio-political crisis.

*Ali Ouattara in Agnibilékrou, chicken farming pioneer*

At one end of the chicken manure supply chain was Ali Ouattara, entrepreneur-innovator in chicken breeding, whose poultry farm near Agnibilékrou became one of the largest in the country. His innovation/investment in poultry farming was imitated both by villagers as well as by city-based upper-middle class investors. This imitation process soon led to the generation of large amounts of waste, unused and bulky, until some individuals – farmers, son of farmers or traders – discovered that this worthless ‘waste’ actually had great potential in the western part of the country. They played an important role in building the ‘fertilization of cocoa trees by chicken manure’ innovation (9). For many years, anyone wanting to collect manure from poultry farms could do so for free; the poultry farmers were glad to get rid of it. The only cost was that of transport by truck. The profit opportunity ensured that there was a consistent supply. But locally, the demand for chicken manure

grew for applying on maize (increasingly itself being used as chicken feed), and thus transportation opportunities to the west of the country probably grew more slowly than the demand warranted.

*Prices and migrants' networks create new supply and consumption zones*

In neighbouring Ghana. Poultry farms have come up a few kilometres from Agnibilékrou, deeper in the Brong Ahafo region, with as many Ivorian buyers crossing the border to buy manure as do to buy eggs. Recently, the Ivorian transporters have started buying manure from other border regions, such as on the Maféré-Enchi road.

In the centre-west. Smaller poultry farms, such as the ones in Daloa and Sinfra, have developed locally.

Towards San Pedro, in the country's south-west. We observed the adoption of chicken manure in new areas in 2008. For example, near Grand Bereby, still a frontier area, settled by Burkinabe, Malian, Baule and Abron migrants, with still relatively young cocoa plantations but with unfavourable soils for growing this crop, farmers applied chicken manure whose landed price in the villages was 1750 FCFA per bag. This price, lower than in Duékué, can be explained at least in part by the emergence of competition by poultry farms that came up nearby. The farmers of Grand Bereby are very clear that they adopted chicken manure in order to overcome the sharp rise in the price of chemical fertilizer in 2008 (from 13,000 to 18,000 FCFA initially, and then increasing further to 20,000 FCFA and higher still in 2009/10), while cocoa prices stagnated. At that time, the cocoa/fertilizer price ratio (per kg each) fell to 1.

In 2012, cocoa farmers around San Pedro provided a second explanation: chicken manure has a more immediate effect on the crop than does chemical fertilizer. The latter takes at least 6 months to show any impact on cocoa production while the first effects of chicken manure appear as early as in 3 months. The supply chain from Agnibilékrou was created by sons of migrant farmers of Mossi origin who made contact with Agnibilékrou through the sons of migrant farmers of Agni origin.

At Soubré: We met Mr Gabin, a grower/poultry farmer at Soubré in 2013 and a true entrepreneur and innovator of organic fertilization (Box 1). His farm produces 300 to 500 bags of chicken manure per month. To purchase manure, farmers from the surrounding areas pass by his poultry farm or place their orders by phone. Mr Gabin advertises his product and its effectiveness on the radio in the vicinity of Soubré. Without transportation included, chicken manure is sold at very competitive prices. At his poultry farm gate, a 50-kg bag costs only 1200 FCFA, and if the farmer brings an empty bag, the price drops to 1000 FCFA.

Who are the buyers of his chicken manure? The biggest buyers are migrant farmers originally from Mali. They used to buy a large amount of chemical fertilizer despite its price rising to 18,000 FCFA per bag. When they heard of chicken manure and its availability at 1000 FCFA francs per bag, they were the first to try it out. Once convinced of its effectiveness on cocoa production, they started placing orders in the hundreds of bags per farmer. Following them in order of purchase volume per farmer are the large migrant groups, Burkinabe, followed by the Senufo and the Baule. The Bete autochthons, squeezed by low incomes and expensive social obligations (11), are unable to purchase the manure but Mr. Gabin, in his efforts to promote ethnic solidarity, has distributed some bags for free to them.

*Box 1. Mr Gabin, farmer, entrepreneur and innovator at Soubré*

The story of Mr Gabin deserves telling, not for its anecdotal value but because it illustrates perfectly the factors that make an innovation a success.

Mr Gabin is one of the 'big farmers'. With 15 ha of cocoa, 14 ha of rubber trees, 5 ha of palm trees and 2 ha of teak, his holdings are significantly higher than the regional average, which is in the order of 6 ha. From his cocoa revenues, he invested in a chicken farm in 2009.

He got his land from his father, an autochthon of the Soubré region, who was himself a farmer of cocoa and rubber trees. With the help of his father, Mr Gabin in turn soon created capital in the form of a plantation, especially as he started early, deciding to drop out of school after the *classe de 3<sup>e</sup>* (equivalent to year 10 in the UK and 9th grade in the US). He got the idea of chicken farming also from his father, who is of Baoule origin, a teacher and a duck and chicken farmer in his own right and who kept a flock of 50 chickens as part of a school cooperative (a programme put in place in the 1970s under the aegis of the Minister of Agriculture). The son helped out at the farm and soon decided that farming was his vocation. Once he became a full-time farmer himself, he set up a small piggery and poultry and had the idea to test the application of pig and chicken manure. Trials with both types of manure were a total success, with a marked – though unquantified – increase in production. Since working with pig manure required much more labour than with chicken manure, he chose to concentrate on chicken farming. In 2009, when he was 41 years old, his poultry became fully operational and profitable. He emphasizes that he first chose to create capital in the form of his plantation and only when he was financially secure did he take the risk of diversifying into livestock farming. His poultry's main objective is to supply eggs to the local market but he has already adopted the practice of fertilization of his own crops with chicken manure.

He has also hired a permanent technician.

Never one to stand still, Mr Gabin continues to invent/innovate, trying out new combinations of organic fertilizers, including mixtures of chicken manure and rice bran.

### **3. At first assessment, the hypotheses seem to be confirmed**

The 2007, 2012 and 2014 surveys and these stories of innovation at Duékué, Grand Bereby and Soubré clearly highlight the role played by the low price of manure in conjunction with the sharp rise in the price of imported chemical fertilizers. These price differences attracted innovative farmers who tested and verified the effectiveness of chicken manure – at least its immediacy – in a process very similar to the concept of frugal innovation: to do more with less.

At the same time, there has indeed been an agro-ecological innovation. Once again, we can confirm the market's role in this agro-ecological innovation, through long supply chains (east-to-west crossing of the whole country, even in times of politico-military crisis). A substantial profit margin was necessary to enable this innovation and develop a marketing supply chain. However, the development of chicken farms, such as that of Mr Gabin, in or near manure consumption centres should increase the importance of short supply chains.

All the local stories confirm the fundamental role played by migrants' networks. In the case of Soubré, even though it was a Bete autochthon who was eager to promote the innovation within his ethnic group, it was the migrants who appropriated it. The testimony of all three chicken manure dealers, themselves mainly from Burkina Faso and Mali, confirms that their clientele consisted mainly of migrants from Burkina Faso and Mali, and later of the Baule. Whereas the 'social costs' factor hold back the autochthons, migrants can take advantage of the labour pool in their homelands and of



information networks across several economic spaces, including their villages of origin (see section 5). The beginning of this agro-ecological revolution is thus coloured by a social dimension.

Only the fourth hypothesis is not fully confirmed. Public research and extension structures as well as private companies have been conspicuous by their absence in this chicken manure boom in Côte d'Ivoire. However, public policies have had an indirect, though as yet unquantified, effect, one we believe to be determinant: while the relaying and repairing of roads and tracks has stimulated the agricultural economy in general, it has given a specific fillip to the use of chicken manure in the interior areas.

Nevertheless, some doubts were cast on this generally very positive assessment of the chicken manure innovation. At Soubré, agents of the national extension service have been discouraging the use of chicken manure, saying that its use causes cocoa trees to die. At Agnibilékrou, the main poultry centre, one of our observers, himself a chicken farmer, said the same thing. Is there any truth to these rumours? Can it be a problem with the soil? We undertook 60 exploratory surveys specifically on the adoption and limitations of chicken manure with 15 farmers per site, at Agnibilékrou, San Pedro/Grand Bereby, Soubré and Duékué/Guiglo. The first results are presented in sections 4 to 7, below.

#### **4. A process of agro-ecological intensification and its contradictions**

Of the 15 farmers interviewed in the vicinity of San Pedro, 10 explicitly mentioned the same problem: chicken manure attracts insects and causes diseases. According to them, for manure use to be successful, they have to apply insecticides a minimum of 2 times a year and also have to resort to fungicide treatments.<sup>1</sup> If they do not do so, farmers claim that their cocoa crop is subject to wilting of cherelles (intermediate stage between the flower and the pod), cases of black pod (pod disease caused by a fungus) and production of undersized beans (economically less profitable). A causal relationship between fertilization and black pod has been known for a long time in the case of chemical fertilizers. The most plausible explanation is the increase in amount of foliage, thus reducing aeration and favouring spores, and the increase in the number of pods per cocoa tree, thus leading to easier contamination from one pod to the next.

Of the 15 farmers surveyed near Agnibilékrou, only one, a president of a cooperative, confirmed having suffered high mortality of his cocoa trees 6 months after application of chicken manure, while another wanted to be sure and was awaiting the impact of an application in 2012. But the other 13 continued to apply manure in 2013 or 2014. They explained that the cases of tree death must have been caused by improper farming practices. Like the farmers in San Pedro, they insisted on the need for phytosanitary treatments and clarified that the manure must be applied up to a limited distance from the cocoa tree during the rainy season. A few also mentioned the need to prune the trees and the precautions to be taken regarding the dosage and type of manure: the more it has had time to ferment, the better is the quality.

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<sup>1</sup> This relatively recent adoption of the use fungicides in the late 2000s in Côte d'Ivoire is another technical change that the farmers themselves made. Even though this move was supported by the phytosanitary industry, public policy and the chocolate industry in Côte d'Ivoire were not involved.

The 15 farmers interviewed in Duékué/Guiglo propounded the same precautionary principles: phytosanitary treatments, including of fungicides, are a must. The data too confirm this advice. In Guiglo, 75% to 80% of farmers use chicken manure and the same percentage use fungicides, a proportion far higher than in the other regions surveyed. According to these farmers in Guiglo and Duékué, a farmer must prune the cocoa trees and not apply chicken manure in two consecutive years. He should also apply herbicides because the chicken manure also promotes grass regrowth. These detailed instructions are themselves evidence of the effectiveness of the manure: rich in nitrogen, its first impact is on the foliage growth, which increases self-shading by the cocoa trees and the growth of grasses, which in turn leads to increased moisture and pod rot. Another indication of local know-how: five farmers claimed that manure from laying hens was of better quality than from broilers, an observation largely confirmed by researchers' analyses (12).

In Soubré, the innovator, Mr Gabin, has come to his own conclusions. None of his neighbour-clients have experienced deaths of cocoa trees on their farms. To explain the rumours of increased mortality levels in Agnibilékrou, he offers three explanations. First, the soil factor cannot be excluded. Chicken manure is not necessarily suitable for all types of soils. Second, the rainfall factor: 'rain and chicken manure go together' since rain promotes flowering. But rainfall is generally less plentiful in Agnibilékrou as compared to the country's west. And, third, a probable lack of phytosanitary treatments because chicken manure indeed attracts insects. But farmers in the country's east take recourse to phytosanitary treatments much less frequently than those in the west.

In summary, these exploratory surveys highlight two key points. On the one hand, this agro-ecological innovation requires localized expertise. And, despite its imperfections and the obvious need for a support research programme – something that is acutely missed –, local know-how is very much present. Farmers have acquired expertise on their own through experience and their networks without any help from the research community, public extension programmes or the cocoa industry. On the other hand, the advent of this agro-ecological innovation is far from signifying the end of chemical inputs: even though the use of chemical fertilizers may not increase or may even decline, more pesticides, fungicides and herbicides will be required. Moreover, laying hens and broilers are not fed exclusively on locally produced maize. They are also fed industrial feed that complicates the life cycle of the chicken manure product or by-product.

## **5. A process of frugal innovation still under construction**

Of the 60 farmers surveyed, 45 claim that chemical fertilizers are more effective than chicken manure and they purchase the latter only because of economic reasons. However, they are not always able to clearly define the concept of effectiveness. For many of them, the criterion for effectiveness of chemical fertilizer, usually 0-23-19-5 (0% nitrogen, 23% phosphorus, 19% potassium, 5% magnesium), is the resilience it imparts to the cocoa trees over the long term.

But some dozen farmers, mainly in Guiglo and Soubré, claim that chicken manure is more effective precisely because it is fast-acting. Many of them referred to the impact of chicken manure on yields in 3 to 6 months after application, against 6 months to a full year for chemical fertilizers. Some farmers also mentioned the effect of chicken manure in improving the regularity of production and of spreading it out more evenly over the year, a key criterion for families that find income-free

months increasingly difficult to handle. The irregularity of production over the year is one of cocoa's biggest problems and a major factor in the adoption of rubber cultivation. Increased annual yields of 30% with the use of chicken manure, well-distributed across the year, were mentioned.

Our various trials with chemical fertilizers over the past few years confirm the good effects some of them have from the second year of application, but which are limited in the first year (13). However, we have not yet been able to undertake trials with chicken manure and we are unable to validate the reported impacts on yields. But the high levels of adoption of chicken manure in some villages indeed imply that this is a 'frugal innovation' in every sense of the concept: not only cheaper but, also in some ways, better with less.

## **6. Migrants' networks**

The chicken manure supply chain as well as the consumption of the product itself involves only migrants for the most part. Of the 60 adopters surveyed, 52 are migrants or locally born migrants, with a very large majority of Burkinabe and Malians. Although the proportion may seem low, it is important to note that 5 farmers claimed that they knew of chicken manure in their villages of origin, in Mali or Burkina Faso, where it was used on millet and vegetable crops, especially by women. A technology transfer has indeed taken place from one economic space to another within the West African sub-region through networks of migrants from Burkina Faso and Mali (14, 15).

Another mechanism for the dissemination of the innovation by migrants is linked to the politico-military crises of the 2000s. War displaced migrants from frontier areas between Duékué and the Guinea border. When they returned to their farms or those of their parents in Soubré or Daloa, they were confronted by the deterioration of the aging and poorly maintained cocoa trees and recalled the impact of chicken manure use in Duékué, the first major area of adoption. This transfer mechanism remains to be quantified but it seems to have helped accelerate the use of chicken manure in areas between Soubré and San Pedro.

Surveys confirm that the innovation is being disseminated through networks of friends and relatives, usually within the same ethnic group, but not exclusively. Nevertheless, Burkinabe and Malian networks of both sellers and buyers appear to have played significant roles in the overall development of the village plantation economy of Côte d'Ivoire, with a continuous rise in power and influence of these 'people from the north'.

## **7. Involvement of the public and private sectors through cooperatives and certification**

The cocoa industry is actively involved through its support for cooperatives and a mass certification programme. If farmers agree to follow specifications on agricultural practices and environmental and social criteria, the system implemented by international NGOs trains them in these good agricultural practices and promises incentives.

In any innovation system which involves several actors upstream and downstream of producers, the role of cooperatives is open to question (16). According to our investigations, none of the cooperatives have played any role whatsoever in the chicken manure innovation. Indeed, several of

them had started getting involved instead in the distribution of chemical fertilizers. Faced with soaring fertilizer prices in the late 2000s and early 2010s, cooperatives organized themselves, sometimes with the support of industry. In order to retain their existing farmer-customers or to attract new ones, they began providing fertilizer on credit, often in conjunction with certification programmes. But as cooperatives obtained certification, they did not always pass on the incentives to farmers, or paid them only in part. Farmers who had obtained loans for fertilizer purchases then refused to repay them until the cooperative honoured its commitments. The system is fragile and may collapse any time. Can't we consider the transition from fertilizers to chicken droppings in some villages due to the defaults in the payment of incentives as a form of rejection of the 'Industry-Certification Agency-Cooperative-Farmer' system or as an adoption of an alternative to this system? And by cooperatives, we must also include the many so-called 'cooperatives' created by "traitants" (middlemen) and big "pisteurs" (trackers working for middlemen) in order to capture the certification incentive. This technical innovation is indeed associated with a social and institutional dimension.

## **Conclusion**

While this exploratory paper throws light on an impressive innovation that rural society discovered on its own, one that concerns a village plantation economy undergoing profound transformation, it also highlights many outstanding issues. Lacunae in knowledge on the innovation's short and long-term impacts call urgently for the involvement of the public and private sectors in this new innovation process – without waiting for years as they did for chemical fertilizers.

Regarding the first point, we have to emphasize how impressive this innovation truly is. Until the early 2000s, organic fertilization was completely unknown – or at least totally neglected – by cocoa farmers in Côte d'Ivoire and its neighbouring countries. In 2000, in a sample of 500 farmers, only 4 used organic fertilization in the form of cow manure to replant some cocoa. Now, at the beginning of 2015, while awaiting the results of our latest survey, we estimate that about 30% of farmers have purchased or ordered chicken manure. An innovation and an entire sector have been created without a single FCFA having been spent by the State or the private sector, let alone the chocolate consumer. No doubt more research and demonstrations are necessary, but we still cannot help comparing this result with the limited and questionable impacts of certification and 'good agricultural practices' on cocoa yields (2). Public sector institutions and much of the private sector still have to learn to better recognize the knowledge and innovation originating from villages and villagers. From this chicken manure case study, we can see that the farmers of Côte d'Ivoire help the chocolate multinationals as much as they are helped by them.

On the second point, among the many gaps of knowledge that have to be filled, it suffices to note the following paradox: according to the farmers, cocoa responds faster to chicken manure than it does to chemical fertilizer. It is obvious that agricultural station trials and participatory research in the villages need to be conducted urgently.

Despite the outstanding issues and while awaiting more quantitative proofs, the three major hypotheses to characterize this boom, market-related 'frugal innovation', 'agro-ecological intensification associated with social change', and 'innovation of migrants' networks' are validated.

The fourth hypothesis, on the role of public policy, finds a response in the State's investment in the rehabilitation of roads and tracks (with the help of funding entities such as the French Development Agency (AFD)). Indeed, this is a very interesting observation of this case study as it illustrates well the adage of Louis Malassis, Professor of Agricultural Economics in the 1970s and 1980s: 'There are no agricultural solutions to agricultural problems.' The idea is to let farmers take care of agriculture and to help them indirectly by creating an enabling environment for their activities.

In fact, in addition to chicken manure, Côte d'Ivoire is host to a proliferation of initiatives and innovations on all forms of organic fertilization: cattle manure, sheep manure, pig waste as well as household waste. We even identified 2% recovery of human waste from village latrines. The latest innovation, and one that is spreading fast, is the use of palm frond ash. And this multiplicity of farmer innovations concerns much more than fertilization. We have also observed examples of farmer insights and imagination to reduce the use of herbicides and even pesticides. For example, the agroforestry-based innovation of the reintroduction of trees in cocoa plantations – a rare case of an innovation that has spread over thousands of hectares –, in the form of cocoa-cashew interplanting throughout the forest-savannah contact zone – and occasionally further south – has largely taken place on the initiative of smallholders. It has been observed across countries that very often agricultural innovations are disseminated by villager networks, with no involvement of development institutions (17). For decision makers and development agents of the public and private sectors, this quasi-universal reality is hard to accept. Through their innovations and adaptations to changes in economic and ecological environments, smallholders show themselves to be often ahead of the public institutions, multinationals, and international NGOs. Even though the so-called world of sustainable development, as represented by the public and private sectors, puts in a real effort in this Ivorian plantation economy in profound mutation, does it not need to reflect on why it is always lagging behind?

## References

(1) See two articles on certification of cocoa on the Inter-réseaux site (in French)

<http://www.inter-reseaux.org/ressources-thematiques/article/forum-certification-du-cacao> and

<http://www.inter-reseaux.org/ressources-thematiques/les-notes-d-inter-reseaux/article/penurie-de-cacao-agro-industrie-et>

(2) Ruf F, 2012. *Adoption of fertilizer in cocoa farms in Côte d'Ivoire*. 17th International Cocoa Research Conference. COPAL, Yaoundé, 15-20 Oct 2012.

(3) Similar 'frugal' innovations take place in European societies in a crisis of declining purchasing power of the middle class. Industrial entrepreneurs innovate at low cost while maintaining or improving quality. In particular, see the 'success story' of low-cost vehicles developed by Renault in the book by Navi Radjou and Jaideep Prabhu (2015). *Frugal innovation: How to do more with less*. Economist Books.

(4) Among the founders of this approach, under the term 'double green revolution', are Griffon M and J Weber, 1998. 'Economic and institutional aspects of double green revolution. Development of Research network for Natural Resources', *Environment and Ecology* (USA). 9 (4):39-42.

(5) Les Echos of 20/02/2015. Michel Griffon restates that *'the agriculture of tomorrow will be ecologically intensive.'*

(6) For example, in the late 1970s and early 1980s, migrants, mainly of Burkinabe origin, were the first to replant cocoa in old coffee plantations, an agroforestry technique that marked a break with the usual strategy of clearing of primary forests. The networks of these migrants facilitated the dissemination of information and the financing of the purchase of old coffee plantations. This too is an example of a market-driven innovation. (Ruf F, 1981. « Le déterminisme des prix sur les systèmes de production en économie de plantation ivoirienne ». *Cahiers du CIRE* (28-29): 35-52).

(7) One of the first research studies in Côte d'Ivoire to formalize the importance of migrants' networks in innovation processes is the thesis of R. Balac.

Balac R, 1998. « *Gens de terre, gens de réseaux : mécanismes de production et lien social. Pour une nouvelle perspective de l'économie de plantation en Côte d'Ivoire* ». Doctoral thesis in Economic Demographics. Institut d'Etudes Politiques de Paris. 276 p.

(8) In the diffusionist model, an innovation is analyzed by the speed of its adoption by individuals within a population, regardless of its construction. The diffusion follows an S-curve: at the beginning are a small number of adopters who take the risks, the 'innovators' (2.5%), followed by the 'early adopters' (12.5%), then the majority, and finally the latecomers. [Rogers M.E, 1971. *Diffusion of Innovations*, 3<sup>rd</sup> edition, The Free Press, New York]. In this case of chicken manure adoption by cocoa farmers, we would be in the innovators phase at the beginning of the 2000s, that of the early adopters in 2012, and that of the majority in 2015.

(9) This phenomenon of dissemination under conditions in which the supply chain is profitable for the intermediaries is a major aspect of a 'frugal innovation'. Other aspects include the concepts of construction and modification of the innovation by several interacting actors, including distributors. These approaches are lacking in the diffusionist model, a criticism made by several sociologists in the 1990s, most notably Akrich, Callon, and Latour. For example, see Akrich M, 1993. « Les formes de la médiation technique », *Réseaux*, 60, 87-98.

(10) Ruf F, 2010. « *Les zones forestières et la lente intégration de l'élevage dans les exploitations de cultures pérennes. Ghana, Côte d'Ivoire et Indonésie* ». In: *Systèmes de production et durabilité dans les pays du Sud*, B. Thibaud and A. François (eds). Paris, Karthala: 169-190.

(11) Among the many factors behind the growing economic dominance of migrants over the autochthons, the 'social costs' factor cannot be overlooked. Heads of autochthonous families form part of a social network that glorifies the values of solidarity and redistribution, especially through the funeral ceremonies. The autochthonous cocoa farmer, residing in his village cannot escape the pressures or the obligations of this network, either in time or in expenses. In contrast, migrants, especially younger ones, far from their villages of origin, can avoid social pressure and find it easier to concentrate on their cocoa farms. Indeed, looking beyond scholarly articles, one can find a perfect illustration of this process in Venance Konan's novel (in French): *Les Catapillas, ces ingrats* ('The Caterpillars, Those Ungrateful Ones') (published by Jean Picollec, 2009). In the eyes of the autochthonous chief, the hard-working 'caterpillar' is, of course, the migrant from Burkina Faso who can clear 2 to 3 hectares of forest in a few weeks.

(12) Chabalier PF, Van de Kerchove V, Saint Macary H, 2007. Guide de la fertilisation organique à La Réunion.

| Voir les fiches sur la fiente, tirées de ce guide :

[http://www.mvad-reunion.org/FCKeditorFiles/File/fiches/fum\\_poulet\\_chair.pdf](http://www.mvad-reunion.org/FCKeditorFiles/File/fiches/fum_poulet_chair.pdf)

[http://www.mvad-reunion.org/FCKeditorFiles/File/fiches/fiente\\_poule\\_pond.pdf](http://www.mvad-reunion.org/FCKeditorFiles/File/fiches/fiente_poule_pond.pdf)

(13) Ruf F, Bini S, 2012. 'Cocoa and fertilizers in West Africa.' <http://agris.fao.org/agris-search/search.do?recordID=GB2013201578>

(14) While many studies exist on the use of crop residues and manure from different livestock species in the Sahel, none mention chicken manure explicitly. For example, see Blanchard *et al.*, 2014. « Diversité de la qualité des engrais organiques produits par les paysans d'Afrique de l'Ouest : quelles conséquences sur les recommandations de fumure ? » *Biotechnol. Agron. Soc. Environ.* 18 (4): 512-523.

(15) While farmers in Mali and Burkina Faso have been using organic manure for a very long time, they have not adopted the use of chicken manure due to the relatively small number of industrial poultry farms in these countries. Just like in Côte d'Ivoire, rising fertilizer prices in the late 2000s also helped boost the adoption of organic manure in Burkina Faso (Patrick Dugué, pers. comm., April 2015).

(16) Spielman D.J, Ekboir J, Davis K., 2009. 'The art and science of innovation systems inquiry: applications to sub-Saharan African agriculture', *Technol. Soc.* no. 31, p. 399-405.

(17) Neilson J, 2007. 'Global markets, farmers and the state: sustaining profits in the Indonesian cocoa sector', *Bulletin of Indonesian Economic Studies*, 43 (2): 227-250.