

Cocoa: From Deforestation to Reforestation

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In addition to non-agricultural factors such as logging and mining and other crops, cocoa has been an important agent of deforestation for centuries and especially during the twentieth century. For hundreds of years, farmers have been using the world forest as a production factor and the system proved to be fairly defensible. Except in some countries like Brazil where cocoa plantations were concentrated in few hands, cocoa distributed wealth and sent millions of children to school. In some countries like Ghana and Côte d'Ivoire, cocoa migrations were a basic tool for building a multiethnic society. Forest consumption also helped to make chocolate relatively cheap and affordable for consumers. However, it generated externalities in terms of loss of biodiversity and damage to the environment. More important, it often backfired on producers themselves, who have been exposed to boom-to-bust cycles and recessions as a result of too-rapid migration and deforestation.

There are some signs that this may change in the twenty-first century. The main hypothesis is that at least in countries which are severely deforested but still have limited alternatives to agriculture, farmers have little choice but to replant and try to grow cocoa on fallows and grassland instead of forest. These constraints are hard but are also enhancing creativeness and innovations among smallholders. By combining cleverness, labour, trees and agroforestry techniques, fertilisers and chemicals at various levels, farmers in Indonesia and Côte d'Ivoire are increasingly capable of growing cocoa independently from forest (Ruf, Konan, Ardhy 1995). Although this may pose other problems, another hypothesis is that the declining prices of a number of inputs also favour the change. By combining and diversifying tree crops, producers may even increase the acreage of cocoa cultivated by 'sustainable agroforestry systems'.

Our hypothesis is that 'green revolutions' or 'double green revolutions combining high yields and an improved sustainability (Griffon, 1997) may be on the way when farmers

no longer have access to forests and if they are encouraged in this direction by commodity prices. This may well apply to a number of tree-crops world-wide, including cocoa.

In short, the main objective of this paper is to show that under certain conditions cocoa may switch from a status of deforestation agent in the twentieth century to a reforestation agent in the twenty-first. In the meantime, less dependency upon primary or secondary forest probably means more sustainability in terms of yields, life-cycle of the cocoa farms and thus in revenues and the livelihood of families. This paper explores ways of attaining these goals.

After a look at the 'forest rent' and its impact on cocoa cycles by interacting with price, social and political factors (Section 1), we rapidly explore a possible 'post-forest rent' era which would represent a gap in cocoa yields and intensification level, and possibly in sustainability (Section 2). We then review recurrent choices and changes in shade management throughout the world and hence a concept of "shade cycles" (Section 3). This is followed by an analysis of other determinants of the 'shade/no- shade' options. Planting material, plantations versus smallholdings and migrants versus autochthons (Section 4). Then come the proposals (Section 5) How can long term yields and the livelihood of small scale producers be improved while minimising environmental degradation?

COCOA CYCLES AND "TREE-CROP SHIFTING CULTIVATION"

Cocoa is one of the major world tree-crops to be characterised by shifts of production from one country to another, from Mexico to Central America in the sixteenth century, the Caribbean in the seventeenth, Venezuela in the eighteenth, Ecuador and then Sao Tomé in the nineteenth, Brazil and Ghana and Nigeria in the early twentieth century, followed by Côte d'Ivoire. Although Africa remains quite strong in the late 1990s, and although the Malaysian surge was one of the shortest boom-to-bust cycles in the world cocoa history, Asia remains a potential candidate for the twenty-first century, mainly in Indonesia and possibly in Vietnam and neighbouring countries.

Cocoa is not the only 'shifting perennial crop'. During the twentieth century, rubber supplies have moved from Amazonia to Asia and oil palm from Africa to Asia. Brazilian and Côte d'Ivoire coffee also hide shifts of production from one region to another within each country.

All these tree-crop booms have mainly occurred throughout the world by a combination of massive migrations and deforestation. One of the reasons is that the available land is usually sparsely populated forest. There are also economic advantages in growing a crop after forest clearing, and this can be interpreted as a 'differential forest rent'. The shift of production observed from one country to another is partially related to this thirst for land and forest rent.

Forest rent and the biological basis of cocoa cycles

When trees grow older and when forest has been massively cleared, cultivation becomes more difficult. Farmers have to face more weeds, more pests and diseases, lower soil moisture content and fertility, physical erosion, more wind, possibly disturbed rainfall patterns, at least less effective rainfall, less timber resources which may increase housing costs and less game resources, thus increasing the cost of living and the labour costs.

In short, forest rent has vanished. Weeds, pests, loss of fertility, lower yields and shortened economic life mean more labour and inputs, thus a higher average production cost. The older the tree, the higher the costs, constituting the first difficulty in replanting. If the farmer waits too long before taking the decision, he cannot face replanting costs. This is one of the endogenous factors in boom-to-bust cycles.

There is also a higher investment cost in replanting. Tree growth is less rapid, also requiring more labour and inputs, hence a higher investment cost. This is the second difficulty of replanting and these factors form the 'biological basis' of the replanting problem which partially explains regional shifts of cocoa supply. Producers seek lower production costs and first of all a lower investment cost.

The 'differential forest rent' applied to cocoa is defined as the difference in production cost and investment costs between a tonne of cocoa produced in a farm established just after a forest was cleared and a tonne of cocoa produced by replanting on fallow land or after felling of the first plantation (Ruf 1987, 1995).

The investment phase

The notion of forest rent also applies to food crops intercropped with cocoa. Without forest rent, the return on food crops decreases during the investment period, limiting the cash flow and limiting the chances of obtaining inputs. This also handicaps the replanting of cocoa (Ruf 1988, Temple and Fadani, 1997).

For instance, in the Sulawesi uplands in Indonesia, considering that all the labour is assessed using an average opportunity cost, gives a difference in investment of some \$414 per ha (Table 1). In relative value, this represents a *near doubling of the overall investment cost*. This corresponds to smallholders' observations: 'you have one hectare of cocoa after grassland and two hectares after forest'. This shows one of the main 'laws' of replanting. At the critical phase of the investment, replanting requires either capital or extra labour.

The mature phase

The great majority of Sulawesi smallholders consider that a cocoa plantation in the hills after grassland, which does not benefit from forest rent, requires more maintenance and fertilisers. This is illustrated by results drawn from farm budgets (Table 2). The cost of production in the hills, including depreciation, is evaluated at approximately 36 cents per

kg in plantation after forest and 46 cents per kg after grassland (Table 2). Application of the precise definition of 'differential forest rent' to cocoa in the Sulawesi hills in 1997 results in a figure of approximately 10 cents per kg. The disappearance of this rent therefore increases the average production cost by 30%. The figure would probably approach 50% if all the risks of failure were included. In short, one attains + 80% to + 100% at investment and at least + 30% during the production phase.

The economic, social and political bases of cocoa cycles

In addition to this forest rent and bio-ecological basis of cocoa cycles, there are social, economic and political bases which cannot be examined in detail here and are mentioned rapidly-. Price and non-price factors strongly interact (Fig. 1).

Figure to be posted later

A major social component of the model is the *family life cycle* which interacts with the *tree life cycle*. Farmers and their trees grow older together. When replanting time comes, the farmers are old and lack a labour force, especially if they sent their children to school. If they wait too long, they also face declining yields and returns at the very moment they need to invest cash and labour in replanting. In addition, family size and consumption have increased. Heads of households are 'squeezed' and hence there is a new, urgent need for credit, farmers' organizations and technical innovations.

Another major socio-economic component is the evolution of land ownership during the cocoa cycle. In most cases, at the very beginning of the boom, land is cheap and easily acquired by migrants. Land is becoming scarce 20 or 25 years later and is a source of increasing conflicts between autochthons and migrants, and possibly between generations within both groups. These land tenure problems may trigger local cocoa recessions.

The major economic component is the frequent sudden price slump almost 'planned' by too rapid migration and investment in new cocoa plantings and which worsen the situation 20 years later.

Political issues consist of the recurrent temptation to maintain or even increase taxes when cocoa prices are falling and to reduce foreign labour. These are the two typical ways of killing the goose which lay the golden eggs.

All these factors strongly often interact over a period of 25 years which is more or less the sequence of international price cycles (for more details, see Ruf and Siswoputranto 1995 and Ruf 1995). These cocoa supply cycles and shifts of production from one region to another would occur even at even price levels. The principle of production costs increasing with tree ageing and deforestation is sufficient to trigger new migrations and new plantings rather than replanting, without the influence of price (upper part of Fig. 1). Then, of course, the price factors enhance the mechanism and accelerate the shift of production (lower part of Fig. 1). Thus calculations of price-elasticity are often over-estimated. They include 'hidden' non-price factors.

This principle works as long as forest is cheap and available and as long as other inputs are costly. A change in access to forests and a change in price ratios help to modify farmers' decisions and behaviour.

POST-'FOREST RENT' COCOA FARMING

In the 1990s, Sulawesi smallholders seem to be demonstrating that the loss of the forest rent can be overcome in terms of yields, possibly not in upland conditions but at least in the plains, with rich alluvial soils. With 500 to 600 kilograms of fertiliser per hectare, high quality pruning, and a reasonable amount of cheap pesticides, they easily harvest 2,500 kilograms of dry cocoa beans per hectare with no shade or limited shade. What we do not know is for how long they can maintain this yield level. Some 20-year old farms still seem to be doing very well while others already show signs of exhaustion.

In addition to the advantage of having rich soils and a sudden devaluation which made producer prices rocket in local currency, these first signs of yield decline may be one of the reasons why Sulawesi smallholders keep on clearing and planting. This should rapidly bring Indonesia to the threshold of 500,000 tonnes of cocoa per year. However, they also are more and more interested in replanting cocoa after clearing grassland and other supposedly degraded land, including land encroached with *Imperata cylindrica*. The low cost of fertilisers and herbicides (especially Round-Up), which is approximately three times cheaper than in Côte d'Ivoire, also plays a role.

Despite much higher costs of fertilisers, pesticides and herbicides, Côte d'Ivoire smallholders as well as those in south-west Cameroon may also pave the way for a new future of intensive cocoa farming in West and central Africa.

In south-west Cameroon, some farmers no longer hesitate to control the serious problem of *Phytophthora* infestation by spraying fungicides 12 times a year. This leads to yields of around 1,000 to 1,200 kg/ha (Varlet and Berry, 1997:87-88). In addition, they seem to be performing high quality pruning. This trend of new plantings in the south-west was triggered before market liberalisation but intensification and wide use of inputs were encouraged by the reform-driven increase in cocoa prices paid to producers.

In Côte d'Ivoire, large parts of the Soubré orchards were already 25 years old and on the decline in the mid-1990s. However, an external factor has limited the 'bust' trend for the moment: new, unexpected adoption of fertiliser is enabling an increasing number of farmers to delay the mortality of trees and the slump in yields (See Section 4).

With their backs to the wall, migrants have had to innovate. They started looking for fertilisers. The very beginning of the initiative came from relatively big farmers in the 1980s. Fertiliser adoption then soared in 1994 with the re-launch of the whole marketing chain of cocoa and the apparent increase in cocoa prices after devaluation, jumping from CFAF 200 to 240 per kg in January 1994 and then to 310 in November 1994. This happened despite a near doubling of fertiliser prices. The sudden 1997 price jump to CFAF 455 tremendously increased demand.

In the meantime, not only in Soubré region but in the whole Côte d'Ivoire, smallholders are beginning to resume pesticide purchases. Our latest observations also confirm the trend for replanting cocoa after *Chromolaena odorata*. All in all, and despite increasing signs of new *Phytophthora* infestation, an annual Côte d'Ivoire threshold of 1,500,000 tonnes seems in view. Despite possible delays in the impacts of market liberalisation, the coming reform should shore up this hypothesis. These findings and hypothesis raise three to four related issues.

a) Is it reasonable to have so much cocoa in a small country, including from the point of view of that country? The 'cocoa cycle model' may strike back. Technical progress may not be sufficient to avoid recessions, including massive outbreaks of old and new diseases. Previous cases of too much dependency on cocoa reminds Côte d'Ivoire that it also need to accelerate its tree-crop diversification.

b) Integrated Pest Management methods seem promising. However, with regard to cocoa, as long as they only seem promising, reasonable use of chemicals seems unavoidable.

c) Some observers may worry about the use of chemicals. However, inputs such as herbicides may help to save thousands of hectares of tropical forest. By making grassland more attractive to cocoa replanting, herbicides help to modify Sulawesi smallholders' choices. Not in the hills but in the plains, most of them would take grassland rather than forest land for planting cocoa if they are offered the alternative.

d) A combination of tree-crops and chemicals is relatively friendly to the environment. Replanting cocoa after *Imperata cylindrica* only requires herbicide application for two years. The cocoa trees subsequently form a canopy that generally normally protects the soil and controls weeds.

Cocoa alone is sometimes not sufficient. There is a need to benefit more from trees as biological capital and combine its properties with other inputs. That is why more and more Sulawesi cocoa farmers use agroforestry techniques to replant cocoa after *Imperata cylindrica*. They frequently use *Gliricidia*, at least as a provisional shade tree.

SHADE AND AGROFORESTRY MANAGEMENT RELATED TO COCOA FARM LIFE- CYCLES

Cocoa comes from the tropical forest and has long been cultivated under heavy shade. With a few exceptions, the main objective was *not to maintain biodiversity* but to *lengthen the economic life* of the cocoa tree, seen as a shade-loving tree. Another good reason was the technical difficulty of cutting down large trees. Twenty years ago, chain saws were still extremely rare in the cocoa world. Eventually, the idea was also to keep some 'food trees' in order to provide ready food for farmers and workers, which is a component of 'sustainability'. Jackfruit played this key role in countries such as Brazil and Sao Tomé.

At least since the beginning of the twentieth century, and probably before, farmers and scientists discovered and rediscovered that cocoa yield much more without shade. The tree responds to light. Others argued that the life-cycle of cocoa farms was shortened. Some chose the middle road and considered that it depended on local conditions. "The golden rule is that there is no golden rule' (Knapp 1920:40). However, at least during the twentieth century, from Trinidad to Malaysia, agronomists and research institutes, extension services and agricultural policies have been divided, have changed their recommendations and have promoted 'full sun' systems before opting for shade trees again. The same fight and stories have been repeating themselves from one country to another, sometimes without much being gained from previous experience.

With regard to 'shade trees', mature cocoa farms established after forest clearing can be classified in five to six types:

- a/ Selected jungle trees saved by selective cutting and partial burning. In this case, the shade trees form a stratum 20 to 40 metres above the cocoa groves.
- b/ Spontaneous and selected regrowth of jungle trees previously cut down (and burnt but the fire does not destroy the entire root systems). The shade stratum is much lower than in the previous case.
- c/ Trees planted by farmers. The most frequent are leguminous trees supposed to have a positive impact in terms of shade and nitrogen supply. One of the most famous is *Erythrina indica* nicknamed '*el madre del cacao*', 'Mother of cocoa' in Central America and the Caribbean.
- d/ Tree-crops such as various fruit trees planted for direct agriculture and economic purposes but which may also provide some shade and wind breaks to cocoa.
- e/ Bananas and plantains which are supposed to provide only temporary shade to young seedlings but in a number of situations mats regenerate every year.
- f/ 'Zero shade' systems or strict monoculture after complete forest clearing and regular elimination of any shoots during weed control.

If agroforestry is defined as a combination in space and time of at least two tree species or even one tree and one annual crop, the first five systems can be said to be 'agroforestry systems'. Only the sixth would be pure monoculture. However, the frontier between monoculture and agroforestry and between no shade and shade is far from obvious.

During the immature phase, most cocoa farms are intercropped with paddy, maize, yams, taros, cassava, bananas, etc. These food crops provide shade for cocoa seedlings. Nobody challenges the need for a degree of shade for young cocoa trees. At the beginning of its life-cycle, a cocoa farm is almost always an 'agroforestry' system.

Secondly, during the mature phase, there are plenty of intermediate forms between 'monoculture' and 'agroforestry'. European plantations in Côte d'Ivoire in the 1930s and Malaysian estates in the 1980s were often surrounded by one row of leguminous trees. It is the 'box system' concept to protect cocoa against winds. It lies between 'agroforestry/shade' and 'monoculture/no-shade'. Although it may be called 'agroforestry', it has nothing in common with some old and highly complex agroforests in Bahia, Brazil.

Thirdly, the status of plots as "with shade/without shade" and "monoculture/agroforestry" are reversible. Less maintenance and ageing of a pure monocropping farm in Côte d'Ivoire may rapidly turn it into a 'spontaneous' agroforestry system of cocoa mixed with oil palms. Thus, although the concept of agroforestry may apply to a combination of trees in time, monoculture or 'zero-shade' cocoa may well be part of an agroforestry system and part of a shade cycle. Our hypothesis is as follows.

At the beginning and at the 'end' of a cocoa tree cycle, shade and agroforestry are necessary to lengthen this cycle. However, during an intermediate phase, at least under certain favourable ecological and economic conditions, *a monoculture phase may make sense*. Some producers may not be interested in a long-term objective of lengthening the life-cycle. In this case, the problem and solution do not lie in shading techniques but in institutional aspects (see next section). Secondly, high yields and quick returns improve the farmer's livelihood. However, according to our 'cocoa cycle model', part of the 'favourable ecological and economic conditions' are related to the forest atmosphere and the pioneer stage. Some of these conditions are lost after a number of years of clearing and new plantings.

The difficulty is thus that of reintroducing shade and agroforestry in time, before the farm and the whole region is struck by climatic and/or economic changes. In some cases, if the regional environment is not too degraded, the temporary abandonment of the farms enables 'agroforestry' to take over from 'monoculture'. It might be a strategy of 'tree-crop shifting cultivation' which is a perfect example of agroforestry management in time: let forest trees regrow for 5 to 20 years before clearing the farms again and replanting. This was perfectly understood by Blanckenburg in the 1950s and Ruthenberg in the 1970s:

"Perennial crops may be followed by a lengthy forest or bush fallow. Thus old cocoa plantations in West-Africa revert to bush vegetation, which is then cleared after one or two decades. The rotation runs: fallow-food-crop farming-cacao-fallow (von Blanckenburg 1964, p.38)" (Ruthenberg 1980, p. 269).

However, the 'ideal' situation of ecological balance between tree-crops and forest does not always work. Among 'perennial long-term rotations', Ruthenberg mentions many other types of 'rotations' including those which lead to the development of grassland.

"Perennial crops may be followed by grassland. Thus in southern Brazil old coffee plantations are chopped down and the ground becomes covered with grass and serves as rough pasture. In tropical high-rainfall areas, an even more negative sequence can be

observed: exhausted coffee plots gradually turn into fields of useless *Imperata* grass." (Ruthenberg 1980, p. 269).

This observation clearly shows the relationship between micro-economic management of tree-crops and shift of supply and plantations at national and regional scale. It applies to coffee quite well in countries like Brazil and Côte d'Ivoire and it also applies to cocoa in many countries.

We believe that the ideal balance between cycles of cocoa farms and forest regeneration - in short the ideal principle of shifting cultivation applied to 'perennial crops'-- only works when the population density remains relatively low. As all types of 'shifting cultivation', the ecological balance no longer works when migration is too rapid and the land taken over too quickly. However, after a number of years, migrants may rediscover the problems triggered by too rapid deforestation and reconsider their strategies with regard to clearing techniques and various types of shade.

In short, even if we agree with Knapp that "the golden rule is that there is no golden rule" and that rules vary according to local conditions, there is a trend in the life-cycle of the cocoa farms and in the life-cycle of migrants (and their children) and their acquired experience of cocoa. This hypothesis is reviewed through literature about Trinidad and Grenada, Brazil, Côte d'Ivoire and the former Gold Coast. This review is reported in Annex 1.

Our observations in Côte d'Ivoire and Indonesia as well as reports in the literature lead us to the following conclusions. Beyond differences of rainfall patterns and soils which can partially explain choices between shade and no-shade,

a/ 'Zero shade' is nothing new and not directly related to the development of 'hybrids' since the 1960s. It was invented perhaps in the nineteenth century and probably much earlier.

b/ Whatever the rainfall, zero-shade seems to be a recurrent temptation. Its positive impact on short-term yields is periodically rediscovered in every cocoa-producing country.

c/ Most planters, smallholders, agronomists and extension services fall victim to its attractiveness one day.

d/ Whatever the original rainfall pattern, these features seem to confirm a long-term negative impact of 'zero shade' in comparison with well-shaded cocoa. It shortens the life-cycle of cocoa farms. Rainfall distribution and the general ecological environment seem to suffer more damage. (Many other examples could have been given in Ghana, Sao Tomé, etc. See, for instance, Navel 1920, Lass and Wood 1985, Ruf 1995, Leonard and Oswald 1996).

e/ After a certain experience of these negative effects, there is a tendency to diversify with food crops and other tree crops and also a trend towards staying in cocoa by reintroducing shade, agroforestry and thus biodiversity.

f/ The tree regrowth and 'agroforestry' trend sometimes reflects only a temporary abandonment of the cocoa farm. It may be voluntary or not.

In short, at least under certain conditions of soil and/or rainfall patterns, some heavy shade systems have been able to produce cocoa for 60 to 80 years, with spontaneous and encouraged coppicing. This line of work should be explored. However, reports mentioned in Annex 1 also lead to another concept.. It may make sense to play with a short cycle. This idea is nothing new either.

"The effectiveness of permanent shade for mature cocoa is debatable... I could not see clear differences in the sturdiness of cocoa growing unsheltered and that sheltered by trees left during the forest clearing. However, as cocoa plantations should not live more than some twenty years, native people should be encouraged to intercrop cocoa with other trees, every 15 meters, for instance with oil palms, colas and avocados which provide them with valuable produce when the main crop disappears." (Vuillet 1925).

Such a strategy would not mean that cocoa supply would remain unsustainable at the scale of a whole region or country. The idea is that of a rotation and a shade/agroforestry cycle. After a short phase of temporary shade at the immature stage, cocoa trees are left without shade for a few years and then the regrowth and introduction of new trees is favoured by the strategy of converting the cocoa farm into a productive agroforestry system. In turn, when this agroforestry system is making sufficient biomass, including trees which can be sold as timber, it could be cleared and planted with cocoa again. Such an agroforestry strategy copies and improves the 'shifting cultivation' concept which also allowed agriculture to return to the same place after a period of several years. In fact, agroforestry strategies are undertaken when the original agroforestry techniqueshifting cultivationdoes not work any more. Trees need to be reintroduced in a cocoa farm when there are no more jungle trees around the cocoa farm. Otherwise, in the middle of a jungle, a zero-shade cocoa farm thrives. This is one of the main reasons for the existence of this 'shade cycle' in most cocoa-producing countries.

OTHER DETERMINANTS OF SHADE/NO SHADE OPTIONS

Planting material and hybrids

Although zero shade systems were already implemented with Amelonado types and various other Forasteros, they were enhanced by the switch to Upper Amazons and hybrids which started in Ghana in the 1950s and accelerated everywhere in the 1970s. Meanwhile, the upper Amazons types, with their shorter immature phase and vigour,

enabled the planting of less suitable soils and made cocoa more attractive. They accelerated migration and thus enhanced the strength of cocoa booms, especially in Côte d'Ivoire.

For instance, Baoulé migrants who launched their cocoa migration to the central-western region in the mid to late 1960s planted Amelonado up to 1973. They then adopted upper Amazon varieties introduced from Ghana and hybrids (F1 and many F2, F3, etc.) bred by Côte d'Ivoire Research and extension services. They were all called 'Cacao Ghana'.

In the late 1980s/early 1990s, Baoulé smallholders experienced the first high rate of mortality of cocoa trees with Amelonado types. Planted without shade, Amelonado survived for 20 years. In the mid- 1990s, Upper Amazon and hybrids started dying as well.

In Côte d'Ivoire, without shade and without fertilisers, hybrids may not survive much longer than Amelonado. Under shade, in relatively good soils, Amelonado may live for 50 to 60 years and we do not yet know how long hybrids can survive. However, a number of farmers in Côte d'Ivoire and Ghana express their confidence. They stress the vigour of the hybrids and say that with fertilisers, pesticides and herbicides, they can lengthen the cocoa life-cycle and replant.

[Fertilizers, pesticides, herbicides ... Protected forests and cocoa prices](#)

In Côte d'Ivoire, in the Soubré region, the recent adoption of fertilisers has clearly played a decisive role in the sustainability of cocoa farms. Because of its stony soils, this region had been classified by researchers as unsuitable for cocoa. In the early 1980s, it became the country's new cocoa belt. Migrants rushed to the region in tens of thousands. In the early 1990s, a huge number of households were already suffering declines in yields and high increases in tree mortality. This was not only related to the price slump. Poor soils accelerated the local cocoa cycle; 15-year old trees looked like 30-year trees in the eastern region. In the mid-1990s, many farmed plots had already disappeared but others were saved just in time by fertilisers. The recent increase in producer prices to 450 CFAF from 320 is tremendously accelerating the adoption of fertiliser and giving new impetus to the region.

At first sight, this might not look very satisfying in terms of biodiversity but it is indeed! Farmers stopped leaving the old farms and looking for new virgin forest. This is an 'earthquake' which did not happen in this region by chance. Firstly, the soils in the region were so poor and the life-cycle of the cocoa farm so short that it made the migration investment meaningless. After only 10 years instead of 25 years, it was less easy to give up and restart a cocoa cycle elsewhere. The farmers had their backs to the wall and had to innovate. Secondly, 1988 was the official 'forest year' and forestry services started to be more active than before. Rumours about difficulties in protected forests spread. This was new. Thirdly, had the price not been increased in current terms in 1994 and in real terms

in late 1997, most farms would have been unable to buy fertilisers and the Soubré region would have already disappeared as a cocoa belt.

In the meantime, similar innovations spread in totally deforested regions, where forest had been converted into cocoa, coffee and food crop farms and where many of these farms switched to *Chromolaena odorata* fields. Replanting started. Cocoa trees gaining some ground on *C. odorata*. Associated trees are quite useful in preventing *C. Odorata* from growing too quickly.

To a certain extent, the high prices paid to Sulawesi smallholders also account for the intensive use of fertilisers and labour devoted to pruning. Both increase the cocoa life-cycle. There are lessons to be learnt from this.

a/ When primary forests become scarce, they need to be totally protected and this protection should be much-publicised.

b/ If forests are not protected, a sudden cocoa price increase will lead to more deforestation. However, a sudden price slump may have similar effects because farmers have to find new ways of surviving. This happened in Brazil (Alger and Caldas 1992), in Cameroon (Gockowski, personal communication) and in Côte d'Ivoire (Ruf 1991).

c/ If forests are protected, a reasonable price of cocoa is a factor of high sustainability. It helps farmers to adopt and invent new technologies. It helps them to save cocoa farms and encourages replanting and thus the reforestation of degraded land.

Other considerations on the subject of shade trees

In some cases, even in ageing orchards, smallholders eliminate shade trees not to increase yields but rather because they think that these shade trees may have more disadvantages than advantages with regard to the survival of the cocoa trees. For instance, in case of extreme drought, a huge shade tree may become a killing competitor for cocoa groves with regard to soil water resources. In other cases, a number of primeval trees are accused of being reservoirs of harmful insects such as mirids (Ruf et al, 1996). In Côte d'Ivoire some farmers who cut down shade trees argue that these trees increased risks of destructive bush fire (Lachenaud 1998, personal communication).

Plantations versus smallholdings: no shade determinant but a sustainability factor

In the examples described in Trinidad and Brazil (Table 3 and Annex 1), 'plantations versus smallholdings' determine neither the adoption nor the type of shade. In addition, there are frequent changes in strategy. A further example is given by Sabah estates. In the 1980s, when the cocoa price fell below their break-even point, the plantations started removing shade. They achieved better yields for a few years, just before insects and especially the pod borer hit the industry. The problem was finally 'solved' by felling the cocoa trees and planting oil palms. Among the few estates which resisted a little bit longer than others, the BAL plantation recommended a return to some "shade trees", for

instance by planting coconuts, not for shade but for restoring an ecological balance and facilitating IPM (Teh C. L. and Yeow K. C., 1995).

Whatever the shade used (in Brazil and Peninsular Malaysia) or the absence of shade (in Sabah), cocoa production based on estates resisted poorly to a combination of price slumps and pest and disease outbreaks. These two cocoa sectors are rapidly losing ground. Smallholdings seem to be more flexible and more resistant to price slumps. This is a criterion of sustainability.

If shade is based on *Erythrina* or *Gliricidia*, the choice of adopting shade seems technical and economic. If we consider primeval trees left during the forest clearing or active regrowth of spontaneous and intercropped trees, the adoption of shade may involve institutional issues and especially land ownership. At least, this would seem to be shown in Table 3. Rather than 'plantations versus smallholders', a much more important criterion seems to be the 'migrants versus autochthons' paradigm.

'Autochthons and shade' versus 'migrants and no-shade'

Côte d'Ivoire is an excellent example here. With regard to shade trees, the opposition between the eastern and western regions observed in the 1930s contrast with that of the 1980s (Annex 1). What happened in the meantime? The answer is that there were two or three waves of migration in the western region. The difference between autochthon and migrant strategies with regard to cocoa and shade starts with the type of forest clearing operations.

The initial autochthon method used to leave some primeval trees. One of the main reasons was the lack of suitable tools and the difficulty in felling them. It led to 'cocoa farms' under big trees.

Then, with the introduction of modern axes and later under the pressure of research institutes and extension services, clearing was total. As was well described by Schwarz, "there is no sight more depressing than cut-over tropical forest walled in by virgin jungle, where huge dead trees lie prostrate beside young saplings in unbelievable confusion, waiting to be fired" (Schwarz 1931:14). However, while the larger tree trunks are still smouldering, most of the root systems of the felled trees remain alive. Later on, according to smallholders' strategies or negligence, tree regrowth is quite possible. Some chance is left for forest regeneration. It is one of the explanations and methods for changes in 'shade' practices.

The 'migrant method', or the so-called 'Baoulé method' because it was widely used by the Baoulé groups and then copied by Mossi from Burkina Faso, overcomes the difficulty of cutting down the big trees by burning them as they stand. The dried undergrowth cut down a few weeks previously is gathered around each large tree and then set alight. The trees die and lose all their leaves. The result of this method is a no less 'depressing landscape' of huge dead upright trees. However, it is a very efficient technique. Firstly, it saves substantial labour. This serves migrant strategies. They wish to clear as much land

per year as they can. Secondly, trees degrade slowly. Branches fall and then pieces of trunk. It takes 15 years. Even though it does some damage to the cocoa groves, these pieces of dead trees provide free fertiliser for 15 years. In addition, the complete elimination of a canopy 30 or 40 meters above seems to suppress insect habitats, at least for a while (Ruf, Konan, Zadi 1996). Twenty years later, some migrants rediscover the disadvantages, including the change of microclimate and the lack of shade. Others already anticipate it and are ready to move to another virgin forest area.

To a certain extent, the autochthonous techniques are much more environmentally friendly because over decades their farming techniques have incorporated knowledge of the environment and the need to conserve it. Migrants may have less knowledge and certainly less incentive. They are never sure whether they can stay and anticipate forced out by autochthons. Even if they are not sent back to their own region, most are determined to retire to their home village. They came to make money as rapidly as possible, and only secondarily to build a patrimony to be transferred to their children.

In addition and even more important, the 'purchase' of land was never clear. Most migrants anticipate that autochthons will take over the land if the farm looks like a regenerated forest. This is not a theoretical view. In the central-western regions, we collected several testimonies of migrants who left their farms in the eastern region thirty years ago. At that time, the 'Baoulé method' was not yet frequently used. Some forest tree regrowth occurred and those farms have been taken back by autochthons and 'resold' to other migrants.

This is one of the reasons why most migrants opt for somewhat destructive clearing. However, this is also one of the reasons why they introduce new cultivated trees when they rediscover the disadvantages of monoculture and massive forest clearance. For instance, the 1983 and 1986 droughts and more recent ones triggered the introduction of trees in Baoulé cocoa farms. We have observed this since the late 1980s in the central-western region (Ruf and Pescay 1989, Oswald 1997). After a phase of monoculture after pioneer fronts, there is an ecological determinism in favour of more agroforestry-oriented systems. This is a sort of 'migrant cocoa farm life-cycle' effect. After 25 years' experience, migrants must reconsider certain ecological laws.

[Land tenure policies](#)

Land and forest policies greatly influence the relationship between autochthons and migrants and thus have an indirect influence on both deforestation and reforestation. A policy which widely favours migrations such as implemented by the former president of Côte d'Ivoire from 1960 to 1987 encourages rapid, complete deforestation. A policy which helps autochthons to hamper migration and control it as it was done in southern central Cameroon (but neither in M'Bam nor in the south-west region) accounts for a slow rate of selective forest clearance with many trees saved at the clearing stage (Losch 1995, Ruf 1995: 340,348).

In Indonesia, a policy with ambiguities concerning forest land property rights may account for some poor migrants' preference for grassland instead of forest, at least in the fertile plains. However, it also favours deforestation by migrants who have capital and/or local political clout.

[Back to techniques: a lack of forest clearing tools](#)

Before the 1970s, chain saws and even hand saws were extremely rare in cocoa-producing countries. Migrants could not have afforded to buy them anyway. The use of chain saws started with the increasing activity of logging companies and in some cases of local loggers. As some of their employees often decided to stay and become cocoa farmers once the company finished harvesting timber, they had access to considerable information about tree cutting, saws and sometimes chain saws. This has resulted in more zero-shade cocoa since the 1970s.

Before that, and although migrants had also invented other clever techniques of land clearance without cutting down the big trees (see above), complete clearing of primary forest was usually considered as a huge task and often avoided, hence more agroforestry systems before the 1970s.

[Influence of research and extension services](#)

As is mentioned above, most agronomists and extension services were themselves seduced by complete forest clearing and often by zero-shade cultivation, especially in the 1970s and 1980s. No wonder complete clearance was encouraged if not imposed through subsidies, as was the case in Bahia (Brazil) and Côte d'Ivoire.

[Why the complex cocoa agroforest in Central-South Cameroon?](#)

All the determinants presented above seem pretty well verified by the case of Central-South Cameroon. Firstly, shade is heavy in relation to the 20 to 40 years of shade tree growing. This is the 'farm life cycle effect'.

More importantly, there was an 'autochthon effect' (see above). In addition, some governments supported autochthons in slowing migrations. Although some migrants came, they were kept under control and progressively integrated in society through marriage or just accepted as seasonal workers. This is the main difference with Côte d'Ivoire where massive waves of migrants were encouraged by explicit policies (Losch 1995, Ruf 1995).

The absence of chain saws until the late 1980s also seems to be one of the reasons why cocoa farms in central southern Cameroon (and some in eastern Côte d'Ivoire) are densely shaded.

With regard to planting material, central southern Cameroon was also marked by an error of strategy in the diffusion of planting material. Early distribution of plagiotropic cuttings

proved to be too sophisticated and unsuitable for central southern smallholders. It may have hampered the replanting of ageing trees.

A shortage of available inputs but also a conviction shared by most researchers and extension services that shade was absolutely necessary to cocoa (which obligatorily reduces the impact of inputs) maintained a fairly conservative approach in shaded cocoa.

To a certain extent, this strong belief by agronomists based in Cameroon was a chance and finally an advantage with regard to the biodiversity maintained by these cocoa agroforests. However, it did not help in terms of the sustainability of cocoa supplies. The apparent maintaining and even increasing of cocoa supply in Cameroon is related to the more recent cocoa regions where new plantings and small booms have occurred. These regions are M'Bam and the south-western area and they mainly rely on migrant techniques, with much less shade. In the meantime, supply from ageing cocoa agroforest continues to decline in the central southern region. However, once again, these agroforests have a huge potential for agriculture and non-cocoa incomes. The problem lies more in market opportunities and marketing legislation than in farming techniques.

PROPOSALS

Ways of achieving more sustainability of cocoa farming systems and more biodiversity go beyond the framework of ecology and agronomy. There is plenty of room for social and economic policies. Several measures and policies may well have an impact on the three main objectives: a/ minimising environmental degradation and maximising biological diversity, b/ improving long term yields and returns, and c/ improving the livelihood of small scale producers. The only way to combine the first and second objectives is to achieve the third one. The reverse is also true. To a large extent, the protection of public goods and new regulations aiming at minimising environmental damage are a prerequisite for the improvement of smallholders' livelihoods.

Minimizing environmental degradation and maximising biological diversity

Forest protection

There are no reasons to prevent forested countries from entering the cocoa sector if they so wish and using up some forest for the purpose. The objective should be to manage forest territories. Some forests should be totally protected. Others could be managed as sources of renewable timber and non-timber products. Others can be cleared by techniques enabling forest regeneration.

Even though centuries of tropical stories prove its difficulty, an attempt can be made to control migration, or more probably to anticipate migration by involving autochthon

populations in the management of their forests. There would certainly be a need for civil servants to look after these different forest and land statuses but the ultimate guarantee would be the social control of their work. This means that farmers and rural populations would have a political power, access to the media, etc.

Some international assistance and funding would be necessary. Otherwise policy makers are put in difficult situations. If tropical forests are a world heritage, there are no alternatives to strict protection funded by world-wide organisations. In 1995, we proposed at an ICCO meeting a tax on chocolate consumption (and other tropical commodities such as coffee) which could fund international assistance to protect certain tropical forests (Ruf, Konan, Ardhy 1995).

In countries which have almost no more forest left, again, this 'public good' is too much of a temptation. The last forests, if any, must be totally protected. Otherwise planters and smallholders not to speak of civil servants and timber companies cannot resist. This is a prerequisite. Again, timber companies should be forbidden to enter these last forest reserves owned by a country. If timber extraction is not forbidden, it is difficult, if not impossible, to ask smallholders not to follow the tracks opened by bulldozers.

Paying smallholders the value of timber

As a corollary to forest protection, the awarding of the value of timber to smallholders is another prerequisite to any research and extension work on cocoa agroforestry. In some countries, as forests and timber 'belong' to the state, farmers are bothered and fined by civil servants when they sell bundles of coffee or cocoa firewood on rural markets. They cannot sell Iroko or any other forest tree remaining in their cocoa farms. Worse, timber companies feel authorised to enter cocoa farm plots and cut down the remaining primeval trees without asking permission from the farm owner, giving at most miserable tip while earning thousands of dollars and destroying a substantial part of the cocoa plot.

This is probably the most dramatic change to be achieved. Pay farmers for their timber and help them to organise themselves and facilitate competition between timber buyers and possibly develop local timber processing at village scale. Otherwise, how could farmers be interested in protecting some tree species during the clearing phase and during weed control? How could they plant any timber trees?

Reintroducing forest trees in the cocoa farm plots

One of the few advantages of the abandoning of Vietnamese rubber plantations is that the seedlings have grown so much that they have acquired considerable value as timber. This helps to fund replanting with clonal material. Up to now, cocoa has not yet gained any timber value but it is already sold on rural markets as firewood (and sometimes subject to

fines). It may change with progress in wood processing. However, the ability of cocoa to produce reasonably well under shade could be used. Wood species could be planted for felling 25 to 30 years later. For a Côte d'Ivoire migrant who started clearing forest and planting cocoa in 1968 when he was 25, it would have been a perfect timing to sell a few Iroko or Frake any time between 1989 and 1993, at the heart of cocoa crisis. Being 50 years old, the migrant would have still a lot of things to do with that timber money, including replanting. Even a 40-year timber cycle might be compatible with a family patrimonial strategy. Species with shorter cycles could be also adopted. It would be a perfect retirement capital. In the meantime, the cocoa farm would make the maintenance of timber trees almost free of charge. Some contracts and institutional arrangements between farmers and forestry services or wood processing companies could be explored to trigger these investments.

Village-managed forbidding of bush fires during certain periods of the year

On one hand fire remains an irreplaceable tool in humid tropics. On the other, in many tropical countries, had farmers and estates not used fire, forests would spread spontaneously.

Some regulation is needed.

In some countries, the most destructive and uncontrolled fires have been lit by estates and timber companies, not by smallholders. This has been proved by satellite images and this tool could be used to fine and punish those who keep burning the country.

In other countries, fires lit by negligent farmers, jealous neighbours, temporary hunters looking for easy ways to capture small game remain major sources of damage to vegetation and spoil any chance of forest regeneration. Smallholders can react. For instance, in Côte d'Ivoire, some villages have managed to regulate fire. They set rules. Here it is forbidden to lit a bush fire for a few months. There is it forbidden to set light to cut vegetation more than three days after rainfall.

This type of local regulation needs backing at national levels. As there are periods when hunting is forbidden in Northern countries, there should have periods when bush fires are forbidden in tropical countries. Then, at village level, additional rules could be discussed, added and enforced.

Replanting and herbicides

One of the major components of forest rent is the slow recrudescence of weeds after forest clearing. Thus, one of the major constraints in replanting is the extra time and cost of weed control, especially at the investment phase. The Indonesian example proves that

easy access to herbicides is a major incentive for the replanting of cocoa after grassland fallow. If neighbouring forests are given some protection, the adoption of herbicides should be a decisive complementary factor in forest saving. It would make grassland fallow and *C. Odorata* fallow much more attractive.

Improving long term yields

Improving long term yields can be achieved by two main approaches. One is to lengthen the life-cycle of the tree. The second is to shorten it if replanting can be funded. This is a way of keeping the orchard young.

A number of techniques can simultaneously lengthen the life-cycle of the tree and increase yields. Proper pesticide control have a direct impact on yields and a cumulative effect on tree vigour. In case of disease, more or less the same can be said of fungicides. Under almost all conditions, fertilisers and pruning have a decisive impact on the yields of the year as well as in subsequent years since they also play a key role in maintaining tree vigour and productivity. This is proved by Sulawesi smallholders' ability to use fertilisers and prune trees, by south-west Cameroon smallholders and their ability to prune trees and control black pod and by the impact of recent adoption of fertilisers in the Soubré region of Côte d'Ivoire. How can these practices be enhanced everywhere?

By increasing producer prices

The examples of Sulawesi, south-west Cameroon and Soubré in Côte d'Ivoire prove that a high price paid to producers is essential to accelerate these innovations. We are fairly in favour of liberalising cocoa marketing chains in African countries. However, serious follow-up is necessary to make sure that buyers do not organise cartels to underpay farmers. Another condition is that liberalisation must be matched with drastic protection of the remaining forests. Otherwise, the last few forest reserves of West- Africa will go up in smoke.

By extending pruning techniques everywhere

In countries like Côte d'Ivoire, currently hit by invasion of *Loranthus*, an epiphyte which thrives on badly maintained cocoa, this constraint must be used to demonstrate the key role of pruning. It is not yet known everywhere. The idea of using a constraint is similar to the process observed for fertiliser adoption in Soubré. Côte d'Ivoire smallholders did not adopt fertilisers in regions with rich soils where they could have easily afforded inputs but in regions with the poorest soils and under conditions which left no other choice but "Apply fertiliser or let your cocoa die".

By favouring competition among fertiliser and pesticide suppliers

At the end of a meeting organised by BCCCA at Brussels in 1996, we recommended that it should be ensured that the supply of fertilisers would meet the highly probable increase in demand if producer prices were to rise in Côte d'Ivoire. A price increase generates an inflated price of tradable inputs if these inputs are not tradable enough. This is for instance what has happened to Kenyan coffee growers in the past (Bevan et al, 1989). This did not occur too markedly in Côte d'Ivoire in late 1997, owing to an ability of the fertiliser sector to partially adapt to the demand. One of the reasons seems to have been the establishment of a new importer. However, the market is still tense and the recommendation is still topical.

By lowering cocoa tree densities

In the 1980s, Malaysian agronomists launched a 'new' concept of high density planting, especially with plagiotropic material, with up to 3000 and even 5000 trees per hectare. The experiments proved to be a failure. Anyway, the idea of high density is not new.

In Africa, a way of minimising weed control and risks of early tree-mortality is to maximise the density of direct seeding. In Côte d'Ivoire, some migrants increased planting to 10,000 beans, with trees at 1 m x 1 m intervals. Even though natural mortality take its toll, mature farm plots frequently end up with 2500 to 3500 trees per hectare. This is too much. The trees compete for light and grow too fast. They are not vigorous and finally the farm plot has few chances of surviving for longer than 15 years and yields, after a quicker start, also decline rapidly.

Some migrants may well have adopted this 'extreme' technique to deal with the risks of expulsion either by autochthons or by forestry services. 'The sooner the returns, the better'. In contrast, other smallholders may adopt this technique for replanting, with special emphasis on management of drought risks. These issues deserve surveys in relation to technical alternatives such as nurseries (and capital to fund these nurseries and the transfer of seedlings from nurseries to fields) and in relation to land tenure.

By lowering densities while cocoa trees are ageing

"In a plot with declining yields, removing three in four trees increased the final yield per tree fivefold... These results were later confirmed ... with a thinning rate of 0.50... These various facts suggested that one of the reasons for low yields in adult plots could be over-high densities, exacerbating the competition between trees ... This concept of changing the density in line with tree age by thinning would provide a new approach to the general problem of regenerating cocoa plantings, which we feel has become so crucial because of poor crop practices" (Lachenaud and Oliver 1998).

This idea put forward and demonstrated by Lachenaud is confirmed by our field observations. Farmers who undertook replanting of old cocoa farms, of hybrid and Amelonado types, underline the unexpected reaction of the two dozens of surviving old

trees after clearing and replanting young cocoa and yams. These trees suddenly developed and became covered with pods. Two to three dozens of trees are sufficient to provide some 100 kg, which helps to fund replanting. This is also one difficulty of underplanting. When producers observe the positive impact of partial clearing on old cocoa trees, they never remove the remaining old trees. Last, the thinning seems very much in line with the idea of intercropping Irokos, Fraké or Framire.

With regard to planting material

The decisive role of upper Amazons and hybrids in cocoa booms since the 1970s and the relative smallholders' confidence in these hybrids for replanting has been stressed above. However, is it not a pity to give up research on Forastero types? One of our hypotheses concerning Bahia's longevity as a cocoa-producing region (before it was hit by price slumps, by its nineteenth century structure of large farms overexploiting workers and of absentee landowners, and only lastly by witches' broom disease) is precisely Forastero's efficiency in coppicing. Some cocoa farms plots may have been planted 60 years ago but most of the trees could be 30 years old.

Improving the livelihood of small scale producers

Producer prices and marketing chains

Not surprisingly, as economists, we stress once again that producer prices are the main tools for improve growers' livelihoods. On this issue, the best demonstration is that of Sulawesi smallholders. In less than 20 years, the cocoa boom has turned thousands of starving farmers into families who buy nice clothes, live in nice wooden or even concrete houses, own TVs and dish-aerials and who have accomplished the life-long dream of a pilgrimage to Mecca. Along with the great talent of Bugis as farmers and middlemen, the highly competitive marketing chain and almost no-tax policy were major factors in this complete change.

However, once again, liberalisation in Africa may face difficulties. At least during the two first years, preliminary experience in Cameroon seems to show the ability of exporters to make arrangements and keep producer prices relatively low. This deserves special attention. The same appreciation can be made of input supply marketing chains: how can one make sure that farmers are supplied by highly competitive marketing chains? As in Sulawesi, a clear sign would be to have several shops in all big villages and several suppliers on every market day.

Credit and producers' associations

At the time of pioneer fronts, easy access to forest resources and small families of young migrants make credit unnecessary. At the time of ageing orchards and replanting, it becomes necessary. This change is a key point in cocoa cycles. It does not mean that credit must come from public institutions. In Côte d'Ivoire, we find evidence of an increasing role of private input traders, able to get credit from importers and ready to offer credit to farmers. In Sulawesi this role is also played by cocoa middlemen. In Côte d'Ivoire, an increasing role also seems to be played by farmers' organisations involved in cocoa marketing (Daviron and Losch 1996).

Forest protection and policies

In terms of environmental protection, it was stressed above that the only way to protect the last forest reserves is to forbid access to them by timber companies. Similarly, the only way to combine forest protection and improvement of most smallholders livelihood is to expel those who have entered protected forests that can still be saved. This is the only way to definitely convince farmers that the only method is fallow clearing and replanting, not forest clearing. However, expelled farmers must receive reasonable compensation. This is the only way to recognise the responsibilities of policy makers and bilateral and multilateral assistance which have long turned a blind eye to the deforestation process. Of course, what has been said above about deregulation of timber applies to the improvement of smallholders' livelihood.

Land tenure and labour policies

If countries like Brazil and Malaysia wish to recover some of their cocoa brilliance, history proves that the only way is to let smallholders have access to land and credit for replanting. It means a partial reconversion of estates to be sold to smallholders.

If Côte d'Ivoire wishes to lower the social risks of land conflicts, it should pursue the experiments launched on land ownership mapping and think harder about how to avoid the historical mistake made in Ghana in 1969, namely the Alliance Compliance Order. How can the risk of expelling foreigners in case of social conflicts be avoided? (Ruf, Konan, Zadi 1996).

Food security and green revolutions in the lowlands

One paradox of cocoa is the switch from food surpluses during the pioneer phase to shortages during the ageing phase. At the beginning, the food surplus reflects the efficient intercropping of cocoa and annual crops, both benefiting from forest rent and from the 'labour rent' provided by large-scale migration. The food surplus is the by-product of cocoa migrations and of their free surplus of labour at different periods of the year (Ruf 1988, Vol. 2).

The Sulawesi success story is partially related to surpluses achieved by its green revolution in paddy rice. This helped by covering part of migration costs, enabling farmers to concentrate on cocoa without fear of lacking food, and by accelerating transfer of technology to cocoa.

In terms of development of inland valleys, and despite smallholder dynamism, West Africa is still lagging behind. There is a huge demand in irrigation, fishponds, oil palms. Some fish farming projects developed with smallholders have proved their relevance (Oswald 1997).

CONCLUSION

Periodic cocoa recessions and environment degradation after periods of booms have a biological basis that interferes with social, economic and political bases. Hence, 'remedies' must be chosen in agronomy, ecology, economics and politics and will interact. Some solutions seem well known and well established and only waiting for national and international political will. Others are much more empirical and would deserve continuous experience and more participative research with all cocoa actors (Table 4). The three objectives are totally interdependent. None can be achieved without the other.

Finally, with regard to the conjuncture and (always risky) forecasts, one cannot ignore the new trends which seem to appear in the current main cocoa producing countries. According to our observations, Côte d'Ivoire might be at the dawn of a green revolution in cocoa. Unless El Niño strikes very hard, unless a spectacular disease outbreak and/or a major policy error occurs, we believe that Côte d'Ivoire farmers may rapidly reach 1,500,000 tonnes per year and possibly exceed that threshold. Ghana, Cameroon and even a small country like Togo seem to confirm new dynamism of cocoa farmers in Africa, which is consolidated or will be consolidated by market liberalisation. Although market liberalisation seems the best farmer's environment, a number of precautions and intermediate steps seem to be needed. Otherwise, despite or due to the increasing consumption of inputs, a new boom may not necessarily be more sustainable than in the past.

In other continents, only Indonesia, and more specifically Sulawesi, continues to plant cocoa. Indonesian smallholders, highly stimulated by the skyrocketing price of cocoa in rupiahs after the drastic devaluation combined with an almost perfect internal cocoa marketing, may rapidly reach 500,000 tonnes.

In other words, some 80% of the world's cocoa is concentrated in two relatively small sub-regions, with around 65% in Côte d'Ivoire, Ghana, Nigeria, and Cameroon, and soon some 15% to 20% in Indonesia. Cocoa history teaches us that it is neither a new nor a sustainable situation. It is not even certain to be a good thing in a country like Côte d'Ivoire which increase its risks of too much economic dependency upon cocoa and which needs to accelerate tree-crop diversification. Anyway, as they know that a period

of relatively low prices is usually the right time to invest, a few new countries may well enter the cocoa sector soon.

Table 1. First estimate of forest rent, as the difference of the investment cost during the first year of immature phasis, in the hills of Sulawesi, Indonesia.

	(a) after forest	(b) after grassland	a - b forest rent
Number of days labour (in days)	203	314	111
Labour costs (*) (US cents)	664	1027	363
	20	52	32
Input costs (US cents)	208		-19
Output (US cents)	476	180	
Total (US cents)		890	414

Source : survey by Ruf, Yoddang, CIRAD, 1997.

Table 2. Estimation of production cost per kilogramme of cocoa and forest rent in the hills of Sulawesi

	after forest	after grassland	Forest rent
Net input costs (*)	cents/kg	cents/kg	cents/kg
Labour costs			
Total	8	16	7
	28	31	3
	36	46	10

Source : survey by Ruf, Yoddang, CIRAD, July 1997

(*) Note: Net input costs are lowered by the impact of food-crop output during the investment phase while the net labour cost is increased by taking into account the depreciation cost of labour invested during the first years.

Table 3: Dominant farming systems with regard to shade / no shade options within plantations and smallholdings in different countries

	Plantations	Small scale family smallholdings
Peninsular Malaysia	light shade (cocoa introduced under already established coconuts)	light shade (established coconuts) except in Pahang where there is more `zero shade' by migrants
Sabah (Eastern Malaysia)	light shade (leguminous trees) zero shade switch to oil palm	zero shade
Sulawesi (Indonesia)	light shade and zero shade	migrants: zero shade
Brazil	- Complex agroforestry systems - light or heavy shade provided by <i>Erythrina</i> and others	
Côte d'Ivoire		migrants : zero shade autochtons : light shade
South Cameroon		autochtons: heavy shade
M'Bam and South-west Cameroon		migrants : zero shade light shade

Table 4. Matrix of current knowledge base and recommendations related to sustainable cocoa production

	Minimizing environmental degradation. Maximizing biological diversity	Improving long terms yields	improving the livelihood of small-scale producers
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What we know	<ul style="list-style-type: none"> - Forest reserves are necessary - Forbidding timber extraction in these forest reserves - highly complex agroforestry systems and "tree-crop shifting cultivation" used to be a way to regenerate forest tree species and forest environment 	<ul style="list-style-type: none"> - Fertilisers - Pesticides and Fungicides - Pruning - Minimal shade - high price of cocoa - relatively high price of land 	<ul style="list-style-type: none"> - highly competitive marketing chains, limited export taxes and thus high producer prices, but social impact to be monitored (*) - No barrier to direct delivery of cocoa to exporters and factories by smallholders and middlemen (no 'quality control' by civil servants) - reasonable access to credit and inputs
What we think we know	<p>Replanting after <i>Imperata</i> <i>Cylindrica</i> and <i>Chromolaena odorata</i> fallows by</p> <ul style="list-style-type: none"> - planting leguminous trees such as <i>Gliricidia</i> - using herbicides - planting cocoa after 	<ul style="list-style-type: none"> - Thinning cocoa farms in line with aging - Intercropping fruit trees 	<p>Uncertainties on land and cocoa farm ownership after inheritance hamper maintenance of old farms and replanting under old trees</p> <p>but political interferences may be dangerous</p>
What we think is worth pursuing	<ul style="list-style-type: none"> - Intercropping trees, including timber species in line with thinning of aging cocoa trees. 	<ul style="list-style-type: none"> - A potential interest in Amelonado, not only in UPA. 	<ul style="list-style-type: none"> - Intercropping trees, including timber species - reconversion of estates to be sold to smallholders with State help.
Recommend.	<p><i>Public goods:</i></p> <ul style="list-style-type: none"> - Forest reserves - Forbidding bush fires at certain periods of years, under village control. - Tax on chocolate consumption for project funding <p><i>Private resources:</i></p> <ul style="list-style-type: none"> - Retrocede to farmers the rights of selling timber 	<ul style="list-style-type: none"> - Extension work on pruning and fertiliser by farmers themselves. Why not bring farmers from Indonesia to Ghana and Côte d'Ivoire and vice-versa ? - Projects on replanting in all cocoa producing countries, including control of C. 	<p>(*) follow-up of marketing liberalisations in Africa, which are not riskless</p> <ul style="list-style-type: none"> - facilitating an easier access to credit and inputs through farmer's associations - facilitating exchange of farmers between countries - Retrocede to farmers rights to sell timber

	- experiments of intercropping of timber species and contracts with forestry services - promoting small scale wood processing units at village level.	Odorata and I. Cylindrica. - More research on Forastero types and coppicing	- More participative research on land tenure and labour policies. - Monitoring of land conflicts and promotion of local arrangements by smallholders themselves
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Sources: Ruf and Zadi, 1998.

Appendix 1: A brief review of literature about cocoa shade management

Trinidad and Grenada

From 1900 to 1920, the shade problem seemed solved in Trinidad in favour of abundant planted *Erythrina*. The question also seems answered in Grenada but in a contrasting manner.

"Some Trinidad planters believe that their trees would die without shade, yet in Grenada, only a hundred miles north as the steamer sails, there are whole plantations without a single shade tree. The Grenadians say: "You cannot have pods without flowers, and you cannot have good flowering without light and air" (Knapp 1920: 38).

"One who has seen the carefully shaded cocoa plantations in Trinidad (with *Erythrina* species) is much surprised to see no shade at all in Grenada. The explanation lies more in heavy rainfall, the dense clouding and the higher humidity. The resistance of the variety planted, also has to be taken into consideration. A yearly rainfall of less than 100 inches is a rarity in Grenada, but the rule on Trinidad. Grenada has *an annual rainfall of approx. 3,000 mm.*

The Grenada planters at least partly offset the lack of shade by close spacing of the cocoa with different consequences. Without shade, but with sufficient moisture, the tree becomes productive sooner...

However the *trees without shade exhaust faster, especially when planted in close spacing.* In Grenada the planting width of 9 x 9 feet is not exceptional. If one wants to preserve the productivity of the trees, the soil has to be fertilised and tilled. This is extensively practised in Grenada... This is the essential difference between the cultivation methods applied on Trinidad and Grenada" (Preuss 1901: 30-31).

However, the role of shade issue was already challenged in Trinidad.

"Les questions de l'ombrage, de la taille et des gourmands, (chupons) ont amené de nombreuses discussions ici et il semble qu'elles ne sont pas près d'être résolues par les intéressés. A mon humble avis, l'ombrage est aussi utile au cacaoyer qu'au caféier, à moins toutefois que les arbres ne se trouvent dans un ravin profond ou dans un endroit humide. J'ajouterais qu'un excès d'ombrage peut être préjudiciable, notamment en propageant les chancre, *si les arbres-abri ne s'élèvent pas très haut* comme l'immortelle. En somme, l'ombrage doit simplement garantir les cacaoyers contre le vent et maintenir, en même temps, une humidité suffisante dans le sol: deux choses absolument indispensables (Serre 1915: 18).

As shown by Moll's testimony in 1960, the concern was justified.

"Shade versus no shade has been a major controversy in Trinidad. Early plantings after the war were made on a basis of no shade with close planting. These plantings failed, yields were poor after the initial bearing phase was passed. Most of these areas have since been thinned out and shade planted. Government now insists that plantings under the Subsidy Scheme be with overhead shade." Moll 1960: 7.

In Grenada also, in the late 1950s/early 1960s, some partial 'shade' or at least some new lateral protection was introduced with the rehabilitation phase, after a hurricane in 1956.

"Permanent windbreaks are established at right angles to the prevailing winds. The main windbreak consists of seedling mangoes... planted staggered in triple rows. These take time to establish and quick-growing subsidiary hedges are planted around and through the fields in conjunction with contour drains. Arabica coffee is often used as a subsidiary hedge and is planted in staggered double rows" (Cruickshank 1970: 7).

In 1914, in Jamaica, Van Hall already stressed the need for protection against winds.

"The planting, in time, of trees for permanent shade is another matter which has not always been practised in the right way. The absence of shade trees, at the time they are needed, is in Jamaica more prejudicial to the cocoa than in other countries, because strong winds are not rare, and even hurricanes occur now and then. Only in suitable and sheltered places can cocoa be grown in Jamaica, as in other countries, without shade... The hurricanes make the question of shelter-belts of great importance" (Van Hall 1914: 428).

In short, although there are differences between countries and regions, these testimonies

and observations over a considerable period of time seem to show a clear trend. Sooner or later, there are temptations and attempts to get rid of any shade and protection in order to increase yields. Depending on the local ecology, this may work for a few years or decades. However, a cocoa industry often goes too far and goes beyond a threshold of forest rent consumption. Farmers then have to rebuild protection and return to agroforestry practices. This confirms our definition of agroforestry: a smallholder strategy for rebuilding part of the forest rent (Ruf 1995).

Bahia, Brazil

In the 1990s, despite recent heavy felling as a result of the cocoa price slump (Keith 1992), Bahianese cocoa farms can still be considered as some of the most shaded of the main cocoa producing countries. It was even more true in the 1950s.

"Looking down from the unheated military plane flying from Rio de Janeiro to Salvador, Bahia, the neophyte looks for cocoa much as he looked for and found coffee plantations on Sao Paulo's red earth and later saw sugar fields near Salvador. But he finds himself addressing the undifferentiated green below, "is this it?" "Can that be cacao? or is that jungle.".... Only slowly does the uninitiated person become aware that this "forest" and the `forest' that appeared so formidable in the latter stages of his trip into the cacao region is that same huge orchard of cacao which he has sought from the air and from the truck window. He learns to recognise the tall trees as jungle trees left during the clearing of the land as shade for the low cocoa trees." Leeds, 1957: 36 and 39-41.

However, this contrasts strongly with reports in the 1910s and 1920s

"There are cocoa kings with 200,000 trees without one shade tree. It should be mentioned, however, that in these countries the cacao trees are planted more closely, (about 8 feet apart) and themselves shade the soil (Knapp 1920: 38).

"The methods of cultivation adopted in Brazil are very simple. Shade trees are not planted. Formerly a certain number of forest trees were left standing, *but this is no longer the custom...* When the forest has been cleared, however, and the cocoa seeds have been put into the soil, secondary bush is frequently allowed to grow between the young cocoa ... This secondary bush is occasionally cut down a little ... but it is sometimes omitted

Generally, however, the bush is partially removed every year, until the branches of the young trees spread and reach each other. This is soon the case, for the trees are planted fairly close together; the planting distance varies from 6 to 12 feet, but is generally between 7 and 9 feet. ...

The primitive methods of cultivating the young plants, *and the growing of older plants without shade* would in most other countries result in the death of the trees, but here it meets with success owing to the extremely favourable natural conditions". (Van Hall 1914: 308-309).

This contrast between descriptions in the 1910s/1920s and 1950s may have three complementary interpretations.

Firstly, the authors may not describe the same areas. There is a strong argument in favour of this hypothesis. In 1914, Van Hall also gave some figures about the main producing regions. At that time, they were in the *município* of Belmonte and Canaveiras, with exports estimated at 7,600 tonnes. The *municípios* of Ilhéus and Itabuna exported only 1,500 tonnes. Belmonte and Canaveiras plantations were mostly along the rivers with rich, humid alluvial soils. Producers could afford zero shade for a few years or even decades. In the 1950s, in line with the principle of "cocoa shift in production", the cocoa belt moved to the hills of Ilhéus and then Itabuna. There, in upland regions and with shallow soils, "zero shade" was perhaps tried but producers probably verified at their expense that it was more dangerous.

Secondly, one feels the recurrent changes in producers strategies and practices in time in each region. As suggested by Van Hall, producers in Belmonte probably discovered the "zero shade" option after a period of more shade trees in the late nineteenth century. Eventually, the farms vanished. There are also very good descriptions of ageing and abandoned plantations along these rivers in the 1910s and 1930s (Zehntner 1914, Monbeig 1937). In Ilhéus and Itabuna, heavy shade certainly helped to lengthen the life cycle of cocoa farms in the mid-twentieth century. However, when CEPLAC was founded, new attempts of zero shade were promoted and led to the same effects: an accelerated rate of tree mortality.

Thirdly, although Van Hall mostly refers to the youth of cocoa farms, the periodic omission of weed control certainly interferes with the growth of 'shade trees' and 'exploitative' practices in Bahia.

"Plantation practices in Bahia are notably extensive and exploitative... Once planted, the young trees are given almost no attention until they come of bearing age... Thereafter, instead of clearing away the bush and weeds each year, this kind of work is done only every four or five years. When yields decline, the older plantations are abandoned and new ones are set out on virgin soils... here is speculative and destructive economy at its worst, one that is bringing temporary and unstable activity to Ilhéus and Salvador" James 1942, quoted by Leeds, 1957.

These practices were exploitative in terms of primary forest consumption. However, in most cases, this abandonment strategy and typical "tree crop shifting cultivation" strategy led to rebuilding secondary forests. In that sense, this is more an 'agroforestry strategy' as an exploitative system..

In addition, when Leeds described the 'cocoa jungle' in 1957, it just coincided with a period of low prices and serious crisis on the sector after World War II. As maintenance of established tree-crop farms varies greatly according to the price of the commodity, especially in estates which rely on (even badly) paid labour, it can be assumed that a

large number of plantations had been abandoned or neglected for 10 years. This favours the growth of 'shade trees'. It is commonly involuntary.

In short, the 'exploitative' system was not so negative and this is what enables the current Bahianese state administration to promote its 'Cabruca' system and its rich biodiversity deserving some subsidies to be protected. The major source of deforestation becomes the one to be protected and saved from a new stage in deforestation. It has been made possible partially because plantations were neglected at the first stage and occasionally later on.

One may also notice the recurrent comment that a 'zero shade' strategy works here "owing to extremely favourable natural conditions". These words are similar to those used by Preuss to explain why Grenada planters chose no-shade systems. Again, these natural conditions remain favourable for a certain number of years or decades but not for ever.

Gold Coast / Ghana

Descriptions of native cocoa farms in the Gold Coast at the beginning of the twentieth century are also somewhat contradictory. Some authors like Chevalier (1908) mention cases of cocoa farms where all forest trees had been removed and nothing planted instead and other cases of splendid cocoa trees shaded by primeval forest trees saved at the clearing phase. The author favours a 'discrete' presence of these huge forest trees. Schwarz (1931) referred to Gold Coast farms as shaded with primeval shade trees.

Reports were conflicting in the 1920s. Gold Coast farms seem to have been mostly shadeless in the 1910s and 1920s. Scientists like Knapp (1923) complained about the primitive indigenous way of growing cocoa for a few years without shade and then abandoning cocoa to bush and clearing forest again. Ghanaian farmers were accused of drying up the country.

"Owing to the excessive clearing of the forests and the lack of anything approaching scientific cultivation, the cacao tree may cease to thrive.

The effects of forests on climate is well known. Over a century ago Von Humboldt expressed the opinion that the cacao of Caracas (Venezuela) was no longer so good as it was originally, because the country had become denuded of trees and hence was dryer and more exposed to winds. The effects of 'shifting cultivation' with its reckless felling of forests in a country like the Gold Coast, which has already probably the lowest rainfall of all cocoa producing countries, will no doubt be disastrous if persisted in. It is to be hoped that the Agricultural Department will be listened to and their advice followed, for it is contended by experts that, unless 25 per cent of the land remains covered with forest, the climate will become too dry for cocoa." (Knapp 1923: 78).

Others were less pessimistic but confirmed the zero shade practice in the country.

"Jadis on admettait que le cacoyer devait toujours être abrité contre le soleil et cela à toute époque de son existence. Cette opinion a du être modifiée et sans citer encore la Gold Coast où mes plantations de cacaoyers ne sont généralement pas ombragées, mentionnons les dires de Harisson (1914), pour lequel la diminution de l'ombrage a, sur le rendement du cacoyer, une influence plus considerable que l'amélioration du système de drainage et des méthodes culturales" (*Revue Generale de Botanique*, 1924).

In that country too, the contrast between what is said about the eastern region in the 1920s and what can be observed by any traveller in Ghana in the 1990s is surprising. Coming from Côte d'Ivoire, the traveller is surprised to see so many huge trees above the old cocoa groves. In relation to inheritance conflicts on farms, absenteeism of heirs who stay in towns and lack of maintenance, a number of less shaded cocoa farms have vanished and disappeared under *Chromolaena odorata* (Ruf 1995: 189 and 415). Old orchards which survive in the eastern region are widely shaded which is logical since shade reduces weed growth. Especially in a deforested environment subjected to high weed pressure, well- shaded farms are less vulnerable to lack of maintenance. This is a good reminder of strong interactions between social and ecological changes in explaining the mortality of cocoa farms.

Côte d'Ivoire

In 1931, US Department of Commerce commissioner reported as follows:

"Cocoa growing as an Industry was started by the Ivory Coast native and the present output is almost entirely the result of his efforts. Recently, however, Europeans have interested themselves in cocoa as a crop, and have introduced it on their plantations"(Schwarz 1931:2).

"In those areas (in the valleys between Tiassale and Sassandra) the carefully spaced young cocoa trees stand in rich, well drained soil and in an environment that provides ample protection against the sun and the prevailing winds. .. In short, the environment is so nearly perfect for cocoa that it strongly indicates the true scientific approach".

Ivory Coast planters apparently do not belong to that school of cocoa growers which insists that permanent shade is a basic consideration in sound cocoa culture and that the cocoa tree will have to struggle for its life if such shade is not provided" (Schwarz 1931: 14).

Here again, the 'no shade' practice is explained by 'an almost perfect environment'. Again, 60 to 70 years later, as in Grenada and Brazil, and even after a supposedly 'true scientific approach', these cocoa plantations are long gone, as well as the forest, and the environment is undoubtedly less favourable. The only 50 to 60-year-old farms still

existing in Côte d'Ivoire are well shaded (and in very good soils). Almost certainly, two to three generations of zero shade cocoa plantations and small scale farms have been more harmful to environment than the shaded farms.

"Farms in the western cocoa-growing areas are ordinarily well provided with primeval bush shade, as in the Gold Coast; but in the central and eastern districts, where the influence of the European planter is strongest, the shade for cocoa is often provided by bananas and plantains, as is done on plantations. (Schwarz 1931:6).

Although European planters might also have been influenced by African farmers, this observation helps to remind that the "zero shade" strategies promoted by research institutes in Brazil and Côte d'Ivoire in the 1970s/1980s are neither new nor strictly related to hybrids. In the 1930s, producers used only Forastero types. More important, this comparison between the eastern and western regions of Côte d'Ivoire has totally reversed. In the 1980s, the western cocoa growing regions were 100% managed under full sun while shaded farms can be found almost only in the eastern region and part of the central- western region.

Again, this change can be partially interpreted as the result of time. The principle of declining maintenance and farm ageing account for the spontaneous regrowth of "shade trees". In addition, farmers have experienced "zero shade" failures and favour tree regrowth.

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