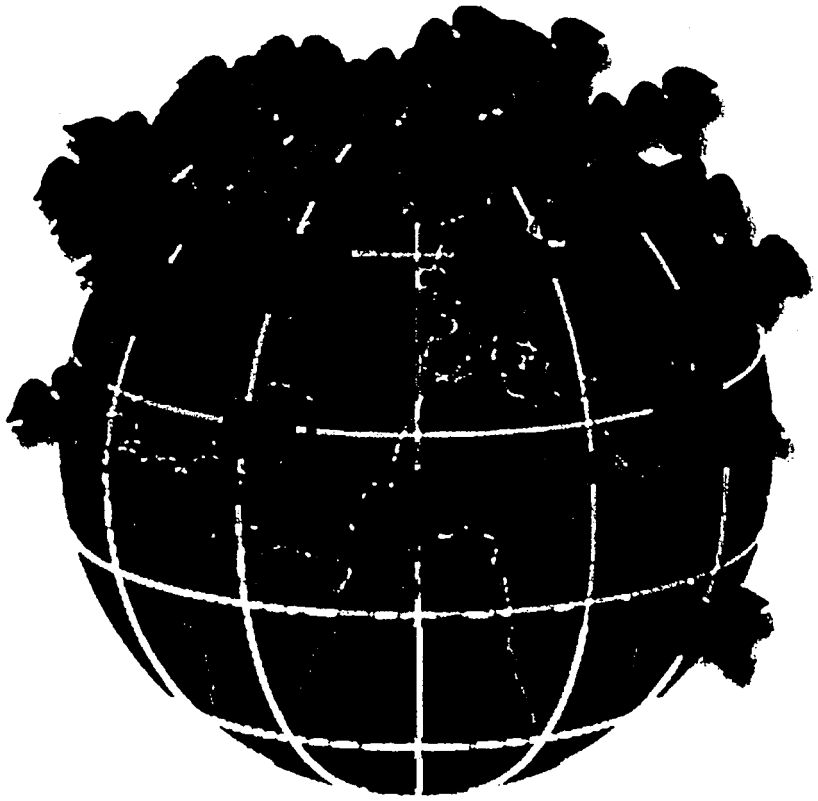

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After tropical forest, replantation of rubber trees and cocoa: Garden of eden or of chemical inputs?

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Abstract: Smallholders in humid tropical zones have often preferred to extend their plantations by clearing primary or secondary tropical forest rather than attempt replanting. The two main advantages procured by tropical forest—low 'land rent' and substantial 'forest rent'—are verified in Indonesia and Côte d'Ivoire, in cocoa and rubber. The two rents logically tend to become reversed as the cycle proceeds. This reversal may create conditions that are more favorable for replanting, possibly through a land market. The technical, economic and social factors of the decision to replant or not to replant and then possible determinants in the 'monoculture/agroforestry' dualism are reviewed succinctly. Monoculture is a migrant's strategy and agroforestry that of autochthons or long-established migrants. From a technical point of view, agroforestry emerges as one of the conditions of sustainability in humid tropical zones and in particular for replanting. However, we are far from having seen the end of monoculture with inputs, especially with regard to replating. From a social point of view, land conflicts which coincide with the replanting phase deserve a great attention as well as great cautiousness on behalf of policy makers.

Smallholders in humid tropical zones have often preferred to extend their plantations by clearing primary and secondary tropical forests rather than attempt replanting. The two main advantages procured by tropical forest are 'low land rent' at the beginning of the adoption of a tree crop and great technical and economic advantages provided by very substantial 'forest rent'. This model based on migrations and deforestation can be called *model 1* and it is assumed here that this model 1 has been dominant in the tropical history of tree crops.

However, there are some exceptions and among them a *model 2* based on complex agroforestry strategies. Here, the main cultivated tree is intercropped with a number of other trees, either planted or spontaneously regrown from the root system or from seeds after the forest clearing. At the end of their life span, these plantations may have a structure similar to an old secondary forest. In other words, this agroforestry strategy rebuilds a 'forest rent' or an 'agroforestry rent' which seems to makes replanting much easier compared to monoculture (Ruf 1995, Penot 1998). Thus, after a first cycle of the agroforestry system created after primary forest clearing, smallholders may cut it down and start a second cycle. This is a sort of replanting and an alternative to forest clearing.

The planting of a tree crop after grassland such as *Imperata cylindrica* and *Chrolomaena odorata* involves technical changes and inventions with regard to the plantation techniques used after the clearing of forest. Innovation is called for to counter the effects of the disappearance of 'forest rent'. Even if in this case there is no felling prior to the perennial crop, 'planting after grassland' has common features with replanting in the strictest sense. This is also a form of *replantation* which is called here *model 3* but it is assumed that it has been scarcely applied until recent years.

1. Pioneer fronts and the development of tree crops at the expense of forest

The 'differential forest rent' applied to tree crops is the difference in production and investment costs between a tonne of the commodity produced in a farm established just after a forest was cleared and a tonne of the same commodity produced by replanting on fallow land or after felling of the first plantation (Ruf 1987, 1995). The difference is often positive and helps to explain why model 1 has often been dominant in tree crop history. However this 'forest rent' interferes with a number of other factors which may lead to an evolution towards the other models.

Appraisal of the forest rent on cocoa farming in Côte d'Ivoire

Differential forest rent appears in land prices in Côte d'Ivoire. This is one of the ways of demonstrating its strong existence in the case of cocoa farming in Côte d'Ivoire and it explains why the model 1 has been dominant in that country, at least until recent years (Table 1). However, this rent was also enhanced by the Ivoirian land tenure policy, with the 1963 rule that 'the land belongs to he who farms it'. This bill has never been promulgated but is always applied in practice, giving a considerable advantage to migrants. By definition and according to the objectives of the government of Côte d'Ivoire, the rule tends to weaken landholding rent and hence the cost of

access to land. As a result, the value of the 'differential forest rent' in the Ricardian sense of the term increases in relative value. Comparison of the price of forest and falloffs is not always easy in the same village land area. The dividing line between 'forest' and 'shrub fallow' is not well defined and is cause for discussion. At the beginning of the 1980s, 10 to 12-year old fallow was still common and Nevertheless, it is possible to determine average prices indicating the value awarded to forest not for its timber but for its 'previous crop' value. Forest is sought for its positive effect on the growth of cocoa trees, their yield and that of intercrops. The average Figures for the central western part of the country in the 1980s and 1990s are given in table 1.

Table 1 The per-hectare cost of land in the Nekeidé region in central western Côte d'Ivoire in 1982

	x 1000 CFAF 1982
Forest	100
Fallow	70
Old coffee farm	100

Source: Ruf 1988, Vol. 4.

The price of old coffee farms is comparable to that of forest. These farms are often abandoned, almost totally unproductive and sometimes similar to secondary forest. Price parity with that of forest can be seen in relation with the principles of forest fallow and tree-crop shifting cultivation. Thus, most purchasers of this type of old plantation wish to clear the land and replant cocoa.

This latter case is a good introduction to a form of model 2 which also exists in Côte d'Ivoire but with a much lower frequency and importance. Contrary to some preconceived ideas, cocoa replanting does exist in Côte d'Ivoire and is based on agroforestry principles. Smallholders abandon some of their cocoa and coffee plots or, rather, let them age. By doing this, they favour the development of intercropped trees and the biomass. In other words, they try to rebuild 'forest rents' and 'agroforestry rents'. It makes replanting much easier, especially if they replant young cocoa seedlings under old coffee groves (as they did in the 1980s) or if they replant young coffee seedlings below old cocoa trees (as they began to do in the 1990s). However, although used increasingly, these models remain much less implemented than model 1 because of massive migrations and abundance of available forest.

Appraisal of the forest rent on cocoa farming in the hills of Sulawesi

Plantation budget data can be used to appraise forest rent in different ways and hence the cost of the replanting innovation in grassland (model 3). The method selected here consists of using the investment phase assuming that this is the main constraint to be dealt with (Table 2).

considered by some smallholders as secondary forest. There was still little land under *Chromolaena odorata* and it was not often sold. In addition, the sale of 'forest' is not a formal transaction but is often accompanied by more or less clearly defined labour services whose monetary value is difficult to calculate.

There is a substantial difference in the number of working days: 200 days to install a cocoa plantation in 3 years after forest and more that 314 days after grass-dominant fallow. The main reason for this extra labour is weed management and the fourth year of work necessitated by the slow growth of the cocoa trees and, possibly, tree mortality and replacement (Table 2). As in West Africa, 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 handicaps the replanting of cocoa (Ruf 1988, Temple 1997).

Table 2. Estimate of forest rent, as the difference of the investment cost during the first year of immature phases.
The case of cocoa in the hills of Sulawesi

	(a) after forest	(b) after grassland	b – a forest rent
Number of days labour (in days)	203	314	111
Labour costs (us $)	664	1027	363
Input costs (us $)	20	52	32
Output (us $)	208	188	-19
Total (us $)	**476**	**890**	**414**

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

If it is considered that the labour required during the investment period is provided by the family unit, for example with the help of a son, the investment difference in inputs and in lost income on the sale of food crops is only $50.

However, considering that all the labour is assessed using an average opportunity cost we obtain a difference in investment of some $400 per ha. In relative value, this represents a *near doubling of the overall investment cost.* This result corresponds to smallholders' observations: 'you have one hectare of cocoa after grassland and two hectares after forest'.

This clearly shows one of the main 'laws' of replanting: at the critical phase of investment, replanting requires either capital or extra labour or

both.
That is why this type of model 3 replanting is still scarce in the hills of Sulawesi. However, it is much more frequent in the alluvial plains because of the 'plain rents' which interfere with the 'forest rent'. In these rich alluvial plains, a number of forest rent components may be overwhelmed by the soil fertility rent and the location rent of the plains. In addition, the free market and high producer prices help to buy weedkiller and fertilisers which are a new way to overcome some of the problems related to the loss of the forest rent (see section 4).

Appraisal of the forest rent on rubber farming in Sumatra and Kalimantan

To a large extent, the concept of 'forest rent' matches the history of rubber in Sumatra. Although initial smallholder plantations (jungle rubber) were similar in terms of structure and biodiversity to a secondary forest, the environment went through several changes with the clearing of primary forest and the increase in human settlement. These changes led to an increase in labour costs during the early years of hevea. Higher incidences of weeds, especially grasses such as *Imperata cylindrica*, required more labour for weeding, or weedkiller for rubber and associated foodcrops, in particular when using clonal rubber planting material. Crop protection also became more costly: with more frequent attacks on rubber trees by wild boar and tapirs, smallholders had to pay for additional labour to fence their plantations. According to our surveys in South Sumatra and Jambi, for example, replanting 1 ha of clonal rubber takes about 385 labour days; only 125 days are needed to set up a plantation on cleared primary forest (Gouyon 1995: 300).

Agroforestry practices help to ease the replanting problem by decreasing inputs and labour needs during the investment period but do not suppress it totally. In addition, the monoculture and clonal material effects also interfere. To summarise, three or four cases can be put forward. 1. Replanting jungle rubber after old jungle rubber is not a major technical problem as jungle rubber maintains most of the initial components of the forest rent but it takes 7 to 10 years. This worked in the past but is no longer suited to the present situation. 2. The replanting of complex rubber-based agroforestry with clonal rubber works but is more difficult than planting rubber seedlings after primary forest clearing. 3. Replanting with clones requires additional inputs and labour, either in monoculture or in complex agroforestry systems (CAF), (Penot 1998). 4. The need for additional inputs increases if replantation occurs after grassland (model 3).

Thus, as for cocoa, a difficult choice has to be made in replanting: either the agroforestry strategy, which works when there is plenty of time or more labour and/or capital during the investment phase.

2. The main determinants of tree-crop replanting and partial 'reforestation'

In short, according to this forest rent theory, especially after a pure monoculture cycle, replantation is more costly than a new planting after forest clearing. However, this does not explain the possible lack of replanting.

Together with forest rent factors and throughout both cocoa and rubber cycles, a major social-economic component is the evolution of land ownership. In most cases, at the very beginning of the boom, land is cheap and easily acquired by migrants. 20 or 25 years later, land is becoming scarce and a source of increasing conflict between indigenous people and migrants, possibly between generations within both groups. In some cases, land can be also seized by estates and politically connected personalities. These land tenure problems may trigger conflicts and local recessions. As a result, the dominant model is again a lack of replanting.

However if land rent and forest rent logically tend to become reversed as the cycle proceeds, land rent increases as the supply of available land decreases. Unless a complex agroforestry system can be maintained and renewed, forest rent decreases with deforestation at a regional and national level.

This reversal creates conditions that might be more favourable or even more necessary for replanting. Does this theoretical reversal of relative prices of fallow and forest happen in practice? Does this facilitate replanting? When and under which conditions?

The Côte d'Ivoire showcase

In the 1990s, despite the increasing scarcity of forest in the central western region, when a sale is concluded, the price is hardly higher than that of fallow and of *C. odorata* fallow in particular.

Table 3 The per-hectare cost of land in the Nekeidé region in central western Côte d'Ivoire in 1996

	x 1000 CFAF 1996
Forest	100-110
Fallow	100
Old coffee farm	114

Source: Ruf et al, 1996.

These relative prices in 1996 reflect an apparent loss of economic importance of the forest rent. Why ? The first reason is that 'forest' is no longer a primary forest or even a 'good' secondary forest. The few remaining hectares of forest have been degraded by logging companies. Workers and machines have already taken off several trees per hectare which has had a compacting effect on the soil. More importantly, this activity enhances the invasion of the soil by seeds of *Chromolaena odorata* and various weeds. All this makes the forest less attractive.
The 'second' reason is a social one. The main buyers of land are foreigners coming from Burkina Faso (table 4). They may rely more on fallow than on remaining forests because the 'real' owners of the land are better known. With fallow there is less risk of having complaints from other farmers claiming a right to the land after the purchase.

More importantly, these Burkinabe migrants are coming by thousands from poor regions; they have low incomes and are ready to accept a relatively low labour productivity on these fallow in the ex-forest region. Compared to what they get in their own country, the labour productivity remains very attractive.
Lastly, by being ready to work fallow, the Burkinabe acquire skill in mastering the *C. odorata* and are well able to replant on this type of land.

However, the main reason for their relatively successful replanting since the late 1980s is their low labour opportunity cost and easy access to labour reserves back in their home country. Thus they really monopolise the fallow land market and the first phases of the model 3 cocoa replanting (table 4).

Table 4 : Average investment per land transaction and per origin of buyer, in Nekeidé village, between the end of 1994 and the beginning of 1996 (27 transactions recorded by the village chief himself)

Buyers' origin	Average investment per transaction (Fcfa)	number of transactions	nvested	total i %
Indigenous	450,000	1	450,000	8.8
Migrants from the central region of Côte d'Ivoire	290,000	2	580,000	11.4
Other migrants from Côte d'Ivoire (trader, woman)	80,000	1	80,000	1.6
Burkinabé (Neighbouring country)	173,000	23	3,980,000	78.2
Total		27	5,090,000	100

Sources : Ruf & al, 1996: 118.

The Indonesian rubber showcase

The situation in Indonesia (Sumatra and Kalimantan) has some common features. Land is also becoming scarce but this is not so much due to the increase in population. It comes from the extension of private plantations of oil palm and *Acacia mangium* after land is taken back by the government and given to projects (transmigration projects and governmental estates) or private companies.

As in West Africa, one also finds the 'tree marker' effect on land ownership but with an additional 'selected tree factor'. Forests are still often considered communal property by indigenous families and supposed to be managed by the community at the village level. Communal property is not allowed to be sold. Like West Africa, long term tree crop plantation such as rubber gives a 'permanent' and inheritable right, not unlike the notion of individual property in Roman law. However, because 'jungle rubber' is not recognised officially as a real cropping system (but only by local communities under the local land tenure system), replanting clonal rubber plantations (in monoculture or under CAF), protects land rights. Clonal rubber-based plantations are officially recognised as 'cropping systems'.

Therefore, replanting clonal rubber after old jungle rubber gives value to land. The land market is clearly emerging in traditional rubber areas as well as in pioneer zones where official 'transmigrants' (in projects) or non official transmigrants are looking for land to buy in order to extend the small amount originally allocated by the Ministry of Transmigration (2.5 ha/family).
Relative prices of fallow and forest also have their importance in Sumatra with at least a double land price for old jungle rubber, which can be considered as secondary forest. The situation is partly similar to that of cocoa in terms of forest rent. Old jungle rubber or valuable secondary forest is necessary for the replanting of new jungle rubber. It lowers the cost of replanting clonal rubber (in particular in the CAF system). The only difference

is that replanting rubber after rubber, including clones, seems to imply fewer agronomic problems than those encountered with cocoa.

Table 5 Cost of land in 1996 in Jambi in rupiah/ha

Village	Sepunggur central plain	Muara Buat Mountains	Rimbo Bujang Transmigration project
Bushland/ fallow	320 000	120 000	750 000
Jungle rubber	780 000	315 000	900 000
Clonal rubber plantation	no plantations		10 000 000 rubber plantation project credit (to be reimbursed) included

Source : A Kelfoun, E Penot, I Komardiwan 1997.
Note 1US $ = 2200 Rp.

Conclusion about the main determinants of replanting

The main technical, economic and social factors of the decision to replant or not to replant and its success or failure are clear.
- *Shortage of forest land.* The first determinant is obviously a shortage of available forest. Otherwise migrants occupy the remaining forests. This is a pre-condition to reverse the value of fallow from the farmers' point of view.
- *Surplus of labour.* The second condition is labour. As replanting after degraded plantations and on *C. Odorata* fallow is labour demanding, this is also a pre-condition before restarting a cocoa or a rubber cycle.
- *A minimal amount of capital.* The third condition is a minimal amount of savings and capital
. to buy fallow land which logically increases, at least in nominal terms
. to buy inputs such as weedkiller which may save labour (see part 4) and improved planting material (especially important for clonal rubber)
. to help to compensate the loss of income if the replanting is done by cutting down a still productive plantation
- *A relative fluidity of the land market.* The three conditions cited above often lead to a major social change. A number of those who planted cocoa some twenty or thirty years earlier find it difficult to replant. They are squeezed between increasing family consumption and declining income. The same trend occurs with smallholders who rely on jungle rubber. This squeeze is a typical household cyclical phenomenon since it is related to the ageing of their trees and people. The replanting is often done with the creation of a market of land . This is efficient in terms of economics since land is sold to people who have more available labour and savings but it is also risky from a social and political point of view.

3. The determinants of monoculture and agroforestry: indigenous and migrant effects

Among various possible determinants in the 'monoculture/agroforestry' dualism, the hypothesis that monoculture is above all a first-generation migrant's strategy and agroforestry that of indigenous or long-established or second-generation migrants is perfectly matched by the comparison of cocoa and rubber.

In Côte d'Ivoire, the zero-shade system has been invented or re-invented and adopted by migrants, firstly by Ivoirian migrants and then followed by foreigners coming from neighbouring countries. It is still the dominant system in the 1990s. In Indonesia, the dominant rubber system is still the jungle rubber system which is a highly complex agroforestry system invented and developed decade after decade by indigenous people in Sumatra and Kalimantan. It is true that spontaneous migrants adopted the same system (mainly Javanese in Sumatra) but the flow of migration was quite low and progressive (over a period of 70 years). Migrants must become integrated in the dominant indigenous society in some way. This cannot be compared to the massive flow of cocoa migrants in Côte d'Ivoire and Sulawesi which often enable them to be the winners of the plantation economy, at least for some years.

In fact, a more brutal migration did occur in Sumatra and Kalimantan through the government-sponsored transmigration programme bringing in poor landless Javanese farmers. Some of them had access to clonal rubber plantations. Most of them adopted rubber monoculture because they did not have cultural references to agroforestry and probably also because they were neither authorised nor convinced by the potential interest of agroforestry. As migrants, they were looking for quick returns. However some of them reintroduced later agroforestry practices in order to optimise labour on their very limited land (Penot E, 1997).

In Côte d'Ivoire, those who maintain 'classical' agroforestry systems, based on jungle tree species which have not been cut at the clearing stage or which regrow spontaneously from seeds and roots left in the soil, are mostly indigenous. In that case, they may have less technical problems of replanting.
Still in Côte d'Ivoire, since the indigenous people seem to develop more sustainable systems partly thanks to their accumulated knowledge of the

environment, agroforestry emerges as one of the conditions of sustainability in humid tropical zones and particularly for replanting. This also seems to be the view of numerous migrants who call their monoculture system into question after a number of years. However, the initial ecological, social and economic environments in which the most markedly agroforestry practices and strategies developed have disappeared. They need some help to replant and diversify their tree-crop farms.
So in Côte d'Ivoire as in Indonesia, there are several testimonies of an initial migrant strategy to adopt monoculture, mostly to get quick returns, and later on to reintroduce some agroforestry practices in order to protect their patrimony, when they rediscover the constraints of monoculture.

In Côte d'Ivoire, part of that strategy of coming back to more sustainable farming systems is served by fruit trees such as avocado and orange trees, let alone coffee groves. These trees are used as border trees and help to protect cocoa against drying winds but also are intercropped at relatively high density with cocoa, by migrants. This build relatively 'light' agroforestry systems.
Another component of that strategy may come form inputs. Observation of farmers' innovations and the technical changes accompanying these changes in the environment also reveals increasing adoption of fertiliser, pesticides and weedkiller. In Côte d'Ivoire, the adoption of fertilisers and weedkiller on cocoa is just starting. In Indonesia, it is already much developed.

4. The weedkiller adoption and a minimal need of inputs

Deforestation often creates a niche to *Imperata cylindrica* grasslands, maintained year after year by annual burning of these grasslands and leading to a non-reforestation pattern. *Imperata* can be very aggressive and virtually jeopardise all crops if weeding is not sufficient and if it is not properly contained. Risk of tree-mortality is higher with *Imperata.*
Our surveys in one cocoa village in the hills of Sulawesi show that weedkiller has been adopted by 80 to 90% of migrant smallholders in 1997 (Fig.1). This is mainly the result of massive investment in young cocoa trees and the establishment of new cocoa farms in regions of already much degraded forests. It became impossible to control weeds by hand alone. In addition, the availability of weedkiller has become much easier since the early 1990s.

This undoubtedly encouraged Sulawesi farmers to plant cocoa after grassland when they can afford buying weedkiller. This is often the case since the price ratio cocoa:input is extremely favourable in Indonesia. The same principle works in the case or rubber.

Rubber growing in an *Imperata*-invaded field does not compare. Entry into production is delayed up to the 8th or the 9th year. In short, the 'forest rent' is destroyed. *Imperata* containment by manual control is possible but it requires an amount of labour generally not compatible with farmers' extensive strategies. Like the cocoa farmers in Sulawesi, the rubber farmers recently adopted a specific weedkiller, *Round-up* (Glyphosate). At a rate of 2 to 5 litres/ha, it suppresses Imperata and enables paddy to grow. The input cost of 40,000 to 100,000 rupiah per hectare (in 1996/1997) is compensated by labour saving. Weedkiller is also used in the rubber rows during the paddy crop or during the first 4 to 5 months. The cost is then 25 to 50,000 rp/ha with only 1 to 2 litres/ha. (All these costs are valid in early 1997, before the Asian crisis). Farmers used the *gotong-royong* system (theoretically a 'mutual aid'), but then the cost of weeding is far higher and technically less effective. Its cost has increased in the last few years, in particular in West-Kalimantan within Dayak communities.

Conclusion

Inexpensive integrated pest management (IPM) solutions with maximum respect of the environment are being developed. In the meanwhile the best compromises or symbioses between economic profitability in the short and long term, between the maximising of returns, the renewal of resources and the re-internalisation of costs may depend from the technical point of view on clever combinations of chemical inputs and agroforestry. However, we are far from having seen the end of monoculture with inputs.

From a social and political point of view, replanting (and thus 'regreening') is far from being a technique and is at the heart of social stability. The principle which favours and accelerates replanting through the land market is economically efficient but not without social risks. In the meantime, a 'regulation' of that market coming from the state also has negative and even disastrous effects. The best option is probably to help smallholder groups of interests to avoid land conflict.

References

Courbet Ph, Penot E & Ir. Hilahang. Farming system characterisation and innovations adoption process in West-Kalimantan. In the proceedings of

the SRAP workshop on RAS (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor,.

Gouyon, A., 1995. Government Policy and smallholder changes in sustainable tree crop development in the tropics : a comparison of rubber and cocoa. *In*: Ruf, F. and P.S. Siswoputanto (eds.), Cocoa Cycles. The economics of cocoa supply. Woodhead Publishing. Cambridge. pp 291-313.

Kelfoun A, Penot E & Komardiwan I. Farming system characterization and innovations adoption process in Jambi. In the proceedings of the SRAP workshop on RAS (Rubber Agroforestry Systems), ICRAF, 29-30th September 1997. Bogor, Indonesia.

Oswald, M., 1997. Recomposition d'une société au travers de plusieurs crises : la société rurale Bété (Côte d'Ivoire). Thèse de doctorat de 3e cycle, INA-PG, Paris, 285 p.

Penot E. 1998. L'amélioration des agroforêts a hévéa en Indonésie. Plantation Recherche-Development, CIRAD, mars/avril 1998, Montpellier, France.,

Ruf, F., 1995. Booms et crises du cacao. Les vertiges de l'or brun. Karthala, Paris, 459 p.

Ruf, F. and P.S. Siswoputranto, 1995. Cocoa Cycles. The economics of cocoa supply. Woodhead Publishing. Cambridge. 400 pages.

Ruf, F., 1996. Les booms cacao de la Côte d'Ivoire ... et du Burkina Faso. L'accélération des années 1980/90. CIRAD et Ministère de la coopération, Montpellier et Paris, 400 p.

Temple, L., and A. Fadani,1997. Cultures d'exportation et cultures vivrières au Cameroun. L'éclairage d'une controverse par une analyse microéconomique. Economie Rurale, 239: 40-48.

Fig.1 Cocoa migration to Tampumea and adoption of herbicides