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Diversifying and Intensifying the Cocoa Agroforest Landscape: Review and strategic approaches for managing the shade matrix in West and Central Africa

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The Sustainable Tree Crops Program (STCP) is a joint public-private research for development partnership that aims to promote the sustainable development of the small holder tree crop sector in West and Central Africa. Research is focused on the introduction of production, marketing, institutional and policy innovations to achieve growth in rural income among tree crops farmers in an environmentally and socially responsible manner. For details on the program, please consult the STCP website <http://www.treecrops.org/>.

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Executive summary

Cocoa production has been one of the main cash providers of West and Central African economies. With the liberalization of the perennial tree sector, fluctuations of cocoa income increased. This fluctuation coincided with the period when the demand at the local, regional and international markets of plants that are or could be associated with cocoa was rising. Those plants comprised mainly timber and non wood forest products. The gradual reduction of natural forest, from which such products were gathered, implies, among several strategies, the need to grow them in agroforestry systems such as cocoa farms. In those cocoa orchards or agroforests, broadening the basket of crops by complementing cocoa with non-cocoa trees became necessary. Such broadening can help to stabilize and increase income, provide ecological services, etc. Unfortunately, farmers have not been fully exposed to such a cocoa agroforestry model. In view of helping research and development institutions in promoting sustainable tree crop systems, this background and strategy paper attempts, for the main cocoa producing countries of West Africa (Cameroon, Nigeria, Ghana and Côte d'Ivoire), to: (1) present the dynamics at the local and international level underlying the need to develop multistrata and multispecies cocoa agroforestry systems (2) analyze species considerations in line with the development of such systems (3) present structural consideration related to the system (4) present some potential models and (5) give orientations to develop and implement such a system in West and Central Africa. From the study it appears that:

Deforestation is: (i) leading to shortage of suitable forest land necessary to stabilise or increase national cocoa production and (ii) increasing the gap between the demand and availability of non wood forest products (NWFP) and timber by reducing the providing sources. Demand of those products is increasing with the growth of urban and peri-urban centers. This potential of certified products and payments for ecosystem services that can be provided by sustainable cocoa agroforestry systems has not yet been properly exploited.

Cocoa agroforests of West Africa contain fewer species than those of Central Africa. Market access facility influences the type of species that are managed inside cocoa agroforests. Scientists' preferences for suitable trees to be associated with cocoa has moved gradually from any tree that provides shade to timber and more recently to NWFP as the main plants to be managed inside the agroforestry system. Farmers additionally manage some exotic fruit trees in the same land with cocoa. Species preferred by farmers are not necessarily those that are more frequent in the field. Among the species potentially associable with cocoa, those needed by local, regional and international markets are not necessarily those that are more frequent in the cocoa field. Reforestation programs of the region, using species potentially associable with cocoa, have been mainly focused on timber species for wood production. Very little research and development efforts have been put into NWFP.

Cocoa research programs in the region have been very active in producing "new cocoa varieties" which were distributed to farmers through para-statals. Such efforts, with less input, were also made on exotic edible and timber species. Those formal initiatives have decreased with the economic crisis. The private sector has not yet succeeded to take over in this domain. The informal sector (composed of farmers and farmers' communities) is trying to make efforts to satisfy the demand in seedling and planting materials. They are useful in distribution of genetic material and in reaching remote areas, but they do not necessarily have the skill in production and distribution of seedling and planting materials. There is therefore a need to harmonize and make those initiatives complement formal sectors. With increasing demand of seedlings and planting materials for wild plant species, the use of vegetative propagation to clone wild individual plants with desirable traits is becoming common. Without a strong "breeding"/improvement program which will constantly release new varieties, agroforestry initiatives may lead to reduction of the

genetic basis within tree species of the region. Both sexual and vegetative reproductions need to be properly integrated.

Advice on cocoa density in the region has been generally based on the reflection taking cocoa as the main or only speculation. Advice on the density of cocoa, under shade or not, is based on the intention to control or reduce weed development (i.e. increase the cocoa density to facilitate the closing of the cocoa canopy when the system is developed under un-shaded conditions). In some of the current cocoa fields, not all the cocoa trees produce enough pods. Reduction of the density does not necessarily imply a proportional diminution of cocoa production. This can in some situations be advantageous for cocoa production. Little effort has been applied to investigate a proper density for plants associated with cocoa. Few orientations exist on the association of cocoa with one or two plant species. Advice on the density of NWFP, when they are associated with cocoa, is not common. The density of all the associated plants (taking all the individual plants), in farmer fields is higher than what is recommended by scientists or extension services in Cameroon. By managing a high density of associated plants, farmers exploit several strata and increase the basal area of associated plants from probably 20 (if scientists' advice was applied) to 30 m2/Ha. Farmers then allow distribution of the basal area across strata. Cocoa orchards have short life cycles (15 to 25 years) compared to cocoa agroforests (generally more than 40 years). The complex system with components having different life cycles allows replacement of components without the necessary need to destroy all the system (like it is the case with cocoa orchards). Plant replacement for such systems can be between or within species.

Basic information related to input and output of cocoa fields had been based generally on the management of cocoa trees only. These estimations of investment and income do not take other plant components or ecological services provided by cocoa farms. Nevertheless such estimations (of input and output) exist for mono-specific stands of some plants potentially associable with cocoa. They constitute basic quantitative data that can be used to build different theoretical cocoa agroforest options. Some biophysical data exist on the importance of ecological services offered by cocoa agroforests. But those data generally do not concern financial aspects of these ecological services.

Previous research efforts focused mainly on cocoa. Very little research investment was done on timber potentially associable with cocoa. Little or no research effort was put on edible NWFP (except for cola) and under-storey components. Introduced edible fruit trees received research attention but not with the same intensity as cocoa. These respective research efforts were done within separate institutions. The promotion of agroforestry during the mid seventies did not boost the research on the complex cocoa based agroforestry system of West and Central Africa. One of the main efforts was the trial of cocoa growing under some timber tree such as *Terminalia* spp. Such applied research combined with a strong fundamental science is needed to support the promotion of cocoa based agroforestry systems in West and Central Africa.

Extension services on cocoa in the region have been mainly done through the "training and visits" approach and supported by parastatals in charge of cocoa development. Forestry programs were also done through parastatals. Extension services of introduced edible fruits were carried out by state extension workers and no structure was responsible for the promotion of edible NWFP (except for kola which was linked to perennial crops research and extension services). Some charitable initiatives such as the one offered by some missionaries helped the expansion of some edible fruits in some localities. Since the mid nineties, the farmers' field schools approach were introduced in the continent and are now being tested by IITA on the IPM of cocoa. Expanding this approach to include other components of the cocoa farms in curricula taught proper farmers' field schools (FFS) could help in the diversification of the asset within the system. Those FCAMS could be used either to convert former cocoa systems to the more diverse options or to settle new cocoa farms in West and Central Africa. The following parameters need to be taken into consideration when designing the new curricula: (1) type of plant to be associated with cocoa (2)

density of several components (3) the basal area of component, (4) the stratification and the space between components.

Key words. Cocoa, NWFP, timber, fruits, forest, multi-strata, multi-specific

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1. INTRODUCTION

In cocoa orchards and agroforests of West and Central Africa, cocoa production has been the main cash provider. Efforts have been put mainly on very few commodities (cocoa being the main one). Other components of the agroforestry systems have not yet been fully exploited, despite the fact that several organizations agree on broadening the basket of crops as a tool to minimize market and ecological risks associated with the management of cocoa orchards and agroforest systems. Market niches for forestry and agroforestry products and ecosystem services are rising (within the region and abroad) and need to be targeted by small farmers of the humid forest zone. Dependency on few perennial crops (cocoa, coffee, cotton, tea, rubber), with negligible in-country market, is known to be one of the factors that maintained farmers of the south in abject poverty. Converting cocoa capital assets into non-cocoa capital assets to meet the market demand is seen as one way of minimizing risks associated with livelihood and sustainability. By this we mean the elimination of unproductive cocoa trees to make space in the plantations for useful non-cocoa trees.

Although some research/development/conservation institutions acknowledge the importance of associating perennial tree crops with non-perennial tree plants (FAO, 2002), few have developed models presenting combinations of cocoa with many non-cocoa species. This is mainly because it is always thought that the production of crops and the conservation of natural resources and ecosystem services (such as biodiversity conservation, etc…) are considered as activities which can only be implemented by distinct institutions and on separate lands (Sonwa et al. 2002). The general thought is that growing trees inside cocoa orchards will reduce cocoa production. Graduate evidence that the combination of crops can increase production of each component has been mainly focused on biophysical associations of crops with legume. Few people care to verify if the combination of perennial crops and timber, medicinal or edible species could bring about economic, ecological or social improvement. This was mainly the case untill some authors like Wessel and Gerritsma (1993) started to call for re-thinking on the shade policy for cocoa farming in West Africa based on the fact that the high yield potential of unshaded cocoa (demonstrated in experimental fields and advised since the early sixties) was not reflected in the average yields from farmers' fields. Some years later, for general agroforestry systems, Leakey (1996) argued that "we need to demonstrate that productivity and profitability are not necessary environmentally damaging". In a more recent paper, McNeely (2004) acknowledged the fact that agroforestry systems especially those that use native species, can provide substantial biodiversity benefits. It is gradually acknowledged that reducing overproduction problems (of perennial crops such as cocoa and coffee: despite the expectation that Asia may increase its consumption and absorb this overproduction) and enhancing conservation of protected areas, encouraging certified shaded tree crops may help in achieving both economic and conservation goals (Gooding, 2003; Dietsch et al. 2004).

Some main reasons could explain the separation between cocoa and other activities in the forest area: (i) the rural economy of the West and Central African countries was mainly perennial-crop oriented (ii) little research attention (i.e. technical information availability) has been focused on plants to be associated with perennial crops (iii) Timber was mainly available from natural forest, (iv) the NWFP (Non Wood Forest products) were considered to be minor products and were available from natural forest and (vi) the international community was not yet fully sensitized on environmental damages related to forest destruction (partially due to open-sun cocoa development in West Africa) and the poverty situation of farmers at the fringe of the forest. Thus, unfortunately, farmers have not been fully exposed to alternative models, which can help in filling the gap created by new business opportunities in local and international markets. It is then necessary to promote multistrata and multi-species systems to demonstrate different models of association of cocoa with associated plants. In this background and strategy paper, based on the situation in Cameroon, Nigeria, Ghana and Côte d'Ivoire, we will try to:

(1) Present the dynamics at the local and international level in line with the need to develop a more diverse multistrata and multispecific cocoa agroforest system

(2) Analyze species consideration (species on cocoa field, needs of farmers and species need by the market) in line with the development of such a system

(3) Examine vertical and horizontal structures consideration related to the cocoa system

(4) Review previous information on the estimation of investment and income from cocoa fields

(5) Analyze previous orientations of research and extension services

(6) Propose some main parameters to take into consideration to diversify the assets in the current cocoa model

2 DYNAMICS ASSOCIATED WITH COCOA FIELDS

2.1 Economic liberalization and income provided by cocoa beans to farmers

Cocoa has been the "Engine of economic growth" in many rural areas of West and Central Africa (Shapiro and Rosenquist, 2004; Ruf and Padi, 2003; Gockowski and Dury, 1999). Liberalisation of the economic sector in this region has the consequence of slowing or removing the buffer effect of former parastatals like ONCPB (Office National de commercialisation des produits de Base in Cameroon) and CAISTAB (Caisse de stabilization in Côte d'Ivoire) (Bloomfield and Lass, 1992). These structures were in charge of maintaining a fixed cocoa price to farmers. In 1992, It was already evident that structural adjustment had a negative impact on cocoa research, and despite substantial annual crop losses due to disease and pests, cocoa has not benefited from any coordinated research effort (Bloomfield and Lass 1992). This restructuring or closure coincided with the reduction in cocoa price in the world market due to the production boom of new countries such as Indonesia. This happened when subsidies for planting material were gradually reduced or eliminated in West and Central Africa. Additionally, countries like Cameroon and Côte d'Ivoire went through a devaluation of the CFA currency, which led to an increase in the price (or double) of the main inputs generally imported. Under these conditions, poor producers generally use fewer purchased inputs. Farmers of the region were then exposed to low net income and fluctuating cocoa prices.

To avoid the effect of reduction of the cocoa price, devaluation of the CFA and restructuring or removal of the several cocoa board parastatals, farmers started to think about the alternative plants to be managed inside and outside cocoa agroforests (Sonwa et al. 2000). Outside the cocoa plantation, farmers' activities were focused mainly on food crop extension with a drastic effect on the forest. Inside the cocoa plantation, farmers in Cameroon tried to grow mainly tree species (Sonwa et al 2001). This new initiative was seen as a positive way to promote a suitable perennial crop system (Sonwa et al. 2003 a & b).

2.2.Deforestation, scarcity of forest products and reduction of ecosystem services

In West and Central Africa, forest degradation was associated with logging while cocoa has contributed to forest destruction, particularly in countries like Côte d'Ivoire and

Ghana, where open sun cocoa orchards have been highly proposed and supported (Gooding, 2003, Ruf and Zadi 2003, Niesten et al. 2004). Cocoa areas in Cameroon, Nigeria, Ghana and Côte d'Ivoire increased from 3 to 5 million Ha from 1961 to 2000 (Sonwa et al. 2003c). On the contrary, the forest deforestation rate reached 3%/year in Côte d'Ivoire (Koudou et Vlosky, 1997; Sonwa et al 2003a). Increase in cocoa production was mainly the result of forestland consumption (Ruf and Zadi 2003). This is explained by the fact that the farm-level economies and ecology/agronomy conditions drive producers to seek out new areas of natural forest for cultivation rather than replant existing aged farms (Niesten et al. 2004). With the disappearance of forest stand, new lands for the expansion of cocoa became scarce (Ruf and Zadi 2003).

In addition to the shortage of forestland, some little evidence was accumulated showing that ecological modification due to deforestation in the region can have a negative impact on cocoa production (Yao et al 2003). Farmers in the transitional zone between forest and savannah in the Lekie division in Cameroon faced frequent drought. In Côte d'Ivoire, the main growing part of the country (south east), the long rainy season changed from 4 months 10 days in 1950 to 3 months 10 days in 1999 (Yao et al. 2003). In this region a 200 mm reduction in the cumulated rain between April and June the previous year causes an average reduction of 13g in bean weight (Yao et al 2003). Deforestation was then modifying cocoa production through shortage of land and change of ecological condition.

Other functions of the forest such as biodiversity conservation, ecosystem services (Box 1), timber provision, NWFP production became difficult to meet (Jenkins et al. 2004; Scherr et al. 2004) with the reduction of forest lands and impoverishment of cocoa farmers. Deforestation and degradation of forest has then been gradually happening with the increase in the demand of NWFP. Environmental services gradually became difficult to be satisfied. To properly answer all these constraints, the integration approach of landscape became necessary. Approaches such as ecoagriculture, combining incentive conservation tools with production and commercialization of certified products/services, became ways that could help in binding satisfaction of farmers with fulfilment of ecosystem services.

Box 1. Agroforest, forest ecosystem services and the market

Cocoa agroforests are seen as potentially susceptible to playing some of the same functions as forests. These functions concern globally: (1) Purification of air and water (2) Regulation of water flow (3) detoxication and decomposition of waste (4) generation and renewal of soil and soil fertility (5) pollination of crops and natural vegetation (6) control of agricultural pests (7) Dispersal of seeds and translocation of nutrients (8) Maintenance of biodiversity (9) partial climatic stabilization (10) moderation of temperature extremes (11) windbreaks (12) support for diverse human cultures and (13) Aesthetic beauty and landscape enrichment (Daily 1997 cited by Scherr et al. 2004). Among the services offered by forests, the most popular ones are carbon sequestration, biodiversity protection and watershed protection. In West and Central Africa, maintaining forest or growing forest trees to satisfy such services generally means in the broad sense, depriving rural population of their main sources of income or food. Using agroforestry with perennial crops based systems is gradually seen as possible ways to meet those services and additionally fulfil farmers' daily needs. Under the forest shade, farmers can grow cocoa, use forest products for their daily life and receive additional incentives proportionally to the services provided by the agroforestry system they are managing.

Farmers growing cocoa under forest are then susceptible to receive payment in one of the following main categories defined by Scherr et al. (2004): (1) Public payment schemes to private forest owners to maintain or enhance ecosystem services; (2) Open trading under a regulatory cap or floor; (3) Self-organized private deals; and (4) Eco-labelling of forest or farm products, an indirect form of payment for ecosystem services. In West and Central Africa, markets for eco-labelled products for export and for urban consumers are not being fully exploited. As natural forest disappears, products needed by the market need to be grown in farms such as cocoa agroforests. In addition to products they provide, field observation in Cameroon, where cocoa is grown under forest shade, reveal the existence of good practices potentially marketable through ecosystem services.

Cocoa agroforests of southern Cameroon contain 62% of carbon as much as the virgin forest (300 Mg/Ha) (Koto Same et al. 1997). In these agroforests, 116 plant species were found compared to 160 in the forest and 64 in farmland (Zapfack et al. 2002) despite the fact that forest may contain more wild species. Bobo et al (2006) found a Sorensen index of 0.13 and 0.045 between Cocoa agroforest and secondary and primary forest respectively in the South West of Cameroon. In a more detailed field study, Sonwa (2004) found that each cocoa field contains 21 species and an aggregation of 60 cocoa fields gave a total of 201 plant species associated with cocoa in Southern Cameroon. This suggests that giving incentives to farmers to accomplish a "small" species conservation on their land can result in greater achievements at the landscape level by keeping more species than what can be found inside each farm. But this needs to be planned and implemented in collaboration with farmers. Where there is no attraction to keep trees in farms, incentives need to be put in place to make farmers keep more wild species.

2.3. More attention on NWFP

Since Peters et al (1989) drew attention on the role of the NWFP, more effort has been put in this category of products. A recent worldwide survey reveals that Africa has not yet exploited the potential of local and international markets (Ruiz-Perez et al 2004). Half-year sales values of 9 main NWFP in 25 markets provided US$1.94 millions in 1995 and 1996 (Ndoye 1995; Ruiz Perez et al. 1999). With the disappearance of forests, it is gradually becoming evident that the supply of timber and NWFP will come from plantations or agroforest systems.

The fluctuation of income from the cocoa crop at the village level increases the perception that NWFP can also bring complementary income to conventional perennial crops. Gockowski et al (2004) estimated that net returns to management and lands, in cocoa agroforests, of *Dacryodes edulis, Ricinodendron heudelotii*, palm oil (*Elaeis guinensis*), palm wine (*Elaies guinensis*), *Persea americana*, *Citrus sinensis*, *Citrus reticula* (orange) and cocoa stood at 96,913 ; 20,939 ; 4,771 ; 13,250 ; 2,795 ; 16,698 ; 62,700 and 164,000 F CFA/Ha respectively in 2002/2003 in Southern Cameroon. At an exchange rate 1$ = 640 F CFA, these equate to 151, 33, 7, 21, 4, 26, 98, and 256 $/Ha, respectively. Despite the importance of secondary products, some constraints related to their promotion can still be mentioned: (a) the development and commercialization of NWFP have not received support such as the one put on perennial crops; (b) the density of NWFP are less than those of cocoa; (c) the inter-annual variation seems to be more acute on fruits than in cocoa; (d) fruits are generally more perishable than cocoa; (e) the NWFP have been mainly managed by women who do not necessarily grow trees like men do; (f) there are also transport and market constraints; and (g) the problems of tree tenureship that impede planting and management of native trees.

Despite the little attention paid to NWFP some decades ago, some local ecological constraints (like disappearance of forest reserves which used to provide the main part of NWFP) and institutional changes (increasing demand of NWFP by urban and international markets) are pushed to revisit the future management of such category of products. For example, some experts think that countries like Nigeria will lose their forest resources in some decades and the demand for forest products will need to be satisfied through other ways. Agroforestry based perennial crop systems such as cocoa agroforest are then seen as tools to provide forest resources. But unfortunately farmers still need to be exposed to such situations, where cocoa and associated plants are given the same opportunities to bring income to households and play other environment roles.

Management of associated plants faced lack of real technical advice, because extension services were not prepared for management of NWFP or managing perennial tree crops with other associated commercial speculation. In West and Central Africa in general, planting trees is not usual in the region. High dependence on perennial and food crops have not created incentive to growth and maintained tree plantation. About 60% of the on-farm trees in Nigeria are not planted but are wild resources that are protected by farmers because of their economic and ecological value (FAO, 1990). These are not necessary improved trees and are not necessarily arranged in a more homogeneous manner. The new will of farmers to grow trees needs to be supported with proper skills contained in the new curricula.

The will of seeing farmers contribute to the planting of trees is hampered by the trees tenureship. Within many local areas of West and Central Africa, trees belong to the state. Farmers generally need permission from the state to exploit those trees. The authorization to cut the trees is not easy to obtain and thus farmers exploit the trees illegally and generally sold it below the "market" price (Gockowski et al. 2004). This reduces the incentive farmers should have had and so plant more native trees in cocoa agroforests.

To achieve proper development of complex agroforest systems, Leakey (1998) proposed (1) the identification of species of commercial importance relevant to local markets; (2) the development of an entrepreneurial mentality among the community, made up of subsistence farmers and hunter gatherers; and (3) the determination of how best tree species may be combined to develop agroforest. To this list should be added (4) the creation of a conducive legal and institutional framework to encourage farmers to use trees (including tree tenureship). In the next step we will review species consideration, those present in the system and what is needed at the market level.

2.4. Demand of more certified products

The market demand of goods from rural areas of the humid forest zone has been mainly focused on timber extraction and cocoa production. Such activities have contributed to forest degradation and destruction. The money paid by consumers, who some time are not aware on the way such products were grown or harvested, indirectly contributed to environmental destruction. To avoid such situations consumers started requesting that timber comes from forest with proper management plan, that cocoa is grown under shade systems that provide some ecosystem services. For products coming from the humid forest area, consumers need such products in certified form.

They also want to be sure that production of such goods was not associated with human rights violation, forest destruction or any ethical misconduct. NWFP, timber and medicinal products from West Africa are potential products for such markets. Edible NWFP and medicinal plants exported from West and Central Africa (Tabuna, 2000) are mainly from spontaneous plants. Edible NWFP are generally exported from Africa to the Diaspora especially in Europe. The market of certified products (and/or niches market) from cocoa and coffee plantations are mainly occupied by products from Latin America (IIED 1997, FAO et al. 2001). Unfortunately this market has not yet been fully explored and exploited for products originating from West and Central Africa. Coffee and cocoa systems of Latin America are targeting markets of such products with the support of conservation NGOs. Cocoa agroforest of Southern Cameroon can ecologically satisfy the conditions of such demand, but they still need to properly develop regular supply and marketing systems to fulfil the demand. In the other parts of the region, production niches need to be developed, at least for the pilot phase period. West African cocoa farmers need to be "trained" to develop sustainable cocoa systems, which can allow them to respond easily to the multiple demands of the international market.

The current dynamics have thus shaped new environments favourable to use cocoa agroforests to properly achieve development and conservation goals in the humid forest zone of the region if proper attention is paid on this type of vegetation systems (figure 1)

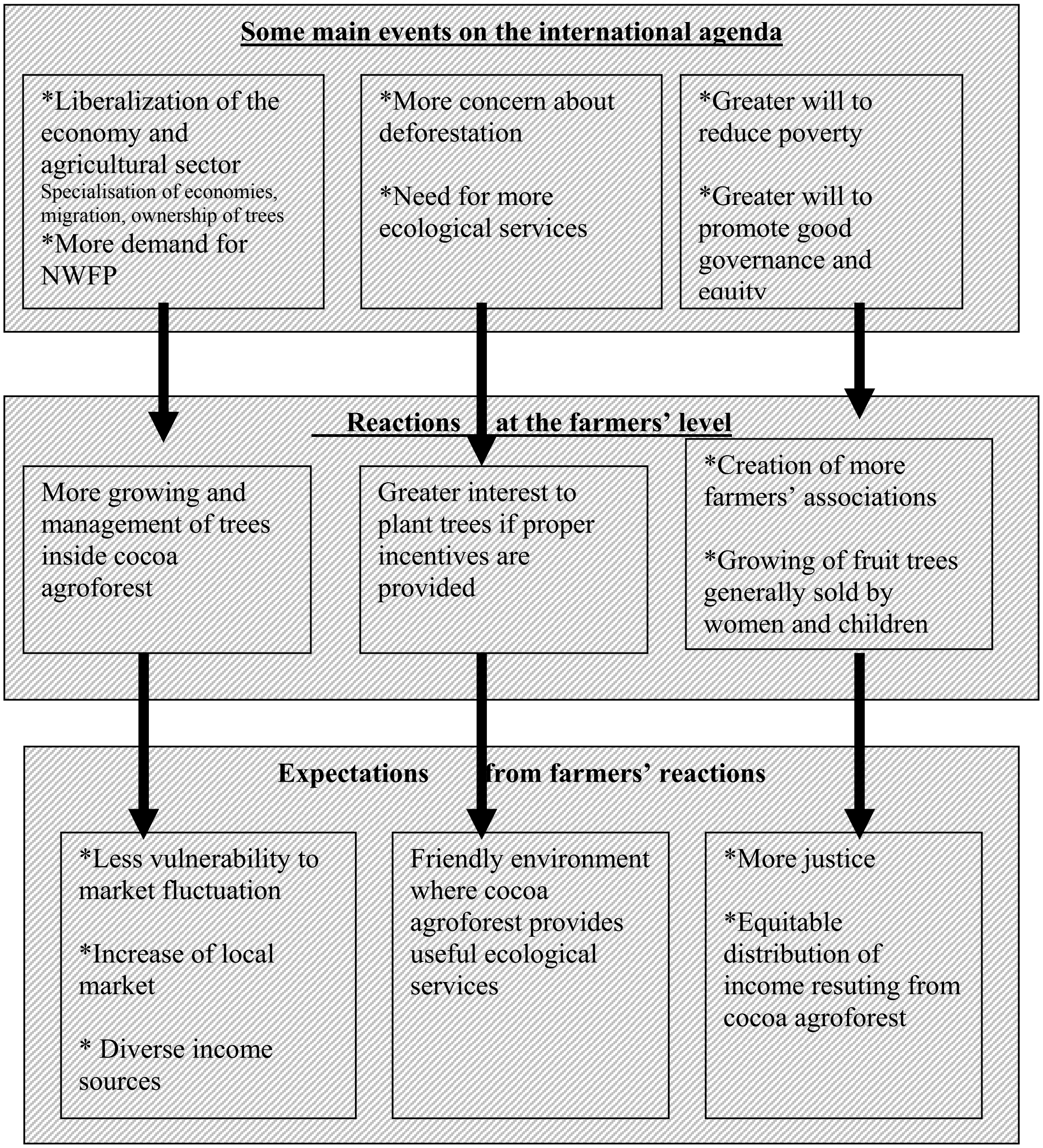

Figure1: Some main events and their implication on cocoa agroforest in the humid forest zone of West and Central Africa

3. PLANT SPECIES AND COCOA AGROFOREST

3.1 Type and number of species in cocoa field

The main functions played by the plant are important factors taken into consideration when deciding to introduce or maintain the plant in cocoa agroforests. The utility of species, their phenological pattern and their growth rate are the main criteria given by farmers when selecting plants for cocoa agroforests (Oduro-Ameyow et al. 2004; Bidzanga, 2005). Previous efforts by researchers have been to introduce trees that can provide shade to cocoa and allow its proper development (Braudau 1969, Van Himme and Snoeck 2001). In addition to shade function, effort were made to manage cocoa with timber species (Koyo, 1982, Petihuguenin, 1995). In Ghana and Nigeria, research has tried to investigate into the association of cocoa with edible plants (mainly coconut, kola and citrus), with the aim of providing additional income and satisfying household needs (Osei-Bonsu et al 2002; Fanaye et al 2003). But attention was paid more on timber than on edible plants. Despite the importance placed on timber by scientists, farmers generally managed cocoa agroforest with the aim of satisfying their daily needs. Some Ghanaian and Ivorian farmers grow cocoa with mainly fruits trees, timber and medicinal plants (Osei-Bonsu et al. 2004; Herzog 1994, Ngoran 2003). Fruit trees are generally prosperous where accessibility to the urban centers (where markets exist) is good. This for example, is the case around the Lekie and Mbam divisions of Cameroon, the Anegby region of Côte d'Ivoire and the Easten and Ashanti regions of Ghana (Gockowski et al. 2004). The main fruits used by farmers to diversify their income are mango, avocado, and citrus which are generally sold in the local market.

A new established cocoa in the Osino district of the eastern region of Ghana contains 9 tree species/Ha against 6 in a mature agroforest. In the Baoule region of Côte d'Ivoire, an average of 5.4 species is found per hectare. A farmer of southern Cameroon maintained an average of 21 species (6 consumable, 2 medicinal, 7 timber and 6 other plants) in his farm (Sonwa, 2004). But those near the market (i.e. around Yaoundé) have the following: 6 consumables, 1 medicinal, 4 timber and 4 other plant species. A survey found that farmers of southern Cameroon usually plant on average 7 plant species (4 fruits and 3 non-fruits) to diversify the cocoa plantations (Sonwa 2004). This clearly shows that to make the system more market oriented, efforts need to focus mainly on edible, medicinal and timber plants.

From the information available, we realized that cocoa farms of West Africa contain less species than those of Central Africa. The type of species within the farm can be influenced by the access facility to markets. Among the edible species, NWFP may have a bright future due to the growth in local markets. Disappearance of forest means bright future for timber but priority for growing inside cocoa agroforest may be put on fast growing ones. Chronologically it appears that Research or Scientist preferences for trees suitable to be associated with cocoa has gradually moved from any tree that provides only shade to timber (with the aim of providing wood) and more recently to NWFP as main plants to be managed inside the agroforestry system. (Table 2)

Table 1: Some concern priorities for trees to be associated to cocoa since the introduction of cocoa in West and Central Africa

	Before 1960 period	Mid sixties to Mid eighties	Since the mid eighties	The future
Research priority	Any tree that provides shade can be maintained (maintain around 60% of shade) Elimination of some tree because they can compete with cocoa	Effort to associate cocoa with **timber** species	Effort to associate cocoa with **NWFP**, **Timbe**r and legume trees	Management of **under-storey** and **livestock, NWFP & Timber**

3.2. Species preferred by farmers

Several species have been generally proposed to be maintained or introduced in farming systems of West and Central Africa. Around 1960, trees such as *Terminalia spp, Milicia excelsa*[1]*, Albizia spp, Alstonia boonei, Ficus vogeliana, Ficus exasperata, Entandrophragma spp, Antrocaryon spp, Pycnanthus angolensis, Canarium schweinfurthii* and *Epathodea campanulata* were considered good providers of shade in Côte d'Ivoire and Cameroon (Braudeau 1969). *Triplochiton scleroxylon and Ceiba pentandra* were supposed to be unsuitable in Côte d'Ivoire, but suitable in Cameroon. The above plant species are mainly managed to provide shade to cocoa. Research and extension services tried without success to promote the growing of *Terminalia* spp with cocoa in Cameroon, Togo, Côte d'Ivoire and the Democratic Republic of Congo (Petithuguenin, 1995). In Ghana researchers target *Terminalia ivorensis, Ricinodendron heudelotii, Spathodea campanulata, Albizia spp* and coconuts as plants that can be associated with cocoa (Osei-Bonsu et al. 2002; Amin-kwapong 2003; Padi and Owusu 2003). The Cocoa Research Insititute of Ghana (CRIG) finally proposed the following as desirable forest trees: *Terminalia ivorensis. Terminalia superba, Milicia excelsa, Albizia coriaria, Entandrophragma angolense, Funtumia elastica, Alstonia boonei and Pychnanthus angolensis* (Manu and Letteh, 1987). CRIG classified the following as undesirable forest trees: *Adansonia digitata, Blighia sapida, Canthium glabriflorum, Carapa procera, Ceiba pentandra, Cola chlamydantha, Cola gigantia, Lecaniodiscus cupanoides, Musanga cecropioides and Myrianthus arboreus*. A recent suggestion by Van Himme and Snoeck (2001) is to manage shade species such as *Gliricida sp, Leucaena sp, Erythrina sp* and *Calliandra sp* (instead of forest species), because they are easier to prune. But those species are likely to have fewer (if any) uses to farmers, in the forest zone probably not even for fuelwood because there is enough wood around. As agroforestry is becoming a more important science and seems a tool for development in the region, scientists such as Leakey (1998) advice the use of species such as *Baillonella toxisperma, Canarium schweinfurthii, Cola spp, Coula edulis, Dacryodes edulis, Irvingia gabonensis* for domestication program inside multistrata agroforestry systems of the Humid Forest Zone of West and Central Africa (Table, 6). This new recommendation, which also considers cocoa agroforest as a system that can receive such species put more emphasis on the management of edible NWFP in the agroforestry system. This new suggestion is not too far from farmers' priority.

Farmers of West and Central Africa, give their preference to the following species as priority for domestication in agroforestry systems of the region: *Irvingia gabonensis/I.*

[1] *Milicia excelsa* is synonym of *Chlorophora excelsa*

wombulu, Dacryodes edulis/D klaineana, Chrysophyllum albidum, Ricinodendron heudelotii and Garcinia kola/G. afzelli (Franzel et al 1996). In a survey on the most preferred plant to be improved in Cameroon, farmers' preference was on *Irvingia gabonensis, Baillonella toxisperma, Dacryodes edulis, Elaies guinensis, Ricinodendron heudelotii, Alstonia boonei, Guibourtia demensei, Entandrophragma cylindricum, Garcinia lucida and Milicia excelsa* (Mollet et al. 1995). A more recent survey revealed that the 5 most edible plant species grown by farmers in cocoa agroforests in southern Cameroon are *Dacryodes edulis, Persea Americana, Mangifera indica, Citrus sinensis and Citrus reticula* (Sonwa 2004). The 5 most non-edible plants are *Terminalia superba, Triplochiton scleroxilon, Milicia excelsa, Ceiba pentandra and Ficus mucuso* (Sonwa 2004). The most frequent species are *Elaeis guineensis, Dacryodes edulis and Persea americana* (Table 3). Farmers usually use 7 plant species (4 fruit and 3 non-fruit plants) to diversify their agroforest. But within the plantation we found an average of 21 species per cocoa farm. This suggests that there is more unplanned aboveground plant diversity in this cocoa. This situation is not far from the one in Côte d'Ivoire where farmers left some trees such as *Ceiba pentandra* (56% of cocoa farms in the Baoulé region), *Milicia excelsa* (28%), *Bombax buonopozense* (22%), *Celtis mildbraedii* (11%), *Dracaena manii* (6%), and *Ficus exasperata* (6%) in farms because they are too big or not worthwhile to be cut (Herzog 1994).

Table 2. The 10 most frequent plant species in cocoa fields and percentage of the plantations where the species are found in Cameroon, Ghana and Côte d'Ivoire.

Plant species	Cameroon	Ghana (Trees)	Ghana (fruits & food)	Côte d'ivoire
Albizia adianthifolia	47			
Albizia zygia		62,28		
Alstonia boonei		70,58		
Antiaris welwitschii var africanum				28
Bombax buonopozense				22
Carica papaya			37	
Ceiba pentandra				56
Milicia excelsa		84,23		28
Citrus reticulata				78
Citrus sinensis			57	67
Cocos nucifera			12	
Cola nitida			33	33
Dacryodes edulis	65			
Elaeis guineensis	80		85	100
Ficus anomanni		60,53		
Ficus elastocoides		69,58		
Ficus exasperata	50			
Ficus mucuso	48			
Ficus spp		60,53		
Mangifera indica			31	50
Margaritaria discoidea	47			
Musa paradisiaca	47		47	
Musa sapientum			46	
Persea americana	62		80	67
Psidium guayava			6	
Pycnanthus angolensis		67,18		
Rauvolfia vomitoria		72,23		
Ricinodendron heudelotii				28
Spathodea campanulata	47			
Sterculia tragacantha		64,1		
Terminalia ivorensis		68,63		
Terminalia superba	48			

Source Ghana: Osei-Bonsu et al. 2004, Cameroon : Sonwa (2004), Côte d'Ivoire : Herzog (1994)

Table 2 provides the 10 most frequent tree species found inside cocoa farms of Cameroon, Ghana and Nigeria. Cocoa farms in Côte d'Ivoire can contain species such as *Trema guinensis, Milicia excelsa, Ficus spp., Pycnanthus angolensis, Terminalia spp* and *Alstonia boonei* (Ngoran, 2003). From a total of 25 mostly wild species used as shaded trees in Côte d'Ivoire, only the following were found in more than 25% of cocoa farms: *Persea Americana, Citrus reticula, Mangifera indica, Citrus sinensis, Cola nitida, Elaeis guinensis, Ricinodendron heudelotii, Antiaris welwitshii, Ceiba pentandra and Milicia excelsa* (Herzog, 1994) (Table 4). In the Osino district of the Eastern region of Ghana, of the 116 species recorded in sixty farms surveyed, only 21 were common on all the farms (Osei-Bonsu et al. 2004). In this country the most frequent species were *Elaeis guinensis* (present in 85% of the cocoa fields), *Persea Americana* (80%), *Citrus sinensis* (57%), *Musa paradisiacal* (47%), *Musa sapietum* (46%), *Cocos nucifera* (12%) and *Psidium guayava* (6%) (Osei-Bonsu et al. 2004). In Southern Cameroon, the 5 most frequent species found in cocoa fields are *Elaeis guinnensis, Musa paradisiacal, Dacryodes edulis, Persea Americana,* and *Ficus exasperata*. The 10 most frequent plant species represented 45% of the total plants associated with cocoa (Sonwa 2004).

From the above review, we realized that research or scientist preferences has gradually move from "any" tree providing shade in the early sixties to timber providing shade (around 1970; Exception for trees incompatible with the growing of cocoa) and more recently (in the early 1990) to NWFP and timber. In their preferences, farmers include exotic edible species such as Citrus, Mango and Avocado. Species such as *Elaeis guienensis* and *Persea Americana* are present in generally more than 65% of cocoa fields in Côte d'Ivoire, Ghana and Cameroon. Within country, species frequencies may change from one locality to another. In Cameroon for example the 10 most frequent species of forested area are not necessary the same in market oriented areas (Sonwa 2004). Little data exist on what is on the field and what farmers preferred. Farmers' preferences are not what are necessarily present in their cocoa fields. In Cameroon, among the 5 edible and 5 non-edible species grown by farmers, only *Dacryodes edulis, Ficus mucuso* and *Terminalia* are among the 10 most abundant plant species found in cocoa agroforests (Sonwa 2004).

3.3. Species need by the market

The demand by consumers for species that can be managed inside cocoa agroforests concern mainly timber, exotic fruits and NWFP (edible and medicinal plants).

Some NWFP are mainly traded and consumed in West and Central Africa. Table (3) gives some of these NWFP for Cameroon, Nigeria and Ghana. Some main exported NWFP from Central Africa to Europe are also presented in this table. Among those species needed by the markets, *Cola* spp and *Garcinia spp* are common for the entire region. Some species are needed in some countries and not necessarily in others (e.g. *Dacryodes edulis* and *Irvingia* are needed in Cameroon and Nigeria and not necessarily in Ghana and Côte d'Ivoire). In Nigeria, household consumption of *Irvingia gabonensis* is estimated at 3.2 to 14.1 Kg/year/household. Demand in urban areas is increasing. The total demand is estimated to reach 78 800 tons (FAO, 1990). *Cola acuminata*, *C. nitida* are heavily traded locally (Falconner, 1990). In Ghana, demand of NWFP is increasing. In Côte d'Ivoire, statistical information for NWFP are not available, the main medicinal plants of the forest zone are *Garcinia afzelli*, *Garcinia lucida*, *Allanblackia floribunda, Voacanga africana, Grifonia simplicifolia* (FAO/Sven under). In Cameroon the trade of 4 NWFP (*Irvingia gabonensis, Cola accuminata, Ricinodendron heudelotii, Dacryodes eduliis*) was around US$1.75 million in the first half of 1995 (Ndoye 1998). In Central Africa, multitudes of species are used for subsistence, whereas only selected species of the main importance are commercialized at the level of national and international markets. Trade edible ones include *Irvingia, Dacryodes edulis, Cola accuminata, Coula edulis, Ealeis guinensis, Piper guinnensis, Xylopia aethiopica, Aframomum spp and Gambeya africana,* and *Gnetum spp, Garcinia sp* (Sven Under-FAO). Species exported to pharmaceutical companies due to their chemical properties are *Prunus africana* (Equatorial Guinea, Cameroon), *Pausinystalia johimbe, Voacanga africana, Strophantus gratus* and *physostigma venenosum* (all exported from Cameroon). The main Non-Wood Forest products from sub-Saharan Africa commercialized in Europe are *Tetrapleura tetraptera, Xylopia aethipica, Mangifera indica, Irvingia gabonensis, Ricinodendron heudelotii, Cola nitida, Garcinia kola, Dacryodes edulis and Elaies guinensis* (Tabuna, 2000). Those species are generally spontaneous.

Table 3. Some main NWFP with high demand in Cameroon, Nigeria, Ghana

Species	Cameroon & other countries of Central Africa	Nigeria	Ghana	From Central Africa and exported to Europe
Acacia kamerunensis			1	
Acacia pentagona			1	
Baillonella toxisperma	1			
Ceiba pentandra		1		
Cola accuminata	1	1	1	
Cola nitida	1	1	1	1
Cola spp			1	
Crysophyllum albidum		1		
Dacryodes edulis	1	1		1
Elaeis guinensis		1		1
Garcinia afzelli		1	1	
Garcinia epunctata			1	
Garcinia kola	1		1	1
Garcinia lucida	1			
Garcinia mannii	1	1		
Gnetum africanum & Gnetum buchholzianum	1	1		
Irvingia gabonensis & *I. wombolu*	1	1		1
Marantaceae	1			
Myrianthus arboreus		1		
Pausinystalia johimbe	1			
Piper guineense	1			
Prunus africana	1			
Pteropcarpus sp.		1		
Rattan *(Laccosperma secundiflorum & Eremospatha macrocarpa)*	1			
Ricinodendron heudelotii	1			1
Spondias mombin		1		
Tabernanthe iboga	1			
Tetraptera tetrapleura				1
Treculia africana		1		
Xylopia aethiopica				1

Source: Falconer, J. (1990); Walter (2001); Cunningham (1993); Tabuna (2000) / FAO documents

Edible exotic fruit trees are also highly consumed in West and Central Africa. In Côte d'Ivoire, fruits such as *Cocos nucifera, Carica papaya* and *Mangifera indica* appear among the most edible ones in Zongoussi, V-Baoule region. In Cameroon the demand for edible exotic fruit trees is increasing (Temple, 1999). Exotic fruit trees have been mainly developed in West and Central Africa by colonists or religious organizations and have became part of the daily consumption of the population (Aulong et al. 2000). Demands of these exotic fruits are very high in the region particularly in urban and peri-urban areas. It is common to find those exotic fruits inside cocoa agroforests. They have been intensively promoted and are very close to the population.

For timber species, *Terminalia* spp, *Triplochiton scleroxylon* and *Milicia* spp are generally exported from Cameroon, Ghana and Côte d'Ivoire (Tables 4). In West Africa (Ghana and Côte d'Ivoire) where forest resources have disappeared, white wood species such as *Ceiba pentandra*, *Pycnanthus angolensis* are exported as timber species and have more importance than in Central Africa. Exploitation of species is concentrated on very few species (e.g. on 60 of the 400 potential species in Côte d'Ivoire). National demand of wood in Ghana exceeds the offer. Reforestation target is 60 000 t/year (IITO, 2003). In Côte d'Ivoire, the rate of reforestation with Frake (T. superba) and Framire (T. ivorensis) as well as the exotic teak (Tectona grandis) and Cedrela odorata is 10 000 Ha/year (200 000 ha of land have already been reforested). The internal demand has not been fully exploited because prices are not different from the exported products. The demand in Nigeria is more important because only 5% (less than 38,620km2) of the original forest of the country remained. Wood supply will mainly come from plantations. In Cameroon the local transformation is increasing due to the ban on exporting untransformed logs. Among the main logging species during the year 94/95 and 95/96 were Triplochiton *scleroxylon, Entandrophragma cylindricum, Lophira alata, Milicia excelsa* and *Entandrophragma utile*. The first two contributed to 55 to 60% of exported volume (Eba'a Atyi, 1998). *Terminalia superba* and *Erythrophleum ivorensis* have gained importance during the year 1994/95 and 95/96. Those species can constitute 75% of the exported volume (Eba'a Atyi, 1998). This important list at the level of each country gives an overview of what can be useful nationally. They are not so different from preferences at the regional level (Table 5 and 6)

Table 4. Main timber species exported from Cameroon, Ghana and Côte d'Ivoire in 2001

Species	**Cameroon**	**Ghana**	**Côte d'Ivoire**
Alfzelia spp	Doussie		
Aningeria altissima		Asaufina	
Aningeria robusta			Aniegre
Antiaris africana		Chenchen	
Baillonela toxisperma	Moabi		
Bombax buonopozense			Kapokier
Brachystegia	Ekop		
Ceiba pentandra		Ceiba	Fromager
Celtis spp.		1	
Milicia excelsa	1	Odoum	Iroko
Cylicodiscus gabunensis	Akoum/Adoum		
Disthemonanthus benthamianus	1		
Entandrophragama cylindricum		sapele	sapelli
Entandrophragma candollei	Kosipo		
Entandrophragma utile	1	utile	Sipo
Erythrophleum spp	Tali		
Gossweilerodendron	Basami-ferum		
Khaya ivorensis		Mahogany	Acajou
Lophira alata			Azobe

Mitragyna ciliata			Bahia
Pterygota macrocarpa		Koto/Kyere	
Pterygota spp			Koto
Pycnanthus angolensis		Otie	illomba
Rhodognaphalon spp			Kondroti
Tectonia grandis			1
Terminalia ivorensis			Framire
Terminalia superba	1	Ofram	Frake
Tetraberlinia spp	1		
Triplochiton scleroxylon	1	Wawa	Samba

Source: ITTO (2003)

Table 5. Main species logged in Central Africa (CIFOR 2004)

Common name	**Scientific name**
Acajou	*Khaya anthotheca*
acuminata	*Entandrophragma congolense*
afrormosia/assamela	*Pericopsis elata*
agba/tola	*Gossweilerodendron balsamiferum*
aiélé	*Canarium schweinfurthii*
andoung/ekaba	*Monopethalantus spp.*
aningre	*Aningeria altissiima*
ayous	*Triplochiton scleroxylon*
azobé	*Lophira alata*
bibolo/dibetou	*Lovoa trichilioides*
bilinga	*Nauclea diderrichii*
bossé	*Guarea cedrata*
doussié	*Afzelia spp.*
ilomba	*Pycnanthus angolensis*
iroko	*Milicia excelsa*
izombé	*Testulea gabonensis*
kevazingo	*Guibourtia spp*
kosipo	*Entandrophragma candollei*
kotibé	*Nesogordonia papaverifera*
koto	*Pterygota bequaertii*
limba	*Terminalia superba*
longhi	*Gambeya spp.*
moabi	*Baillonella toxisperma*
movingui	*Distemonanthus benthamianus*
naga	*Brachystegia cynometroides*
niové	*Staudtia stipitata*
okoumé	*Aucoumea klaineana*
padouk	*Pterocarpus soyauxii*
safukala	*Dacryodes pubescens*
sapelli	*Entandrophragma cylindricum*
sipo	*Entandrophragma utile*
tali	*Erythrophleum suaveolens*
tchitola	*Oxystigma oxyphyllum*
tiama	*Entandrophragma angolense*
wengé	*Millettia laurentii*

CIFOR. [2004]. Workshop to develop a regional applied research program in the Congo Basin [ITTC Decision 10(XXXII)]: pilot study on the social, environmental and economic sustainability of industrial concessions in the Congo Basin, main report, part D: a report prepared for International Tropical Timber Organization. Tokyo, Japan, ITTO. 144p

Table 6. A Sample of the West African tree/shrub/liana species appropriate for inclusion in multi-strata agroforests and for domestication (Leakey, 1998)

Species	Common names	Mature height (m)
Anthocleista schweinfurthii	Ayinda	15–20
Antrocaryon micraster	Aprokuma/Onzabili	40–50
Baillonella toxisperma	Moabi	45–55
Calamus spp.	Rattan	35–45
Canarium schweinfurthii	Aiele/African canarium/Incense tree	45–55
Chrsophyllum albidum	Star apple	30–40
Cola acuminate	Kola nut	15–25
Cola lepidota	Monkey kola	10–20
Cola nitida	Kola nut	15–25
Coula edulis	Coula nut/African walnut	25–35
Dacryodes edulis	African plum/Safoutier	15–25
Entandrophragma spp.	Sapele/Tiama/Utile/Sipo	50–60
Garcinia kola	Bitter kola	20–30
Gnetum africanum	Ero	0–10
Irvingia gabonensis	Bush mango/Andok	20–30
Khaya spp.	African mahogany	50–60
Lovoa trichilioides	Bibolo/African walnut	40–50
Milicia excelsa	Iroko/Mvule/Odum	45–55
Nauclea diderichii	Opepe/Kusia/Bilinga	35–45
Pentaclethra macrophylla	Oil bean tree/Mubala/Ebe	20–30
Raphia hookeri and other spp.	Raphia palm	5–15
Ricinodendron heudelotii	Groundnut tree/Nyangsang/Essessang	40–50
Terminalia ivorensis	Framiré/Idigbo	45–55
Terminalia superba	Fraké/Afara/Limba	45–55
Tetrapleura tetraptera	Prekese/Akpa	20–30
Treculia Africana	African breadfruit/Etoup	20–30
Trichoscypha arborea	Anaku	15–25
Triplochiton scleroxylon	Ayous/Obeche/Wawa	55–65
Vernonia amygdalina	Bitter leaf	0–10
Xylopia aethiopica	Spice tree	15–25

Source: Leakey (1998), with permission.

From this review of the market demand and the findings of 3.3, It appear that species preferred by farmers are not necessarily those which are more present in the field (there are some unplanned biodiversity in cocoa fields), species need by the market are not always those which are the most frequent in cocoa agroforests. *Which species are logged, or commercialised depends both on market demand and availability*. Unfortunately cocoa agroforests are generally established after logging, suggesting that timber resources may be lower than those of forest areas. In the reforestation programs, effort has been put mainly on timber species (generally in mono specific stand). Such reforestation programs are generally for wood production and not for ecosystem services. Research efforts have been mainly put on fruit trees, little on timber and very little on NWFP. To improve the sustainability of cocoa agroforest, efforts need to be put on the species that fall within the national reforestation program but such species need to be associated with those which can be used to satisfy the household and local needs. The cocoa diagram flow of products produced by cocoa agroforests of southern Cameroon (figure 2) gives an idea on the destination of components produced by such systems. There is still some room for amelioration.

Species need for cocoa agroforest systems will then depend on the aim of cocoa AF systems. Intensification (i.e. concentration on 1 or few species) is seen as an easily manageable strategy because of its uniformity. Research effort has been concentrated mainly on fruits (exotic species). Wild species do not attract a lot of attention, except for Cola that has been given little attention in Côte d'Ivoire. Research effort has been put mainly on exotic fruit trees, with little attention on wild species. These wild species offer the opportunity to reproduce the forest structure and competition. The finality will be to use species that satisfy the household need for home consumption and market commercialization. To maintain the target of achieving high planned biodiversity, un-planned plants (biodiversity) needs to be gradually removed or substituted by species/plants identified as priority for the agroforest based on market regulation or farmer preferences.

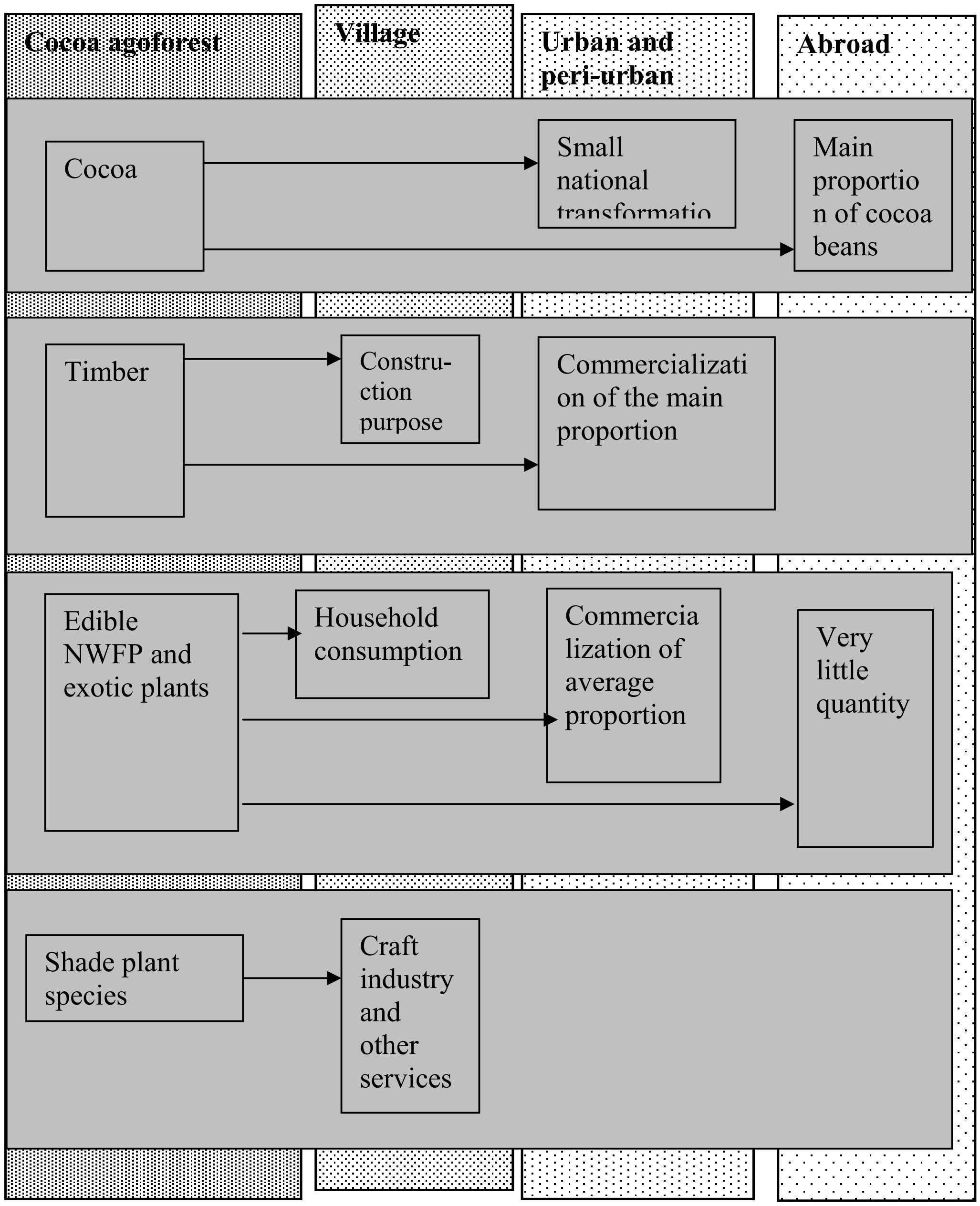

Figure 2. Main destination of products from cocoa agroforests in the Humid Forest Zone of Southern Cameroon

4. SEEDLINGS AND PLANTING MATERIALS

4.1. Cocoa seedlings

With the support of parastatals, farmers of West and Central Africa received seedlings during the seventies and eighties used in the creation of new cocoa plantations. Research efforts were very active in producing new varieties necessary to satisfy the demand of farmers. Distribution was done by SODECAO in Cameroon, which was in charge of promoting the development of cocoa. Agronomic and phytosanitary factors such as high productivity and resistance to black pod disease were the aim of breeding programs. Clone of cocoa of genotypic well-known cocoa seedling was then massively distributed in the humid forest zone of West and Central Africa.

With the decline on research activities and functioning of parastatals, the production of new varieties and distribution of new seedlings decreased. No public structure, following the liberalization of the cocoa sector, took over the selection and distribution of cocoa seedlings in the region. New farmers and farmer communities started to produce cocoa seedlings without enough training in breeding and distribution of cocoa seedlings. With cross pollination occurring on cocoa fields, it became difficult, after production of cocoa pod during several generations, to give exactly the genotype of cocoa currently changing hands in the region. News cocoa generations produced by farmers do not always perform like the ones received from parastatals.

With this reduction in phytosanitary practices, subsidized in the past by the state through parastatal, pest problems have become more harmful (Sonwa et al. 2002). New breeding programs may be directed towards the solving of these constraints, but also aimed at producing improved materials that can adapt and grow well under multistrata agroforestry system. A strong collaboration between NARS, IARC, cocoa farmers and chocolate industry is necessary to achieve this goal. Farmers' associations can help in the distribution of this improved material, but this diffusion needs to be preceded by a strong breeding program that constantly provided good improved materials. A strong gene bank of cocoa accession of the region is necessary. Cocoa programs in the region need to be pro-active and broaden the genetic basis of cocoa by a continuous release of new cocoa varieties.

4.2. Seedlings and planting materials of associated plants

Research efforts on exotic fruits and timber species was supported generally by the state till the end/middle of eighties in West and Central Africa. Those programs were generally coupled with a breeding program complemented by vegetative techniques such as grafting and air layering. Generally some biological information exists to support breeding programs of exotic plant species. Such information is not always available for wild plant species of the humid forest of West and Central Africa.

With the new will of growing wild tree species, the temptation to concentrate on vegetative species is very high. With such initiatives, wild plants with desirable traits are cloned and seedlings distributed to farmers. Without a strong effort to capture, protected genetic variability *ex situ*, and release new ideotypes on a gradual basis, effort to clone some very few plants will lead to reduction of genetic variety (Box 2).

Box 2. The need to complement vegetative propagation initiatives with a strong generative program

Plants associated with cocoa are generally propagated by seed. Except for exotic fruits, tree species (mainly wild ones) spread in the region, spontaneously or deliberately, by sexual reproduction. This type of reproduction generally allows recombination of gene and increase genetic variability. It has succeeded to maintain a good intra-specific variation within plant species of the humid forest zone of West and Central Africa.

With an increase in the demand or market for plants with some particular traits, the tendency of promoting vegetative propagation, by using wild individual trees presenting such traits, is becoming common. This type of reproduction allows cloning of plants with particular characteristics. Mass production of plant material with this type of reproduction alone may increase the risk of reducing the genetic basis of the species. In some cases, this clonal growth plant can influence pollen transfer between plants and thus affect matting opportunities (Charpentier, 2002). Without constant introduction of new improved varieties, the vegetative program may lead to a "plateau". There is then a need to maintain a variety or genetic basis of plant species by regularly releasing new improved materials in the region. This can be done properly if *ex situ* materials are properly managed to supply breeding programs.

In the development of sustainable cocoa agro-forests, clonal multiplication needs to be associated with proper ex situ conservation strategy, robust breeding program and strong policy of releasing of new variety or ideotype.

With the demand of more seedlings, informal enterprises controlled by farmers and farmers' organizations are gradually getting to seedling production and distribution. In the area of seedlings of plants associated to cocoa, formal companies have not yet started playing an important role. Previous research efforts by NARS were on exotic plant species. A proper harmonization is necessary to satisfy the demand (Box 3). Previous experience in sub Saharan Africa has shown that NARS collaboration with IARC, with the support of structures such as the World Bank and some bilateral institutions, has been necessary to provide good production and distribution of seedlings. Such synergies are needed to produce seedlings and planting materials potentially associable with cocoa.

Box 3. Harmonize formal and informal production and distribution of seedlings and planting materials

Public sector of seedling supply has been the center of forestry, agroforestry and agricultural development initiative in West and Central Africa during the 1970 and 1980 period. To support forestry programs and perennial expansion initiatives, the state through parastatal was involved in the provision of seedlings to farmers. In the cocoa sector, parastatals such as SODECAO in Cameroon were in charge of supplying improved cocoa seedlings (generally hybrids) to farmers. In Cameroon for example the World Bank, in 1975, through SODECAO, supported the multiplication and distribution of cocoa seedlings (Essama-Nssah and Gockowski 2000). Such governmental initiatives are sometimes supported by NGOs, like the "Services d'Appui aux Initiatives Locales de Développement" (SAILD) in Cameroon (Tsokgna, 2003) and the Adventist Development and Relief Agency (ADRA) in Ghana. The ADRA succeeded in 10 years in producing 4 million assorted tree seedlings including fruit trees (like mangoes, cashew, guava and Sweet) and woody tree species (Teak, Eucalyptus spp, Neem and Albizia lebbeck) (Djarbeng and Ameyaw, 2002 cited by Assare, 2004). With the structural adjustment program the states' involvement in the production and distribution of seedlings and planting materials has decreased.

Informal seedling programs (through farmers and farmers' communities) are gradually emerging and play a role in the distribution of seedlings and planting materials in the region. Farmers and community nurseries are created, without necessary input of the state or any structure trained in seedling or planting material production and distribution skills. These informal initiatives can be useful to reach remote areas and help in the distribution of improved material. They are at the center of several government and non-governmental development preoccupations. Without the support and link with formal seedling production systems, exchange of genetic materials, by these informal initiatives, may be limited to a small geographic area.

There is thus a need to support a strong formal seedling and planting material production system and link it with the informal seedling initiatives emerging in the region. Both formal and informal (farmers to farmers) initiatives can be complementary in production and distribution of seedlings and other plant materials.

5. STRUCTURE OF COCOA FARMS

5.1. Density of cocoa

In West and Central Africa advice is generally to plant cocoa with a density of more than 1000 trees per hectare with the possibility of reaching 2000 cocoa/Ha. Cocoa density recommendation is 1333 cocoa/Ha in Côte d'Ivoire (Akeyssey, 1992); 1600 cocoa/Ha with the possibility to reach 2000 or 2500 cocoa/Ha for non-shade systems in Cameroon (Nya Ngatchou, 1984). Increasing the density of cocoa when shade is removed generally allows the closing of canopy and reduces the development of weed (Lachenaud 2001). The above density advice to farmers has been based generally on cocoa as the main or only crop. Farmers do not always follow rigorously this advice. Between 1,028 and 1,212 cocoa trees/Ha are under shade around Baoule (Zougoussi and Bingakro), and around 2,400 cocoa trees/Ha are un-shaded in Côte d'Ivoire (Ngoran, 2003). The density of cocoa trees in Ghana ranges from 1,000 to 2,500 trees/Ha despite the fact that extension services advice 1,730 cocoa plants per Ha (Wood and Lass, 1985). A recent survey found that the average density of cocoa in Southern Cameroon is 1168 tree/Ha (Sonwa 2004). The density of cocoa in Nigeria is 1,000 to 1,750/Ha (Wessel, 1971). Cocoa here is grown with little or no permanent shade (Wessel, 1971).

Cocoa is generally planted homogeneously in the farm in West Africa. An "Avenue planting" has been tested in Côte d'Ivoire and Togo (Lachenaud, 2001; and Vaast…) with density sometimes lower than 1,000 cocoa/Ha, with the aim of providing space for food crops at the early stage of the orchard. The thinning of 50% of the 1,333 to 1,666 cocoa could favourably influence the yield. Advice density is generally aimed at controlling weed in the system. In farmers' fields reduction of density does not necessarily slow cocoa production. This production can even increase in the situation where pesticides were not well applied. In some cases, loss due to black pod disease (Phytophtora) are less in the lower density (Moses and Enriquez, 1981). A recent study by Sonwa (2004) reveals that where pesticides are not applied, high density of cocoa do not provide more cocoa beans production.

Overproduction of cocoa is generally used to explain the low price of cocoa at the international market. Some believe that cocoa farmers need to reduce their production to be able to influence the market system (Koning and Jongeneel, 2006). This action does not necessarily mean that cocoa area needs to be reduced. Reduction of cocoa production can be achieved through conversion of some cocoa trees or space to associated plants. This replacement can help in reducing the density of cocoa and increase the importance of associated plants. The situation of Tsan villages in southern Cameroon can be illustrative of this sort of orientation (Box 4).

In the cocoa field, not all the cocoa trees produce enough cocoa pods. In a recent study in southern Cameroon, Sonwa (2004) realized that without fungicide application, 21% of cocoa trees do not produce any healthy pods. With an intensive application of fungicide, 6% of cocoa trees were still unable to produce any healthy pods after two years of experimentation in farmer fields. Investment on such un/less productive trees is wasted effort that negatively affect the management of the cocoa system.

From the above, at least two reasons can be given to justify the need to reduce the cocoa density: (1) proper diversification of speculation means that some cocoa trees need to be substituted by other trees or plant species, (2) reducing the density of cocoa trees can help in slowing the spread of *Phytophtora spp* (putting some few trees will constitute a barrier to the movement of the *Phytophthora*), (3) Among the cocoa trees in the field, not all produce healthy cocoa pods at the acceptable level justifying their maintenance, (4) halving the density does not necessarily reduce the yield of cocoa production. It can sometime increase this production.

Previous findings easily lead to the need to reduce the density of cocoa and increase the importance of other speculations. Few studies exist on the way plants, need to be settled in the farm. Targeting a 600 cocoa/Ha (around half of the current cocoa density) can be a good starting point. Participatory discussions with farmers can help in designing appropriate models

Box 4. Cocoa and Citrus in traditional agroforestry systems of the Ntsan village in Cameroon

In the Ntsan village, efforts to introduce citrus by missionaries were made with the aim of diversifying the food allowance in the early 1970 by giving seedlings to farmers to help in the growth of this plant in Cocoa agroforests. More than 3 decades after, a study undertaken by ITTA-CIRAD (Aulong et al. 2000) program realized that 80% of citrus is grown in cocoa plantations. In this small village where cocoa "orchards" have a density of 900 cocoa/Ha (and more than 2000 for some fields), cocoa agroforests enriched with citrus have cocoa divided by two (i.e. around 500 trees/Ha). Initially grown for consumption, citrus is now being sold as a consequence of the development of the urban and periurban market of Obala and Yaoundé. Despite its importance, farmers still prefer cocoa because citrus production is not far from zero in certain years (e.g. 1997-1998). This is one of the constraints faced by farmers growing citrus in the Ntsan village.

From this Experience, we realized that, (1) other income sources than cocoa can be easily managed in cocoa agroforests (2) Incentives such as those provided by religious bodies in the Ntsan are necessary to support the management of other products in the system (3) a good technical package is necessary to support the introduction of such components in the rural area. NWFP could have also been promoted in the same way as Citrus. What is important here is the dynamics around cocoa agroforests (not the intensification with exotic plants)

5.2. Density of associated plants

Few studies have really focused on the design and density of associated plants in cocoa agroforests. Previous effort to settle cocoa orchard and agroforest put more attention on the existence or presence of shade. For associated plants, advice is to settle them in such a way that they allow 50 to 75% of light to reach the cocoa plants (Van Himme and Snoeck, 2001).

In Cameroon advice from the "projet-semencier" Cacao-Café-ONADEF services (a project which was created to support the development of cocoa in Cameroon around 1990) generally use a "space" of 12m x 10m for the following *Terminalia superba, Spathodea campanulata, Alstonia congensis, Antrocaryon klaineanum, Ficus mucuso, Pycnanthus angolensis and Canarium schweinfurthii* (Table 7). This gives an average of 83.3 Trees/Ha. Although the recognized *Milicia excelsa, Entandophragma, Albizia ferruginea* and *Albizia glaberima* are good shade trees for cocoa they do not provide any density for the association of these trees with cocoa. Density is not far for 85t/Ha advice for species such as *Terminalia spp* at the age of 17 for the mono-specific stand (Memento..). In this monospecific stand of *Terminalia*, expectation is to have 70 plants/Ha at the harvest period (35-45 years after establishment), with a basal area around 20m^2/Ha (Memento, …). In Ghana, the recommendation is 10 to 15 trees/Ha (Padi and Owusu, 2003). Main species targeted by researchers in Ghana are *Terminalia ivorensis, Ricinodendron heudelotii, Spathodea campanulata, Albizia* spp and coconut as plants that can be associated with cocoa (Osei-Bonsu et al. 2002, Anin-Kwapong 2003, Padi and Owusu 2003). Studies on the intercropping of kola and citrus with cocoa show that stem girth and canopy scores of cocoa, kola and citrus in cocoa-kola-citrus were better at longer spacing and lower plant population densities of 17 plants/Ha each of kola and citrus than smaller spacing and higher plant population of 69 plants/Ha although the difference was not significant (p=0.05) (Fanaye et al. 2003). There were no allelopathic effects on any of the component crops. Recently, Van Himme and Snoeck (2001) suggested spacing of 9 to 18 m between plants associated with cocoa. This gives a density of 31 to 278 plants per hectare. After observation of palm oil growing in Côte d'Ivoire, Tchoume (1982) concluded that cocoa could be grown with palm oil in the avenue planting. In the past, Grimaldi (1979) suggested the planting of *Cassia spectabilis* (now known as *Senna spectabilis*) at 5m x 5m for adequate shading of cocoa after 4 to 5 years in Southern Cameroon (Wood and Lass, 1987). In Southern Cameroon 321 associated plants (with diameter ≥ 2.5 cm) per Ha (i.e. average space of 5.38 x 5.38) are found inside cocoa agroforests (Sonwa 2004). This is very high compared to the 12m x 10m advice for the timber species of the "Projet semencier Cacao-café" in Cameroon. The system resisted because of the mixture of species belonging to several strata.

In the pure plantation (Table 7), advice on the space/density of fruit trees are: 10m x 10m for mango; 6m x 6m or 6m x 13m followed by proper thinning for avocado; 9m x 10m (i.e. 110 plat/Ha) for Mandarin; 6m x 7m (i.e. 238 plant/Ha) for Clementinier (Memento); 125 to 200 plants/ha for orange. In pure *Cola spp* plantation in Côte d'Ivoire advise of the density is 156 trees/Ha (8m x 8m) (Table 7). Few studies really exist on proper density of associated plants in cocoa agroforests (Table 8). When data exists, they are not based on proper combination of main species. Density of associated plants needs to be managed with the aim of achieving a certain basal area.

Table 7. Density, in pure stand, of some species potentially associable with cocoa in West and Central Africa

Species	Density	Space between tree	Comment and country
Terminalia spp	70 to 85 Trees/Ha	11.95 m x 11.95m to 10.8 m x 10.8m	Tropic Expected basal area 20 m2/Ha
Mango	100 trees/Ha	10m x 10m	Tropic
Mandarin	110 Trees/Ha	9m x 10m	Tropic
Clementinier	238 Trees/Ha	6 m x 7m	Tropic
Orange	125 to 200 Trees/Ha	8.9m x 8.9m to 7m x 7m	Tropic
Cola spp	156	8 m x 8m	Côte d'Ivoire
Dacryodes edulis	125	10m x 8 m	Cameroon (Center, South and East province)

Source: Mémento de l'Agronome, Agriculture en Région tropicale (Kengue and Degrande, 2003)

Table 8. Advice on the density of some plants associated to cocoa

Species	Density	Average Space	Source
Terminalia superba *Spathodea campanulata* *Alstonia congensis* *Antrocaryon klaineanum* *Ficus mucuso* *Pycnanthus angolensis* Canarium schweinfurthii	83.3 Trees/Ha	12m x 10m (Cameroon)	Cacao-café-Onadef Project
Kola Citrus	17 Trees/Ha	24.25 m x 24.25m	Nigeria
Terminalia ivorensis *Ricinodendron heudelotii* *Spathodea campanulata* *Albizia spp* Coconut	10-15 Tree/Ha	(31.62m x 31.62m) to (25.8 x 25.8)	Ghana
Cassia spectabilis		5m x 5m (not specify)	
Gliricida sp. *Leucaena s.* *Albizia sp.* *Erythrina sp.* *Calliandra sp.* Any Forest species *Terminalia superba*	277.7 to 30.8 Trees/Ha	9m x 9m to 18m x 18m	Van Himme and Snoeck (2001)

Alstonia sp. *Ficus sp.* *Fagara sp.* *Phyllantus discoideus* *Croton haumanianus* *Macaranga sp.*			

From the above observation it appears that little research efforts have been focused on the density of plants associated to cocoa and none has focused on the valorisation of under storey plant species (box 5). For the plants potentially associable to cocoa, density for pure plantation exists for timber and edible exotic fruits, but not for NWFP. Scientists' advice on the density of plants to be associated with cocoa does not always consider association of several species with different types and strata. Density use by farmers in southern Cameroon is higher than the advice of scientists and resist (maintained the climax status) because they belong to plants of several strata.

Box 5. The neglected under-storey plant species

Slashing under-storey components is one of the main management tasks with cocoa agroforests or orchards. Under cocoa based agroforest 1.21 t/ha of weed can thus be returned to the soil again, 3t/ha when shaded is not present (Sonwa 2004). The management option of removing this understorey is driven by the need to avoid competition with cocoa. This continuous removing of plants from year to year help slow the seed bank and reduce the diversity of understorey plant species. Within 9 subplots of 1mx1m in cocoa or coffee agroforestry systems of the Korup area in Cameroon, 137 understorey plants were found as against 364 and 200 respectively in secondary forests and near-primary forests (Bobo et al. 2006).

Little efforts have been made to see if those understorey plant species could be valorised inside cocoa agroforest in one way or other. It is known that forest understorey plays a role in traditional medicine and as food in rural areas (to cheek…) but can also provide some additional services. When well managed, understorey can help in: avoiding land degradation; providing habitat for predator (e.g. beneficial insects or spiders) which can maintain ecological balance between "pests" and other species; provide habitat for a variety of animals; reduce the impact of rain and runoff; contribute to taking nutrient from the soil and depositing it as litter on the surface; provide edible plants and medicine. If the cocoa density is reduced they can improve the quantity per unit of land and reach the acceptable economic level.

When well managed, understorey can play a key role in ecological services and household needs. Consequently, they need proper attention so as to achieve a proper multistrata and multispecies cocoa based agroforest.

5.3. Basal area of associated plants

The basal area is the cross sectional area of the stem or stems of a plant or of all plants in a stand, generally expressed in square units per unit area. In plantation forestry, a fairly good correlation exists within species between the basal area of a tree and the cross-sectional area of its crown, and the sum of all basal areas in a stand (stand basal area) has conventionally served as basis for the scheduling of thinning to reduce inter-tree competition (Smith et al. 1997 cited by Nissen and Midmore, 2002). The basal area is also recognized to be useful for monitoring of agroforestry systems, where crops and trees are mixed (Nissen and Midmore, 2002). Another parameter, which can go with the basal area, is eco-volume (space created by the presence of associated plants and which provide proper ecological condition for other plants and animals). Recent studies by Sonwa (2004), taking into consideration cocoa and associated plants, obtained an average basal area of 36 m^2/ha on which 85% are taken up by the plants associated with cocoa. This study conducted in different ecological zones and different types of cocoa plantations gave the average of 30m^2/Ha for plants associated with cocoa. There was no statistical difference between ecological region and type of cocoa (Sonwa 2004) for better achievement of a multistrata system.

If we consider the advice of 12 m x 10 m *Terminalia superba* per hectare, this can easily lead to the density of 85 trees/Ha (with probably 70 trees/Ha and a basal area of 20 m^2/Ha at harvest period, 35-45 years after establishment (CTFT, 1989). The expected basal area of 20 m^2/Ha is less than the average 30m^2/Ha (Sonwa 2004) found in the farmers' cocoa fields (Table 9), but not far from those obtained by ASB (2000) in the study in 2 cocoa fields in Cameroon (17 m^2/Ha and 20 m^2/Ha for associated plant and cocoa). This expected basal area is greater than the average 13 m^2/Ha of the upper strata (> 20m) of the HFZ. The advice of 17 trees/Ha in cola fields (i.e. 13.34 m2/Ha if all the trees have a diameter of 1m) in Ghana is low but seem more compatible with the possibility of managing other trees under the upper strata. This Ghana potential upper strata is the average basal area of the upper strata (13 m^2/Ha for plants above 20m) in Cameroon.

Few studies have tried to evaluate the basal area of cocoa multistrata and multi-specie systems of cocoa agroforest in West and Central Africa. Ecovolume (space created by agroforest for life cycle) have not been properly exploited. The current advice of scientists to grow cocoa with one specie has left unexploited basal areas. The indigenous cocoa farming system of Southern Cameroon has 30 m^2/Ha (Sonwa 2004), which is greater than what can be expected with the current advice given by scientists. The current advice does not always allow proper distribution of basal area across strata.

5.4. Stratification and space between components

Cocoa agroforests that have a structure similar to the forest are of particular interest from the perspective of the environmental services they can provide. Ruf and Zadi (2003) noted that cocoa established in forest shade trees could form a stratum of up to 40m above the cocoa grove. ASB (2000) observed the mean canopy height of 12 and 18m in maintained (> 45 years) and un-maintained (<30 years) cocoa agroforest respectively in Cameroon. One of the main challenges is to keep the stratum of associated plants at the level that does not hamper the development of cocoa. Few studies exist on stratification within cocoa agroforests. The cocoa agroforest of the southern Cameroon has the basal area distributed across several strata, as a result of different density in those strata (Table 9).

Table 9. Density, basal area and average space between plants in the cocoa agroforest of Southern Cameroon.

		Strata				
		0-5m	5-10m	10-20	>20m	Tot
Yaoundé	Basal area m^2/Ha	1.1	2.5	15.8	10.3	29.7
	Density/Ha	142	64	89	13	308
	Average space between plants (m)	8.39 m x 8.39m	12.5 m x 12.5m	10.59m x10.59m	27.33m x27.33m	5.69m x 5.69m
Mbalmayo	Basal area m^2/Ha	0.4	3.1	14.3	12.8	30.7
	Density/Ha	60	108	161	28	358
	Average space between plants (m)	12.90m x12.90m	9.62m x9.62m	7.88m x7.88m	18.89m x18.89m	5.26m x5.26m
Ebolowa	Basal area m^2/Ha	0.9	1.5	11.9	17.0	31.2
	Density/Ha	67	59	138	34	298
	Average space between plants (m)	12.21m x12.21m	13.01m x13.01m	8.51m x8.51m	17.14m x17.14m	5.79m x5.79m
HFZ	Basal area m^2/Ha	0.8	2.4	14.0	13.4	30.5
	Density/Ha	90	77	129	25	321
	Average space between plants (m)	10.5m x10.5m	11.39m x11.39m	8.8m x 8.8m	20 m x 20 m	5.38m x5.38m

Source: Sonwa (2004)

From the above table, we can derive some basic information on the cocoa agroforest. Using the Cameroon model the basal area of associated plants in cocoa agroforests, at the climax (Janssens et al 2004), will be around 30m^2/Ha (Sonwa 2004). But the system will be more aerated if the density of plants within the strata of 5-10m could be reduced. In the average, without taking into consideration patchiness that sometimes appear in the agroforestry system, plants of the upper strata (> 20m) present a distance between trees of 20m x 20m. By proposing a density of associated plants of 15-18 trees/Ha in Ghana (Asare, 2005), CRIG is advising a space of 26 m x 26m between plants. This is not far from the situation of the upper strata of the Yaoundé block in Cameroon where an average of 27m x 27m is observable. But in the case of Cameroon, farmers tried to exploit the under canopy of this strata by managing other components in the system. This leads to the increase of basal area of associated plants per unit land.

The upper canopy is generally occupied by the timber species, while the lower one is filled with fruit trees or medicinal species or timber plants in the growing phase. To allow proper circulation of air, it will be good to share the basal area of associated plants between the two important strata 10-20 m and the upper strata (more than 20 m). Previous study in Africa usually try to make a combination of cocoa with one or 2 species with the target of only one strata different to the cocoa strata (Amoah et al. 1995; Koyo 1982; Fanaye et al. 2003; Petihuguenin, 1995). Building a multistrata system deserve to fill the gap between the cocoa and the upper strata. It will be good to have a proper vertical distribution of the basal area (ex. 15.8 m^2/Ha within the strata of 10-20m and 10.3 m^2/Ha for the strata >20m) or density of associate plants (89 plants/Ha within the 10-20m strata and 13 within the strata >20m). Management of different strata (Box 6) need to fit in proper chronology cycle taking into consideration life of cocoa and the one of associated plants.

Box 6. How many strata are useful in cocoa agroforest?

Providing shade to cocoa is the main task assigned to associated plants in cocoa agroforests. Previous advice was to manage associated plants such that they allow 60% of sun to reach the cocoa canopy. Although this was admitted as a rule (Braudeau, 1969), few studies are trying to test the proper ways in which associated plants should be managed in an appropriate ecological manner with good economic outputs.

The cover within cocoa agroforest can be expressed in terms of leaf area index. Basal area can also help in expressing the coverage of the upper canopy. One of the main questions that still need to be solved is the vertical distribution of the leaf area index or the basal area. Is it ecologically, agronomically and economically profitable to maintain the leaf area index of the system in one strata or to share it on several vertical strata? One of the main challenges for scientists working on cocoa agroforest will be to try to make investigations in this area.

5.5. Life cycle of components

A complex cocoa agroforest is a combination of plants with different life cycles. At the climax, the humid forest, with a structure similar to forests expected for cocoa agroforest, presents a combination of species and population that are dynamic but with components maintained over time. At the climax (Jansens et al 2004), young individual plants are in quantities enough to replace old ones. Depending on the aim to achieve with the cocoa agroforest, the approach may be different. The cocoa agroforest will probably be related to the local forest climax (Box 7). Un-shaded cocoa last generally around 25 years (Ruf and Zadi 2003). After this period the orchard returns to fallow before cocoa plants are established again. Under shade conditions of southern Cameroon, with the combination of components, each can be changed at the end of its life cycle without necessarily destroying all the system. During the replacement of cocoa, the system is rich in organic matter and does not develop a lot of weed that can compete for water with young cocoa plants.

Box 7. Cocoa agroforest and local forest climax

Having the structure of the forest is the expectation when developing cocoa agroforest. The idea is generally to put in place a system that can provide ecological services offered by forests. Such services in the forest are generally well offered when the forest reaches its climax. This is the final stage in the ecological succession of the forest, when it reaches equilibrium. At this stage, the greater part of the energy produced by the system is devoted to the life of plants and animals in the system. In the forest succession this equilibrium stage is characterized by certain biomass and basal area.

Agriculture and agroforest practices involve deliberate prevention of the ecosystem from developing towards a climax. This agroforestry system need to be in constant production as cocoa beans and other plant products will be removed annually from the system. A study in southern Cameroon reveals that a primary and secondary forest can have a basal area of 44.9 and 39.2 m2/ha respectively (Zapfack et al. 2002). Within the same site, cocoa agroforest has a basal area of 36m2/Ha (Sonwa) or 30m2/Ha (Zapfack et al. 2002). The above data suggest that 5 to 10 m2/Ha can exist between the basal area of an agroforest and the local basal area of the primary forest. The difference between the agroforest basal area and the local climax basal area will then constitute the magnitude left for production of cocoa beans and other products which can be harvested from the system.

The life cycle of components is variable. In general, to expect a wood of 50-60 cm, 25 to 40 years is needed for fast growing trees such as *Terminalia ivorensis, T superba , Cedrela odorata, Triplochiton scleroxylon and Gmelina arborea* (CFTC, 1989). For the same diameter and for plants of the middle growth rate, such as *Tectonia grandis, Aucoumea klaineana, Khaya sp*. 40 to 70 years is needed. Fruit trees such as avocado, citrus, Mango can last for 20 to 40 years, on average. Cocoa can produce for around 25 to 40 years. The summary of different components can be represented in table 18.

Table 10 Potential life cycle of several components of the cocoa agroforest of West and Central Africa.

	0-20 years	20-40 years	40-60 years	60-80 years
Timber	x	X	x	
Fruits (NWFP and Exotic)	x	X		
Cocoa	x	X		
Crop	x			

An agroforest can then be built with the aim of achieving the duration of the life cycle of timber which may be the componets of the system which will stand for too long a time. After this period the renewal of cocoa can be made within the same system. Alternatively, the system can be left in fallow. The option will depend on the farmers' strategy and goals. At the landscape level, the main driving force may lead to different models of cocoa agroforest (Figure 3). An integrated approach is needed to achieve a more sustainable system.

From the above, a cocoa orchard has a life cycle shorter than a multistrata and multispecies agroforestry system. In a complex system with a combination of different components, replacement of each element can be done without necessarily destroying all the system.This is generally the case in cocoa fields of Cameroon and other parts of West Africa which have old cocoa plantations. The multistrata and multispecific approach allows replacing of individual plants between and/or within species.

Box 8. The need for more policy and socioeconomic research on cocoa agroforest

Socio-economic and policy research related to cocoa agroforest and orchards is useful in understanding rural context and achieving development goals in the cocoa belt. Mercier and Miller (1998) recommend that socio-economic research should focus on three principal areas: (1) Understanding the agroforestry adoption decision-making process, (2) Empowering economic analysis of agroforestry system and (3) Analysing the impact of alternative policies (at local, regional and national levels) on the potential of agroforestry-based rural development initiatives. Such recommendation can easily be applied to cocoa agroforestry system. But socio-economic research around cocoa agroforest has been mainly focused on cocoa bean production. These studies concerned village and national economy of cocoa in severals countries of West and Central Africa. The data generally give information on the importance of cocoa for rural and national economies. Since Cocoa land is now targeted for inter-croping timber, non timber production and ecological services, additional reseach is useful.

It will not be exagerated to say that the finding of Russel and Franzel (2004) could also be applied on multipurpose trees growing in cocoa agroforest. These authors noticed, after a general review of agroforestry practices during 3 decades, that forest policy, physical and social barriers to smallholder participation in markets, the overall lack of information at all levels on markets for agroforestry products, and the challenges to out growing schemes and contract farming inhibit the growth of smallholder tree products sector in Africa outside of traditional products. Policy and scoio-economic research are useful to address those issues to allow a proper development of a diverse cocoa agroforestry system.

In the context of West and Central Africa, little data really exist for the demand of NWFP, timber and ecological service and on how the satisfaction of this demand can impact on cocoa farmers.

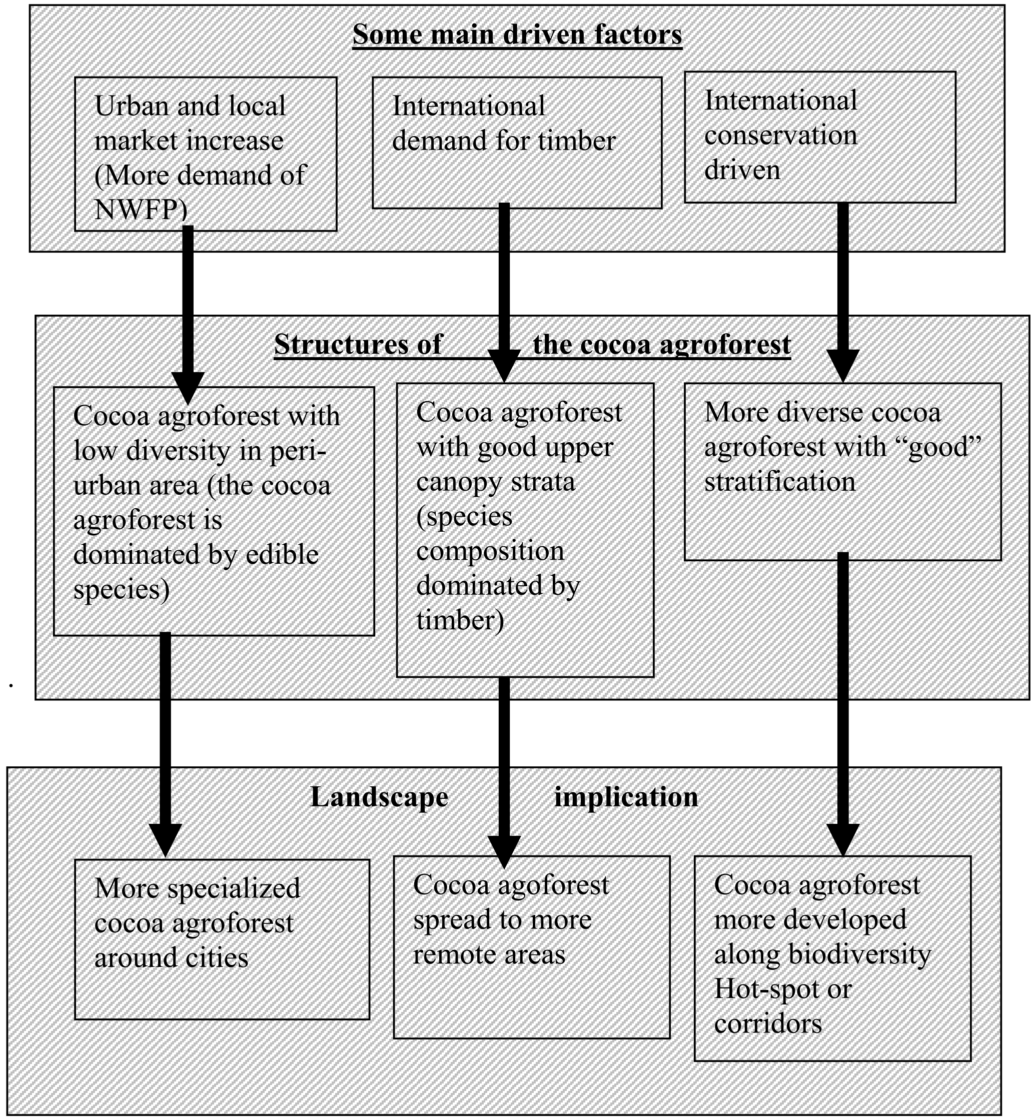

Figure 3: Potential impact of different driven forces on the structure of cocoa agroforest and landscape implication in the humid forest zone of West and Central Africa

6. PRODUCTIVITY OF COCOA SYSTEM

6.1. Inputs

The main task related to the management of cocoa, after its establishment, consist (on the annual basis) of slashing, pruning, applying pesticides and/or fertilizer, harvesting, removing cocoa beans from pods and drying. When associated plants are present the main task generally consists of removing those that provide excessive shade and harvest fruits and wood when necessary.

For a cocoa plantation with the density of 1333 cocoa/Ha (i.e. 3m x 2.5m), with the same density for early shade and final density of 100 trees/Ha for permanent shade the following labour is requested in the tropics (Ministère des affaires etrangères, 2002): 46 workdays for nursery (80m2, for 2000 plantlets); 239 workdays for land preparation under forest; 56 to 62 workdays to plant cocoa; 45 to 61 workdays for installing the early shade; 14 workdays for installing the definitive shade; 119 workdays for maintenance of the cocoa during the first 3 years and 46 workdays after the first 3 years; and 50 workdays for harvesting and processing (for 1 ton of dried cocoa beans). In southern Cameroon, a more specific site study (ASB, 2000) reveals that 123 to 148 workdays/Ha/year are needed for cocoa establishment and 43 to 97 for managing. The same study reveals that establishment of cocoa system under forest shade cost 1188 to 1304$/Ha. In 2002/2003, Gockowski et al (2004) estimated the total labour (from harvesting to marketing) cost of cocoa (600trees/Ha) to be 46000 Fr CFA (at 1000 Fr CFA/workday).

For pure stand of some timber species susceptible to being associated with cocoa (ex. *Terminalia superba*, *Terminalia ivorensis*, *Triplochyton scleroxylon*, *Aucoumea klaineana*), installation and management during the first 6 years can be between the range of 80 to 135 workdays/Ha (CTFT, 1989).

Labour cost (covering tree maintenance or pruning, harvesting, processing, marketing and material, etc…) per hectare related to the management (using an estimation of 1000 F CFA/workday) of some associated edible fruits inside the cocoa agroforest of southern Cameroon was as follows (Gockowski et al. 2004) in 2002/2003: 20507 Fr CFA for *Dacryodes edulis*; 3600 fr CFA for *Ricinodendron heudelotii*; 8667 fr CFA for palm oil (produced by *Elaeis guinnensis*); 55 500 Fr CFA for palm wine (produced by *Elaeis guinnensis*), 5200 for avocado, 4200 for orange and 20500 for Mandarin. Those edible species were present respectively at the density of 9.5 *D. edulis* per hectare; 6 *R heudelotii* per hectare, 22 *Elaieis guinensis* per hectare; 13 avocado per hectare; 7 orange per hectare and 26 Mandarin per hectare.

Data are also available for cocoa management, but little information exist on the management of plants associated with cocoa. The management of associated plants has not yet been intensified similar to that of cocoa. The tendency of "gathering" (like from the forest) still governs attitudes of farmers toward those associated plants. To diversify the income and ensure more stability, we need to shift one part of the current investment on cocoa to associated plants. Like cocoa, associated plants need to be pruned, treated against pest and diseases, and some may need to receive fertilizers. Associated plants deserve more input if one expects more benefit from them.

6.2. Outputs

The main output for cocoa system in West and Central Africa is generally cocoa beans. Income or products from associated plants are usually considered as marginal. Other secondary products from cocoa (such as soap, organic fertilizer, butter and jelly) despite their potential income have not yet been properly valued in the region (FAO, 2002).

An average cocoa system can produce 300 to 580 Kg/Ha/year in Cameroon (Losch et al 1991) and Nigeria respectively (Okouneye et al. 2003). A lot of data is available on cocoa beans production inside orchard and agroforest. A recent study by Sonwa (2004) reveals that 258 to 445 Kg/Ha of cocoa can be obtained under shade as against 768 under direct sun.

During the study, it also appeared that 21% of trees did not produce any healthy pods when pesticides were not applied. With intensive treatment, 6% could not produce healthy pods. Norgrove (….) realized that 80% of cocoa yield could be covered by 20% of the cocoa trees when the plantation is low in fungicide treatement. The above results suggest that some cocoa trees are just occupying space in the system. Such trees may be removed without necessarily affecting significantly cocoa production. Depending on the management objective, this can be replaced by cocoa or other associated plants. Some constraints have not also allowed trees to reach the market and provide more income to farmers. In general, forest policy, physical and social barriers to smallholder participation in markets, the overall lack of information at all levels on tree products and the challenges to outgrowing schemes and contract farming inhibit the growth of the smallholder tree products sector in Africa and outside of traditional products (Russel and Franzel, 2004)

A net return from management of 164 000 Fr CFA per hectare was obtained for cocoa in Southern Cameroon in 2002/2003 (Gockowski et al. 2004). ASB (2000) reveals that a land return of US $424 to 1409 can be obtained for cocoa agroforest in Southern Cameroon.

Timber production does not offer yearly basis production as cocoa or edible fruits. The life cycles of those trees can be between 30 to 60 years. After this life cycle, wood production is generally the main output. For the tropics, and in the pure stand, wood production can be 220 m3/Ha for Frake, 300 to 340 for Okoume, 240 for Framire and 350 for teak. This production figure is valid for the stand of 70 Frake/Ha, 90 to 100 Okoume/Ha, 70 Framire/Ha and 105 teak/Ha. Inside cocoa agroforests of southern Cameroon, Gockowski et al (2004) estimated the respective wood production of 3.25 cu m/Ha and 4.48 cu m/Ha from Milletia excelsa and Lovoa tricilioides. The respective densities of those trees are 6 and 7 trees per hectare respectively.

Despite the role played by associated plants in household fulfilment and in ecological services (Sonwa 2004) they have not yet received great attention from research and extension services. In the area where forests are disappearing, their presence allows for the cocoa system to be one of the only structures providing products and services previously offered by the forest. Despite this, Zapfack et al (2002) and Bobo et al. (2006) are advising the selection and reintroduction of original forest species into cocoa farms to diverse the system. Such action will probably increase the output of the cocoa plantations.

6.3. Ecological services

One of the main characteristics of cocoa orhard and agroforest is its negative or positive impact on the environment.

Expansion of unshaded cocoa orchards is being associated with the shortage of rainfall in Côte d'Ivoire (Yao et al. 2003), and to the destruction of habitats for elephants leading to crop raiding around the Kakum park in Ghana (Barner et al. 1995). On the contrary, a well-managed cocoa agroforest can provide or maintain the small magnitude services offered by forests: pollination, biodiversity conservation, watershed, carbon sequestration (Box 9), etc. In a recent survey, Sonwa (2004) found 208 plant species associated with cocoa. Shaded cocoa agroforest stores 243 Mg/Ha of carbon compared to 60 Mg/Ha under non-shaded system. Using cocoa agroforest as tools to reforest degraded short fallow lands could lead to a discounted net present value of carbon ranging from 550 to 740 US$/Ha in southern Cameroon (Gockowski et al. 2004)

Unfortunately those ecological services are not yet properly valorised. Few studies have really focused on their valorisation and on what farmers can do to take financial advantage of these ecological services.

Box 9. Mixing cocoa with associated plants can help in carbon sequestration

Among the ecosystem services, carbon sequestration is seen as one of the most promising. Under the CDM (Clean Development Mechanism) of the Kyoto protocol, industries can compensate their CO_2 emission by supporting forest projects, which sequester carbon. Although initially the mechanism was forestry project oriented, agroforestry is gradually seen as a possible way to sequester carbon and additionally provide other services to rural farmers.

Reforestation projects are generally based on timber species like *Terminalia*. Using the formula of Brown (1990), a 60 cm diameter of *Terminalia* after 40 years can have 3745.89 Kg, a stand of 85 tree/Ha will then store an average of 318.40 T/Ha. A cocoa orchard of southern Cameroon without trees stores 45 T/Ha of aboveground wooding material (Sonwa, 2004). A complex cocoa agroforest can store 402 T/Ha of wooding material (Sonwa, 2004). In addition to the biomass stored, components in the cocoa are food needed by farmers. Income generated by such activities will be used by many small farmers. This is not always the case with pure forest plantations which sometimes may have negative impact on farmers (FAO, 2002). The use of cocoa orchards to sequester and store carbon need to be promoted, particularly in the cocoa belt where forest had vanished.

One of the main characteristics of cocoa is that it developed by modification or destruction of forests and thus modify ecological services offered by forests. Forest soil suitable for cocoa growth and seeking new areas for cocoa cultivation appear to be economically and ecologically more attractive than replanting existing aged farms (Ruf et Zadi, 2003 ; Niestin et al. 2004). In West Africa, the rainforest zone is suitable for cocoa growth. According to the millennium ecosystem assessment, the following services are generally provided by forest: food, timber, freshwater, fuelwood, flood regulation, disease regulation, carbon sequestration, local climate regulation, medicine, aesthetic values and spiritual values. Thus, growing cocoa or other crops contribute to reduce the magnitude of those services. But the reduction of this magnitude depend on the intensity with which the forest is modified. And it is known that agroforestry practices such as cocoa agroforest are the least ways to change the ecosystem services offered by the forest. In the area where forests have been destroyed , agroforestry practices can be used to recreate forest structure and related ecological services. But little data really exist on the value of this cocoa agroforestry system (Box 10)

Box 10 . What is the 'real' value of cocoa agroforestry?

For many decades, land under cocoa was managed primarily or mainly for commercial outputs (exclusively cocoa beans). With the disappearance of forests (and associated ecological and socio-economic services), such land is now managed additionally for ecosystem services. The ecological services are mainly 'produced' by the management of associated plants inside the cocoa agroforest. This shift has also allowed the promotion of a multistrata and multipecies cocoa agroforestry system. The structure of this agroforestry system is similar to that of the forest.

In such a system, the value or output of the cocoa has been extensively studied. But this is not the case with other components, mainly trees, which are generally from the forest. The services they provide even in the forest are not yet well evaluated, because such services were generally free. Such services were generally produced by forests located in common land. In a recent paper 'Conservation Because It Pays: Shaded Cocoa Agroforests in West Africa.', Gockowski et al. (2004) tried to make calculations in the investement and output of each component of cocoa farms of Cameroon, but a lot of information is still needed for some components and services offered by this agroforest. Such information is useful for management purposes. It may be difficult to give a real value, but some figures need to be available to allow proper decision for public and private partners who are gradually interested in ecological and socio-economic services provided by cocoa agroforests.

7. RESEARCH AND EXTENSION SERVICES

7.1. Research

Research efforts in West and Central Africa lasted for more than 6 decades. Effort were mainly focused on biophysical aspects to resolve pest and disease problems or to improve the cocoa production per unit area and cocoa quality or processing (Agninel, 1984; Martinson 1984, Nya gatchou, 1984). Little effort was put on plants associated with cocoa (Asare, 2005). Advice was generally to produce cocoa in orchards or to maintain trees for provision of early and late shade. On-station research mainly on genetic was the rule and the results or improved cocoa was then disseminated to farmers through parastatals. This research which was not strong enough was recently weakened by structural adjustment (Bloomfield and Lass, 1992).

For species potentially associable with cocoa, research effort was different according to the nature of the tree. Timber did not receive much research effort as reforestation programs were based on introduced species. Edible forest species did not attract any research efforts. Kola received some research effort in Côte d'Ivoire, Ghana and Nigeria. Exotic edible fruit species such as mango, avocado and guava received some research interventions mainly on production, pest and disease. Understorey plants did not receive any research efforts.

Research efforts, when they existed, were mainly on biophysical aspects (with emphasis on pest and disease resistance and increased productivity). Such research efforts were conducted generally in separate structures. Research in cocoa and edible fruits was linked to agricultural research while timber research was attached to the forestry department. Only a few research initiatives have so far tried to test the compatibility of cocoa with some timber trees such as *Terminalia* and *Albizia* (Anin-kwapong 2003; Petithuguenin 1995).

Zac Tchoundjeu 2005 mentioned the following factors relating to the status of species under domestication in West and Central Africa: little knowledge on propagation, less knowledge on management, incomplete knowledge on nutritional qualities, no formal varieties, traditional wild harvests, little cultivation, no promotion campaign, little production development and no market information system.Thus effort put on species potentially associable with cocoa is less than what was put on other aspects of agroforestry. To date, very few or no real study exist on the interactions above and below ground. Some characterization studies exist, but ecological research in the orchard and agroforest is very limited.

The multidisciplinary approach was not common in such research activities. They were more practical and few efforts were focused on fundamental aspects supporting the system. With more trees in the system, agroforests are viewed as the main ecological component in the rural area with the risk of neglecting policy and socio-economic aspects (see Mercer et Miller (1998) and Montambault & Avalapatic (2005) for the review on socio-economic aspects in agroforest research). Research on the system deserve to be multidisciplinary and multi-institutional (Sonwa et al. 2005).

7.2. Extension services

The "training and visit" method has been the main approach used by cocoa extension services of West and Central Africa (Glounaho, 2000). It consisted of training the farmers technically. This technique was generally used by the parastatals in charge of cocoa development. In Côte d'Ivoire, it showed some positive effects such as (1) existence of intervention planned calendar, (2) permanent recycling of extension agents and (3) practical demonstration adapted to the technical level of farmers (Glounoho, 2000). The same author also noticed some weaknesses of this approach such as: (a) heterogeneity of contact groups (farmers with different technical levels) (b) lack of rigourous diagnostic of farmer needs. With the support of the World Bank, extension services for cocoa were increased (i.e. reaching the ratio of 1 extension officer for 344 farmers in 1989). These efforts also helped in increasing cocoa production from 400 to 450 Kg/Ha.

Edible fruits did not receive the same efforts in terms of extension officers like cocoa. Extension services for these edible exotic plants were assumed by extension officers of the government who worked on several other crops. Marginal efforts were also made by some charitable extension services such as missionaries. The example of the Ntsan village in Cameroon can be given to illustrate such a situation. This particular area is characterized today by its high production of citrus due to the effort of Catholic priests who introduced mandarin to diverse farmers' income and support the health of the village (Aulong et al. 2000). Timber is generally owned by state and was managed by a state agent belonging to parastatal. Civil servants of the ONADEF (office National de Dévéloppement des forêts) in Cameroon and SODEFOR (Societe de Dévéloppement des forêts) were in charge of the development of the forestry sector (Koudou et Vlosky 1997).

Advice on the management of cocoa or plants potentially associable to cocoa was generally given by different structures. Due to the economic crisis, extension support given by the state is facing some difficulties. SODECAO and ONADEF in Cameroon for example went through restructuring programs. Great achievements were visible when they were supported either by the World Bank, European Union or bilateral support (Glounaho 2000). The economic crisis came at the moment when civil society was going through a dynamism that led to the emergence of NGOs that focused on extension as their objective. Private extension services are also emerging in the region. NGO extension services have some advantages that can be captured (See Farington, 2000 for details).

The farmers' field school approach has been acknowledged to play a key role in Asia. Initially planned for food crops, it has been covering tree crops such as cocoa in Indonesian (Mangan and Mangan 2003) and community forestry in Nepal (Singh, 2003) since the mid nineties. It is new in Africa and is being concentrated on integrated pest management (IPM). Recently IITA, after a workshop on pest and disease problems faced by cocoa (Vos and Neuenschwander, 2002), took the lead to use it with the collaboration of CABI on cocoa. IITA is thus using this approach on IPM of cocoa. More than 4000 farmers have been trained already by 130 facilitators in 160 farmers' field schools in 4 countries. The first step is on IPM of cocoa and does not directly concern management of plants associated with cocoa. Due to the importance of associated plants, it will be good to develop integrated FFS approach taking into consideration all the components of the cocoa field.

8. HOW TO MAKE MULTI-STRATA AND MULTI-SPECIES COCOA BASED AGROFORESTRY WORK

The current context with the liberalization of the world market is an open door for fluctuation of cocoa income (Bloomfield and R. Antony Lass, 1992; Koning et al. 2006). There is therefore a real will for farmers to diverse their income. Diversifying assets by making more investments in associated plants can then, among other options, be useful to farmers. There is thus the need to refocus on the cocoa system with its entire components instead of putting efforts slowly on cocoa. Other components or services offered by cocoa need to be given more emphasis and space in the system.

With the current level of dynamism in rural areas, and taking the advantage of the demand of ecological services (which can be potential offers, with lower magnitude,by cocoa agroforest) and some products which can be intercropped with cocoa it is necessary to build a real participatory approach to increase the asset of associated plants in the system. This needs to be done at least at two levels: the first one is the determination of proper technology defined by farmers and the second step is the diffusion of such technology in the rural areas.

8.1. Participatory technology development

Although there is a will to diversify the assets inside cocoa agroforests, such an effort has not yet been fully tested in the rural areas of West and Central Africa. The training and visit methods have been generally used as tools for transfer of technology in the region. This approach was easily applicable in the context where parastatals used cocoa to encourage rural development. The current dynamism of farmers offers possibilities to carry out research, and work with them by looking at the best technology in the area for a more diverse cocoa system. The parameters listed in table 11 can be very helpful in this research. It is generally known that in such research scientists only do facilitation and farmers are designers of the technology (Sayer and Campbell, 2004). Such research needs to be demonstrated on farmers' fields, although on-station research is useful to properly investigate, under control conditions, scientific processes beyond the technology designed by farmers. Some of the parameters on table 11 are susceptible to influence the choice of the trees that farmers may prefer for their cocoa fields (Asare, 2006).

Table 11: Some main useful parameters to be taken in to consideration when setting a diverse cocoa agroforest

	Parameter	Comment
	Type of associated plants	Attention needs to be given to plants that have the preferences of farmers and which can have a good value on the local, regional and international markets. Attention also needs to be given to species that can help in achieving forest ecological services. Understorey plants need proper attention because of the fact that they are always neglected despite their ecological importance
	Density of associated plants	Needs to be more important than the current advice of scientists in the region. Data for pure stand of some plants associated to cocoa exist and just needs to be resized to take into consideration the place of other components. See Basal area for details on the integration of those different components.
	Density of cocoa	The current density needs to be reduced to allow proper management of other components.
	Basal area	Needs to be under the basal area of local forest at its climax. The difference between the cocoa basal area and that of the forest at the climax will allow

		the production of cocoa beans and other fruits. It needs to be distributed across strata and between components depending on the management options.
	“Eco-volume”	The area and vertical structure need to be chosen in such a way that they help in achieving partial forest ecological services. Plant components do not need to be within the cocoa strata. They need to be above so that they allow air to circulate easily. In addition, the entire volume (‘Eco-volume’) created by the agroforestry system needs to allow expression of some life components of the system.
	Stratification and space between components	These parameters need to be linked to the density of components and the basal area distribution across strata. Good stratification can allow proper expression of each component in the system.
	Input and output	All labour or investment needs to be taken into consideration and potential output of the system needs to be proportional to the investment and susceptible to give incentives to farmers.
	Stage of the plantation	The main concern here is about the stage of the plantation (New establishment or modification of the existing plantation).
	Source of seed or planting material	The main concern here is the availability of seeds or planting materials. The need generally is to use the most appropriate vegetative methods to ensure that certain preferable traits are maintained. Another concern here is also the management of the nursery.
	Extension services	Demonstration through Farmers’ cocoa agroforest management Schools (CFAMS) can be an easier way to help in the diffusion of the more diverse cocoa based agroforestry systems.
	Market	The establishment of cocoa needs to be client oriented. Market opportunities need to influence the type of cocoa agroforest that will be established.
	Soil fertility	There is a need to be sure that the soil on which cocoa agroforests will be established can support both cocoa and associated plants.

8. Diversify output from cocoa agroforests

Few studies have made a proper evaluation of all the components from cocoa agroforests. In Cameroon, in a more complexe system, Gockowski et al (2004) have estimated income from cocoa to be 43% and non-cocoa to account for 57%. These figures do not take into account the non-market services provided by agroforests.

Diversification is known to be useful in providing more stabitlity for household income. Indigenous fruits and timber which can be sold locally or regionally have an income less volatile than cocoa beans. If well managed, they can also increase ecological services of the system. The main challenge here is to support the development of local enterprises and remove policy barriers to local market participation (Scheer et al. 2004; Russel et Franzel 2004). Cocoa Agroforest systems thus need to be managed as an environemental enterprise. CI (Conservation International) views such enterprises as those which can allow conservation (Millard, 2003). A sustainable cocoa system needs to provide ecological services or should be susceptible to release pressure on natural resources.

8.2. Use of farmers' field schools to spread diverse cocoa systems designed by farmers

The transfer of technology defined by some key informants to more farmers need to be done in a participatory manner. The FFS approach is giving promising results on IPM of cocoa. There is a need to develop components on plants associated with cocoa inside cocoa agroforests. This can be done through Farmers' cocoa agroforest management Schools (CFAMS), (Box 11).

Box 11. The needs of the Farmers' Cocoa Agroforest Management Schools (FCAMS)

Since the introduction of cocoa in West and Central Africa, effort on extension services has been mainly through the use of the "training and visit" approach with the support of parastatals. At the same time, other parastatals are in charge of forestry programs in the same area. The above types of parastatals have been mainly operational with the support of foreign financial support of bi or multilateral funding (Bloomfield, E.M.; Lass, R.A. 1992) . With the recent economic crisis, cocoa farmers have tried to diversify their income by growing some timber or other edible plants in their cocoa plantations. Unfortunately they do not have contact with extension services (in Cameroon only <u>10%</u> of cocoa farmers have contact with extension services) (Sonwa, 2004).

The Farmers' Field School approach has contributed, in the eighties, to the green revolution (previously based on the training and visit approach) in Asia; and since the mid nineties it is gradually moving to also include IPM of cocoa (Mangan and Mangan, 2003) and community forestry (Singh, 2003). Since its introduction in Africa, FFS are being used on several crops with promising future (Simpson, 2002). IITA is recently taking the lead in developing and promoting IPM on cocoa in many countries of West and Central Africa. Currently this project focuses mainly on cocoa. It therefore needs to be extended to support the diversification of assets in the cocoa system. These FFS need to lay strong emphasis on all components through proper Farmers' Cocoa Agroforest Management Schools (FCAMS).

9. CONCLUSION

The increasing market demand for products that can potentially be grown in cocoa agroforests offers opportunities for small farmers of West and Central Africa. The reduction in resources from natural forest implies that they be produced in agroforestry systems such as cocoa agroforests. Unfortunately is the products that are in demand on the markets are not always those that are most present in cocoa fields. Reducing cocoa density in favour of such associated plants can lead to more stable income. Depending on the targeted aim (market products and/or ecosystem services), several models of cocoa agroforest can be developed based on density of plants, basal area, stratification and type of associated plant species.

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