Forest & Landscape

Conference Paper
May 2006

A review on cocoa agroforestry as a means for biodiversity conservation

Richard Asare

KVL A UNIVERSITY OF LIFE SCIENCES

A review on cocoa agroforestry as a means for biodiversity conservation

Richard Asare Centre for Forest, Landscape and Planning Denmark

Paper presented at World Cocoa Foundation Partnership Conference
Brussels, May 2006

Content

Introduction

This is a desktop review of work done on cocoa production in relation to its use as a biodiversity conservation mechanism. First the paper presents arguments by scientists on the need to look beyond protected forest areas to the agricultural landscape as potential areas for biodiversity conservation, especially in the tropics.

It continues with allegations levelled against cocoa cultivation as an agent of deforestation and then explores the opportunities for using cocoa agroforestry as a system for biodiversity conservation in landscapes outside protected areas. The review puts forward lessons learnt from projects that looked at cocoa cultivation as a sustainable tool for biodiversity conservation around the globe, and finally this review ends by making recommendations for the way forward.

Why agricultural landscapes?

Klein et al., (2002) assert that even though agro-ecosystems dominate tropical landscapes, its potential value for conserving biodiversity has been ignored (see Pimental et al., 1992; Perfecto et al., 1996; Watt et al., 1997; Moguel and Toledo, 1999; Power and Flecker, 2000). This argument has been made previously by a number of scientists.

Siebert (2002) contends that maintenance of biological diversity is likely to be determined by agricultural and forestland uses outside formally protected areas. According to Janzen (1998) and Putz et al. (2000) even under the most optimistic scenarios, tropical protected areas are insufficient to preserve biological diversity and ecosystem services. Parrish et al. (1998) suggest that it is about time that conservationists looked beyond protected areas to the agricultural landscapes in order to obtain alternative strategies to protect biological diversity that are compatible with human needs. According to Parrish and colleagues, biological diversity is eroding due to:

- The increasing pace at which forest environments are being converted into agricultural lands;
- The isolation and scarcity of protected areas and;
- The perpetual rise of the global population.

Human disturbance on forested ecosystems is posing a serious threat to local biodiversity (Dobson et al., 1997). In most areas of the world tropical deforestation has been attributed to timber extraction and agricultural expansion (Brown and Pearce, 1994; Kaimowitz and Angelsen, 1997: cf. Benhin and Barbier 2004; Donald, 2004). The highest rate of deforestation in Africa has been reported to have occurred in West Africa with the most rapid forest clearance of between 1.3% and 1.5% occurring in countries like Ghana (WRI, 1994; FAO, 1997).

In Ghana, forestlands are categorised into reserve (protected) and off reserve (unprotected) (Prah, 1997). It is estimated that 50-70 % of the total area of protected forestlands in parts of the Western Region[1], where Ghana has its last remaining tropical high forest zone, have been illegally encroached (England, 1993) by human disturbances like agriculture expansion, mining, and timber extraction (ITTO, 1993; Ministry of Science and Environment, 2002). Furthermore, it is estimated that the country has incurred an economic loss of approximately US$54bn through the loss of biodiversity due to deforestation and land degradation. This amount is equivalent to 4% of the

[1] One of the last frontiers of remaining forest covers in Ghana (Amanor, 1994)

national GDP, and is comparable to the country's annual economic growth (Tutu, *et al.*, 1993: *cf*. Ministry of Science and Environment, 2002; GPRS, 2002).

According to Hawthorn and Abu Juam (1993), out of the total area of 16340 km^2 of protected forest reserves in the tropical high forest zone, only 9000 km^2 are in a stable condition; the rest is either degraded or significantly depleted. This condition does not pertain only to the reserve forests but also in the off reserve forests which are owned and managed by individuals (Owubah et al., 2001). Results of work conducted by Owubah et al., (2001) in Ghana on forest tenure systems and sustainable forest management showed that farmers still perceive forests as land banks for increasing agricultural productivity to support subsistence living.

The Ministry of Agriculture (MOFA, 1991) indicates that out of the 13.6 million hectares, representing 57% of the land area classified as arable land, about one-third has been cultivated since 1990. The government projects that expansion of agricultural land will proceed at a rate of 2.5% annually for the production of tree and food crops like cocoa and maize (MOFA, 1991). However, productivity of land and labour is low due to the use of extensive traditional farming methods such as slash and burn and burning (Quansah et al., 2000), which sometimes result in widespread forest fire (Benhin and Barbier, 2004).

Given that agricultural activities diminish biodiversity by displacing or replacing natural environments, the major challenge for conservationists and agriculturists in biodiversity hotspots is how to balance the economically driven agricultural expansion with strategies necessary for conserving natural resources, and maintaining ecosystem integrity and species viability (Pimentel et al., 1992; Perfecto, 1997: cf. Parish et al., 1998). In light of these issues, some scientists (see Sanchez, 1995; Dobson, 1997; Huang, 1998b; Leaky, 1999, Rice and Greenberg, 2000) have embraced agroforestry as an integrated approach for biodiversity conservation on farm. Huang et al., (2002) recommends the use of agroforestry amongst others as a conservation tool to buffer biodiversity loss.

Does cocoa agroforestry promote biodiversity conservation?

The West African sub region is host to the world's main cocoa producing countries, including Côte d'Ivoire, Ghana, Cameroon and Nigeria. These countries are also undergoing major deforestation processes through progressive conversion of forests into cocoa fields (Ruf and Zadi, 1998, Padi and Owusu, 1998). In Ghana and Cote d'Ivoire for instance, 50% of total cocoa farm area in both countries is under mild shade while an average of 10% and 35% is managed under no shade in Ghana and Côte d'Ivoire respectively (Freud et al., 1996: cf. Padi and Owusu, 1998). Today, majority of cocoa production is concentrated in established biodiversity hotspots (Myers et al., 2000).

However, cocoa cultivation that maintains higher proportions of shade trees in a diverse structure (cocoa agroforestry) is progressively being viewed as a sustainable land-use practice that complements the conservation of biodiversity (Alger, 1998; Duguma, 1998; Parrish et al., 1998; Power and Flecker, 1998; Rice and Greenberg, 2000; Leakey, 2001; Schroth et al., 2004). One reason is because cocoa agroforestry has been noted to meet ecological, biological and economic objectives. In particular, cocoa agroforests can create forest-like habitats, which harbour tropical biodiversity in rapidly degrading landscapes (Greenberg et al., 2000), while providing an economic crop for small-holder farmers (Young, 1996; Perfecto, 1996), and serving as faunal refuges (Griffith, 2000). This is particularly true in fragmented landscapes, where cocoa agroforests have been noted to provide habitat and resources for plant and animal species and maintained connectivity between different land uses, particularly fragmented forests.

Cocoa agroforests are also regarded as environmentally preferable to other forms of agricultural activities in tropical forest regions (see Power and Flecker, 1998; Greenberg, 1998). Research conducted in Latin America indicates that the capacity of cocoa plantations to conserve birds, ants and other wildlife is greater than in any other anthropogenic land use systems (Rice and Greenberg, 2000; Jimenez and Beer, 1999). In areas like Southern Cameroon and Eastern Brazil cocoa agroforests are credited with conserving the biological diversity of the humid forest zone (Ruf and Schroth, 2004) and the Atlantic forest (Rolim and Chiarello, 2004), compared to farming activities that produce food crops like maize and cereals. In Ghana, Conservation International has had success in using cocoa agroforestry as a buffer zone around protected areas (the Kakum National Park project in the Central Region) to reduce forest encroachment. Also in the Western Region of Ghana SAMATEX Timber Company has been able to increase the diversity of forest trees in cocoa farms by working with farmers to plant economically valuable timber species.

It is important to recognise, however, that even though research suggests that cocoa agroforests are generally environmentally preferable to other forms of agriculture, cocoa agroforests do not equate with primary forests (Donald, 2004). According to Rolim and Chiarello (2004), cocoa agroforestry not only supports relatively lower species richness but also impairs natural species succession and gap dynamics compared to floristically and climatically similar sites of secondary or primary Atlantic forest in Brazil. And as a result, tree species of late successions are becoming rare while pioneer and early secondary species are becoming dominant. They attribute this shift in successional patterns to management practice, which involve the clearing of undergrowth twice a year that eliminates most regeneration, except in a few trees which escape cutting.

Acknowledging these limitations, however, does not change the fact that cocoa agroforestry provides real opportunities, compared to other agricultural systems, to conserve biodiversity by providing niches for a variety of faunal and floral species (Noble and Dirzo, 1997; Rolim and Chiarello, 2004). And beyond simple conservation, cocoa agroforests may have positive environmental effects in landscapes already impoverished by human disturbances (Estrada et al., 1997; Reitsma et al., 2001).

Global recognition of cocoa as a useful crop for biodiversity conservation

In March 1998, the Smithsonian institute, with the support of the Mars chocolate company, organised a workshop in Panama bringing together cocoa researchers, ecologists and representatives of the chocolate industry from 22 countries to formulate a strategy to maintain and develop sustainable cocoa farms. This was an important step as it concerned specifically cocoa.

To review recent findings and methodologies in the area of perennial crops, IUFRO convened a workshop at CATIE on “multi-strata agroforestry systems with perennial crops” in February 1999 (Jimenez and Beer, 1999). The idea was helpful as CATIE has for more than two decades been involved in research on coffee and cocoa agroforestry systems, with the support of GTZ and DANIDA (Beer 1987, 1991; Imbach et al., 1989; Beer et al., 1998).

Following the actions of GTZ and the Mars chocolate company to support the conservation of Tai park in Côte d'Ivoire, a “Sustainable Tree Crop Programme” (STCP) based in IITA, was launched in May 2000, with the support of USAID and the chocolate industries of Europe and America, to promote cocoa agroforests in West and Central Africa (Sonwa et al., 2003). In this new programme, the shaded cocoa agroforests of Southern Cameroon were seen as a sustainable model that can be promoted elsewhere in the sub region where cocoa cultivation is contributing to forest habitat destruction.

To slow down the destruction of forest resources, which play a key ecological, sociological and economic role in rural areas, domestication of NTWP in agroforestry systems was realised to be important in the 1990s. In February 1996, ICRAF hosted the first international meeting in Nairobi, solely to draw attention to issues relating to the domestication and marketing of non-timber forest products (NTFP) in agroforestry systems.

Lack of insight into cocoa cultivation and its potential as a conservation mechanism

In spite of the purported potentials and abilities of cocoa agroforestry and the various recommendations from research and development agencies, Parrish et al., (1998) states that there has only been a few attempts to use cocoa agroforestry as a large-scale conservation instrument in tropical countries.

Furthermore, Greenberg et al., (2000) claim that to date biological diversity in cocoa production has been poorly studied, and argue that there is only a limited amount of work which upholds the notion that cocoa farms with diverse shade canopies support greater biodiversity, especially of forest-dependent organisms, as compared to other cash crop systems in the low-land tropics (Rice and Greenberg, 2000).

In addition no work has statistically compared biodiversity across the whole spectrum from pristine forests, to different levels of shade to no-shade cocoa systems. Hence, it is quantitatively difficult to assess the implication of cocoa production for biodiversity and to identify the specific elements of shade production that are important (Donald, 2004).

Trends in research and development on cocoa agroforests in West Africa

Traditionally, small holder cocoa farmers establish their cocoa farms by removing the forest understorey and thinning the forest canopy so that cocoa seedlings can grow into productive trees by utilising the 'forest rent' of the newly cleared area[2] and the shade provided by the remaining trees. In Ghana, cocoa farmers also actively nurture and manage the regeneration of forest species in their farms for their ecological, economic, or cultural value (Amanor, 1996).

As a result, plant species associated with cocoa are largely the result of interactions between farmer preference, research recommendations and extension services. Generally, farmers place more importance on enhancing cocoa production but also using the cocoa farm to meet their daily household demands and needs, whereas research on biodiversity in cocoa farms places only a very limited importance on the productivity of the cocoa tree.

[2] Forest rent refers to soil fertility that has built up in the forest.

The current body of work aimed at improving sustainable cocoa cultivation through the use of forest trees in West Africa by governmental and international research institutions, and local and international NGOs is extensive and growing in scope. The majority of this work is conducted as on-station research with only a few isolated cases of on-farm research.

A study conducted in West and Central Africa on farmers' preference for trees to domesticate in agroforestry systems such as cocoa based systems revealed that farmers' focus is predominantly on edible fruits. These include; *Irvingia gabonensis, I. Wombolu, Dacryodes edulis, D. Klaineana, Chrysophyllum albidum, Ricinodendron heudelotii Garcinia kola, G. afzelii* (Franzel et al. 1996).

Asare (2005) found that extensive research has been conducted on associated trees in cocoa growing systems by individual researchers in Ghana, Côte d'Ivoire, Cameroon, and Nigeria. National and international research institutes and environmental NGOs are also engaged in long-term research on the ecology and compatibility of shade and neighbour trees in cocoa systems. The majority of this work is conducted as on-station research with isolated cases of on-farm research in specific areas.

In an effort to add farmers views to the general body of knowledge, Asare (2005) investigated farmers' perceptions of trees associated with cocoa, and found that while farmers are concerned about exploiting all the necessary components in the system and their interactions to maximise income and reduce risks, research has focused heavily on parts of the system, which is in most cases the improvement of the cocoa tree.

This has resulted in a situation where research recommendations serve as a barrier to farmer innovation instead of improving local knowledge. For instance in Ghana and Côte d'Ivoire, research recommendations have come out with a long list of trees species that are claimed to be incompatible and for that matter should be eliminated from cocoa farms since they serve as alternative hosts for pests and diseases. Most common on the list are *Ceiba pentandra, Triplochiton scleroxylon,* and *Cola nitida*. In a conflict of interest, these species happen to be among the most preferred species of farmers due to their economic and traditional values. Hence, it was not uncommon to find stands of these species on cocoa farms even though there is a campaign in those two countries against them.

Similarly in Nigeria and Cameroon, a lot of work has been put into the domestication of indigenous fruit trees due to available local and international markets but virtually nothing has been done on forest timber species, which farmers also prefer. New propagation methods in addition to natural regeneration and seedlings have been developed for some of these indigenous species particularly *Dacryodes edulis, Irvingia gabonensis, Ricinodendron heudelotti,* and *Garcinia kola*, giving them shorter gestation period, reduced height and relatively smaller canopy. These specifications place these domesticated species in the same stratum as the cocoa tree in the system, hence, the concern that competition between the various species will be increased rather than decreased.

The report continues that while research is focusing on trees in cocoa growing systems, opinions differ in the various countries on optimal levels of shade and those trees that are compatible or incompatible with cocoa. For example, Ghana tends to focus on finding an appropriate balance of shade and on identifying compatible tree species, whereas Côte d'Ivoire focuses on limiting shade and identifying and disseminating information on species that are incompatible with cocoa. In Ghana, species such as *Rauvolfia vomitoria, Milicia excelsa, Sterculia tragacantha, Alstonia boonei, Milicia excelsa, Terminalia ivorensis, T. superba, Triplochiton scleroxylon, Ceiba pentandra, Pycnanthus angolensis, Entandrophragma angolense, Funtumia elastica,* *Ricinodendron heudelotti, Tetrapleura tetraptera, Citrus sinensis, Persea americana*, *Mangifera indica* and *Elaeis guinensis* are common on cocoa farms (Osei-Bonsu et al., 2003; Asare, 2005).

In Côte d'Ivoire surveys conducted revealed the existence of some 25 mostly wild forest species used as shade trees in that country (Herzog, 1994). Species identified inlude *Persea Americana, Citrus reticula, Mangifera indica, Citrus sinensis, Cola nitida, Elaeis guinensis, Ricinodendron heudelotii, Antiaris welwitschii, Ceiba pentandra* and *Milicia excelsa*. Some farms contained species such as *Trema guinensis, Millicia excelsa, Ficus spp, Pycnanthus angolensis, Terminalia* sp. and *Alstonia boonei* (N'goran, 1998).

In Cameroon and Nigeria cocoa agroforests currently exhibit high levels of shade, thus focusing research and development on efforts to reduce shade and increase production while maintaining important indigenous fruit trees. For instance, the ASB[3] project found a total of 80 and 45 vascular species in unmaintained (>45 years) and maintained (<30 years) cocoa agroforests respectively in the primary forest areas of Southern Cameroon (ASB, 2000).

In the transitional area between the forest and the Savannah of Cameroon, Gokowski and Dury (1998) mentioned the existence of fruit tree species such as *Mangifera indica*, *Persea americana*, *Dacyrodes edulis*, *Citrus reticula*, *Citrus sinensis*, *Elaeis guinensis*, *Cola nitida*, and *Irvingia gabonensis*. In a survey conducted in 37 cocoa plantations in Southern Cameroon, Zapfack et al., (2002) reveal the existence of 116 plant species.

In Nigeria, tree species such as *Cola nitida, Persea Americana, Mangifera indica, Citrus sisnensis, Elaeis guinensis, Millicia excelsa, Irvingia gabonensis, Terminalia superba, Garcinia kola, Triplochiton scleroxylon, Dacryodes edulis, Khaya ivorensis, Cola acuminata* are generally associated with cocoa (Fanaye et al., 2003; Asare, 2005).

Another trend in research and development across all four countries is the current effort to maintain or increase cocoa production, particularly in Cameroon and Nigeria where production has been relatively low. In Côte d'Ivoire and Ghana maintaining or increasing production has meant the rehabilitation of ageing cocoa farms and the recycling of land in response to the absence of new primary forest areas as a result of extensive deforestation. This strategy involves using exotic leguminous species to reduce fallow lengths through soil fertility improvement and creating appropriate vegetation cover as initial shade for cocoa seedlings.

Cameroon and Nigeria have not experienced such extensive loss of their humid forests from cocoa production. Consequently, their efforts to increase production depend upon an increase in the area under cocoa cultivation, and rehabilitation of neglected cocoa orchards.

A third trend particularly developed in Cameroon and Nigeria but also evident in Ghana and Côte d'Ivoire is to diversify cocoa systems using fruit trees. In Nigeria and Cameroon the attention is on indigenous fruit trees that have a strong demand in national and regional markets. In Nigeria for instance, work conducted by the Cocoa Research Institute of Nigeria (CRIN) places more emphasis on the planting arrangement, distance and densities of some indigenous fruit trees. In Cameroon the attention is on how to domesticate the indigenous fruit trees and integrate them in the cocoa agroforests. The World Agroforestry Centre (ICRAF) and the Institut de Recherche Agronomique pour le Developpement (IRAD) are spearheading the domestication process.

---
[3] Alternative for Slash and Burn

A fourth crosscutting trend is the research and development work being undertaken by The Sustainable Tree Crop Programme (STCP), which is an agriculture programme, hosted by the International Institute of Tropical Agriculture (IITA). Its goal is to improve the economic and social well being of smallholders and the environmental sustainability of tree crop systems in West Africa. The objective of STCP is to compare, test, and validate different approaches and intervention to develop socially responsible, profitable and environmentally sustainable cocoa productions systems in a child labour-free environment. In order to achieve this the STCP has constituted a comprehensive and integrated regional programme in Ghana, Côte d'Ivoire, Guinea, Cameroon, and Nigeria where community-focused pilot projects have been launched.

The pilot projects are serviced by three regional projects, which include (I) Child Labour issues; (II) Trade and Information Systems and; (III) Technology Delivery, Research and Impact. To accomplish these the pilot projects in the various countries use the Farmer Field School (FFS) concept to introduce cocoa farmers to integrated pest and disease management and general farm management practices.

The FFS approach is a concept based on principles of adult learning. FFS is best suited for extending knowledge-based technologies and practices. The approach does not advocate technology transfer but instead reinforces farmers' observation skills, decision-making capacity and knowledge. A first step in establishing FFS is community needs assessment to identify communities' needs and production constraints. A curriculum, consisting of discovery learning exercises or simple experiments, is then developed based on research and extension recommendations. FFS also encourages farmer experimentation.

Cocoa agroforestry projects and lessons learnt

As mentioned earlier, conservation groups are calling for the use of cocoa agroforestry as a mechanism for biodiversity conservation. In 1997, *The Nature Conservancy* and the Americas Bird Conservation Programme embarked on an initiation that sought to enhance environmental conservation of a biological corridor stretching across the Talamanca Region in Costa Rica using shade cocoa (Parrish et al., 1998).

The aim was to provide critical lessons for using cocoa agroforestry as a conservation mechanism to underline the importance of integrating science with economic incentives to render conservation applicable to both local communities and protected areas at the same time. The following are some lessons and recommendations that emanated from the project:

<u>Abandoned cocoa farm</u>: From the perspective of biodiversity conservation, it is more profitable for farmers to employ more intensive management practices on their cocoa farms for greater productivity rather than reclaiming abandoned cocoa farms, which may be on their way to forest regeneration in heavily degraded landscapes. Biodiversity conservation therefore provides a window of opportunity for farmers who engage in practices that promote the protection of abandoned old cocoa farms that are located near protected forest frontiers and corridors to be rewarded by conservationists;

<u>Faunal population stability</u>: In order to prevent cocoa habitats from being population sinks for tropical biodiversity, it is advisable to determine the long-term sustainability of faunal populations with different cocoa management intensities.

Plantation size effect: It is essential to compare the biological value of similarly managed plantations that differ in size, since smaller plantations may reach a threshold of forest biodiversity capacity due to their being influenced by surrounding land uses.

Promoting biodiversity compatible chocolate products: Promote the patronage of certified biodiversity-friendly cocoa through educational campaigns in order to maximise the business demand for such products.

Organic versus conventional cocoa production: Assess and compare the level of biodiversity between organic and inorganic cocoa farms of similar landscapes, and the vegetative make-up existing in both fields in order to determine the negative and positive impacts of the various systems on the level of biodiversity. This will help evaluate the extent to which organic and biodiversity criteria may be integrated.

Combining biodiversity and socio-economic work: Most biodiversity work lacks the inclusion of experts in the local community leading to conservation recommendations that are neither applicable nor adoptable. Hence, it is necessary to integrate socio-economic and biological criteria to facilitate sustainability within conservation efforts.

Exploration of innovative economic incentives to encourage biodiversity-compatible cocoa: There should be compensation for ecosystem services, carbon offsets, and integration of buffer zone cocoa into park management plans and financial supports as mechanisms to encourage environmentally sustainable cocoa production.

Conservation International also highlighted the following recommendations after its “Conservation Cocoa Agroforestry Project” around the Kakum National Park area in the Central Region of Ghana:

Farm diversification: for income diversification by farmers, cocoa farmers who incorporate variety of food crops and other non-cocoa trees with young cocoa seedlings improve farm productivity. This reduces the risk of having a single crop in the event of crop failure.

Micro-climate improvement: the retention of original forest tree relics on new and mature cocoa farms provides a diverse nature in the canopy structure which provide habitat for the conservation of some plant and animal species. These trees facilitate ecological functions like nutrient, air and water cycles.

Survival of forest ecosystems: forestlands in cocoa growing areas can be sustained through sound cocoa farming practices that promote species diversity and involve cocoa farm rehabilitation.

Incentive for sustainable cocoa production: provide an incentive package to rewarding farmers who embark on sustainable farming practices that promote farm intensification rather than expansion into new forest areas.

Reduced risk on farmers health: biodiversity conservation provides increased opportunity for using integrated crop protection management that eliminate routine spraying regimes and hence reduce cost and risk of agro-chemical poisoning.

Scientists working on biodiversity conservation have come up with various recommendations as to how cocoa cultivation can improve biodiversity status in the agrarian landscape. Greenberg (1998) suggests that a significant amount of research is necessary to properly develop an integrated conservation plan for cocoa producing areas. He contends the following:

Ability of cocoa to conserve flora and fauna: research should compare cocoa farms with other agricultural habitats using different cocoa management regimes in an effort to emphasise the ability of different types of cocoa agroforests to harbour forest-dependent flora and fauna.

The long-term stability: organisms in traditional cocoa production should also be assessed. With particular importance for developing an integrated agro-ecosystem is the evaluation of the selection of shade trees and the mode of management necessary for optimising farm productivity and biological diversity.

Use of shade trees by other organisms: research should conduct a detailed regional assessment of use of shade trees in cocoa systems by forest organisms of various taxa. There should also be an investigation into how low intensity systems reduce the outbreak of diseases and pests and improve pollination levels.

Farmer incentives: There should be socio-economic studies that will help develop full range incentives for farmers who engage in a biodiversity-friendly cocoa production.

Research needs

Somarriba and Beer (1998) report that there is the need for new on-farm research on the ecological, financial, and the agroforestry aspects of cocoa-based agroforestry prototypes in remote and buffer zone areas. This should be done according to research-controlled, on-farm experiments focusing on the study of shade-fertility-yield interaction in cocoa-based agroforestry systems.

Rice and Greenberg (2000) assert that the ecological services provided by the cocoa agroforestry approach plays out over a long period of time. Hence, a decision must be considered in light of short-term profits for farmers. They suggest that there should be additional market and institutional incentives for farmers who embark on shade managed cocoa production.

Rolim and Chiarello (2004) also indicate that in the interest of long-term conservation of biodiversity, management practices like the eradication of non-native species and the promotion of permanent saplings of native species should be encouraged to ultimately replace mature or over-mature canopy trees in the cocoa agroforest. Also, a landscape mosaic that contains cocoa agroforests is probably more viable for conservation of biological diversity than a homogeneous landscape composed solely of cocoa agroforestry (Ewel, 1986; Myers, 1986: cf. Rolim Chiarello, 2004).

Way forward

While it is clear that cocoa agroforestry systems cannot replace primary forests, it is also evident that under certain conditions they can play valuable ecological roles in human dominated landscapes and agro-ecosystems. Today, however, the means of producing cocoa in countries like Ghana have increasingly moved towards a management system of lower conservation value than the multi-strata cocoa agroforests that harboured a diverse population of forest species and producing over farmers' lifetime. The reasons for such changes have much to do with national policies, the development of new cocoa technologies, fluctuations in market prices, the persistence of pests and diseases and changes in Ghana's forest ecosystem; thus no one person or group is to blame.

Any effort to re-orient cocoa production to meet conservation objectives will necessarily demand a change in how cocoa farmers and their families use the natural and agricultural resources. Most governments and organisations are committed to the idea that they can change how people use resources (Firey, 1999), but in truth many projects fail because they are unable to understand the human aspects of the system (Scott, 1998). Therefore, if farmers' behaviour or management decisions have to be changed then there is the need to present options that are *ecologically possible*, *socially adoptable* and *economically gainful* (Firey, 1999).

Ecologically possible requires an understanding of the environmental conditions and requirements for establishing and maintaining a cocoa agroforest in a particular area. Interactions between flora and fauna, interactions between non-cocoa and cocoa trees, soil conditions and nutrient requirements, and regeneration mechanisms (whether they be of natural origin or derived from a nursery) all require consideration.

Socially adoptable highlights the fact that a specific cocoa agroforestry system geared towards a full scale biodiversity conservation process must fit into the local farming norms, which vary between populations groups and may be influenced by ethnicity, education level and/or economic status. Therefore, it is often more effective to provide a series of options or models which cater to diverse social contexts. The most appropriate models are typically based upon local farming techniques and systems, as compared to models developed outside the sphere of farmers' social and ecological realities. The use of local models also increases the chance that they will be adopted and used over time. Nonetheless, the introduction of any new idea takes time to be disseminated and adopted, and typically only 20% of farmers adopt a new idea at the beginning; the rest only jump on board when the idea or new system has been further adapted to local conditions and confirmed (Rogers 2003).

Obtaining an understanding of the opportunities and constraints associated with the different cocoa management regimes is also essential. Participatory methods, which give the average farmer a real voice in the process, not just a symbolic seat at a large table full of dignitaries, officials and experts, are well proven in this regard. Because farmers are the stewards of their cocoa farms it is essential that the proposed changes make sense to them, and fit into their livelihood strategies and goals.

Economically gainful recognises that cocoa farmers in Ghana are engaged in a commercial activity to make money. Whether the income is derived from cocoa, timber trees, or agricultural products is less important than the timing, reliability and amount of money gained. In this regard, cocoa agroforestry for conservation must also meet farmers' financial expectations. Yet, what is *economically gainful* for a wealthy farmer, who can afford to pay for inputs up-front or wait for returns from forest products many years down the road, might not be plausible for a capital-poor farmer. Therefore, *gainfulness* should be assessed according to multiple standards.

Finally, landscape scale conservation initiatives must take into account those policies and institutional mandates that overlap within the same terrain. In fact, according to Ashley et al., (2006) the policy terrain of conservation landscapes has a major effect on agroforestry's potential to contribute to conservation. The major challenge is in harmonising the multiple (and often contradictory) mandates, rules, practices and needs of the wide range of actors living and working within the landscape. Therefore, it is important to reconcile conservation goals with the existing policies, extension messages, and on-the-ground practices of cocoa production, agricultural development, and rural development.

Conclusion

As stated already, human disturbance on forested ecosystems is posing a serious threat to local biodiversity in tropical landscapes. In Ghana, a significant proportion of both protected and unprotected forest areas has been degraded by agricultural expansion, mining and timber extraction. Given that forest ecosystem disturbances diminish biodiversity by displacing or replacing natural habitats there is the need to balance the economically driven agricultural expansion with strategies relevant for conserving natural resources, and maintaining ecosystem integrity and species viability.

Achieving these feats call for the development of a comprehensive intervention that is *ecologically possible, socially adoptable* and *economically gainful*. The project proposal by Conservation International Ghana on "*Conserving Globally Significant biodiversity in Cocoa Production Landscape in West Africa*" is an intervention that seeks to provide strategic options that will mitigate diminishing biodiversity in the agrarian landscape. The proposal acknowledges that there is a scientific foundation that enhancing shaded cocoa farming together with landscape management interventions for biodiversity conservation can increase the socio-economic benefits of the farming population and the ecological benefits of the landscape.

The project proposal therefore emphasises best practices in cocoa agroforestry that build on Ghana's traditional shade cocoa systems, both in existing farms and through the rehabilitation of degraded forest areas. It also stresses on maintaining ecosystem services such as erosion control, carbon sequestration, watershed protection, seed dispersal and rainfall, all of which have a significant effect on the region's cocoa production.

References

Alger, K. 1998. The reproduction of the cocoa industry and biodiversity in southern Bahia, Brazil. Paper from workshop held in Panama , 3/30-4/2, 1998. Smithsonian institution. Washington, D.C

Amanor, K.S., 1994. The new frontier: Farmers response to land degradation: A West African case study. Zed Press, London and UNRISD, Geneva.

Amanor, K.S., 1996. Managing trees in the farming system: The perspective of farmers. Forest Farming Series No. 1, Forestry Department, Ghana., Pp. 198

Asare, R. 2005. Cocoa Agroforests in West Africa: A Look at Activities On Preferred Trees in the Farming Systems, Danish Centre for Forest, Landscape and Planning (KVL)**:** 77

ASB. 2000. Alternatives to slash-and-burn: Summary report and synthesis of phase II in Cameroon. ASB Coordination Office, ICRAF-Nairobi

Ashley, R., Russell, D., & Swallow, B. 2006. The policy terrain in protected landscapes: challenges for agroforestry in integrated landscape conservation. Biodiversity and Conservation 15: 663-689

Benhin, J. K. A., & Barbier, E. B. 2004. Structural adjustment programme, deforestation and biodiversity loss in Ghana. Environmental and Resource Economics 27: 337-366

Beer, J. 1987. Advantages, disadvantages and desirable characteristics of shade trees for coffee, cacao and tea. Agroforestry Systems 5:3-13.

Beer, J. 1991. Implementing on-farm agroforestry research: lessons learned in Talamanca, Costa Rica. Agroforestry Systems 15:229-243

Beer, J., Muschler, R., Kass, D. and Somarriba, E. 1998. Shade management in coffee and cacao plantations. Agroforestry Systems 38: 139-164.

Brown, K., & Pearce, (eds). 1994. The causes of deforestation. London: University College London Press

Dobson, A. P., Bradshaw, A. D., & Baker, A. J. M., 1997. Hopes for the future: restoration ecology and conservation biology. Science 277: 515-522

Donald, P, F. 2004. Biodiversity impacts of some agricultural production systems. Conservation Biology 18: 17-37

Duguma, B., Gockowski, J. & Bakala, J. 1998. Smallholder cocoa (*Theobroma cacao*) cultivation in agroforestry systems of west and central Africa: challenges and opportunities. Paper from workshop held in Panama , 3/30-4/2, 1998. Smithsonian institution. Washington, D.C

Estrada, A., Coates-Estrada, R., & Meritt, D. A. 1997. Anthropogenic landscape changes and avian diversity at Los Tuxtlas, Mexico. Biodiversity and Conservation 6: 19-43

England, P. 1993. Forest protection and the rights of cocoa farmers in West Africa. J. African Law 37 (2): 164-176

Ewel, J. J. 1986. Designing agricultural ecosystems for humid tropics. Annual Review of Ecology and Systematic 17: 245-271

Fanaye, A.O., Adeyemi, E.A. and Olaiya, A.O. 2003. Spacing Experiments in cocoa/kola/citrus intercrop. (poster). 14^{th} International Cocoa Research Conference, 13 – 18 October 2003 Accra Ghana.

FAO (1997). State of the worlds forests 1997. Rome: FAO

Firey, W. 1999. Man, mind and land. Middleton, Wisconsin. Social Ecology Press

Franzel, S., Jaenicke, H. et Janssen, W. 1996. Choosing the right trees: setting priorities for multipurpose tree improvement research. Report 8. ISNAR, The Hague.

GPRS, 2002. Ghana Poverty Reduction Strategy 2002-2004.

Greenberg, R. 1998. Biodiversity in cocoa agroforestry systems: shade management and landscape consideration. Paper from workshop on Shade Grown Cocoa held in Panama, 3/30-4/2, 1998. Smithsonian Migratory Bird Centre. Washington, D.C.

Greenberg, R., Bichier, P. and Cruz Angón, A. (2000). The conservation value for birds of cacao plantations with diverse planted shade in Tabasco, Mexico. Animal Conservation, vol. 3, 105-112

Griffith, D. M. 2000. Agroforestry: a refuge for tropical biodiversity after fire. Conservation Biology 14: 325-326

Hawthorne, W. D., Abu Juam, M. 1993. Forest protection in Ghana: with particular reference to vegetation and plant species. Forest Inventory and Management Project. Overseas Development Administration and Forestry Department, Kumasi-Ghana

Herzog, F. 1994. Multipurpose shade trees in coffee and cocoa plantations in Côte d'Ivoire. Agroforestry Systems. 27: 259-267

Huang, W. 1998b. productive co-existence and gain in agroforestry systems. Acta Forestalia Fennica 260: 1-72

IITO (1993). Study of incentives for the sustainable management of the tropical high forest of Ghana, A report prepared by IIED and the Forestry Department of Ghana, unpublished.

Imbach, A. C., Fassbender, H.W., Borel, R.., Beer, J. and Bonnemann A. K K. 1989. Modelling agroforestry systems of cacao (Theobroma cacao) with laurel (Cordia alliodora) and cacao with poro (Erythrina poeppigiana) in Costa Rica. IV: Water balances, nutrient imputs and leaching. Agroforestry Systems 8:267-287.

Janson, D. 1998. Gardenification of wildland nature and the human footprint. Science 279: 1312-1313

Jiménez, F. and Beer, J.1999. Multistrata Agroforestry Systems with Perennial Crops, Proceedings of the International Symposium on Multi-strata Agroforestry Systems with Perennial Crops, 22-27 Feb. Turrialba, Costa Rica

Kaimowitz, D. & Angelsen, A. 1997. A users guide to economic models of deforestation. Bogor: Centre for International Forestry research (CIFOR)

Klein, A-M., Steffan-Dewenter, I., & Tscharntke, T. 2002. Predator-prey ratios on cocoa along a land-use gradient in Indonesia. Biodiversity and Conservation 11: 683-693

Leaky, R. R. B. 1999. Agroforestry for biodiversity in farming systems. In: Collins W. W. & Qualser C. O. (eds), Biodiversity in Agroecosystems. CRC Press, New York, USA. Pp 127-

Leakey RRB (2001). Win:Win landuse strategies for Africa: 1. Building on experience elsewhere and capitalizing on the value of indigenous tree products, International Forestry Review, 3, 1-10

Ministry of Science and Environment (2002). National Biodiversity Strategy for Ghana. Accra, Ministry of Science and Environment

Moguel, P. & Toledo, V. M. 1999. Biodiversity conservation in traditional coffee systems in Mexico. Conservation Biology 13: 11-22

Ministry of Agriculture (1991). Agriculture in Ghana: facts and figures. Accra: Policy Planning, Monitoring and Evaluation Department (PPMED), Ministry of Agriculture.

Myers, N. 1986. Forestland farming in Western Amazonia: stable and sustainable. Forest Ecology and Management 15: 81-93

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858

N'Goran, K. 1998. Reflections on a Durable Cacao Production System: The Situation in the Ivory Coast, Africa. Paper from workshop held in Panama , 3/30-4/2, 1998. Smithsonian institution. Washington, D.C.

Noble, I. R. & Dirzo, R. 1997. Forests as human-domain ecosystems. Science 277: 522-525

Osei-Bonsu, K. Ameyaw-Oduro, C., Tetteh, J.P., 2003. Traditional cocoa agroforestry: 1. Species encountered in the cocoa ecosystem of a typical cocoa-growing district in Ghana. Paper presented at the 14th International Cocoa Research Conference, Accra Ghana. 13-18 October

Owubah, C. E., Le Master, D. C., Bowker, J. M., Lee, J. G. 2001. Forest tenure systems and sustainable forest management: the case of Ghana. Forest Ecology and Management 149: 253-264

Padi, B. and Owusu, G. K. 1998. Towards an Integrated Pest Management for Sustainable Cocoa Production in Ghana. Paper from workshop held in Panama , 3/30-4/2, 1998. Smithsonian institution. Washington, D.C

Parrish, J., Reitsma, R., & Greenberg, R. 1998. Cacao as crop and conservation tool. Paper from workshop on Shade Grown Cocoa held in Panama, 3/30-4/2, 1998. Smithsonian Migratory Bird Centre. Washington, D.C.

Perfecto, I., Vandermeer, J. 1996. Microclimate changes and the indirect loss of ant diversity in a tropical agro-ecosystem. Oecologia 108: 577-582

Perfecto, I., Vandermeer, J., Hanson, P. & Cartin, V. 1997. Arthropod biodiversity loss and the transformation of a tropical agro-ecosystem. Biodiversity and Conservation 6: 935-945

Pimentel, D., Stachow, U., Takacs, D. A., Brubaker, H. W., Dumas, A. R., Meaney, J. J., O'Neil, J. A. S., Onsi, D. E. & Corzilius, D. B. 1992. Conserving biological diversity in agricultural/forestry systems. Bioscience 42: 354-362

Power, A. G., & Flecker, A. S., 1998. Agro-ecosystem and biodiversity. Paper from workshop held in Panama , 3/30-4/2, 1998. Smithsonian institution. Washington, D.C

Power, A. G., & Flecker, A. S., 2000. Agroforestry systems and Biodiversity. http: //www.si.edu/smbc/cacao/power.htm

Prah, E. 1997. Joint Forest Management: the Gwira-Banso experience. The 5th Commonwealth Forestry Conference, May 1997.

Putz, F., Redford, K., Robinson, J., Fimbel, R., & Blate, G. 2000. Biodiversity and conservation in the context of tropical forest management. Biodiversity Series Impact Studies, no. 1. The World Bank, Washington, DC.

Quansah, C., Drechsel, P., Yirenkyi, B.B., and Asante-Mensah, S. 2001. Farmers' perception and management of soil organic matter – a case study from West Africa. Nutrient Cycling in Agroforestry Systems 61: 205-213

Reitsma, R., Parrish, J. D., & McLarney, W. 2001. The role of cacao plantations in maintaining forest avian diversity in south-eastern Costa Rica. Agroforestry Systems 53: 185-193

Rice, R.A. and Greenberg, R., 2000. Cacao cultivation and the conservation of biological diversity. Ambio 29: 81-87

Rogers, E. M. 2003. Diffusion of innovations. New York, Free Press

Rolim, S. G., & Chiarello, A. G. 2004. Slow death of Atlantic Forest trees in cocoa agroforestry in southeastern Brazil. Biodiversity and Conservation 13: 2679-2694

Ruf, F. and H. Zadi, 1998. Cocoa: from deforestation to reforestation. Paper from workshop on Shade Grown Cocoa held in Panama, 3/30-4/2, 1998. Smithsonian institution. Washington, D.C.

Siebert, S. F., 2002. From shade- to sun-grown perennial crops in Sulawesi, Indonesia: imlication for biodiversity conservation and soil fertility. Biodiversity and Conservation 11: 1889-1902

Schroth, G., Gustavo A.B. da Fonseca, C. A. Harvey, C. Gascon, H.L. Vasconcelos, and A-M. N. Izac. (eds.). 2004. Agroforestry and Biodiversity Conservation in Tropical Landscapes. Island Press, Washington DC. 523 pp

Scott, J. 1998. Seeing like a state: how certain schemes to improve human condition have failed. New Haven, Yale University Press

Somarriba, E. & Beer, J. 1998. Cocoa-based agroforestry production systems. Paper from workshop on Shade Grown Cocoa held in Panama, 3/30-4/2, 1998. Smithsonian Migratory Bird Centre. Washington, D.C.

Sonwa D.J., Weise S. F. , Ndoye O. and Janssens M. J.J. 2003. The promotion of cocoa agroforest in West and Central Africa. Voluntary paper presented during the XII world Forestry Congress on Forests, Source of Life. Quebec city September 21 to 28, 2003. http://www.fao.org/DOCREP/ARTICLE/WFC/XII/0478-B5.HTM

Watt, A. D., Stork, N. E., Eggleton, P., Srivastara, D., Bolton, B., Laren, T. B., Brendell, M. J. D., & Bignell D. E. 1997. Impact of forest loss and regeneration on insect abundance and biodiversity. In: Watt S. D., Stork, N. E. & Hunter M. D. (eds) Forest and Insects, pp 273-286. Chapman and Hall, London

World resources Institute (WRI). 1994. World resources 1994-1995: People and the environment. Oxford: Oxford University Press

Young, A. M. 1996. The chocolate tree: a natural history of cacao. Smithsonian Institution Press, Washington DC

Zapfack, L., S. Engwald, B. Sonké, G. Achoundong, and B.A. Madong,. 2002. The impact of land use conversion on plant biodiversity in the forest zone of Cameroon. *Biodiversity and Conservation* 11(11): 2047-2061