Forest Genetic Resources Training Guide

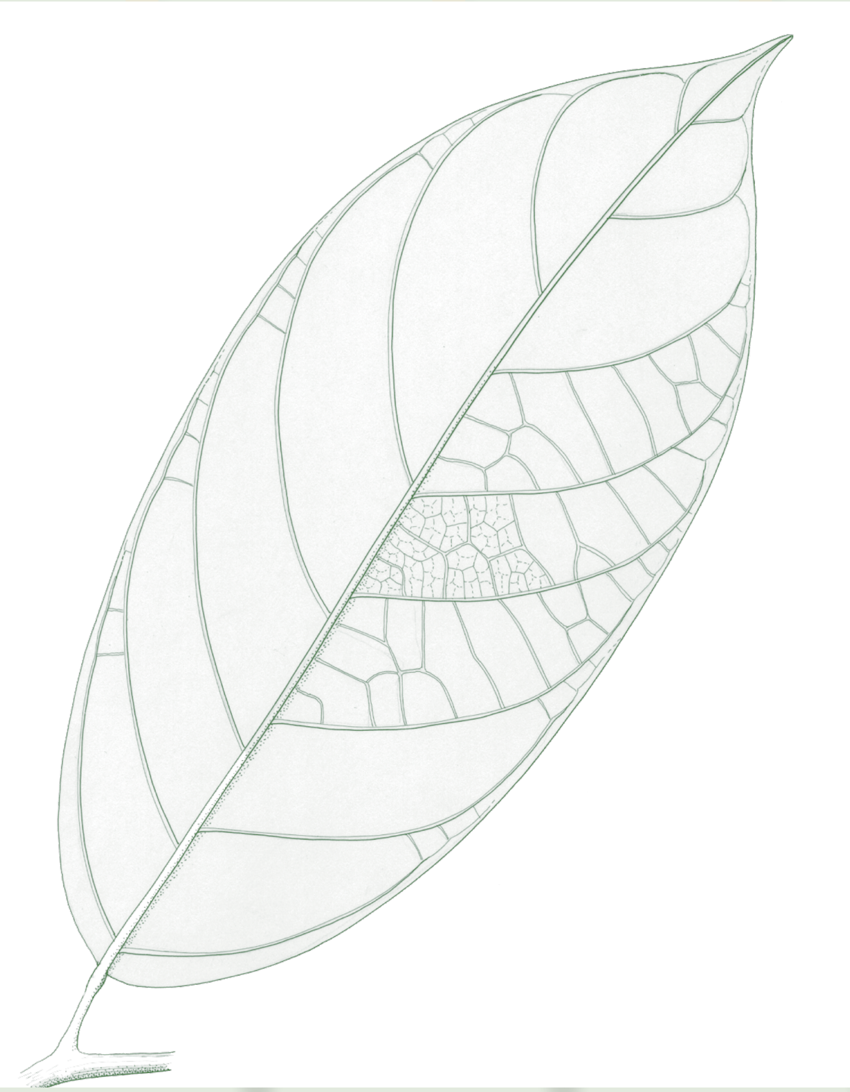
Bioversity International

MODULE 2
Trees outside of forests

Teacher's notes 2.1

Conservation of tree species diversity in cocoa agroforests in Nigeria

David Boshier



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Conservation of tree species diversity in cocoa agroforests in Nigeria

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Introduction

These Teacher's notes aim to assist teachers in using the **Case study 2.1 Conservation of tree species diversity in cocoa agroforests in Nigeria** in classes. The notes:

- Describe the key concepts covered in the case study, with references to forest genetic resources textbooks or papers where explanations of these principles can be found (full references at the end of these notes).
- Give tips on how to prepare and run the exercise and discuss the main learning points (genetic and other) that students should be able to derive from the case study.
- Give an outline commentary to the PowerPoint presentation which is used to introduce the case study to the students. The presentation contains pictures of the species, sites where it occurs, relevant land-use issues in the area, and figures/tables from the exercise.

The following support materials can be found on the accompanying DVD or at the Forest Genetic Resources Training Guide webpage at www.bioversityinternational.org

- Teacher's PowerPoint presentation
- Two short videos
- The Case study

Key concepts to cover/introduce in this Case study

General conservation

- ***In situ*, *ex situ* conservation:** see FAO et al. (2004a) pp. 5-16, 33; FAO et al. (2001); FAO et al. 2004b; Finkeldey (2005) pp. 181-198; Geburek & Turok (2005) pp. 6-8, 535-562, 567-581, and **conservation through use on farms - *circa situm***: Boshier et al. (2004).

- **Measures of diversity and species prioritization for conservation**: see outline in the case study and IUCN categories.

Genetic concepts

- **Minimum viable population, the 50/500 rule and effective population size compared to census size:** see FAO et al. (2004a) pp. 43-44; FAO et al. (2001) pp.7, 10, 61; FAO et al. (2004b) 10-12; Finkeldey (2005) pp. 177, 181-198; Geburek & Turok (2005) pp.162-164, 420-431.

How to run the exercise

The exercise can be run in a number of ways depending on the time available and size of the class. The exercise works best if students work in groups of 4-5 (no more than six). It is best if the students have already read the case study before they start the exercise. *This way valuable class time is not lost with students reading the paper during the class.* So give the case study out in a prior class with instructions to read it before the next class. It perhaps goes without saying that it is vital that the teacher and any assistants are fully familiar with the whole text! NB: the exercise is set in the context of the 2000s, both in terms of the status of the cocoa farms and the country. Therefore, more recent information and changed contexts are **not** included as they are not relevant to the exercise.

Ideal number of students: 4-15.

Ideal length of class: 3 hours, broken down as follows:

- ***Introduction***: use the video(s) followed by the PowerPoint – *approx. 20 minutes*.
- ***Group work***: suits 1-3 groups of 4-5 in each group. Each group tends to take a different approach and different issues are raised, so that overall, most points are covered. Students discuss the case study amongst themselves, responding to the specific points and developing their strategy. The teacher should be around to answer any queries the groups have. However, it is not essential that all of the time is spent with the whole class together with the teacher. Once the teacher and groups are happy they understand the assignment and issues, each group could meet, discuss and prepare the strategy outside of class time - *1.5 hours*.
- ***Presentations***: each group presents its strategy verbally to the class (supported by main points written on large paper or on a PowerPoint presentation) – *10 minutes* per presentation, with *5 minutes* after each presentation for questions/comments by the rest of the class and teacher;*15 to 45 minutes* depending on the number of groups.
- ***Final discussion***: led by the teacher allowing them to make general comments about what was good, what was missed, etc. – *10 minutes.*

Background information

Depending on the time and facilities available, use any combination of the following resources to provide background to the exercise: i) IUCN video on forest landscape restoration to introduce the general topic; ii) short video on cocoa agroforests in Ghana; iii) PowerPoint presentation.

Video: it may be appropriate to use the IUCN video as a more general introduction prior to the specific cocoa video. The IUCN video entitled '*Forest landscape restoration – see the bigger picture*', lasts 4½ minutes and presents a global overview of issues related to forest landscape restoration. The World Cocoa Foundation video lasts 4.5 minutes and shows the Cocoa Livelihoods Program in Ghana, similar to that mentioned in the case study. The teacher can use one or both of these videos as introductions to the exercise depending on how it is felt they meet the interests and needs of the class.

PowerPoint: about 15 minutes to go through. It covers general concepts of conservation and, in particular, the idea of conservation on farms (*circa situm*). It also has images related to cocoa agroforests in West Africa, the trees associated with them, and figures and tables from the exercise.

Slide 1: the title shows the focus is on trees outside forests, rather than the traditional focus on intact undisturbed forest. The cartoon from a Honduran newspaper shows that nowadays Little Red Riding Hood often has no option of walking through the forest!

Slides 2-3 (optional): an optional exercise the teacher can use near the start to get the students thinking is to ask them to say verbally along the following lines (their answers can be written on a board below headings of 'impacts' and 'genetic impacts'):

> *What are the impacts of human interventions on trees?*
>
> *What are the genetic impacts of human interventions on trees?*

This will allow the teacher to understand some of the ideas that the students already have about the topic and to see what areas might need to be explored which the students have never thought about. Once this is done, *Slide 3* can be used to show the main points raised by a previous class of students.

Slide 4: summarizes some of the impacts. It stresses the importance of maintaining viable populations.

Slide 5: allows the teacher to emphasize that genetic impacts should not be seen in isolation, but as part of the bigger picture, with emphasis on understanding where such impacts may be limiting.

Slides 6-11: summarize traditional approaches to conservation, i.e. *in situ/ex situ* and associated problems. The emphasis should be on their complementary nature, rather than either/or. The emphasis will however shift depending on the characteristics of the species and the population of concern.

Slide 6: the two principal conservation approaches.

Slide 7: points out that selection of most protected areas tends to be for conservation of 'megafauna' – large furry animals, leading to bias in what is conserved.

Slide 8: deforestation and fragmentation is not random – usually the best land/lowland is cleared for agriculture and we are left with the forests on the hillsides (picture taken from a hill of a biological reserve in Costa Rica, looking towards a national park on the other hill . The intervening lowland has been cleared for growing rice). So, we may well have lost both species and populations adapted to the lowlands and good soils. The remnant trees in these situations may represent the only examples of this gene pool and therefore are important for conservation.

Slide 9: summarizes the issues and limitations related to *in situ* conservation.

Slide 10: the two principal conservation approaches – now we want to look at *ex situ* conservation.

Slide 11: shows examples and some of the limitations of *ex situ* methods.

Slides 12-14: introduce the idea and debate around whether trees found in agricultural landscapes may be important for conservation of some species (sometimes known as *circa situm* conservation) and the negative view that they are not. The "living dead" quote is from noted US ecologist/conservationist Dan Janzen (for definitions of terms see Box 1; for more detail see Introduction to Module 2: Trees outside of forests).

Box 1. *In situ, ex situ* and *circa situm* conservation.

- ***In situ*** conservation involves the conservation of flora or fauna in the location and the ecosystem (in as natural a state as possible) in which they naturally occur.
- ***Ex situ*** conservation involves the removal of flora or fauna from the location where they naturally occur, and their conservation either in a dormant state (e.g. as tissue or seed) or in breeding populations (e.g. in zoos or seed orchards).
- ***Circa situm*** conservation involves the conservation of biodiversity within its native range but under conditions which have been highly altered by human activity.
- Conservation through use is the conservation of any resource motivated by perceptions of its utility. Conservation through use may occur in either intact or disturbed ecosystems, and be applied either to the ecosystem as a whole (e.g. a forest) or to components of the same (e.g. individual tree species).

How does conservation through use relate to other approaches?

- **On-farm** tree management: much discussion of the importance of trees on-farms in recent years has focused on their importance for livelihood support. In this respect, on-farm tree management is clearly a form of conservation through exploitation. However, only under certain circumstances does it contribute to the conservation of biodiversity.
- ***Circa situm*** conservation: trees are often conserved *circa situm* due to their use and consequent active retention. However, many other trees persist in altered ecosystems without active protection or management, due for example to their vigour or the limited resources available to farmers to remove them. *Circa situm* refers to where the conservation is carried out, rather than its motivations.
- ***In situ*** conservation: trees may be conserved under natural conditions due to their use, or that of the ecosystem in which they are found, but *in situ* conservation may also occur for other reasons such as existence value. *In situ* again refers only to location rather than motivations.
- ***Ex situ*** conservation: the same applies for *ex situ*, e.g. seed orchards may seek to make germplasm available for plantation use at the same time as conserving diversity, whereas other gene banks (either planted or *in vitro*) may be inspired solely by existence value.

Slide 13: threatened species *Leucaena colinsii* subsp. *zacapana* and *L. esculenta* conserved on farms in Guatemala and Mexico where the forest has disappeared, i.e. *in situ* is no longer an option. Agroforestry systems where valuable timber trees are conserved - *Cedrela odorata* in a coffee plantation in Costa Rica and *Cordia alliodora* in a cocoa plantation in Honduras.

Slide 14: raises some of the main issues of concern that need to be addressed if the potential of *circa situm* conservation is to be established.

Slide 15: shows two examples previously seen of trees in agroforestry systems and raises the basic question related to the exercise.

Slide 16: summarizes some data from coffee agroforestry systems in Central America. Sales of coffee from agroforestry coffee is promoted as being ‘bird-friendly’ – helping the conservation of bird species associated with this system.

Slide 17: similarly, the marketing of cocoa produced in agroforests is based on Fairtrade organic labels that give premiums to small-scale producers.

Slide 18: maps show: i) the location of Nigeria; ii) areas of economic activity – note the brown area of cocoa production in the south-west of the country; iii) vegetation zones – cocoa growing is where there is rain forest vegetation; iv) the states of the Nigerian Federation – Ondo state where the study is centred is found in the south-west of the country.

Slide 19: shows that cocoa production has a long history in the region. The second group of photos gives an impression of the structure of the cocoa agroforests. The farmer field schools are a training initiative of the Sustainable Tree Crops Programme of the World Cocoa Foundation in West Africa.

Slide 20: shows two of the tree species that are listed in the study.

Slide 21: shows a photo guide for forest trees in Ghana which is available locally and allows farmers to learn which species they have on their land and which are rare or common. The examples show three of the species found in the study.

Slide 22: shows two of the species of trees that are listed in the study and classified as threatened under one of the IUCN categories. The captions draw attention to differences between the cocoa agroforest and native forest in terms of species occurrence (NB: these captions can be deleted if the teacher is confident students can derive these differences from their own reading and discussions of the study).

Slide 23: shows the rarefaction graph included in the students' study which compensates for the different sizes of the sample plots. Rarefaction is used to standardize and compare species richness from samples of different sizes. Rarefaction allows calculation of the species richness for a given number of sampled individuals and the construction of rarefaction curves. The curve is a plot of the number of species as a function of the number of individuals sampled. On the left, the steep slope indicates that a large fraction of the species diversity remains to be discovered. As the curve becomes flatter to the right, a reasonable number of individuals is sampled; more intensive sampling is likely to yield only few additional species.

Slide 24: this allows the teacher to re-emphasize an important issue regarding conservation (raised in pages 3 to 4 of the student exercise) and the possible conservation importance of these agroforests.

Slide 25: allows the teacher to go over what the students should be doing in the exercise. The teacher should stress: i) the need to be specific in what the plan includes – students tend to be too general in their recommendations; ii) the need to prioritize – students tend to recommend doing everything, failing to recognize that resources for actions are extremely limited; iii) the students should indicate what information/evidence they used to justify each activity; iv) they need to present a convincing case that would sway a donor/government to give them funds and/or enact policy or legislation to aid conservation; v) they do not need to answer all the questions, but nevertheless these are things they need to think about in developing a plan.

Important points to draw out in discussion and to cover in students' presentations

Comments about the questions

- *Use the data provided to summarize the differences (numbers of species, types of species – by ecological guild, by use, by threat) between the species found in the cocoa agroforests and the natural forest.*

Number of species. 487 trees from 45 species and 24 families were identified in 21 ha of cocoa agroforests surveyed, compared to 163 trees from 62 species and 29 families in the 0.56 ha of reserved forest surveyed (Table 1). Although the cocoa agroforests contained a wide variety of non-cocoa trees, Shannon's index showed them to have lower diversity of tree species than the floristically and climatically similar site of primary or natural forest. Rarefaction curves indicate that cocoa agroforests support relatively lower species richness (Fig. 2). The rarefaction curves show that with greater sampling, species diversity in the forest is likely to be higher (i.e. a greater variety of species), whereas it is unlikely to increase significantly in the agroforests.

Types of species – by ecological guild. In terms of species numbers, these are summarized below, with higher percentages of exotics in the agroforest, and more shade-bearing and non-pioneer light demander (NPLD) species in the forest:

- Cocoa agroforest - pioneer 16 (35.6%), NPLD 11 (24.4%), shade bearer 6 (13.3%), swamp 2 (4.4%), savanna 2 (4.4%), exotic 8 (17.8%), not classified 0.
- Forest - pioneer 20 (32.2%), NPLD 23 (37.1%), shade bearer 13 (21.0%), swamp 4 (6.5%), savanna 0, exotic 0, not classified 2 (3.2%).

Types of species – by use. In the cocoa agroforests, the 10 most abundant species make up 77% of all the trees. Most of these are exotic fruit tree species cultivated for their direct products (economic crop or local consumption) as well as shade for the cocoa. *Elaeis guineensis* (oil palm) topped the list followed by *Cola nitida* (cola), *Citrus sinensis* (orange), *Mangifera indica* (mango), *Anacardium occidentale* (cashew), *Psidium guajava* (guava), *Persea americana* (avocado). There was also a marked occurrence of native species not native to that ecological zone, introduced for fruit (e.g. *Dialium guineense*). Overall, 423 edible fruit trees of 16 species in 13 families were recorded, of which only 26.3% of these species were indigenous (Table 2). The proportion of non-fruit trees to fruit trees in the natural forest is very high with only five edible fruit tree species (*Ricinodendron heudelotii*, *Chrysophyllum albidum*, *Bligha sapida*, *Diospyrous mespiliformis*, *Parinari curatelifolia*).

The non-fruit tree species present in substantial numbers in the cocoa agroforests were *Alstonia congensis, Ceiba pentandra, Triplochiton scleroxylon* and *Milicia excelsa*, of which the latter two were on the list of preferred trees because of their use for timber (Table 1), but always at lower densities (<less than 10%) their natural occurrence in the forest. A number of the rarer economic tree species (e.g. *Brachystegia eurycoma*, *Afzelia africana* and *Terminalia superba*) were also found on the cocoa farms, but again densities were much lower than in the natural forest.

Types of species – by threat. In the cocoa agroforests five (1 LRnt, 3 Vu, 1 En; 11.1%) of the species are categorized with some degree of threat (IUCN categories), while in the natural forest 12 (1 LRnt, 10 Vu, 1 En; 19.4%) of the species have IUCN threat categories. All the threatened species within the cocoa agroforest were also found in the natural forest, whereas 58% of the threatened species found in the natural forest were not found in the agroforest. The most endangered species, *Gossweilerodendron balsamiferum,* was also found in the cocoa agroforest showing the importance of these agroforests for increasing population numbers of some threatened species.

- *The factors that influence what tree species are maintained in the cocoa farms.*

Farmers are likely to retain or plant trees if they are useful. Productivity, in a broad sense, is therefore a very important factor. Oil palm was the most common species, regenerating naturally in most cases, its seedlings being protected by farmers because of its important contribution to family income. The high proportion of exotic fruit trees in the cocoa farms is an indication that farmers were interested in planting or retaining fruit trees, rather than timber trees (see also Table 1 where the list of preferred trees is dominated by fruit species). This is probably because of the opportunities to use the products domestically and to sell them in local markets. The negative attitude of farmers towards the retention of timber trees may be connected with factors such as: a) the tree tenure system; b) the long period for timber trees to mature; c) the need for other income sources to augment farm income; d) damage to cocoa trees that usually accompanies timber extraction. The timber species on the cocoa farms, though few in number, were trees of merchantable size which tend not be harvested because of the fear of destroying surrounding cocoa trees or because of tenure issues. There were, however, indications that some of the farmers were making deliberate efforts to plant some timber tree species on their farms, especially *Terminalia* spp.

- *The scale over which cocoa agroforests occur, densities of individual species and what this means for viability of individual species.*

The background information in the case study shows that cocoa occupies a total area of 700 000 ha in Nigeria, with an average farm size of only 1.7 ha. Given the small size of most cocoa farms, the scale of implementation is important; biodiversity benefits require implementation of beneficial management over a large area and hence by a large number of farmers.

The emphasis in cocoa agroforests is obviously on cocoa production with the number of cocoa plants per hectare maximized. Consequently, basal area and density of non-cocoa trees in the cocoa agroforests were low (16% and 8% respectively) compared to those of the natural forest (Table 2). As mentioned in the discussion of species characteristics, numbers and densities of individual species in the cocoa agroforests were much lower than in the natural forest. With densities for most native species of 0.05-0.5 trees per ha, large areas of cocoa agroforests are required to maintain significant populations of individual species, e.g. at least 10 000 ha for the lowest density species (0.05 trees/ha) to have a census population of 500 trees; much more than 10 000 ha is required for an effective population size of 500 trees.

With tree densities being much lower, there may also be impacts on the reproductive capacity of individual species and levels of genetic diversity. NB: *there is not enough scope within this case study to discuss all the potential impacts of lower tree densities on within-species genetic diversity. However, these issues are dealt with fully in the other case study within this module and in Module 4 on Forest Management.*

- *What information is missing that would help to make more definitive statements/recommendations?*

The data are derived from relatively small samples, both in terms of the cocoa agroforests and native forest. There is therefore no information about how species distributions may change across farms (i.e. levels of aggregation for different species). Nor do the data say anything about trends in densities, i.e. whether the observed presence and densities of species in the agroforests is stable or decreasing. This can only be guessed at based on how farmers' preferences and issues of tenure influence decisions on how many and what type of trees to retain. Nevertheless, recommendations can be made to help stabilize or improve the situation in terms of tree cover and conservation.

- *The extent to which cocoa grown in traditional agroforests affects the diversity of forest tree species.*

In terms of numbers of trees, the cocoa agroforest is dominated by exotic and pioneer species, whereas in the forest, NPLD and pioneers predominate (see summary figures below, derived from Table 3). The high abundance of exotic, non-primary forest species (e.g. oil palm, mango, avocado) points to the degree of alteration of the cocoa agroforests compared to primary forest.

Cocoa agroforest - pioneer 135 (27.7%), NPLD 20 (4.1%), shade bearer 67 (13.8%), swamp 6 (1.2%), savanna 10 (2.1%), exotic 249 (51.1%), not classified 0.

Forest - pioneer 50 (30.7%), NPLD 73 (44.8%), shade bearer 29 (17.8%), swamp 6 (3.7%), savanna 0, exotic 0, not classified 5 (3.0%).

- *How can you both conserve the diversity of native tree species and meet the expectations/demands of cocoa farmers?*

As noted on page 2 of the case study (*Biodiversity* '*pros*' *and* '*cons*' *of cocoa agroforests*), cocoa production tends to move towards a management system of lower conservation value than the traditional multi-strata cocoa agroforests. This trend is related to national policies, development of new cocoa technologies, fluctuations in market prices, and the persistence of pests and diseases. Any efforts to re-orient cocoa production for conservation purposes must reduce this trend and should be socially and economically acceptable to farmers and, ecologically feasible. To prevent ecologically unacceptable loss of shade cover and diversity and improve the livelihoods of small cocoa farmers may also require economic incentives. Incentives may be in the form of organic and Fairtrade certifications whereby farmers directly receive a premium price or pay a low certification cost. Diversification of species and products may also require development of diverse value chains to avoid over-intensification of any one species.

Cocoa farmers are engaged in a commercial activity, and so cocoa agroforests for conservation must also meet their financial expectations. Whether income is derived from cocoa, timber trees, or agricultural products is likely to be less important than the timing, reliability and amount of income. What is economically beneficial for a wealthy farmer, who can afford to pay for inputs upfront or wait years for returns from forest products, may not be feasible for a capital-poor farmer. An understanding of the opportunities and constraints associated with the different cocoa management regimes is therefore essential, as are participatory methods, which give farmers a real, and not just symbolic, voice.

The most appropriate models are typically based upon local farming techniques and systems, as compared to models developed outside farmers' social and ecological realities. Promotion of local models also increases the chances of uptake and use over time. However, any new idea takes time to be disseminated and adopted, requiring consistency of policies, messages and programmes over a sufficient time-frame. Often, only a few farmers initially adopt a new idea; uptake increases when the idea/system has been further adapted to local conditions and adequately demonstrated.

The size of farms has a major effect on the potential of cocoa agroforests to contribute to conservation. This requires harmonisation of multiple (and sometimes contradictory) mandates, rules and practices and also the needs of the wide range of stakeholders 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 and rural development. The number of farmers trained through the farmer field schools (FFS) approach, shows that the required scale for implementation of management favourable to conservation is feasible.

A comparison of Tables 1 and 3 shows preferred species that are absent from the cocoa agroforests. These species could be targets for measures promoting diversification through the availability of planting material (e.g. *Irvingia gabonensis*).

Comments about students' presentations

*Use the information given here to: **a) present a case for the conservation benefits in terms of tree species diversity in the cocoa agroforests of Nigeria***

In addition to the detailed responses to questions that are given on the previous pages, the main points are:

- Cocoa agroforests in Nigeria are classified as having medium shade levels with high numbers of forest tree species (see Nigeria background in Case Study).
- The case study showed that the cocoa agroforests of Ondo State contain a diverse population of non-cocoa forest tree species, some of which are threatened.
- Trees in cocoa agroforests may play an important but varied role in the long-term viability of some native tree species by: i) maintaining minimum viable populations of threatened species; ii) facilitating gene flow between existing patches of native forest; iii) conserving particular genotypes not found in reserves; iv) acting as intermediaries and alternative host habitats for pollinators and seed dispersers.
- Given the small size of most cocoa farms and low population densities of most native species, in order for biodiversity to benefit, implementation of appropriate management is necessary over large areas of cocoa agroforests and hence by a large number of farmers. The number of farmers trained through the FFS approach of the Sustainable Tree Crops Programme (STCP) shows that the required scale for implementation of management favourable to conservation is feasible.
- It is important to recognize the complementary role that maintenance of trees on farms plays to *in situ* conservation. Underestimating the capacity of many species to persist in these agroforests under current practices could lead to the misdirection of limited conservation resources toward species not under threat. The fact that some tree species can be conserved through existing practices can free resources for the conservation of more critically threatened species needing more conventional, resource-intensive approaches.
- Although cocoa agroforests are environmentally preferable to many forms of agriculture, they do not equate with primary forests.
- Tree species composition in cocoa agroforests is quite distinct from, and much lower in number than that of natural forest; exotics and pioneers dominate and population densities of individual forest tree species are low (see earlier in these teacher notes for more details).
- The extent of conservation benefits varies depending on the level of shade, intensity of management and hence the stage of agro-ecological succession attained. There is a danger that the cocoa agroforests' management system, and hence conservation, may not be stable and may change gradually towards one of lower conservation value than the traditional multi-strata agroforests.
- Smaller plantations may reach a critical threshold of forest biodiversity capacity due to their being influenced by surrounding land uses.
- Planting of cocoa can lead to loss of primary rain forest in West Africa.

Remaining forest cover in West Africa constitutes only one-fifth of its original extent. However, for Nigeria the Case study suggests that this indicates the beginning of the end of cocoa farm expansion into forested areas. Efforts to increase production depend more on the rehabilitation of neglected cocoa orchards rather than increasing the area under cocoa via deforestation.

or use the information given here to: ***b) derive an action plan to ensure optimum conservation benefits in terms of tree species diversity in the cocoa agroforests of Nigeria***

In addition to the main points and data summaries made on the previous pages, the main elements expected in an action plan are:

- The background information in the exercise identifies the current challenge for policy makers in Nigeria as to how to increase production in cocoa orchards, but at the same time conserve biodiversity.
- Actions that help prevent intensification that leads to ecologically unacceptable loss of shade cover and consequently tree species diversity. This is likely to require complementary actions that improve the income and livelihoods of small cocoa farmers as an incentive for implementation of biodiversity-friendly, shade cocoa cultivation, e.g. incentives from organic and Fairtrade certifications.
- In addition to the production of cocoa, cocoa agroforests have the capacity to produce a diversity of products (e.g. timber, edible fruits) and help conserve a number of native forest species. Achievement of all these multiple benefits requires improved management.
- This in turn requires greater stimulation of interest for cocoa farmers in maintaining and planting native trees on their farms, greater support to farmers in terms of relevant technical knowledge on the dynamics of the system and identifying forest tree species that are both beneficial to farmers and to the environment as neighbour trees in cocoa systems (i.e. those which are threatened species which should be conserved and those which are of economic interest and could be available for harvesting). The availability of simple pictorial tree guides, such as that shown in the PowerPoint presentation (*Slide 21*), can be of use in aiding farmers and extension agents in this process.
- Advocacy work is needed to change policies that currently discourage cocoa farmers from keeping naturally occurring high-value timber species on their farms, or stop them deriving adequate benefits. For example, a means could be developed to register planted and nurtured timber trees on farms, so that tree ownership is redefined to benefit farmers. Farmers also need technical assistance in the optimal timing of felling timber trees and other techniques that reduce surrounding damage in the cocoa plantation to levels that do not deter harvesting and reaping benefits from nurturing timber trees.
- Obviously, the most effective means for implementing such action will be through the existing Farmer Forest Schools of the STCP. As outlined in the background information for Nigeria, STCP works in collaboration with the research body Cocoa Research Institute of Nigeria (CRIN), to promote cocoa agroforestry, encouraging farmers to protect, plant and harvest timber trees, to improve soil conservation, and to serve as a platform for dissemination of research results on cocoa shade trees.
- Research and development has focused on reducing shade and increasing cocoa production, while diversifying both production and species through the incorporation of indigenous fruit trees with a strong demand in national and regional markets. There has, however, been virtually no work on the forest timber species that farmers also prefer. Thus, there needs to be advocacy that directs research towards alternative means of diversifying and increasing income by e.g. timber production and ensuring premiums through production of biodiversity-friendly cocoa. As shade levels may be strongly related to the

cocoa variety grown, there is also a case for more work on the development and deployment of shade-tolerant cocoa varieties which are both productive and beneficial for conservation.

- The following needs to be studied: interactions between flora and fauna, interactions between non-cocoa and cocoa trees, soil conditions and nutrient requirements, and regeneration mechanisms (whether of natural origin or derived from a nursery). As mentioned in the text, new propagation methods for some indigenous fruit trees have resulted in reduced height and relatively smaller canopy that locate them in the same stratum as the cocoa tree, giving rise to concern that competition between species will be increased rather than decreased.

Further information

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Forest Genetic Resources Training Guide

MODULE 1 Species conservation strategies
- 1.1 *Leucaena salvadorensis*: genetic variation and conservation
- 1.2 *Talbotiella gentii*: genetic variation and conservation
- 1.3 *Shorea lumutensis*: genetic variation and conservation

MODULE 2 Trees outside of forests
- **2.1 Conservation of tree species diversity in cocoa agroforests in Nigeria**
- 2.2 Devising options for conservation of two tree species outside of forests

MODULE 3 Tree seed supply chains
- 3.1 Genetic bottlenecks in the restoration of *Araucaria nemorosa*
- 3.2 Tree planting on farms in East Africa: how to ensure genetic diversity?

MODULE 4 Forest management
- 4.1 Impacts of selective logging on the genetic diversity of two Amazonian timber species
- 4.2 Does selective logging degrade the genetic quality of succeeding generations through dysgenic selection?
- 4.3 Conserving *Prunus africana*: spatial analysis of genetic diversity for non-timber forest product management

MODULE 5 How local is local? – the scale of adaptation
- 5.1 Selecting planting material for forest restoration in the Pacific north-west of the USA
- 5.2 Local adaptation and forest restoration in Western Australia

Other modules to be published among the following:

Plantation forestry, Tree domestication, Forest restoration, Genetic modification