Project 13

Integrated Perennial and Annual Cropping Systems (InPACS): Building Household Assets

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13.1 Project goal

To increase the productivity of agricultural land and labor employed by asset-poor households and enhance the environmental services of the landscape by increased investment and improvement in natural capital stocks (tree assets).

13.2 Project purposes

1. National agricultural research and extension systems (NARES) evaluate and disseminate technologies and knowledge for creating tree stock assets on deforested/degraded land in the moist savanna, humid forest, and mid-altitude ecologies of West and Central Africa in a sustainable manner.
2. Measured parameters associated with the environmental services of multi-strata perennial land use systems are used to assist in the development of economic incentive structures for rewarding proper land stewardship.
3. Enabling policies and new institutional arrangements evolve for building and improving tree stock assets by the poor.

13.3 Project rationale

Overcoming the rampant poverty that still exists in much of rural West and Central Africa demands an integrated effort in building and improving upon rural assets. In West and Central Africa tree stock assets are integral to the rural livelihoods of countless smallholders. Facilitating small farmer investments in tree stock assets and improving the performance of those investments is the *raison d'être* of the InPACS project.

Perennial tree crop systems in Africa are important *inter alia* for national macroeconomic balances and rural livelihoods. In a period of rapid globalization and market liberalization, countries in Africa are pursuing their comparative productive advantage to foster growth under a new liberal economic context. The pursuit of comparative advantage implies a continued if not larger role for tropical commodity exports (both traditional and non-traditional) in order to generate foreign exchange and economic growth. The new liberal economic context while providing new opportunities has also revealed certain institutional weaknesses and remaining policy distortions that are impeding the realization of greater benefits particularly among the poor. To avoid the further marginalization of the poor requires technological, institutional and policy solutions to ensure their participation.

In the humid forest and moist savannah zones of West and Central Africa, oil palm, cocoa, robusta coffee, and various fruit and nut bearing trees already contribute to the livelihoods of innumerable households, while generating foreign exchange needed for the purchase of capital goods and government revenues. Economies of scale in these cropping systems do not appear to be significant, indeed there is a school of thought which holds that heterogeneous crops such as cocoa are intrinsically suited to small holder production systems. Perennial crop systems have provided an equitable development pathway even for asset-poor households (e.g. recently installed Burkinabe cocoa and coffee farmers in Côte d'Ivoire) and should with the right support continue to do so.

The working hypothesis of this project is that rural poverty is intricately linked with the quality of resources at the farmer's disposal and the farmers' stock of productive assets. A lack of productive assets and a degraded resource base define resource-poor farmers in this context. This particular class of African farmer is the target of project interventions.

13.3.1 Natural Resources, Poverty and Sustainable Livelihoods

In sub-Saharan Africa, four categories of resources form the principal foundation of rural livelihoods—land, labor, physical and natural capital. In the humid forest tropical lowlands among the most important natural capital assets are forest resources and vegetative biomass within which most plant nutrient stocks are found. These nutrient stocks become available when slash and burn shifting cultivation transforms them into wood ash. After the cropping phase, households with still abundant land endowments are able to fallow their land for sufficiently long periods so as to permit the re-accumulation of this natural capital. However, as both population pressures and land distribution inequalities arise, land-poor households are forced to return to the same piece of land before an adequate accumulation of natural capital has occurred. This can trap the household into a spiralling situation of degrading natural resources and poverty. Similarly, in the savannah regions of West Africa, soil nutrient depletion and soil erosion, if not addressed, may also result in a poverty-resource base spiral.

One means of averting these downward spirals is to invest in ecologically sustainable productive assets. For the moister ecological zones of SSA, perennial tree crop systems are well suited to this need and have been shown agronomically to be most suited to the conditions of West and Central Africa. While agronomic foundations are important, sustainable production systems also depend on conducive socio-economic and institutional foundations. A stable social structure is a *sine qua non* of a sustainable production system and *vice versa*. Societies rife with inequities, poverty and degraded natural resources are prime candidates for civil strife and unrest. To successfully build tree assets the constraints that limit investment by the poor must be understood and overcome. These are likely to include agronomic and socio-economic problems ranging from biological production lags to a lack of rural credit and dependable food markets. Understanding the agronomic, socio-economic and ecological foundations of the sustainability of tree based systems and the differences that exist across system types (e.g. full sun cocoa/coffee versus shaded systems) is one of the research thrusts of the project.

The project's spatial focus is West and Central Africa, which present both similar and differing eco-regional issues. In the humid forest zone across both regions, tree-based systems such as cocoa, oil palm, and coffee have been most often established by converting forest. Globally, the social costs of tropical forest conversion are becoming prohibitive as the supply of intact closed canopy tropical forest ecosystems rapidly diminishes. Because of the need to conserve Africa's remaining forest resources for their timber value and the non-timber products and environmental services provided, the creation of new household assets among the poor is exclusively focused on the reforestation of already deforested lands through establishment of productive multi-product agroforests.

In the humid forest zone of West Africa the conversion of the forest is nearly complete. Nothing remains! Indeed an influx of migrants from the savanna regions to establish perennial cropping systems in West Africa has been a major contributing factor to deforestation particularly in Côte d'Ivoire and Ghana where development of the forest zone was actively encouraged by past governments. In most of West Africa, the tropical forest has been replaced by a secondary forest-cultivation mosaic characterized by extensive tracts of degraded fallow (often consisting of the thicket-forming perennial *Chromolaena odorata*), interspersed with perennial crop systems and annual food crops.

In the Congo basin of Central Africa which is the world's second largest contiguous tropical forest biome, up to 85 to 95% of the deforestation process is attributed to small holder slash and burn agriculture for subsistence food production. As compared to West Africa, the smallholder perennial crops sub-sector is much less developed and land pressures are also much lighter. In Central Africa the greater development of tree stock assets among the poor could stabilize the deforestation process by moving resources out of shifting slash and burn systems to permanent agriculture.

13.3.2 Institutional Change and Supportive Policies

Concerns also surround the new institutional environment for the marketing of cocoa and coffee in most of West Africa. In the past, official producer prices were maintained at stable but low levels by state controlled marketing boards and stabilization funds; in the new liberal context producer prices are directly linked to world prices by competitive market structures. This has led to a subsequent increase in the price risk faced by farmers which can be a problem for households with heavy dependence on a single tree crop. However there are many cocoa and coffee producing households which rely on a combination of commercial agricultural enterprises and typically garner less than 50% of their annual revenues from tree crops. These types of farming systems are better adapted to the ups and downs of the new riskier market environment and offer lessons for the design of new systems to meet the needs of the rural poor.

World-wide concerns over the sustainability of cocoa systems have been expressed at the 1998 International Sustainable Cocoa Conference in Panama and in the 1999 Paris Declaration of Intent by chocolate industry concerns. West Africa produces approximately two thirds of the world's cocoa supply and the annual foreign exchange earnings range from USD $2 to 3 billion. Here the concern is that the full-sun systems planted with improved varieties (found mainly in Cote d'Ivoire), while high yielding in the short term, may not be sustainable due to both biotic and abiotic stresses. Among the biotic factors is the increasing prevalence of cocoa mirids as shade disappears from the system and the stresses engendered by high production which can more rapidly age the cocoa plant particularly the higher yielding Amazonian varieties. The emergence and spread across West Africa of a new more virulent agent of cocoa blackpod disease caused by *Phytophthora megakarya* (versus *P. palmivora*) is also of major concern. Abiotic factors include nutrient imbalances over time and the low level of nutrient cycling in less shaded systems coupled with the difficulties faced by poor farmers with no access to credit in purchasing soil amendments.

While the inclusion of more shade into full sun systems may help to address the issue of sustainability in West Africa cocoa and coffee systems, it would at the same time likely lead to a reduction in overall production. However, in the case of Côte d'Ivoire, which accounts for over one-third of world cocoa production, such a trade-off might actually be revenue enhancing because of the potential supply effect on world prices. The traditional means of achieving supply control in countries with a dominant market position has been to "optimally" tax producers, reducing supply and thereby raising world price and overall revenues (assuming an inelastic demand schedule). An increase in the shade canopy would similarly reduce supply while generating concurrent environmental benefits ranging from carbon sequestration, local climate mitigation and maintenance of biodiversity. These concurrent benefits are particularly important in West Africa where most closed canopy tropical forest has disappeared due to population pressure. If the shade species also produce secondary products such as fruits for local markets and medicinal products the long-term sustainability of the system from the smallholders' private perspective is also likely to increase.

Building productive tree assets among asset-poor rural households requires a focused and supportive policy regime. As mentioned above, since the mid-1980s, the role of the private sector in marketing has grown. While in theory this injection of competition into the marketing system should lead to greater efficiencies and higher farmer revenues (as marketing costs are competed downwards), several unforeseen problems have arisen that require second generation approaches and institutional innovations. In many countries, the marketing board by distributing and subsidizing agro-chemicals to farmers provided a substitute mechanism for overcoming underdeveloped rural credit and input markets. In today's liberal context farmers purchase inputs from private suppliers out of their own cash reserves. The underlying premise for liberalizing was that the profit motive in a privatized input market should lead to increased efficiencies and more timely provision of inputs. While input supply markets have evolved and are relatively competitive and efficient in areas with adequate infrastructure; rural credit markets have almost universally failed to develop. This is one of the biggest problems facing the sustainability of the tree crop sector as many producers are prevented from using the appropriate input quantity, even though they may be available in the private market.

Another significant issue stemming from liberalization with the potential to affect producer livelihoods in West and Central Africa is the shift in market power that has occurred with the dissolution of marketing board apparatus. The monoply power once wielded by national export marketing boards no longer exists and is at risk of being usurped by large consolidated agro-industrial concerns on the buying side. Thus while one structural market imperfection on the selling side (marketing boards) has been removed, another imperfection on the buying side (an oligopsony of agro-industrials) has grown stronger.

13.3.3 A Private-Public Partnership to Address Sustainable Livelihoods

In recognition of the important issues currently threatening sustainable smallholder livelihoods derived from cocoa production, chocolate industries in both Europe and North America are supporting research and development activities in West and Central Africa through a joint public-private partnership under the Sustainable Tree Crops Program (STCP). The industry through STCP is seeking to develop partnership projects involving cocoa growers, processors, chocolate manufacturers, development agencies, governments, NGOs, conservation groups and research institutes to address sustainable cocoa production. The industry defines sustainable cocoa production as that:

*"grown within a biologically diverse and environmentally sustainable agricultural system, being capable of providing lasting economic, social, and environmental benefits. Grown in such a system, cocoa is a crop ideally suited to smallholder cultivation". [*Source: Concluding Declaration of 1st International Workshop on Sustainable Cocoa Growing, Panana City, Panama, April 1998*]*

The STCP is convened by IITA with its program office and co-ordinator based in Yaounde, Cameroon. The program, which was launched in May 2000 in Accra Ghana with stakeholders from Cameroon, Côte d'Ivoire, Ghana, Guinea, and Nigeria, is focused primarily on cocoa, coffee and cashews. There are 4 basic program components—Research and Technology Transfer, Grower and Business Support Services, Policy Change and Implementation, and Market and Information Systems. A good portion of the research in the InPACS project on cocoa systems is funded by the STCP. This includes research on the agro-ecological foundations of the sustainability of cocoa agroforests.

13.3.4 Project Cornerstones

To achieve the project goal and purpose, *four cornerstones* are being laid through specific project outputs. These are: (i) collective learning among stakeholders, (ii) the development and spread of technical innovations, (iii) measuring, monitoring and rewarding land stewardship, and (iv) enabling policies and institutional innovations.

The *first cornerstone* aims to equip farmers and their organizations with tools needed for analyzing and adapting to rapidly changing global markets in the new liberal context. This includes efforts aimed at strengthening farmer organizations by including their members in participatory experimentation and interactive situational analyses of opportunities, needs and constraints. National networks made up of diverse partners under the STCP are another method for sharing ideas and spreading knowledge more broadly.

The *second cornerstone* addresses technical constraints to sustainable production and marketing systems ranging from plot level production constraints to post-harvest information constraints which prevent farmers' organizations from achieving a better marketing result. In designing technical interventions, special considerations are given to overcoming the constraints of the resource poor. For instance, the profitable integration with food crops during the establishment phase of the perennial tree system is one means of addressing a short planning horizon among poor farmers.

The *third cornerstone* pursues means of rewarding farmers with market incentives for proper land stewardship. This entails, *inter alia,* defining standards of sustainability and developing and testing product attribute information systems with farmer organizations to maintain product identity through the supply chain. The attributes include ecological as well as quality criteria.

The *fourth cornerstone* is exploring new policy options and institutional arrangements to facilitate the transition process to a more liberal economic regime. Particularly crucial in this regard will be the development of new marketing arrangements with the potential to offset the shift in market power that has occurred with the dissolution of state control marketing apparatus. One policy incentive under investigation is the possibility of cash credits for carbon sequestered when degraded bush fallow is converted to productive multi-strata, biologically diverse agroforests.

13.4 Ongoing and Future Activities

13.4.1 Constraints and opportunities for impact identified, prioritised, and research strategy formulated

A participatory learning approach in conjunction with farmers and their organizations generates the knowledge used to prioritise problems and guide the project in an iterative fashion towards the achievement of the project goal. The location-specific nature of natural resource management dictates an inductive approach drawing on a combination of both local and scientific knowledge. Human perspective at the local level is paramount as the point of departure for social learning and process innovations. Participatory learning focused on the management and sustainable development of tree stock assets involves several steps. The process can be visualized as a set of learning cycles consisting of experimentation/monitoring/evaluation. Findings on constraints and opportunities by local communities are used to arrive at the consensual identification of a shared problem and the collective action necessary to address it.

13.4.1.1 Conduct literature review of socio-economic and agronomic research on the establishment of InPAC systems in the moist tropics with initial focus on cocoa and cashew-based systems.

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This activity is ongoing across the region and involves the collection of both published and non-published manuscripts in collaboration with STCP partners. The envisaged output is an annotated bibliography of pertinent literature.

13.4.1.2 Explore strategies for transferring carbon-offset benefits to smallholders establishing InPAC systems under the Clean Development Mechanism of Kyoto Protocol.

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In February 2000 a workshop was jointly organized by the Center for International Forestry Research and the University of Maryland at the Bellagio International Conference Center. The workshop engaged policy makers, pilot forest carbon project managers, and researchers in a discussion of how to generate benefits for rural communities through forestry management and agroforestry projects under the Clean Development Mechanism of the Kyoto Protocol. It was concluded that well conceived projects can benefit local communities by augmenting and diversifying their source of revenues, by offering greater access to forest resources and services, by improving land use productivity, and by developing local institutions and capacity for managing projects. On the other hand poorly conceived projects could have negative effects on local populations for instance restrictions on access to forest resources integral to livelihood strategies.

To ensure broad-based benefits the following measures were proposed:

- Inclusion of forest management and agroforestry in the CDM mechanism.
- Social impact assessments for all CDM projects
- Increased incentives for projects generating multiple benefits (e.g. rural development, biodiversity conservation and carbon sequestration)
- The reduction of transaction costs of community projects
- Use of tonne/year carbon accounting as the preferred measure of C sequestration
- Increased local, national and international capacity for CDM forestry and agroforestry projects.

The findings of the workshop have been published as a policy briefing and are available in English, French and Spanish languages. Copies can be obtained by contacting either J.Gockowski@cgiar.org; CIFOR@cgiar.org; Web site http://www.cifor.cgiar.org

13.4.1.3 Dynamics of diversification of cocoa multistrata agroforestry systems in southern Cameroon.

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Faced with declines in profits and labor productivity of cocoa, smallholder cocoa farmers in southern Cameroon are increasingly diversifying their income generation and food production activities. With the goal of diversifying land use systems and increasing incomes, farmers can either convert their plantations or enrich them by increasingly integrating forest species, fruit trees, and annuals within the plantation system. The particular dynamic of interest to us in this study is the diversification within cocoa plantations. The important ecological, economic, and socio-cultural factors that have led and are leading to different types of cocoa agroforests need to be understood to better target research interventions. These multistrata systems deserve to be investigated as they are excellent models of associations between non-domesticated forest species and cultivated species; between the production of food, nuts and seeds, and the provision of environmental services; and between flexible management opportunities and household food security.

The objectives of this study are:

1. Characterize the factors explaining the dynamic changes of cocoa multistrata agroforestry systems in the humid forest zone;

2. Characterize the vegetation structure and composition of the evolving agroforestry systems and its environmental role;

3. Characterize the management and production of the evolving agroforestry systems;

The study is being conducted within the Forest Margins Benchmark in southern Cameroon. The benchmark can be classified into three distinct blocks on the basis of population pressures and resource degradation. The Yaounde block represents an area with a relatively high population density (about 80 persons/km^2) and greater pressure on the natural resources, while the Ebolowa block is an area with low population density (5 persons/km^2) and where land and forests are still abundant. The Mbalmayo block is intermediary to these two situations. This report focuses on different tree species that farmers plant to intensify and diversify their cocoa agroforests and the differences across blocks. The results are based on a survey of 300 farmers in 21 villages of the benchmark area.

In the benchmark area, 93% of the cocoa farmers use fruit trees to intensify and diversify their cocoa plantations (Table 1). The highest percentage of farmers not planting any trees was found in Mbalmayo, i.e. 14%. Eighty-seven percent of the farmers use 3 or more species.

Over twenty fruit tree species (24 specifically) are planted by farmers into cocoa agroforests (data not presented). Of these, 63% are exotic species and the rest indigenious. The ratio of exotic to indigenous increases from 2 in the Ebolowa block to 2.5 in the Yaounde block indicating an increased use of exotic species under a more deforested and market-oriented environment. Overall, of the five most important species used, *Dacryodes edulis, Persea americana, Mangifera indica, Citrus sinensis* and *Citrus reticula*, only the first is indigenous. These species are used by 83, 77, 71, 56 and 27% of the cocoa farmers, respectively (Table 2). The first four species are more commonly used in the Ebolowa block than in the other blocks of benchmark area. Amongst these five major fruit tree species, *Dacryodes edulis* is found at the highest densities in cocoa plantations, i.e. on average 17 trees per ha (based on a survey of 60 plantations). This is followed by Persea americana, Mangifera indica, Citrus sinensis and Citrus reticula with 13, 6, 1 and 1 trees per ha, respectively.

In the benchmark area, 81% of the farmers plant non-fruit tree species to intensify and diversify their cocoa plantations (Table 3). No signifcant differences were found between the blocks, though there appears to be a trend towards more widespread use of non-fruit tree species in the Yaounde block, i.e 90% of farmers compared to 73 to 80% in the other blocks. Nearly two-thirds of the farmers use 3 or more species.

The five most common species used are *Terminalia superba, Triplochiton scleroxylon, Chlorophora excelsa, Ceiba pentandra* and *Ficus mucuso* (data not presented). They are planted by 32, 31, 25, 18 and 13% of the cocoa farmers, respectively. In the cocoa plantations, *Ficus mucuso, Terminalia superba* and *Cholorophora excelsa* are found at densities of 6 to 7 plants per ha, and *Ceiba pentandra* and *Triplochiton scleroxylon* at about 2 plants per ha (based on a field survey of 60 plantations). Amongst all the non-fruit tree species used for intensification and diversification, 15% are of high timber value, i.e. species being exported regularly based on information provided by ONADEF (local forest regeneration buro).

Overall, nevertheless, the farmers have a strong preference for the use of fruit trees compared to non-fruit tree species for the intensification and diversification of cocoa agroforests in southern Cameroon. The drive to integrate fruit trees is strongest in the more forested areas, as the farmers seek to secure additional income through their main perennial crop system, given limited alternative income generating opportunities.

Table1: Number of fruit tree species used by farmers for the intensification and diversification of cocoa agroforests in southern Cameroon (in percent of farmers).

	Number of fruit trees species used							
	0	1	2	3	4	5	Total	P-value
Yaoundé	4	1	7	21	29	38	100	< 0.0001
Mbalmayo	14	2	5	17	20	42	100	< 0.0001
Ebolowa	2	1	3	18	27	49	100	< 0.0001
Total	7	1	5	19	25	43	100	
P-Value	0.0234	0.7644	0.4603	0.8763	0.5970	0.4196		

Table 2 : The five fruit tree species most commonly planted by farmers for the intensification and diversification of cocoa agroforests in southern Cameroon (in percent of farmers).

	Yaoundé	Mbalmayo	Ebolowa	HFZ
Dacryodes edulis	79	80	90	83
Persea americana	74	73	82	77
Mangifera indica	70	65	79	71
Citrus sinensis	57	48	64	56
Citrus reticula	39	15	30	27

Table 3: Number of non-fruit tree species used by farmers for the intensification and diversification of cocoa agroforests in southern Cameroon (in percent of farmers).

	Number of non-fruit trees species used							
	0	1	2	3	4	5	Total	p-value
Yaoundé	10	12	15	12	34	17	100	0.0126
Mbalmayo	20	4	12	14	37	13	100	0.0001
Ebolowa	27	3	13	14	35	8	100	0.0004
HFZ	19	6	14	14	35	13	100	
P-Value	0.1252	0.0593	0.8973	0.8593	0.9474	0.2962		

New Activities for 2001

13.4.1.4 Conduct a baseline household survey on smallholder production and marketing systems in the five participating countries of the STCP.

by J. Gockowski, L. Battini[1], J. Mva[2], and C. Akinola[3]

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Farmer responses to economic incentives under the new liberal economic policy regime sweeping across West and Central Africa are likely to be much different from those under the previous more state controlled marketing context. It is important to establish how farmers across the region are reacting to this new environment. Surveys targeting smallholder production of perennial tree crops will be conducted in Ghana, Cote d'Ivoire, Nigeria, Cameroon, and Guinea. Each survey will target approximately 1,000 producing households. The objective is to establish production parameters underlying the short and long run supply elasticities of perennial tree crops in order to better understand how farmers are reacting to both price and non price factors in a new economic context. Given the diversified nature of farming in much of the region, this implies the use of a farming system approach at the household level where the perennial crops are considered as only a part of the system. The survey will also attempt to establish a typology of production systems using indicators of environmental services (e.g. amount and diversity of shade coverage) and level of intensification (e.g. amount of agrochemical usage). Labor practices and sources of hired labor are also under investigation and will be used to establish short run supply response and estimated returns to labor. Among the aspects specifically targeted are the relative importance of perennial tree crops relative to other commercial enterprises (both farm and off-farm). Parameterizing household investment in tree stocks is particularly important for developing understanding of the price and non-price incentives which lead poor households to engage themselves. This includes new planting, uprooting and replanting, and uprooting and diversification behaviours.

13.4.1.5 Determinants of Choice of Techniques in Cacao Farming in Cameroon.

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The purpose of this research is to evaluate the present and potential capabilities of cocoa farmers to increase income in a sustainable manner and identify constraints to these income increases. In Cameroon essentially all cocoa is grown by smallholders with the median holding under 1 ha and this is often grown in association with other fruit trees and biennial crops such as plantain. Cocoa revenues still generate the largest share of annual cash income for a majority of households in the cocoa producing regions of southern Cameroon although these revenues have been declining in recent years for a host of reasons.

The initial problem of this research is to understand how producers make their initial land allocation between cocoa and annual crops and how they make decisions on tree stock adjustments over time as their plantations get older. The second problem, given a calibrated and validated model replicating farmers' decisions is to stimulate the effects of alternative policies aimed at imposing some societal objectives on farm level decision making. The specific objectives are:

1. Evaluate factors influencing farmers' initial planting of cocoa;
2. Given a mature cocoa stand analyze the choice between extensive and intensive production techniques based upon annual inputs allocation;
3. Analyze decisions on tree stock adjustments, especially the choice between replanting and area expansion
4. Incorporate societal goals (soil degradation and carbon sequestration) into the farm decision making and evaluate how this would change farmer activities.

Empirical implementation of the household decision making model involves econometric estimations, linear programming and dynamic simulations.

13.4.1.6 Ecological and economic characterisation of cocoa agroforest systems

L. Norgrove

Cocoa is one of the main cash crops in Ivory Coast, Ghana, Nigeria, and Cameroon and is almost exclusively grown by smallholders. Farmers have generally established cacao plantations either in secondary forest after selective thinning or after clear felling. In the former case, farmers have retained upper-canopy trees in their plantations. These trees are usually selected for their timber, fruits, nuts or medicinal products. However, in Ivory Coast, in the past ten years, farmers have been removing shade trees from their plantations with the aim of intensifying production and increasing cocoa yields. The effects of changing the shade level on the sustainability of the system are not understood and are likely to depend upon other aspects of plantation management, such as fertilizer inputs, pest and disease control measures and whether or not farmers replace dead or old cacao trees with new cacao tree plantings. Therefore it is essential to establish what is current farmer practice.

Interviews with farmers in the forest margins benchmark of southern Cameroon will be carried out with the aid of a structured questionnaire in order to gather information on shading, inputs, management and yields.

Assessment of changes in shade management regimes in Ivory Coast from 1991 – 2001

L. Norgrove

Ten years ago, a study by the Centre Suisses de Recherches Scientifique, Abidjan, assessed the density of shade trees in cacao farms in villages near Bouaké. The same farms will be revisited and the survey repeated to assess the changes in the last ten years and the implications for sustainability.

13.4.2 New knowledge on soil, crop/shade interactions, and weed processes affecting the establishment and sustainability of InPAC systems acquired.

13.4.2.1 The establishment of multi-strata cacao agroforests in Chromolaena odorata and Imperata cylindrica fallow.

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Farmers have traditionally established cacao systems in forest land where high levels of soil organic matter and nutrients facilitate their establishment. Farmers in the forest belt of West Africa and the more densely populated areas of rural Cameroon no longer have access to forest land to create new plantations.

As agricultural productivity for staple food crops increases and as the rural exodus from the forest zone proceeds, short fallow land dominated by Chromolaena odorata and grasses is increasingly available for conversion to agronomically more sustainable land use systems such as the shaded cacao agroforest. In addition to the revenue potential of these land use systems, they also conserve important biodiversity, maintain watershed and landscape functions and may help in stabilizing local climatic patterns by supporting hydrological cycles. However, short fallow dominated by *C. odorata* and grasses is likely to present serious fertility and weed competition constraints in the establishment phase due to previous nutrient depletion and a built up weed seed bank caused by repeated cycles of annual cropping. In addition there may not be any shade available in such land use systems to protect the young cacao in the establishment phase. Farmers in the IITA forest margins benchmark research village of Nkometou III have expressed a strong interest to re-establish cacao agroforests in their degraded short fallows.

The research activity maintains several working hypotheses. (1) The successful establishment of a cacao agroforest requires shade, (2) nutrient depletion in C. odorata-dominated short fallow is a major impediment to reforestation via agroforests and (3) farmers have high subjective discount rates and are risk averse. The latter predisposes them to intercropping during the establishment phase and production of multiple outputs during the productive phase of the perennial component of the system.

The research objectives of this activity are to:

1. Determine with farmers options for establishing cacao agroforests in degraded short fallow bush land
2. Assess the ability of two *Musa* spp. varieties to provide shade to the young cacao and generate income through production of bunches during the first 3 to 4 years after planting the cacao.
3. Determine the effect of fertilizer rates on growth of cacao, fruit trees, timber trees and the yield of the *Musa* spp.
4. Evaluate the economic costs and returns of establishing multistrata cacao agroforests in *Chromolaena odorata* and *Imperata cylindrica* fallow.

Determine the dynamics of carbon sequestration in a cacao agroforest

The specific hypotheses are:

H1: The establishment of complex cacao multi-strata agroforests is possible in *C. odorata*- and grass-dominated short fallow land.

H2: Successful establishment of the cacao component requires shading.

H3: Cooking bananas (ABB) provide better shade and a higher income than local plantains (AAB).

H4: *Inga edulis* provides better shade and for a longer period of time than cooking bananas and plantains.

H5: Shading during the establishment phase of cacao and fruit trees can be provided by natural regrowth.

H6: Use of natural regrowth to shade cacao requires a lower labor input per ha during the establishment phase.

H7: Tree growth (and later on yields) and banana and plantain yields increase with increasing nutrient amendments.

H8: Economic value of carbon sequestration (as valued in the industrialized north) exceeds the economic costs of establishment

This is an on-farm trial with 20 farmers using a two factorial design: shade regime (at four levels) and soil amendments (at four levels).

The shade regimes are: (1) planting of Plantain (*Musa* spp., AAB subgroup, French or False Horn); (2) planting of cooking banana (*Musa* spp., ABB subgroup, var. Fougamou); (3) planting of *Inga edulis* and (4) retaining hedges of the natural regrowth.

Fertilizer amendments are: (1) nil, (2) N at 60 kg/ha (3) P, K, Ca, and Mg at 30, 90, 500 and 100 kg/ha, respectively and (4) N at 60 kg/ha and P, K, Ca, and Mg at 30, 90, 500 and 100 kg/ha, respectively.

Plot size = 17.5 m x 17.5 m. Each farmer has eight plots. The experiment has 10 replicates. Cocoa is planted at a density of 1600 plants/ha while temporary shade trees (*Musa* spp. and *I. edulis*) were planted at a density of 1306 plants/ha. All plots were planted to upper strata trees for permanent shade provision at a density of 294 trees/ha. This initial shade density falls within the range of extant cocoa agroforests of southern Cameroon (unpublished data IITA). The trees chosen for permanent shade followed dialogue and consensual agreement with the trial participants. These are avocado, *Persea americana,* at 98 trees/ha, the African plum, *Dacryodes edulis,* at 65 trees/ha, the timber specie *Terminalia ivorensis* at 65 trees/ha and the timber/fruit specie *Ricinodendron heudelotii.*

The planted shade (plantain, cooking bananas and Inga edulis), were evaluated in August and September 2000. This evaluation served to assess the soil fertility in the plots and to allow a ranking of the sites for fertilizer treatment allocation. Within each shade type all 40 plots were ranked by the performance of the species planted and separated into groups of four. The four worst performing plots of each shade type formed the first block and all other blocks were demarcated in the same manner.

Cooking bananas had more leaves, larger and higher pseudostems and more suckers than the plantains, thus provided more shade, yet may have caused more competition. *Inga edulis* trees had reached up to 4 m height.

Survival of cacao of the first dry season until January 2001 was 73.4% and was neither affected by the shade regime nor by the fertilizer regime. Survival was higher in blocks with good growth of shade plants.

The longer than usual dry season 2000/2001 may have led to further cacao plant losses. An additional evaluation of survival at one month after re-commencement of the rains will be conducted before replanting lost cacao.

13.4.2.2 Impact of soil chemical, organic matter, and physical differences on the establishment of multi-strata cacao agroforests in Chromolaena odorata and Imperata cylindrica fallow.

S. Hauser, L. Norgrove

A soil sampling to one-meter depth was conducted in the experiments described in Activities 2.1. and 3.1. Statistical analysis of the laboratory results is ongoing.

13.4.2.3 Participatory development of oil palm systems in southern Cameroon on degraded lands.

J.C. Ngongang Nono[1]*, S. Weise, S. Hauser, J. Gockowski;*

[1]*IRAD*

Native oil palms are an integral part of farming systems in the forest zone. Until recently oil palms were not planted with supplies coming from wild seedlings simply retained in the system. Farmers utilize native palm supplies primarily for subsistence oil production and palm wine tapping. As urban markets have grown rapidly in recent years, farmers have started showing interest in establishing small-holder oil palm systems using improved varieties. Such systems can provide an alternative income source to cocoa and coffee. In contrast to commercial plantations, systems have to be developed that require minimal external inputs for fertility and pest management and provide some income during the establishment phase of the palm.

In early 1997, group meetings were held over several months with farmers of 2 benchmark villages in southern Cameroon. After extensive consultations a total of 26 farmer fields were selected, i.e. 12 in Nkolfoulou and 14 in Awae, and the oil palms were planted between July and September 1997, each farmer's field containing 36 hybrid palms (Tenera). The main objectives of the study are to:

- Develop sustainable oil palm systems for small-holder farmers that provide early income through intercropping with food crops.
- Assess different methods of soil fertility and weed management and its impact on oil palm growth.
- Determine the preference of farmers for different management systems.

Each field has been divided into two, which then constitutes a treatment plot. Fields originate from two basic type of fallows, i.e. tree-based vegetation or bush fallow (mostly dominated by *Chromolaena odorata*). Following treatments have been implemented:

T1: fertilizer with cover crop (F+/CC) – 8 replicates in Nkolfoulou and 7 in Awae

T2: fertilizer with natural vegetation (F+/NV) – 4 replicates in Nkolfoulou and 7 in Awae

T3: no fertilizer with cover crop (F-/CC) – 4 replicates in Nkolfoulou and 7 in Awae

T4: no fertilizer with natural vegetation (F-/NV) – 8 replicates in Nkolfoulou and 7 in Awae

The annual recommended rate of fertilizer application was initiated in 1997 in Nkolfoulou and in 2000 in Awae. The cover crop used is *Pueraria phaseoloides*.

The cover crop was re-seeded in mid-year 2000 since establishment was poor in the 1999. Even this second attempt was not fully successful with good establishment in only 4 plots of 12 in Nkolfoulou and 4 of 14 in Awae.

Oil palm growth parameters have been monitored since the start and include:

- Frond production – every 2 months

- Girth – every 6 months
- Length of the fourth leaf "F4" – every 6 months
- Nutrient content of the ninth leaf – annually

Initial analysis have found no significant differences in oil palm growth due to village location, origin of the field in which the oil palm was established and fertilizer use (Tables 1, 2 and 3). However, trends indicate that the growth in fields originating from bush fallows was lower and that fertilizer application, particularly in these fields, enhanced growth. Whether these trends will have any impact on production will become clear in 2001. The first oil palms came into production in December 2000. Leaf analysis showed that nitrogen and potassium were below recommended critical levels even with fertilizer application. Phosphorus was also limiting particularly in Awae and in fields derived from bush fallows. Calcium and magnesium were not limiting.

In 2001, oil palm observations will be continued. Farmers will be brought together to discuss their experiences during this establishment phase of an oil palm system and to then themselves develop recommendations for other farmers who would like to start new plantations.

Table 1: Effect of village on selected growth parameters of oil palms in (data are the least squares means)

	Frond production (no. over 12 months)			Length of F4 (in cm measured in December)				Girth (in cm measured in December)			
Village:	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
Nkolfoulou	11.3	18.4	19.8	42.3	94.5	182.2	285.6	12.7	31.1	89.5	146.5
Awae	11.9	15.2	19.7	39.4	106.4	180.0	251.3	--	--	80.1	127.7
P-Value	Ns	0.005	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 2: Effect of field origin on selected growth parameters of oil palms (data are the least squares means)

	Frond production (no. over 12 months)			Length of F4 (in cm measured in December)				Girth (in cm measured in December)			
Previous Vegetation:	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
Tree	12.3	19.5	20.0	49.2	108.0	200.8	315.4	16.3	39.9	96.5	148.0
Bush	10.4	17.4	19.5	35.7	82.3	164.3	255.3	9.2	22.5	82.5	145.4
P-Value	Ns	Ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

Table 3: Effect of fertilizer use on selected growth parameters of oil palms in Nkolfoulou (data are the least squares means)

	Frond production (no. over 12 months)			Length of F4 (in cm measured in December)				Girth (in cm measured in December)			
Annual Fertilizer:	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
None	10.5	17.3	19.2	41.9	88.4	173.3	262.0	12.5	28.8	94.3	135.8
Yes	12.2	19.5	20.5	43.0	102.0	191.8	308.7	13.0	33.7	94.7	157.7
P-Value	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 4: Effect of village, field origin and fertilizer application on leaf nutrient content in December 1999 (data are the least squares means)

		N % of dm	Ca % of dm	Mg % of dm	K % of dm	P % of dm
Effect Type:	Recommended Critical values	2.70	0.50	0.23	1.25	0.16
Village	Nkolfoulou	2.46 b	0.71	0.34	0.67	0.33
	Awae	2.22 a	0.72	0.32	0.57	0.14
Previous Vegetation	Tree	2.48 b	0.69	0.31	0.63	0.30
	Bush	2.20 a	0.74	0.35	0.60	0.15
Fertilizer (Nkolfoulou)	None	2.49	0.76	0.37 b	0.52 a	0.45
	Yes	2.44	0.67	0.30 a	0.83 b	0.16

Note: Numbers are significantly different at a 5% probability level if followed by different letters within a column and effect type.

13.4.2.4 Farmers' participatory research with fruit trees and food crop integration for poverty alleviation and ecosystem conservation

F. Ishida, G.Tian, and D. Keatinge

Rapid population growth in West Africa continues to place increasing pressure on available land resources. This has caused a severe reduction in the long fallow periods, which were traditionally used to replenish soil fertility after a cropping phase without external inputs. Improved tree fallow systems have been designed by IITA to assist in preventing soil nutrient depletion but farmers lack incentives to adopt these systems as they usually require taking land out of food production for the fallow phase. As an alternative IITA is proposing to test systems integrating annual cropping with perennial fruit trees such as cashew (*Anacardium occidentale*). It is hypothesised that the cash revenues from such a system would attract farmers and help maintain soil fertility from leaf litter fall and nutrient recycling.

The research objectives of this activity are:

1) To compare the early establishment, productivity and potential sustainability of improved integrated farming systems including cashew with continuous cereal mono-cropping.

2) To examine the role of additional locally available organic inputs, such as rice husk, in maintaining the soil fertility of such a system

3) To monitor farmer's perceptions of the likelihood of adoption of such systems and to track opportunities for the potential adaptation of the technology by users.

The on-farm trial is located in the village of Bida which lies in the southern Guinea savanna of Nigeria. The design is a randomized complete block with four replicates of the following main treatments: (1) Cashew planted with maize; and (2) Sole maize. Sub-treatments are: (i) control; (ii) chemical fertiliser (100N/40P/100K kg ha^{-1}); (iii) rice husk (100 kg N ha^{-1}) and (iv) rice husk (50 kg N ha^{-1}) + chemical fertilizer (50N/20P/50K kg ha^{-1}). The cashew has been planted in rows at a spacing of 8 x 2 m. Maize is planted between cashew rows at a spacing of 1 x 0.25 m.

The observations include annual soil sampling, food crop yield, periodic assessment of tree growth; nutrient and water flow between trees and crops; nutrient balances; carbon sequestration; soil loss and soil biota. Laboratory analyses will include soil organic C, total N, available P, exchangeable Ca, Mg and K, pH, NO_3^-, soil moisture and particle size will be determined.

New Activities for 2001

13.4.2.5 Establishment of cocoa on degraded land

L. Norgrove

The trial described in section 13.8.2.1 above was established in 1999/2000 in the Lekié Division, an area where high population pressure has led to degraded forests. Seedlings from selected trees of a local cacao variety were planted in May 2000 under four different temporary shade treatments (plantain, cooking banana, *Inga edulis* and in alleys of natural regrowth dominated by *C. odorata*). Timber and fruit tree seedlings were planted which will later form the more permanent shade canopy. Soil sampling to 1 m depth has just been completed and four fertilizer treatments have been applied. Standard agronomic measurements are being made.

To complement these measurements, the following high-resolution additions are proposed in selected replicates of the experiment in order to further assess the feasibility of establishing cocoa on degraded lands. The following hypotheses will be tested:

H1 The four different shade crops produce different levels of shading with different temporal shading patterns.

H2 Higher levels and longer duration of shade maintain higher soil water levels during the dry season, permitting young cacao plants to retain more leaves, have a higher leaf surface area and thus higher rates of growth.

H3 Fertilizer application increases cacao water status, growth rate and survival through the dry season.

H4 The effects of fertilizer application do not interact with the shade treatments.

H5 The weed community is determined by the level of shading and the fertilizer regime.

H6 There is higher soil faunal abundance and activity in the more-shaded treatments

This is an established experiment and this work will complement the existing measurements. Among the measurements to be taken in 2001 are:

- Assessment of light levels above the cacao seedlings in different shade treatments
- Assessment leaf area indices of various system components. (via in situ leaf size assessments and leaf counts)
- Soil water content (0-20 cm depth adjacent to cacao plants)
- Weed sampling for biomass and community composition from four 0.75m x 0.75m squares in centre of plot
- Semi-quantitative assessment of termites, divided into functional groups.

- Monitoring of earthworm cast activity (twice per week March -December) and quantitative sampling of earthworms at conclusion of experiment using formol expulsion.
- Development of allometric equations to estimate accurately the carbon and nutrient stocks in newly established cacao plantations.

13.4.2.6 Assessment of effects of current farmer management upon yields and short-term nutrient and carbon fluxes

L. Norgrove

The major biophysical constraint identified by cocoa farmers in most of West Africa is blackpod and copper-based and metalxyl based fungicide is the most common external input used in cacao farms. The effects of these fungicides on nutrient and carbon cycling and plant biodiversity are unknown. The effects of fungicide application, and spraying frequency upon *Phytopthora* spp. damage, cacao yield and sustainability criteria (plant biodiversity, litter decomposition, soil respiration) will be assessed in farmers' cacao farms.

The outputs from this activity will include recommendations on optimum spraying regime from a disease control, yield, and ecological perspective and the fine-tuning of sustainability standards with respect to agrochemical use.

13.4.2.7 To what extent can cacao plantations perform those landscape level functions attributed to areas of secondary forest? An evaluation of the role of cacao in the landscape.

L. Norgrove

In southern Cameroon, the landscape is a mosaic of patches of primary and secondary forest, fallow of differing ages, cocoa plantations, and crop land. Different kinds of forest edges have developed, influencing vegetation structure and composition on both sides of the edges. Cocoa plantations are one of the most stable features in this landscape. Forest and fallow proximity can both influence the natural regeneration of cropped land and affect the species composition of the forest and fallow itself. Furthermore, no information is available on how cocoa plantations affect forest, cropped fields and fallows along their edges and thus, if cacao plantations perform similar functions as forests in terms of the supply of seed and facilitation of plant establishment. Therefore vegetation structure, composition and plant species diversity change along the forest – field and cacao – field interior-edge-exterior transect will be determined.

13.4.3 Appropriate germplasm for InPAC systems tested and selected

13.4.3.1 Response of cacao varieties to shading and fertilizer application when planted in degraded fallows.

S. Hauser, J. Gockowski, S. Nyasse[1]*, B. Eskes*[2]

[1]*IRAD;* [2]*IPGRI*

Farmers have traditionally established cacao agroforests in forest land where soil properties are expected to be optimal for establishment and early growth of cacao. However, not only soil fertility aspects lead to a dominance of the shaded cacao agroforest system but additional benefits such as a reduced infestation and severity of pests and diseases. However, shaded cacao systems are more susceptible to cacao black pod disease (*Phytophtora megakarya*) because of the higher humidity under shade. Thus the future of shaded cacao systems with their significant environmental benefits, depends on cost efficient control measures for black pod disease. Currently, farmers' most efficient control option is the frequent application of fungicides. Input prices have increased over the last five years. Agronomic and sanitation efforts are labour demanding and not sufficiently efficient. Thus screening for varietal differences in resistance to *Phytophtora megakarya* is a research imperative. Farmers in the more densely populated areas of rural Cameroon no longer have access to forest land to create new plantations. Therefore this experiment combines the testing of different varieties with two strategies to establish cacao in degraded fallow land with different fertilizer regimes (in varieties planted at a sufficient number).

The research objectives are to:

1. Test cocoa blackpod disease resistance (*Phytophtora* spp.) of six cacao varieties under two shade regimes
2. Participatory assessment of two options for establishing complex cacao agroforests in degraded short fallow land.
3. Assess the ability of the natural regrowth and two *Musa* spp. types to provide shade to the young cacao.
4. Determine the effect of two fertilizer rates and sources on growth of cacao.

The trial was set up with 7 farmers (= 7 replicates) in Nkilzok, near Yaounde, southern Cameroon, in 1998. Average annual precipitation is 1513 mm with a bimodal distribution. Rains start in mid-March. A short dry season follows from mid-July until the end of August. The main rainy season is from September to the middle of November.

The design is an incomplete three factorial design with two shade treatment levels, six varieties and up to four fertilizer levels. Six different varieties, including four clones from Cote d'Ivoire, one IRAD SNK variety and the local material from farmers' plantations are tested at two shading regimes.

The shade treatment was natural regrowth versus a mix of plantain and cooking banana. Each farmer provided two adjacent plots of 15 x 55 m and a total of 84 plantain suckers. Two cacao establishment systems, one using the fallow regrowth to shade, the other planting plantain (cv. Essong, medium French) and cooking banana (cv.

Fougamou) to shade, were implemented. Each farmer slashed one of the two plots at ground level in August 1998. Six rows of 21 plantains (PL) or cooking bananas (CB), arranged as follows: PL, CB, PL, PL, CB, PL, were planted on 28 September 1998. Planting distance was 2.5 m within and between rows. All suckers were pared before planting to reduce the risk of nematode and banana weevil (*Cosmopolites sordidus*). Neither fertilizer nor insecticides were used on the *Musa* components. Details on the growth and yield performance of plantain versus cooking banana are reported in the annual report of project 2.

The cacao plants were transferred from a nursery to the field in May 2000 and planted into 20 x 20 x 20 cm holes placed in the center between plantains or cooking bananas and with the same inter and intrarow distance of 2.5 m in the natural regrowth. The natural regrowth was partially slashed, forming alleys.

The fertilizer treatment was incomplete because there was not enough seed of all varieties. The IRAD SNK variety received fertilizer in a two factorial design with the first factor N added at two levels, nil versus 60 kg/ha and the second factor P, K, Ca, and Mg added at two levels, nil versus 30, 90, 500 and 100 kg/ha of P, K, Ca, and Mg, respectively. The local variety was only fertilized at nil N plus nil P, K, Ca, and Mg versus 60 kg/ha N plus 30, 90, 500 and 100 kg/ha of P, K, Ca, and Mg. The clones received 60 N plus 30, 90, 500 and 100 kg/ha of P, K, Ca, and Mg. The fertilizer rate was split into two dressings, with the first dressing applied in October 2000.

Soil chemical properties were different between farmers' fields. These differences were however not consistent across all nutrients. The plots were separated into four subplots within which soil samples were taken to obtain data on spatial variability. In some cases there were strong significant gradients along the plot in nutrient concentrations. Soil properties will be used later as covariates in data analyses.

Survival of the first dry season was generally low. Across sites and shade regimes, 30.2 % of the cacao plants died. Neither the shade regime nor the variety had a significant effect. However, site or farmer had a highly significant effect and interacted significantly with both, shade regime and variety. Thus in some farmers' fields *Musa* shaded cacao had a higher survival rate while in others the survival rate was significantly lower under *Musa* shaded conditions. It appeared that the level of weeding had an effect on survival: clean weeding reduced survival.

In mid September 2000 a cacao growth evaluation was conducted in which the diameter and the height of the cacao was measured and the formation of the jorquet as well as the survival of the terminal bud was established. Fertilizer had not been applied at that time and was thus not considered. The plant diameter was unaffected by the shading regime. Plants in the bush alleys were taller (77.2 cm) than under shade provided by *Musa* (71.3 cm). The formation of the jorquet was unaffected by the shade regime, however 58.3% of terminal buds were still alive in the bush alleys compared to 49.1% (P = 0.0135) under *Musa* shade.

The varietal differences were more pronounced than differences caused by the shade regime. The clones had larger diameters (15.8 mm) than local (10.7 mm) and SNK material (12.3 mm) and SNK material had larger diameters than local material.

Differences in height were similar, yet were less pronounced. The clones 1 and 3 had significantly taller plants than all other varieties. In clones 3 and 4 a larger proportion of plants had formed a jorquet.

Amongst the clones, it appears that clone 2 is the weakest, with little differentiation between clones 1, 3 and 4. The local material underperformed in all aspects, with SNK material being only slightly better than the local material.

Site differences were highly significant in all parameters. However, it appears that there were four sites of similar performance, two of intermediate performance and in one site cacao plants were significantly larger and further developed, yet had lost more terminal buds than in all other sites. A site * shade regime interaction was found, which was manifested in the cacao being less large and less developed in *Musa* shaded plots than in the bush alleys versus sites where no differences were found.

It has to be assumed that some farmers paid more attention to weeding in the *Musa* shaded plots to ensure good plantain and banana production, thereby affecting cacao performance. There were no shade regime * variety interactions and site * variety interactions were very weak.

13.4.4 Recommendations leading to improved policies and strengthened institutional/organizational arrangements for supporting establishment of InPAC systems by asset-poor farmers.

13.4.4.1 Establishment cost analysis of cocoa agroforest systems

J. Gockowski

The conversion of degraded lands to productive cocoa agroforests is likely to entail establishment costs exceeding those of establishing cocoa on forested lands. The calculation of those costs is important for designing policy instruments such as planting subsidies which can compensate farmers for those costs. Such subsidies may be justified by the failure of market institutions to capture the value of environmental services generated by agroforests (carbon sequestration, biodiversity conservation and watershed functions). This market failure results in an under allocation by society of resources to this land use type. Furthermore, as new market institutions such as carbon emissions market evolve the costs of sequestering carbon through reforestation of degraded lands will have to be compared with other means of climate mitigation.

The costs of the various elements of the cocoa agroforestry establishment trial described in section 13.8.2.1 above are estimated. Tables 1 and 2 present detailed estimates of year 1 and 2 costs for the *Inga edulis* shade treatment. Tables 3 and 4 provide summaries of labor, variable, and fixed costs by shade and fertilizer treatments, while Table 5 gives the estimated total costs of all treatment combinations for the first two years. The lowest cost treatment to date is the planting of cocoa and permanent shade trees into cleared alleys in the *Chromolaena* thickets with no fertilizer (the equivalent of USD $508 per ha), while the most expensive was the plantain shade treatment with full fertilizer (USD $1,759 per ha). This large cost differential is largely due to the high cost of imported lime in Cameroon (USD $594 per tonne). If there are significant effects of calcium and liming on the productivity of the system, then the high cost of lime will become a potential constraint to adoption. Alternative cheaper sources of calcium, that could then be investigated, include wood ash generated by the estimated 15 million tonnes of fuelwood consumed annually in Cameroon.

Table 1. Year one establishment costs of degraded land for cocoa agroforest with *Inga edulis* as temporary shade provider (F cfa per ha).

Item	Unit	Quantity	Useful life	Deprec.	Unit cost	Total Cost
Nursery (I. edulis—1547 trees, D. edulis—71 trees)						
Nursery site clearing	Day	0.3			1,250	404
Construction of nursery	day	4.6			1,250	5,709
Filling of nursery bags	day	7.1			1,250	8,879
Seeding	day	1			1,250	1,250
Watering	day	17.4			1,250	21,801
Soil mounding	day	2.1			1,250	2,577
Pest management	day	0.3			1,250	383
Field operations						
Field clearing (Feb.)	day	9.7			1,250	12,076
Staking	day	11.1			1,250	13,909
Dig planting holes	day	15.4			1,250	19,229
Transport I. edulis, D. edulis, and P. americanus	day	3.9			1,250	4,894
Transport 163 kg of chicken manure	day	0.3			1,250	336
Transplanting of I. edulis, D.edulis, and P. americanus	day	6.1			1,250	7,666
Spreading of manure	day	0.3			1,250	313
Field pest management	day	1.4			1,250	1,803
Weeding	day	3			1,250	3,750
Labour cost subtotal		84				104,979
Poly bags for I. edulis, and D. edulis	bag	1618			9	14,562
Grafted Persea americanus	plant	98			1,200	117,600
Insecticides (Décis 25)	liter	0.4			13,000	5200
Fungicide (Cocide 101)	packet	8			275	2,200
Variable input cost subtotal						139,562
Wheelbarrow	ea	1	3	5,000	15,000	5,000
Cutlass	ea	1	2	1,250	2,500	1,250
File	ea	1	1	1,800	1,800	1,800
Knapsack sprayer	ea	1	3	11,667	35,000	11,667
Planting dibble	ea	1	3	1,167	3,500	1,167
Watering can	ea	2	2	750	1,500	1,500
Interest on fixed costs (18% per annum)	18%					3,570
Fixed cost subtotal						25,953
Total cost						270,494

$1 USD= 740 F cfa

Table 2. Year two establishment costs per hectare of degraded land for cocoa agroforest with *Inga edulis* as temporary shade provider at four fertilizer levels.

Item	Unit	Quantity used	Useful life	Depreciation	Unit cost	Cost
Nursery site clearing	day	0.4			1,250	495
Construction of nursery with shade	day	5.6			1,250	6,992
Filling of seedling poly bags	day	8.7			1,250	10,875
Seeding	day	8.0			1,250	9,961
Watering	day	21.4			1,250	26,701
Soil mounding	day	2.5			1,250	3,156
Pest management	day	0.4			1,250	469
Field practices						
Dig planting holes (1671 holes)	day	17.7			1,250	22,155
Transport cocoa and fruit trees (1600 and 136 trees)	day	4.4			1,250	5,554
Plant cocoa, R. .heudelotii and replacement fruit trees	day	13.7			1,250	17,116
Pesticide applications	day	6.1			1,250	7,582
Transport fert. T0 (no fertilizer control)	day	0.0			1,250	0
Transport fert. T1 (65kg of urea)	day	0.2			1,250	224
Transport fert. T2 (625 kg dolom.,1400 kg lime, 75 kg TSP, 90 kg KCl)	day	2.0			1,250	2,520
Transport fert. T3 =T1 +T2 (urea + cations)	day	2.2			1,250	2,743
Fert. Application—T0 (no fertilizer control)	day	0.0			1,250	0
Fert. Application—T1 (urea)	day	1.1			1,250	1,362
Fert. Application—T2 (dolomite, lime, TSP, KCl)	day	2.3			1,250	2,820
Fert. Application—T3 (urea + cations)	day	2.5			1,250	3,125
Weeding (2x)	day	14.0			1,250	17,500
Labor cost subtotal (no fertilizer application)						103,791
Poly bags for seedlings	bag	1853.0			9	16,677
Cocoa seeds for nursery	ea	1760.0			0.5	880
Avocado grafted seedlings for replacement	ea	49.0			1,200	58,800
Insecticide Thiodan 35EC	Litres	1.2			13,000	15,000
Fungicides (copper, manganese)	50 g	19.2			275	5,288
Herbicide (Roundup)	Litres	1.2			13,000	15,000
Fertilizer-- T0 (no fert. Control)	Kg	0.0				0
Fertilizer—T1 (urea)	Kg	65.0			180	11,700
Fertilizer-- T2 (dolomite, lime, TSP, KCl)	Kg	2190.0			341	746,824
Fertilizer-- T3 (urea + cations)	Kg	2255.0			336	758,524
Variable input cost subtotal (no fertilizer control)						111,645
Wheelbarrow	ea	1	3	5,000	15,000	5,000
Cutlass	ea	1	2	1,250	2,500	1,250
File	ea	1	1	1,800	1,800	1,800
Knapsack sprayer	ea	1	3	11,667	35,000	11,667
Planting dibble	ea	1	3	1,167	3,500	1,167
Watering can	ea	2	2	750	1,500	1,500
Interest on fixed costs (18% per annum)	18%	19833				3,570
Fixed cost subtotal						25,953
Total cost (T0: no fertilizer applied)						241,389
Total cost T1						262,034
Total cost T2						991,033
Total cost T3						1,003,038

$1 USD= 740 F cfa

Table 3. Partial establishment costs for year 1 and 2 of four temporary shade treatments, no fertilizer application (F cfa per ha).

	Shade treatments			
	Inga edulis	Cooking banana	Plantain	Bush control
Labor costs	208,770	204,440	206,857	152,348
Variable costs	251,207	278,189	278,189	171,980
Fixed costs	51,906	51,906	51,906	51,906
Total costs	511,883	534,535	536,953	376,234

$1 USD= 740 F cfa

Table 4. Additional costs of fertilizer treatments (F cfa per ha)

	Fertilizer treatments			
	No fertilizer	Nitrogen	Cations	Cations plus Nitrogen
Labor costs	0	1,586	5,340	5,868
Variable costs	0	11,700	746,824	758,524
Fixed costs	0	0	0	0
Total costs	0	13,286	752,163	764,392

$1 USD= 740 F cfa

Table 5. Total costs of establishment for year 1 and 2, all treatment combinations (F cfa per ha).

	No fertilizer	Nitrogen	Cations	Cations plus Nitrogen
Inga	511,883	525,169	1,264,046	1,276,275
Cooking banana	534,535	547,821	1,286,698	1,298,927
Plantain	536,953	550,239	1,289,116	1,301,345
Bush	376,234	389,520	1,128,397	1,140,626

$1 USD= 740 F cfa

New activity for 2001

13.4.4.2 Pilot development of a cocoa production and marketing information system in Cameroon.

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In today's globally interdependent food economy, consumers are demanding more information on the methods and means used in the production of what they consume. These concerns have grown with recent events such as outbreaks of bovine spongiform encalopathy (BSE) disease and dioxin contamination of animal feeds in Europe. At the same time smallholder producers need better information for managing their production and marketing systems and in matching production with the demands of the market.

Project 13 of IITA in partnership with the Sustainable Tree Crops Program and the Earth Resource Observation System (EROS) of the United States Geological Survey is developing a tree crop quality information system with the *Confederation des Organisations Rurales pour un Cameroun Economique* (FORCE) an umbrella organization of farmer groups in southern Cameroon. The information system will monitor in an open and transparent manner the production practices of cocoa producers and the various quality attributes of their product destined for export.

The goal of this pilot activity is to improve the ability of Cameroon's smallholder producers to compete in increasingly competitive global markets. The activity intends to develop with individual entrepreneurs (i.e. farmers) and their associated marketing organizations a system of data collection and record keeping on their production methods. Included among the expected producer benefits of this activity are:

- Information essential for developing business plans at the farm level,
- Information needed for developing appropriate extension methods within local farmer organizations such as farmer field schools and integrated pest management, and
- A means of collateral for production credit from financial institutions.
- Improvements in the quality of the cocoa through best management practices and
- Tangible rewards for quality.

The data from individual producers will be aggregated at the level of village groups typically comprised of 10 to 50 producers and posted on the World Wide Web using Internet Map Server Technology. In addition to its management value to farmers and their organizations, the information will inform the consuming public concerned over issues such as exploitative child labor and destruction of biodiversity in the tropical regions of West Africa. The spread of this information is expected to generate greater demand and public awareness for the majority of Cameroon producers who do not exploit labor, and who, by maintaining a shade canopy of diverse forest species, manage one of the most biologically diverse land use systems in Africa.

The activity is most importantly expected to reward producers for the production of quality cocoa by better linking producers with the consumers of their product. Cameroon cocoa prior to liberalization in the early 1990s received premiums in the bulk processing market because of its high fat content and the reddish colour of the cocoa powder derived from its beans. Since liberalization, due to a multitude of reasons, these premiums are no longer paid and instead Cameroon origins are now discounted. Recapturing these quality premiums for the small producer is one of the immediate objectives of this activity.

As a pilot effort, the operation is initially working with 20 village-based farmer organizations operating under the FORCE umbrella. Each organization has selected democratically a village-based extension representative from their respective village groups who will be trained as village extension agents with an emphasis on business management. These agents will collect in conjunction with farmers data on production and post harvest methods including:

- Sources of labor used,
- Type, levels and application methods of pesticides,
- Biological and mechanical pest and disease control,
- Means of fermentation, drying and storage

as well as the ecological characteristics of the cocoa plantation such as:

- Extent of shade coverage,
- Size and location of cocoa agroforest
- Type and amount of forest biodiversity maintained,
- Slope, etc.

These data will be maintained at multiple levels, beginning most importantly with the farmer's own record keeping. There will also be aggregated databases maintained at the various levels between the farmer and FORCE. These include the farmer's common initiative group CIG, which is the grassroot village organization, the unions and federations, which encompass several or more CIGs, and at the highest level, FORCE. The data will be incorporated into a GIS structure and posted on the web allowing potential customers access to this information. The initial production target is to document the production attributes of approximately 300 to 500 tonnes of Cameroon cocoa (representing less than 0.5% of total national production). Once cocoa of certifiable quality and attribute is bulked and stored in the village organizations, buyers will be solicited for competitive bids on this "full information" cocoa.

The system is designed to trace the product back to its production origins and in doing so recapture the premium for the unique attributes of Cameroon's cocoa. This will depend on maintaining its identity through the marketing and processing chain to the final end user demand (bakeries and consuming households in the case of red powder).

With the liberalization of export crop marketing, the government of Cameroon also liberalized the laws of association giving farmers more freedom to take their affairs into their own hands. A quality information system can potentially infuse farmer organizations with countervailing power in world markets. At the same time, the implementation process is likely to be a dynamic learning experience, which can help nascent farmer organizations develop the entrepreneurial capacity needed to compete in today's global economy. FORCE is hoping to see the development of a new farmer-owned market exchange where the various product attributes of Cameroon cocoa would be transparently shared in the open market and valued accordingly. The development of such a structure would be a step towards the type of sustainable market institution so needed for achieving lasting social progress in Africa.

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