INTERNATIONAL TROPICAL TIMBER ORGANIZATION

ITTO

PROJECT PROPOSAL

TITLE	TOWARDS SUSTAINABLE INDIGENOUS MAHOGANY TIMBER PRODUCTION IN GHANA: PHASE II, REFINING THE SILVICULTURAL "TOOL KIT" AND PRACTICAL TRAINING FOR INDUSTRIAL-FORESTERS AND COMMUNITY FARMERS
SERIAL NUMBER	PD 528/08 Rev.1 (F)
COMMITTEE	REFORESTATION AND FOREST MANAGEMENT
SUBMITTED BY	GOVERNMENT OF GHANA
ORIGINAL LANGUAGE	ENGLISH

SUMMARY

Mahogany (Meliaceae: Swietenidae) is a valuable tropical timber, but continued supply is threatened by overexploitation of natural forest reserves and the prevention of successful plantation culture by a single pest species, the shoot boring moth *Hypsipyla robusta*, that devastates young stands by killing main stems, causing excessive forking and branching, and, in worst cases, contributing to mortality. This project will demonstrate an integrated management strategy for plantation establishment incorporating a number of pest management measures based on sound experimental evaluation. This second phase will refine the silvicultural "tool kit" to optimized planting in mixed stands with an aim to reducing economic losses from *Hypsipyla*, and will promote the establishment of additional industry and community plantations through the development of a "How to" cultivate indigenous mahogany practical handbook and a series of field workshops for industry foresters and community farmers. Also comparable information on wood quality and lumber characteristics of plantation-grown mahogany and natural forest mahogany will be made available.

EXECUTING AGENCY	Forestry Research Institute of Ghana (FORIG)
COLLABORATING AGENCIES	Michigan Technological University, USA SAMARTEX Timber and Plywood Company Ltd, Ghana
DURATION	48 MONTHS
APPROXIMATE STARTING DATE	TO BE DETERMINED

BUDGET AND PROPOSED SOURCES OF FINANCE

Source	Contribution in US$	Local Currency Equivalent
ITTO	**465,264**	
Government of Ghana	147,150	(In kind)
Michigan Technological University	101,500	
SAMARTEX	61,200	(In kind)
TOTAL	**775,114**	

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List of Acronyms

AAC	-	Annual Allowable Cut
ACIAR	-	Australian Centre for International Agricultural Research
AfDB	-	African Development Bank
CATIE	-	Centro Agronomico Tropical de Investigacion
CD	-	Compact Disk
CDM	-	Clean Development Mechanism
CIDA	-	Canadian International Development Agency
CITIES	-	Convention of International Trade in Endangered Species
CRM	-	Collaborative Resource Management
DANIDA	-	Danish International Development Agency
DFID	-	British Department for International Development
FAO	-	Food and Agriculture Organization
FAWAG	-	Furniture and Wood Workers Association of Ghana
FORIG	-	Forestry Research Institute of Ghana
FRIN	-	Forestry Research Institute of Nigeria
FRMP	-	Forest Resource Management Program
FROGGIE	-	Forest Reserves of Ghana Graphical Image Exhibitor
GEF	-	Global Environment Fund
GHAFOSIM	-	Ghana Forest Simulation Model
GTA	-	Ghana Timber Association
GTMO	-	Ghana Timber Miller Organization
GTZ	-	German Agency for Technical Cooperation
IIBC	-	Institute of Biological Control
IRNR	-	Institute of Renewable Natural Resources
ISSER	-	Institute of Statistical, Social and Economic Research
ITE	-	Institute of Terrestrial Ecology
ITTA	-	International Tropical Timber Agreement
ITTO	-	International Tropical Timber Organization
IUCN	-	International Union for Conservation of Nature
IUFRO	-	International Union of Forest Research Organizations
JICA	-	Japan International Co-operation Agency
KNUST	-	Kwame Nkrumah University of Science and Technology
MTU	-	Michigan Technological University
NGOs	-	Non-Governmental Organizations
NRMP	-	Natural Resource Management Program
NTFP	-	Non-Timber Forest Products
OCAP	-	Oda-Kotoamso Aforestation Project
PROTA	-	Plant Resources of Tropical Africa
PRSP	-	Poverty Reduction Strategy Paper
SFIT	-	Swiss Federal Institute of Technology
SODEFOR	-	Société de Développement des Forêts
TSS	-	Tropical Shelterwood System
UK	-	United Kingdom
UN	-	United Nations
USA	-	United States of America
USDA	-	United States Department of Agriculture
UV	-	Ultraviolet

Origin

Mahogany (Meliaceae: Swietenidae) is a valuable tropical timber, but continued supply is threatened by overexploitation of natural forests and reserves. Further complicating the supply problem is a major insect pest problem, the ubiquitous shoot boring moth, *Hypsipyla robusta* that continues to devastate young stands and plantations of mahogany by killing main stems, causing excessive forking and branching, and in worst cases, contributing to mortality. The recent ITTO project PD105/01 Rev.3 (F) Phase I, executed by FORIG have recorded significant outputs to support the development of tools towards sustainability of the native mahoganies via plantation culture. In the Phase I of this project, our team has proven that:

1. Plantation establishment of indigenous species is possible;
2. Genetic diversity is sufficient in all indigenous mahogany species tested, to allow for selection of superior provenances, families and clones;
3. Industry and community stakeholders are interested in and capable of establishing indigenous mahogany plantations.
4. vegetative propagation technology can be used to clone superior mahogany genotypes

To date, we have established some 32ha of indigenous mahogany plantations over 4 ecological zones in the southern half of Ghana. In addition, our industrial partners have established some 20 ha of commercial plantations with a high percentage of indigenous mahogany. *Hypsipyla* attacks continue to extract a large economic loss on these plantations. In this second phase of our project, we will refine the silvicultural "tool kit" to optimized planting in mixed stands with an aim to reducing economic losses from *Hypsipyla* and we will promote the establishment of additional industry and community plantations through the development of a "How to" cultivate indigenous mahogany practical handbook and a series of field workshops for industry foresters and farmers. Also critical to sustainability of interest in growing mahogany in plantations by the industry is getting comparable information on wood quality and lumber characteristics of plantation-grown mahogany and natural forest mahogany which the project seeks to address.

2. Ghana Sectorial Policies

The objectives of this project are in conformity with the overall goal of Ghana's Forest and Wildlife Policy of 1994 which all the forest management related legislation, strategies, programmes and projects in Ghana should support. This is to "conserve and sustainably" develop the nation's forest and wildlife resources while maintaining environmental quality and perpetual flow of benefits to all segments of society". The Forestry Department Master Program (1996-2020) and the Poverty Reduction Strategy Paper (PRSP) of Ghana emphasize the importance of Collaborative Resource Management (CRM). In 2001 the Forestry Commission of Ghana developed a CRM policy and strategy with this goal; "Working partnership between different stakeholders which enhances the management and development of forest and wildlife resources and leads to equitable distribution of benefits".

Specifically, the priority objectives of the Forest and Wildlife Policy include:

- Manage and enhance Ghana's permanent forest estate for conservation of biological diversity and sustainable production of domestic and commercial produce.

- Promote research-based and technology-led forestry and wildlife management, utilization and development to ensure resource availability, socio-economic growth and environmental stability.
- Promote public awareness and active involvement of rural people in forestry and wildlife conservation so as to maintain life-sustaining systems, preserve scenic areas, enhance the potential for recreation, tourism and wealth creation opportunities.
- Promote the development of viable and efficient forest-based industries, particularly in secondary and tertiary processing, so as to fully utilize timber and other non-timber forest products (NTFP) including health and wildlife resources that satisfy domestic, local, national and international demand at competitive prices.

Strategies outlined in the Forestry and Wildlife Policy, CRM, PRSP and supported by the proposed project are:

- Protect, rehabilitate and sustainably manage the national land, forest and wildlife resources through collaborative management and aimed at increasing the incomes of rural communities who own these resources.
- Enhance community involvement in the management of forest and wildlife resources and savannah woodland resources and improve the benefit flows to communities from resource sales.
- Increase community and farmer adaptation of improve land and water management techniques.

2.1 Ghana's Sectorial Policies on Plantation Establishment

The goal of Ghana's plantation establishment initiative is to develop 200,000 ha of plantations that are financially, environmentally and socially sustainable by creating an enabling environment primarily for the private sector to engage and operate effectively in Best Practice plantation forestry, both industrial and non industrial. The policy recognized a distinction between industrial and nonindustrial plantations as they have different expectations, inputs, and requirements.

2.2 Ghana's Key Policy Principles for Plantations

200,000 ha is a realizable target of forest plantations on suitable lands which are required for the economic development of Ghana because:

- It will satisfy the projected future demand for timber;
- It will rehabilitate unproductive lands;
- It will provide additional livelihood options for rural people and private sector;
- It will reduce pressure on natural forests;
- Plantations are one suitable land use for degraded forest reserves;
- The private sector is the principal sources of investment and engine of growth for plantation development;
- The government should act principally as a facilitator to the process by providing an enabling environment and appropriate support mechanisms and incentives;
- Forest plantation development must be environmentally and socially acceptable;
- Government forestry institutions should be reformed to make them accountable and cost effective;
- Existing industrial beneficiaries of natural forests should be obliged to reinvest in plantations to restore degraded forest reserves.

2.4 Ghana's Land and Tree Tenure

(i) Forest Reserves – The traditional stools own the land but have nothing to do with its management. The stools only have a share of the benefits that the government accrues

from forest resources. The management is vested in government in trust for the land owners (stools). The law provides for the grant of lease to communities and commercial investors to encourage them to establish plantations in degraded forest reserves. The 2008 approved benefit sharing for commercial forest plantation development has a clearly defined tree ownership right for afforestation and reforestation in Ghana. Any body including communities that invest into commercial plantations on degraded forest lands, the benefits from the resources will be shared with this formula; Investor gets 90%, landowner (stool) 6%, Forestry Commission 2%, and Local community 2%. Here the investor manages the plantation until harvesting of the trees.

In the case of the improved Taungya plantation system, the government provide the seedlings for farmers to inter plant with their food crops in degraded forest reserve the benefit sharing is according to this formula; Farmer 40%, Government 40%, Landowner 15%, and local community 2%. Here the forestry commission manages the plantation after the farmers has collected his food crops.

(ii) Outside forest reserves (private land) – Tree planting and forest resource development is protected by legislation that allows planted trees to be owned by those who plant them after investors have negotiated with landowners for their own benefit sharing schemes (e.g. the OCAP Agreement See appendix). Investors are required to register the land and get a title of deed to secure their investment on the land.

Off-reserve land (private/outside reserve land) available for plantations are subjected to market forces of supply and demand, based on the relative profitability of alternative land uses and land owners' preferences. The policy recognizes that grants, subsidies and incentives may encourage land owners to start plantations thereby reducing access to land for tenant farmers. In the short term this is unlikely to be an issue. Investors who want to acquire private land for forestry plantations have to establish a legal tenure with the landowners. The investor will then own the trees planted on the land. The investor can sell or use its produce for profit making as any other cash crop grown in Ghana *e.g.*, cocoa, oil palm, etc.

3. Program and Operational Activities

Complementary measures and programs supported by legislative enactments to achieve the goals and objectives of the forest policies of Ghana include the following:

- Ensuring an equitable distribution of natural resource benefits to communities, resource owners, and farmers as a way of facilitating effective participation of all relevant stakeholders in the sustainable management and development of resources;
- Transparently and efficiently allocating timber resources through competitive bidding and controls against over-exploitation of timber;
- Appropriate pricing timber and other forest-based products to increase revenue, and thus address the problem of under-pricing of forest resources;
- Reviewing annual allowable cut (AAC) as a transitional measure to salvage valuable timber being destroyed in off-reserve timber utilization contract areas;
- Mobilizing chainsaw operators into alternative productive ventures, and the control of illegal chainsaw logging and lumbering operations;
- Rationalizing the timber industry and adopting fiscal, as well as market-based, incentives that improve the efficiency of the industry while at the same time encouraging down-stream processing of wood products;
- Developing an extensive forest plantation program so as to bridge the wood deficit in the timber industry while improving environmental quality; and
- Improving incentives with respect to the co-management of forest resources so as to ensure sustainability.

In this regard, there have been many programs to achieve this broad aim. Some of the programs include Forest Resources Management Program (FRMP) supported by The World Bank, the British Department for International Development (DFID), and Denmark's

DANIDA. Currently, the above Institutions and the African Development Bank are supporting the Natural Resources Management Program (NRMP) and the National Plantation Development Project, respectively. Other major projects contributing to sustainable forest management in Ghana include

(i) The community Forest Management Project funded by the African Development Bank (AfDB)

(ii) The High Forest Biodiversity Conservation Project - funded GEF and the World Bank

(iii) The participatory Forest Management in the Transition Zone Project – supported by JICA of Japan

(iv)Wildfire Management Project and Wildlife Division Support Project being funded by the Royal Netherlands Government

(V) The Northern Savannah Biodiversity Project funded by GEF and the World Bank

(vi) The Land Administration Project funded being funded by the World Bank, FAO GTZ, DFID, KFW, CIDA etc

4. ITTO-Supported Projects in Ghana

Previous ITTO assisted projects in Ghana and lessons learnt from those implemented by FORIG:

Project PD 3/95 Rev.2 (F) "**Conservation and provenance plantings and integrated pest management to sustain Iroko production in West Africa (Ghana, Cote d'Ivoire, Cameroon)**" achieved the objectives set with a couple of outstanding results, including the following:

- pattern of occurrence of Iroko in the` natural forest of Ghana and its relationship to the pest *Phytolyma lata* is documented;
- the establishment of 1.5 hectares of conservation plot with species from various origin (Cote d'Ivoire, Liberia, Cameroon, Kenya and Siera Leone);
- the creation of arboretum for the selection of adapted, provenances and pest-resistant genotypes;
- the establishment of a fully equipped nursery for cutting production, including irrigation facility (water pump and water storage tank), seedling production area and a rooting cutting production greenhouse;
- the establishment of 1-hectare clone bank of made up of 40 clones;
- the matching of Iroko planting material to the 3 major ecological regions in Ghana 1-hectare plot in each region;
- the planting of 3-hectare Iroko mixed with other plantation species and inter cropped with food crops;
- The training of 4 graduate students on the project using the project studies for their dissertation.

A number of lessons were learnt from this project, such as;

- The Executing Agency responsible for coordinating the project should preferably be in charge of the budget and finances to ensure the proper monitoring not only of expenditure and investments but also of research work progress.
- Partners should ensure that they stay regularly informed through modern means of communication
- Planning should ensure that all the partners are completely aware of their responsibilities and commitments before or at the start of the project
- Project must clearly identify and define the actors involve
- Project management and steering teams should remain as far as possible for the whole duration of the project

- A balance should be found between research and development in order to motivate and interest potential project beneficiaries (including a mid-term review in the case of a lengthy project)

Project PD 105/01 Rev.3 (F) **"Towards sustainable timber production in Ghana: Stage 1. Improving shoot borer resistance and developing silvicultural systems to maximize mahogany plantation success".** The goal of this project is to improve the sustainability of mahogany timber supply in Ghana by developing an integrated pest management system to minimize the adverse effects of mahogany shoot borer on young mahogany plantations. The project is to examining methods of improving Mahogany plantation successes by enhancing shoot borer resistance/tolerance, cloning superior planting material, developing silvicultural systems that minimize shoot borer attack, examining semiochemical aspects of shoot borer attack, properties of plantation mahogany and economics of integrated mahogany plantation. The project which is in its final year in the first phase of implementation is being executed in collaboration with 3 timber companies and community tree growers. The project has been very successful in achieving its objectives and preliminary results are being tried by stakeholders across the high forest zone of Ghana.

Project PD 256/03 (F) **"Alternative mixed plantation systems and restoration strategies for conservation and sustainable production of native timber species in Ghana".** The goal of this project is to identify prospects of mixed-species planting as alternative more sustainable plantation strategy to support the development of indigenous species plantations in Ghana. The project objectives include;

- to minimize pest damage to high value indigenous timber species and enhance their success in plantations using mixed-species planting approach;
- to demonstrate the ecological advantages of indigenous mixed-species plantations over exotic monoculture plantations
- to promote the establishment of indigenous mixed-species plantations as viable alternative forest plantation enterprise.

This project is currently in its 4th and final year of implementation with impressive preliminary results and likely to achieve all objectives..

Project PD30/97 Rev.6 (F). **Rehabilitation of degraded forests through collaboration with local communities.** The goal of this study was to arrest the decline and degradation of tropical forests in Ghana. The project achievements included training in nursery seedling production and management in 13 local communities- 4 each from Begoro, Dormaa, Ofinso and one community from the Asankragwa forest district. The communities were involved in rehabilitation of degraded forest through plantations of over 50 hectares. The project also contributed to poverty alleviation in the local communities by equipping project participants with the capacity to produce seedlings and sell to NGOs and agencies involve in plantations and tree planting for environmental sustainability.

Project PD04/98 Rev. 1(F). **Silviculture and economics of improved and natural forest management in Ghana.** This projected aimed at improving natural forest management by developing efficient and cost effective selective logging and management practices in Ghana. A methodology has been developed to estimate the NTFP resources in selected forest reserves, and a yield regulation procedure in the form of a manual has been prepared. The manual has been used to train communities on the sustainable methods for harvesting various NTFPs. One FORIG staff was trained at the level of PhD in the best logging practices under this project.

PD 32/98 Rev. 1(F) **Forest fire management in Ghana**. The project largely achieved the specific objective through awareness creation programmes, adequate training offered to fire volunteers squads which increased their response rate to fires, establishment of networking among all the stakeholders, early detection and communication of fires. These measures have contributed to reduction in incidence of forest fires which is helping in reducing the extent of forest depletion. The success of the project could be attributed to its very strong collaborative

nature, involving research institutions, implementation institutions, and the forest dependent communities.

ITTO has` also supported the following projects in Ghana;

1. Man-made forest of indigenous species - A systematic preparation of industrial tree plantations;
2. Better utilization of tropical timber resources in order to improve sustainability and reduce ecological impacts;
3. Industrial utilization and improved marketing of some lesser used species from a sustainable managed forest;
4. Handbook on tree and wood identification of 100 lesser used and lesser known species from tropical Africa with notes on ethnography, silviculture and uses;
5. Fire-management and post-fire restoration with local community collaboration in Ghana;
6. Investment promotion and enterprise development of the timber industry in Ghana; and
7. Development of energy alternatives for the efficient utilization of wood processing residue: Cogeneration and briquette production.

PART II. THE PROJECT

1. PROJECT OBJECTIVE

1.1 Development Objective

The Development Objective is to **"Improve the sustainability of indigenous mahogany in Ghana by developing superior mahoganies that are ecologically adapted and insect tolerant and expand our collaboration with industrial and community tree farmers".** This will allow rehabilitation of previously degraded and unsustainably logged forests with indigenous mahogany species to restore ecological integrity of the upper Guinean forest of Ghana and enable sustainable timber production.

1.2 Specific Objective

To refine our mahogany silvicultural "Tool Kit" to improve the ability to produce economically viable indigenous mahogany in mixed plantations and to transfer this Technology to Ghana's key industrial partners and community trees growers via a practical "How to Cultivate Indigenous Mahoganies" manual.

1.3 Expected Project Outputs

Output 1. Practical methods for mass production of selected superior *Hypsipyla*-tolerant (upright growing and straight-stem) clones of the seven indigenous mahoganies of Ghana developed.

Output 2. Three hectares of new seed production orchards established for each *Khaya* and *Entandrophragma* species and convert approximately 5 ha of existing provenance trials to seed orchards with the 7 major indigenous mahoganies across the 4 major ecological zones of Ghana.

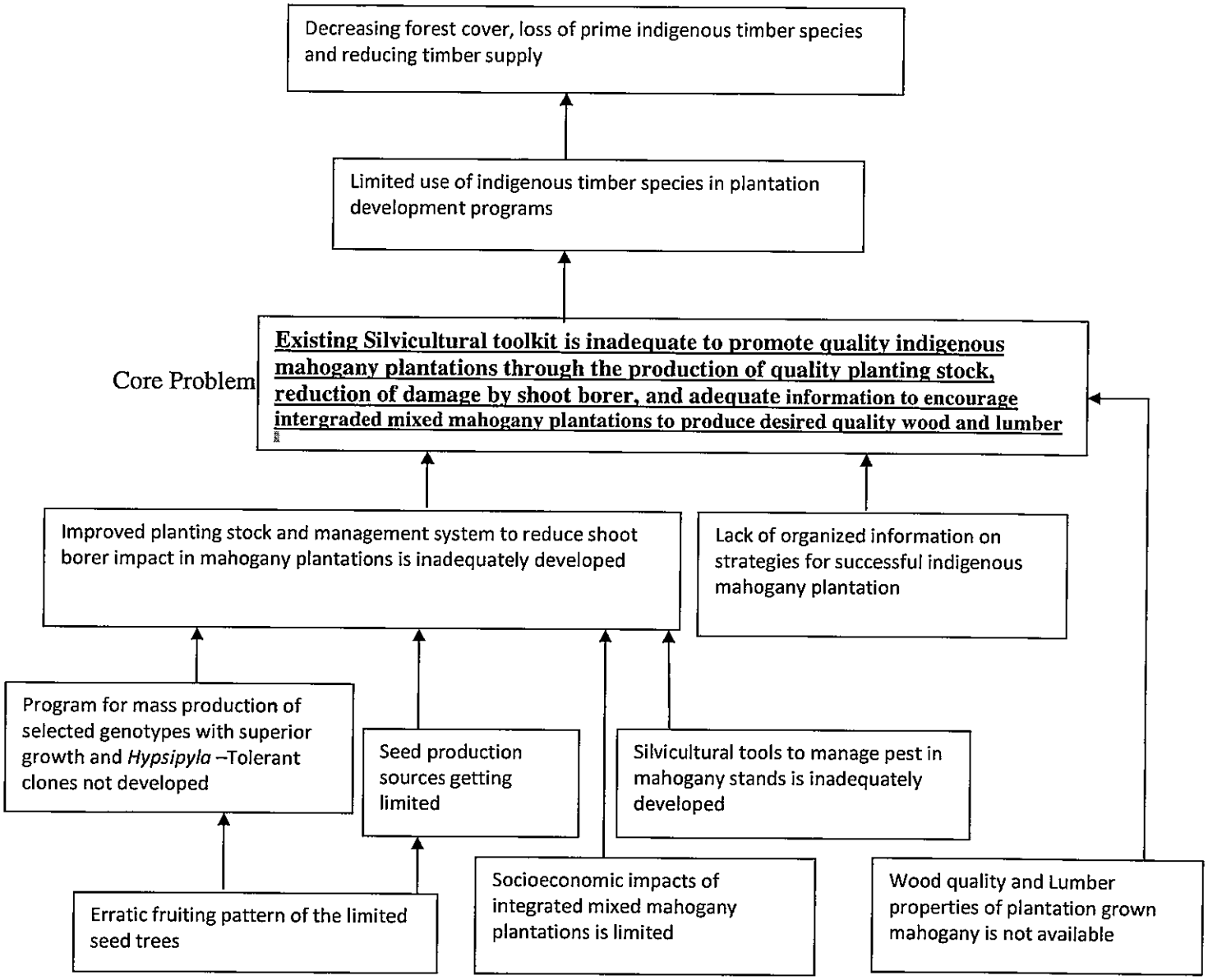
Output 3. Our silvicultural "tool kit" refined to optimize planting of mixed stands in the 4 major ecological zones (including pruning, thinning, shade and use of weaver ants as biological control agents).

Output 4. Wood quality and lumber properties from mature plantation-grown indigenous mahoganies that suffered *Hypsipyla* attacked at younger age are examined.

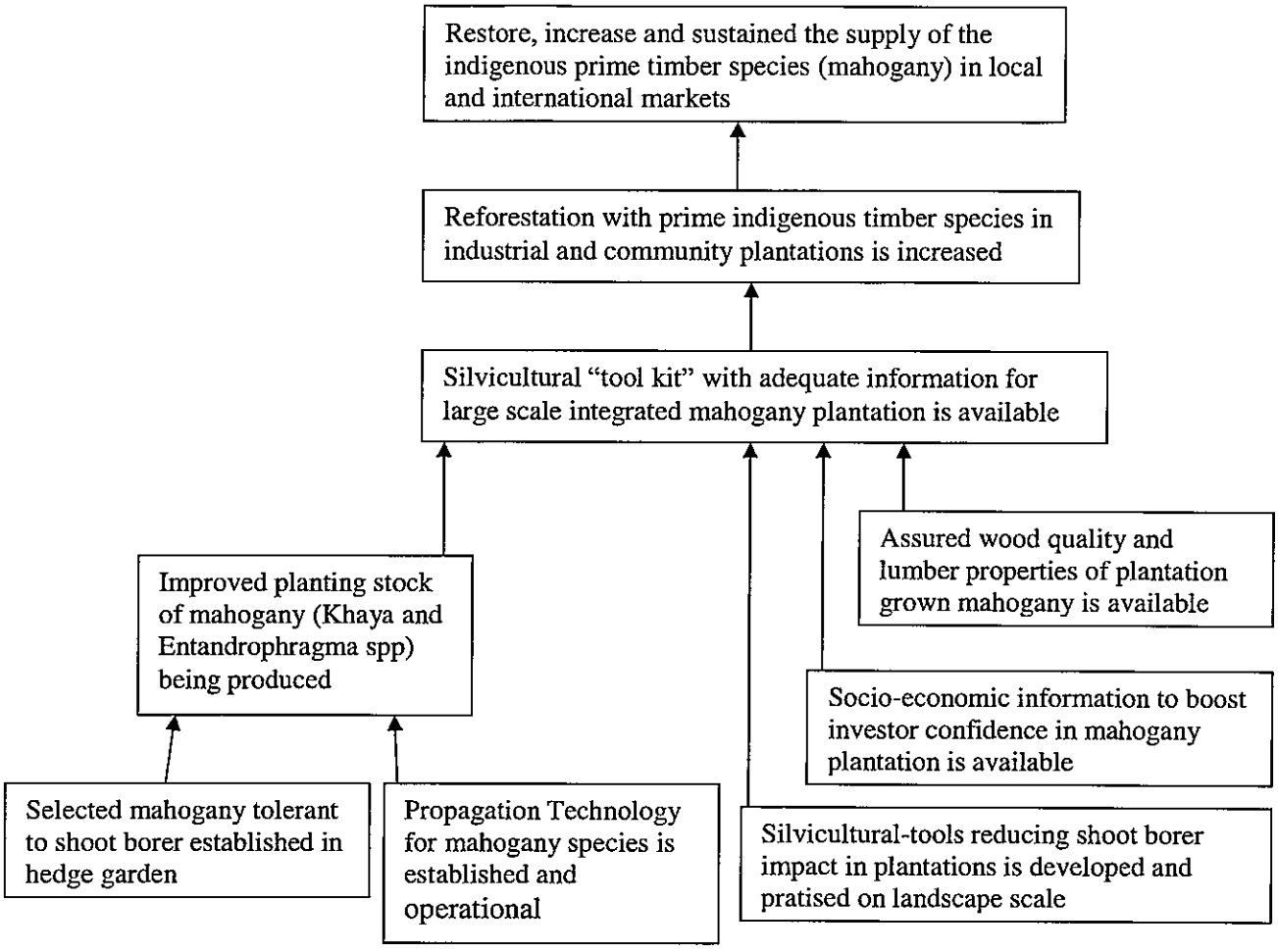
Output 5. Socioeconomic impacts of integrated agroforestry plantations of mixed mahoganies with various short-term crops are determined.

Output 6. A practical "how to" cultivate mahogany in plantations manual is produced

Problem Tree



The Objective Tree



Justification

Considerable outputs were generated during the first phase of the project that has contributed to restoring confidence of industrial and community tree growers in planting of indigenous mahoganies. However, mahogany shoot borer damage in plantations is still significant. Therefore to keep the current interest growing and sustain it we will require to refine our mahogany silvicultural "Tool Kit" to improve the ability to produce economically viable indigenous mahogany in mixed plantations and to transfer this technology to Ghana's key industrial partners and community trees growers via a practical "How to Cultivate Indigenous Mahoganies" manual

Keys to second 4 years

1. Problem—seed collection of indigenous mahogany currently must be done by traveling to where mature trees are and sending a climber up. This is expensive, dangerous and labor intensive. Solution (output)- turn in a few of our mahogany trials into seed orchards: Bobiri guest house- one of our oldest plantations , could be thinned to about a third of its current number of stems by removing small diameter or crooked stems , leaving the best trees as a ''showcase'' and ''seed orchard''- *Khaya anthotheca* and *Khaya ivorensis*.
2. Problem—not many stakeholders outside of our collaborating industries and communities know how to establish and maintain indigenous mahogany plantations.
   a. Solution (output) - develop a practical ''How To'' manual for producing high-quality indigenous mahogany. The manual should include an entire tool kit and shoot be aimed at practical farmers and foresters. Photographs should be liberally used and text should be kept simple and understandable. The manual should include:

- Propagation
  - Seed collection, handling, storage and sowing.
  - Vegetative propagation (grafting, rooted cuttings)
- Silviculture
  - Mixtures emphasized
  - Spacing
  - Genetics (species, provenances, families, clones)
  - Pruning
  - Thinning
  - Fertilization
- Pest management
  - Using ants as biological control
  - Using insect deterrent trees in mixture
  - Corrective pruning
- Agroforestry options
- CDM Forestry options
  - Carbon accounting
- Socioeconomics (plantations, agroforestry, CDM)

   b. Solution (output) – host regional community and industry stakeholder workshops to disseminate the manual and to elicit additional growers from industry and communities.

3. Problem—*Hypsipyla* shoot borer still causes major economic losses to our mahogany plantations across Ghana. We have identified putative Hypsipyla- tolerant indigenous mahogany but we cannot propagate large enough numbers of our Hypsipyla-tolerant indigenous mahogany to allow for widespread use of these superior clones. Using these trees would increase overall plantation growth rates and decrease economic losses from Hypsipyla shoot borer.
   a. Solution (output) – improve our methods to mass propagate superior Hypsipyla-tolerant, rapid-growing and straight-stemmed clones.
   b. Solution (output) – develop practical deployment strategies for utilizing weaver ants as biological control agents in mixed plantations of indigenous mahoganies.
4. Problem—no one has ever examined the wood qualities and lumber potential from harvest-aged, plantation-grown, indigenous mahoganies that had been attacked by *Hypsipyla* when they were young.

   Solution (output) – harvest a number (3-5) 40-year old Khaya species at a FORIG plantation near Amantia. This 30ha plantation, established about 40 years ago, was abandoned due to heavy Hypsipyla attacks when these trees were young. Collaborating industry partner, SAMARTEX, will contribute their man-power and equipment to harvest 3-5 trees and to bring them back to their sawmill at Samreboi where the logs will be sawn and inspected for heartwood properties, extent of decay, etc, along the entire length of each log.
5. Problem—the long-term rotations needed to harvest timber from plantation-grown mahogany are prohibitive to farmers and communities. We are continually reminded by our community stakeholders of the need for economic returns prior to the long-term final harvest.
   a. Solutions (output) – improve our best management practices for mahogany silviculture to reduce the rotation length of indigenous mahogany plantations.
   b. Solution (output) – examine the socioeconomic values for various short-term (agricultural such as groundnuts, beans, etc) crops and mid-term (perennial agricultural crops such as plantain, pineapple, etc) in agroforestry systems with indigenous mahoganies.
   c. Solution (output) – examine the socioeconomic options for economic returns from commercial thinning of indigenous mahogany plantations.
   d. Solution (output) – examine the alternatives for private-market CDM forestry to provide mid-term revenues to stakeholders managing indigenous mahogany plantations.

2.2 Intended Situation After Project Completion

This project will develop and demonstrate an integrated strategy for reducing the impact of *Hypsipyla* on mahogany species. It will provide the technical basis for plantation establishment and will, therefore, improve the feasibility of plantation establishment for private and public sector investors, including community groups. In addition, sufficient information will be produced to restore the mahogany component in degraded forests, under the National Plantation Development Programme in Ghana.

Clonal plots of Shoot-borer tolerant mahogany will have been established on 2 hectare plots for each of the 4 species of the African mahogany.

Mass production technique using vegetative propagation methods for seedling production of the *Khaya* specie `and the *Entandrophragma* species will be available for FORIG industrial and community tree-grower partners to use.

Wood properties and anatomical structure of plantation grown indigenous mahogany will available for the marketing of Ghana's wood in the local and international market.

Finally, a practical manual for cultivation of mahogany on large scale plantations will be made available to prospective investors in plantation in Ghana

2.3 Project Strategy

The mahogany shoot borer is perhaps the most economically important insect pest in tropical forestry. The problem has attracted a great deal of attention from foresters, ecologists, entomologists and plant breeders, but previous attempts at managing *Hypsipyla* have largely been unsuccessful. Recently, however, the prospects for controlling the mahogany shoot borer in West Africa and elsewhere have increased markedly with the identification of partial resistance and tolerance African mahoganies to *Hypsipyla robusta* (ITTO project PD105/01 Rev.3(F)). In the context of shoot borers on mahogany, resistance is defined as the ability of a plant to avoid, suppress, prevent, overcome or tolerate insect attack. Prior to the ITTO project PD105/01 Rev.3(F) FORIG collaborated with SODEFOR of Cote d`Ivoire and FRIN of Nigeria on a pre-project "Development of an integrated strategy for reduction of shoot borer impact on African mahogany in the tropical humid forest of Africa". It is timely that outputs gained from these two projects are used to build an integrated system for sustainable plantation of mahogany in Ghana. Because resistance, or any other method, alone, will not reduce the impact of *Hypsipyla* to uneconomic levels, it is recommended that an integrated pest management strategy based on incorporating pest resistant planting stock into silvicultural systems encouraging natural biological control could be the key to restore mahogany in the tropical forest.

Thus, the concept underlying this project is to develop an integrated pest management strategy for *Hypsipyla* in plantations of mahogany in West Africa.

Although there are several alternatives to the use of insecticides to control shoot borers, the best strategy is undoubtedly to reduce damage to a tolerable level by using a number of different methods in an integrated way This approach, however, requires at least one method which will have a significant effect alone and which will form the basis to build an integrated pest management strategy. In our ITTO project PD105/01 Rev.(F), research aimed at controlling mahogany shoot borers recommended an integrated pest management strategy based on the integration of "pest resistant planting stock in silvicultural systems which encourage natural biological control (especially weaver ants)". This project directly addresses this need by identifying resistance and tolerance in *Khaya* and *Entandrophragma* spp, evaluating silvicultural options of *Hypsipyla* control, and combining these in an integrated pest management strategy.

The selection of resistance within a tree species has a number of advantages. First, it avoids the problem of insects developing resistance to artificial chemical control methods. Second, as the main problem of shoot borer damage is the effect on tree form, any selections based on superior apical growth or recuperative ability should also lead to improvements in tree form as well as tolerance to attack. Furthermore, genetic screening and conservation of many Meliaceae species is now a matter of urgency, as a result of the continuing high rate of depletion of natural stands, especially because pest-resistant genotypes may exist. The project will therefore seek to select provenances of *Khaya* and *Entandrophragma* spp. with reduced susceptibility to shoot borer.

Individual trees showing pest resistance will be further mass-produced vegetatively (by cuttings) for plantations.

Gains from the use of genetically improved trees can only be fully realized if appropriate silvicultural management systems are employed. This might involve the use of mixed species plantations. Species mixtures may alter plant suitability for growth of the insect, may screen host plants from adult insects, or may increase levels of natural enemies. Mixed native species plantations serve as the foundation to tropical forest restoration activities. A canopy of native species along with a seed bank or seed rain is usually sufficient to restore deforested land to natural forests.

This project will employ replicated trials to evaluate different silviculture options for managing shoot borers. The value of different silvicultural methods will be measured both in terms of differences in shoot borer damage and the underlying mechanism(s) or any reduction in shoot borer damage observed e.g. the degree to which plant mixtures reduce shoot borer attack, decrease the biochemical suitability of mahogany for shoot borers, or increase the effectiveness of predators and parasites of the shoot borer. Project activities will therefore focus on identifying and selecting of less susceptible mahogany, the evaluating of the most promising silvicultural techniques (such as mix and companion plantings) and their incorporation in an integrated management system to reduce shoot borer impact. This project will demonstrate operational-scale restoration plantings incorporating successful principles of restoration ecology and integrated pest management.

Finally, this project will examine wood quality and lumber properties from matured plantation-grown mahogany to boost the confidence of industrial plantation investors who are interested in comparable wood qualities of the natural forest grown mahogany.

2.3 Target Beneficiaries

The main target beneficiaries of the outputs of the project in Ghana will be public- and private-sector forestry industries investing in plantation establishment, farmers and community associations. The Ghana Forest Service has collaborated directly in project design and will assist with project implementation. Private companies, particularly SAMARTEX timber and Plywood Company Limited, Swiss Lumber Company.Limited, ABTS company limited. are currently investing in plantation establishment and have expressed interest or have already invested in indigenous Meliaceae as an alternative to exotic species. The Forest Service and FORIG have recognized the increasing interest of individual farmers and community associations in plantation establishment and are promoting woodlot establishment on private land and farms through the Collaborative Forest Management Unit. In the phase I of this project we established 32hectares of pure mahogany and mixed plantations across the high forest belt of Ghana.

2.5 Technical and Scientific Aspects of Mahogany Plantation Establishment

Damage by shoot borers is the overriding factor restricting the establishment of plantations of *Khaya* spp, *Swietenia* spp and other valued tropical timber Meliaceae mahogany species worldwide (Opuni-Frimpong *et al.* 2008a, Newton *et al.* 1993, *Mo et al.* 2001; Watt *et al.* 2001). Our recent ITTO project PD105/01 Rev.3 (F) has made significant contribution in restoration of indigenous mahogany in degraded forest lands. Although several different options for the management of shoot borer species have been identified, these have not reduced damage to acceptable levels yet and will require additional effort to refine the silvicultural techniques to reduce the impact of shoot borer in mahogany plantations. Different approaches to the management of shoot borers are outlined below.

2.5.1. Identifying and Developing Less Susceptible Genotypes

Resistance has been identified against a range of tree pests (Mattson et al. 1988). It has been more widely developed against pests of temperate forest trees than against tropical forest pests but this is undoubtedly largely due to the greater investment in temperate forestry research.

Following observations suggesting that resistant individuals or races exist within wild populations of Meliaceae species (Opuni-Frimpong *et al* 2008b, Grijpma 1976, Watt, *et al.* 2001), the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE, Costa Rica) and the International Institute of Biological Control (IIBC, Trinidad), in collaboration with the Institute of Terrestrial Ecology (ITE, UK), identified *S. macrophyla* and *C. odorata* germplasm which is relatively resistant to *Hypsipyla grandella* (Newton *et al*, 1995, 1996, Watt *et al.* 2001). Promising resistance-selection results have also been obtained in provenance trials on *Cedrela* species (Sanchez *et al.* 1976, Vega 1976, Chaplin 1980, McCarter 1988, Ramnarine 1992).

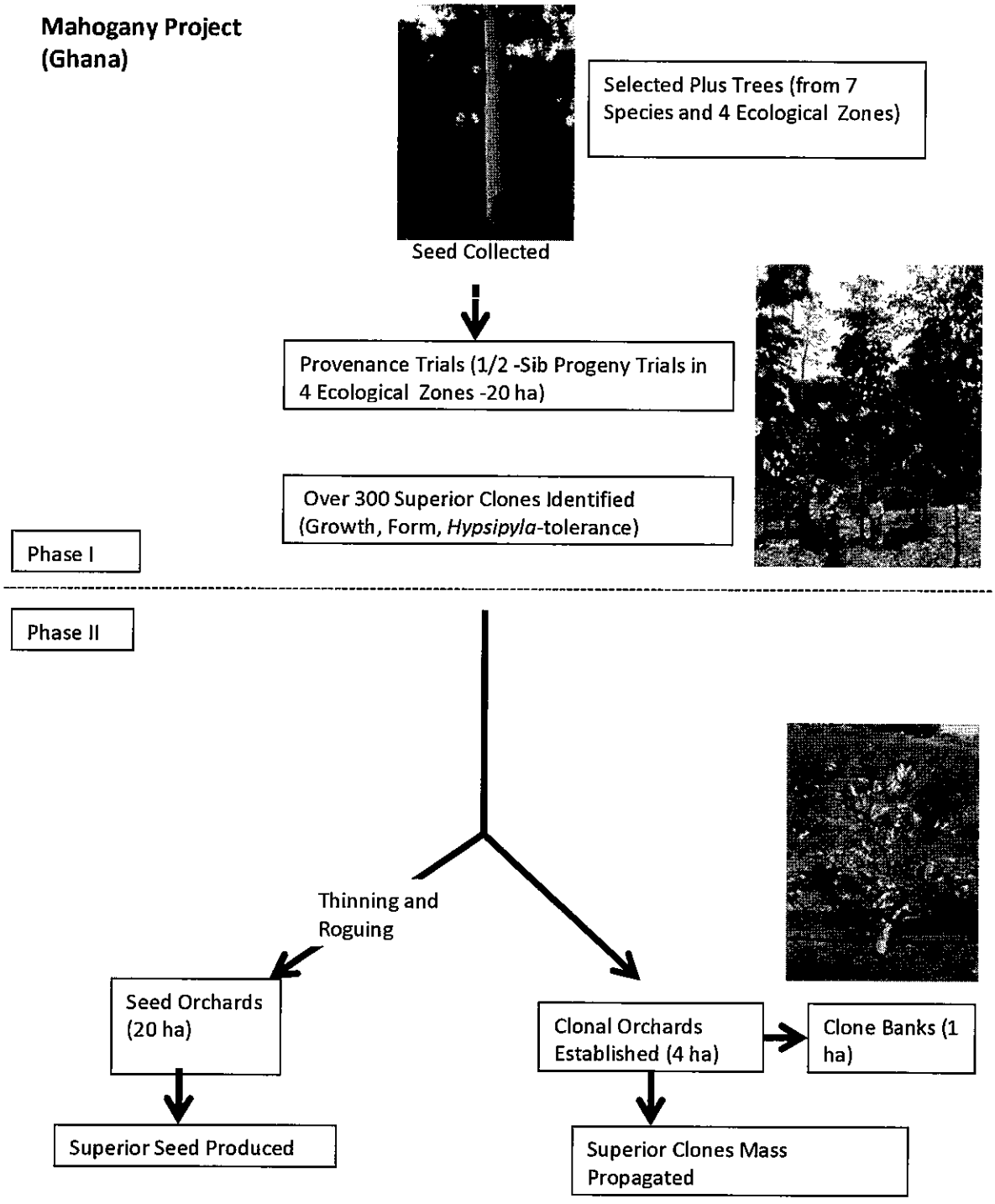
Further encouragement for this approach against tropical forest pests comes from ITTO Project PD3/95 Rev.2 (F) work on resistance in *Milicia* spp to *Phytolyma lata* by FORIG in Ghana. Recent studies on damage of *Hypsipyla* to native mahoganies in Ghana supported by the African Academy of Sciences identified different levels of tolerance in native mahoganies (Opuni-Frimpong, 2000, 2006). Selection of resistant *Khaya* genotypes has therefore been identified as an important area requiring further investigation.

In addition, it must be emphasized that the conservation and sustainability of the West African mahogany germplasm is urgently required before the loss of natural forests further depletes the country's genetic diversity.

Because of the need for a solution to the problem of shoot borers attacking *Khaya* and *Entandrophragma* species, which are among the most valuable native mahoganies in Ghana and the promising results from work on related tree species, this project will examine the resistance of *Khaya* and *Entandrophragma* provenances following the methods described by Newton *et al.* (1992).

Seed collections will be carried out on forest reserves were we could not have fruiting trees during the phase I within the range of *Khaya* and *Entandrophragma* in Ghana. Collections will be carried out at population and individual tree levels. Provenance collections will make use of the information on mahogany distribution from Forestry Department inventory data, in particular the use of FROGGIE (Forest Reserves of Ghana Graphical Image Exhibitor) (Hawthorne and Abu Juam 1995).

A range-wide provenance test will be established at least three sites representing the range of main forest regions in Ghana (Kumasi, Afram Headwaters Forest Reserve and Manso Amenfi). The is to broaden the genetic base and also contribute to ex situ conservation of the limited genetic sources of the indigenous mahoganies. Semi-annual evaluations will be made of phenological state, *Hypsipyla* attack, growth and form traits. Selected resistant seedlings will be cloned and resistance verified in clonal trials. Clonal testing will require developing propagation techniques (rooted cuttings and/or *in vitro* micropropagation).



2.5.2 Silvicultural Options

The use of tree species mixtures, either by the planting of species mixtures in plantations or as enrichment plantings, is likely to be an effective strategy in managing insect pests for several reasons: a) host trees are likely to be more difficult for adult pests to locate in species mixtures than in monocultures, b) plant suitability for larvae may be less (mainly as a result of shading,

see below in species mixtures, and c) natural enemies may be more abundant or effective in species mixtures (Watt 1994, Mayhew and Newton 1998, Hauxwell *et al.* 2001a).

Species mixtures, including enrichment plantings, have been repeatedly recommended as strategies to reduce shoot borer attack (McLeod 1915, Entwistle 1967, Opuni-Frimpong, 2006). Promising results have been obtained for *Cedrela* spp. (Vega 1976) and *S. macrophylla* (Yared and Carpenezzi 1981).

Enrichment plantings in natural forests have proven prohibitively expensive in West Africa. The earliest reforestation programmes with African mahoganies used the tropical shelterwood system (TSS) to enrich the logged forest. Although shoot borer damage was eliminated, the system was abandoned due to the prohibitive costs of repeated canopy opening and weeding (Osafo 1970).

The use of mixed plantings of Meliaceae with other timber species or agricultural crops has also been recommended in West Africa and elsewhere (Beeson 1919, Entwistle 1967, Chaplin 1980, Brunck and Mallett 1993, Hauxwell *et al.* 2001a). As early as 1910, successful reduction in shoot borer damage in *Entandrophragma* plantations in Togo was obtained using teak as a nurse crop (McLeod 1915). The Forestry Department of Nigeria has employed tree species mixtures as an attempt to control shoot borers. When the nurse crop (usually *Nauclea diderichii* or *Gmelina arborea*) and the mahogany were planted in separate lines, there was little evidence of control, but when the nurse and mahogany trees were planted in the same line some degree of control was obtained (Roberts 1966). Similar results have been shown for mixed line planting in Côte d'Ivoire (Brunck and Mallet 1993). In addition, mixed-age species mixtures and mixtures with *Leucena* have shown to give some degree of control (Brunck and Mallet 1993, Dupuy 1995).

Most of the benefit of planting mahogany in species mixtures is thought to accrue from shade (Campbell 1966, Lamb 1966, Entwistle 1967). The mechanisms by which shade per se may influence shoot borer attack are:

(i) Reducing tree growth rate and altering of shoot morphology. For example, Grijpma (1976) noted that stems grown under shade tend to be thinner and woodier, possibly reducing susceptibility to attack, as adults may prefer to oviposit on thick succulent shoots.

(ii) Decreasing in the nutritional value of the shoot (nitrogen, sugar and water content) (Ramos and Grace 1990) so as to be rejected by ovipositing adults or to be unsuitable for larval growth, development and survival.

(iii) Increasing in physical and chemical plant defenses (Westrup 1995), leading, as above, to rejection by ovipositing adults or to a decrease in suitability for shoot borer larvae.

(iv) Better form recovery after attack, specifically by encouraging more vertical growth rather than branching (Yared and Carpenezzi 1981), thereby also reducing the number of sites available for attack (Entwistle 1967, Grijpma 1976).

Although shade may reduce damage by shoot borers, it can also have detrimental effects on mahogany growth. *Khaya* species are 'non-pioneer, light-demanding' species and shade reduces the growth of *Khaya* (Hawthorne 1995). Thus, the use of shade in tree species mixtures must be optimized to reduce shoot borer damage without suppressing tree growth.

Therefore, despite the contradictory evidence on the benefits of shade, there are several reasons why the careful use of shade could reduce the impact of shoot borer damage to mahogany. The same applies to the other benefits of planting mahogany in tree species mixtures, particularly the possibility of natural control by predators and parasites. These benefits will not be realized until the factors leading to reduced shoot borer damage are clearly understood. Therefore, experiments and carefully designed field trials are needed to assess the value of different methods of controlling shoot borers. Only then can effective pest management programs be constructed (Whitmore 1976).

Therefore, the focus in this proposal is to establish experiments that will, first, evaluate the potential of shade in reducing the impact of shoot borers. Even if shade is shown to have no effect, its elimination will allow research and management to focus on other impacts of species mixtures on shoot borer, for example, the screening of mahogany from egg-laying adult moths and the promotion of control by natural enemies (Hauxwell *et al.* 2001b). These aspects, in particular the impact of natural enemies, will also be studied in the field experiments and trials described below.

The degree to which plant species mixtures may reduce shoot borer incidence by screening susceptible plants from adult *Hypsipyla* may be enhanced by interplanting with insect repellent tree or shrub species. Over 70 native Ghanaian plant species with insecticidal properties have already been identified, of which the 10 most promising are to be the subject of a future study (Tuani *et al.* 1994). Therefore, this project will include experiments on insect repellent tree species.

Reducing the incidence or severity of pest attack may be achieved through manipulating crop nutritional status (Waring and Cobb 1992, Kytö *et al.* 1996). Recent research has shown that there is an inverse relationship between attack by *Hypsipyla grandella* on *Cedrela odorata* and soil calcium content (*i.e.*, less calcium, more attacks) (Newton *et al.* 1995). The relevance of these finding for *Hypsipyla robusta* on *Khaya* and *Entandrophragma* species will be investigated in field trials.

In addition to field trials to test and demonstrate silvicultural techniques, analysis will be done of techniques affecting susceptibility to shoot borer. Impacts on yield shoot borer damage and plant growth will be quantified in mixed plantings with both timber species, in particular the impact of shade, and with insect repellent plants.

2.5.2.1 Planting in Associations with Other Timber Species

The value of planting mahogany with other timber species will be assessed through laboratory and field experiments. Opuni-Frimpong (2000) observed different levels of susceptibility of four different species of African mahogany planted together in the moist semi-deciduous forest type in Ghana.

Experiments will be conducted in screen houses infested with shoot borers from laboratory colonies. Under different degrees of shade, the following will be measured: oviposition by adult moths, incidence and severity of attack, larval growth and survival and plant growth and form.

In the field experiments, seedlings of *Khaya* and *Entandrophragma* species will be placed beneath existing trials of other timber species at the FORIG experimental station at Kumasi. Light will be quantified beneath each species using fisheye-lens photography and "Winscanopy" software. Incidence and severity of shoot borer attack, larval mortality due to predators, parasites and other factors, and plant growth and form will be quantified.

Field trials will be established by planting *Khaya* and *Entandrophragma* species together with a selection of timber species with different degrees of shade.

2.5.2.2 Planting in Associations with Insect Repellent Trees

The impact of potentially repellent tree species will be studied in laboratory experiments. Adult setting and oviposition behaviors rates will be examined using laboratory-reared insects. The results of these experiments will be used to select tree species for field trials.

2.5.2.3 Fertilizer Application

Field experiments on the impact of calcium fertilisers on shoot borer damage will be carried out. The following will be measured: incidence and severity of attack, larval growth and survival, and plant growth, form and chemistry.

2.5.2.4 Pruning as a Silvicultural Treatment

Pruning has been advocated as one means of controlling and/or mitigating shoot-borer attack. Recent studies by Cornelius (2001) reported pruned trees had significantly better values for form traits with no apparent difference in growth traits. Opuni-Frimpong (2000) identified some provenances of *Khaya anthotheca* that are able to tolerate *Hypsipyla* attack to some level by natural pruning when planted with other species in close spacing. The impact of pruning on tree form, and borer occurrence shall be studied further in the project in both pure and mixed mahogany plots.

2.5.2.5 Developing an Integrated Plantation-Establishment Strategy

It is unlikely that one approach to controlling shoot borers will be effective alone. Rather, the solution to the shoot borer problem is likely to lie in combining different control methods in an integrated approach. As noted by Pimentel (1991), Speight and Cory (2001), Speight and Wylie (2001) and many others, the combined use of increased pest resistance of the host plants, with other factors reducing borer attack, increases the overall effectiveness of biological control. Thus the strategy being adopted in this project is to identify resistant mahogany and develop a silvicultural system or systems that will enhance the genetic elements of pest management.

It is also important that the recommended pest management strategy is economically viable. Thus, cost/benefit analyses will be an integral part of the project. The design of the trials will be such as to allow the value of the silvicultural treatments to be calculated and either recommended or eliminated as uneconomic. Costs of production of improved stock will also be calculated and the overall benefits of different genetic/silvicultural strategies evaluated.

2.6 Economic Aspects

Mahogany is an important contributor to the economy of Ghana and to the international timber and lumber industries. Mahogany was the first timber to be exported from Ghana in the last quarter of the 19th century and has been contributing 15-30% of total timber exports up to the 1970s (Cobbinah *et al.* 2000). Many of the timber-exporting ITTO member countries export species of mahogany as an important component of their overall timber exports. In ITTO project PD105/01 Rev.3 (F) socioeconomic analysis shows that the smallholder integrated mahogany plantation with farmers is a profitable at 10% discount rate and stable to downward changes in cost and yield factors up to 50%. However, farmers often desire to plant fast growing tree species and those that yield early returns, thus are often not willing to invest in plantations with trees of

very long gestation periods even when they have adequate land resources. Hence manipulation of the system to generate interim benefits to the farmer is essential particularly for household cash needs and maintenance of the plantation over the years. This is important because after the initial benefits from food crop harvests in the first few years (3-4 years) in the establishment phase of the plantation, farmers may have to wait for long periods till the tree matures to be harvested for timber

The supply of mahogany is limited by extraction rates from natural forests which are expected to have a limited lifetime at current rates of extraction (current estimates are for natural mahoganies in Ghana to be exhausted by the end of this decade).There is an increasing demand for plantation-grown tropical timber, in particularly mahoganies. The benefits from an increased mahogany plantation program are expected to be considerable, including a more consistent timber size and certification that native, natural stands are not being harvested for this product.

2.7 Environmental Aspects

Since experiments and trials will be conducted on existing sites, negative local environmental impacts are not expected. Any large-scale plantation programs initiated as a result of the project outputs will be subject to an environmental impact assessments required by law in Ghana.

The evaluation of genetic resources will improve the information available for natural forest management programs by identifying provenance protection areas, with attendant environmental benefits. The demonstration of the use of reserves as genetic resources with economic benefits will support the maintenance of forest reserves.

2.8 Social Aspects

The phase one of the project identified a number of communities who are interested in small scale on farm plantations. We will continue to work with these communities in the second phase and expand the project to new communities. The communities will be trained to establish their own nurseries and the vegetative technology developed will be made available to the communities. We will use simple and appropriate technology which can easily be adapted by the community farmers. The enterprising small scale farmers will be encouraged to go into commercial nursery using our improved planting stock to supply seedlings to industrial plantation farmers to have a supplementary income. Most of our trial will be conducted on SAMARTEX and ABTS industrial plantation lands which employ a lot of the local people with women being majority. Local employment will result from this project and immediate benefits to local communities are expected. Results from the project will be made available to rural communities through the Forest Service Community Forestry Program.

2.9 Risks

Overall, risks to the project are low. The selection of improved stock is dependent upon the existence of variation in susceptibility within the population sampled. The limited studies to date including ITTO PD105/01 Rev.3 (F) suggest there is abundant natural genetic variation in the native mahoganies. **Failure of coppicing the tolerant mahogany genotypes could be a problem to propagating the improved stock plants. However we have observed from the first phase trials that all trees stimulated to coppice sprouted successfully, encouraging us that we could have improve stock to propagate. Species to be used in the mixed stand will**

be selected taking into consideration compatibility of species to reduce negative impact of mixed species on each other. We will establish a very strong channel of communication between project partners to sustain interest of collaborating organizations and communities. The plantation grown mahogany is a research facility and we have very strong support from the management of FORIG to selected merchantable size trees to study wood properties and sawing characteristics of plantation mahogany

Bush fires could destroy experimental plots in the field. We will continue to use fire breaks and other techniques developed by ITTO project PD32/98 Rev.1 (F) to prevent fires as were done in the phase I.

3 Outputs

Specific Objective

Project outputs expected to achieve the specific objective, "To refine our mahogany silvicultural "Tool Kit" to improve the ability to produce economically viable indigenous mahogany in mixed plantations and to transfer this Technology to Ghana's key industrial partners and community tree growers via a practical "How to" Cultivate Indigenous Mahoganies manual".

Output 1. Practical methods for mass production of selected superior *Hypsipyla*-tolerant (upright growing and straight-stem) clones of the seven indigenous mahoganies of Ghana developed.

Output 2. Three hectares of new seed production orchards established for each *Khaya* and *Entandrophragma* species and convert approximately 5 ha of existing provenance trials to seed orchards with the 7 major indigenous mahoganies across the 4 major ecological zones of Ghana.

Output 3. Our silvicultural "tool kit" refined to optimize planting of mixed stands in the 4 major ecological zones (including pruning, thinning, shade and use of weaver ants as biological control agents).

Output 4. Wood quality and lumber properties from mature plantation-grown indigenous mahoganies that suffered *Hypsipyla* attacked at younger age are examined.

Output 5. Socioeconomic impacts of integrated agroforestry plantations of mixed mahoganies with various short-term crops are determined.

Output 6. A practical "how to cultivate mahogany" in plantations manual is produced

4. ACTIVITIES

Output 1. Practical methods for mass production of selected superior *Hypsipyla*-tolerant (upright growing and straight-stem) clones of the seven indigenous mahoganies of Ghana developed.

Activity 1.1 Selection of *Hypsipyla*-tolerant from the range of provenance trials established in the phase I of the project.

Activity 1.2 Establishment of new provenance/genotype selection plots from seed sources which were not captured in the phase I.

Activity 1.3 Cloning *Hypsipyla*-tolerant mahoganies from existing and new trial plots through propagation by cuttings

Activity1.4 Establish hedge garden of *Hypsipyla*-tolerant clones of mahogany for mass production of cutting material

Activity1.5 Establish superior mahogany seedling production center

Output 2. Three hectares of new seed production orchards established for each *Khaya* and *Entandrophragma* species and convert approximately 5 ha of existing provenance trials

to seed orchards with the 7 major indigenous mahoganies across the 4 major ecological zones of Ghana.

Activity 2.1 Mahogany seed orchard with diverse genetic sources will be established for each of the *Khaya* species and *Entandrophragma* species from new seed sources

Activity 2.2 Selection of superior genotypes and conversion of 5 hectares of phase I mahogany trial plots into seed production orchard

Output 3. Our silvicultural "tool kit" refined to optimize planting of mixed stands in the 4 major ecological zones (including pruning, thinning, shade and use of weaver ants as biological control agents).

Activity 3.1 Examine different densities of mahogany in mixture with other native tree species that occur together in natural stand effect on *Hypsipyla* attacks

Activity 3.2 Examine the effect of the mixture of mahogany with food crop farming on *Hypsipyla* attack in an agroforestry system

Activty.3.3 Pruning effect on shoot borer incidence and tree form of mahogany in existing and new plantation trials

Activity.3.4 Thinning and spacing effect on shoot borer attack in mahogany stands

Activity 3.5 Examine the activity of weaver ants as biological control agents in mixed stand and pure stands

Activity 3.6 Develop a system for introducing weaver ants as biological control agent of *Hypsipyla* in mahogany plantations

Output 4. Wood quality and lumber properties from mature plantation-grown indigenous mahoganies that suffered *Hypsipyla* attacked at younger age are examined.

Activity 4.1 Harvest a number (3-5) 40-year old *Khaya* species at a FORIG plantation near Amantia

Activity 4.2 Determine sawing characteristics of mature logs of mahogany from plantation (infected by *Hypsipyla*) and natural forest

Activity 4.3 Compare anatomical properties of mahogany grown in plantation to that in Natural forest of similar sizes

Activity 4.4 Establish the mechanical and strength properties of mature plantation grown mahogany which suffered *Hypsipyla* attack at younger age

Activity 4.5 PhD training

Output 5. Socioeconomic impacts of integrated agroforestry plantations of mixed mahoganies with various short-term crops are determined.

Activity 5.1 comparative socio-economic analysis of different model/systems of plantation establishment with farmer communities in project areas

Activity 5.2 Evaluate the economic viability of smallholder plantations

Activity 5.3 Economic analysis of vegetative propagation

Activity 5.3 Economic assessment of the basis for Mahogany research from the perspectives of the timber industry in Ghana

Output 6. A practical "how to cultivate mahogany" in plantations manual is produced

Activity 6.1 Prepare a handbook for establishment of Mahogany plantation

Activity 6.2 Organize an International Workshop for restoration of the mahoganies in forest ecosystems in the Tropics

5. LOGICAL FRAMEWORK MATRIX

Project Component	Measurable Indicators	Means of Verification	Relevant Assumptions
Development Objective Improve the sustainability of indigenous mahogany in Ghana by developing superior mahoganies that are ecologically adapted and insect tolerant and expand our collaboration with industrial and community tree farmers	Increasing areas planted with indigenous mahogany by industrial and community farmers	-Plantation statistics -demonstration plots available -increasing supply of superior clone seedlings	
Specific Objective To refine our mahogany silvicultural "Tool Kit" to improve the ability to produce economically viable indigenous mahogany in mixed plantations and to transfer this Technology to Ghana's key industrial partners and community tree growers via a practical "How to" Cultivate Indigenous Mahoganies manual	Model mahogany mixed plantation with reduced *Hypsipyla* attack established in industrial and community farms	-Project reports -Field visits -Reports on workshops with stakeholders	Industrial and community partners willingness to expand plantations
Output 1. Practical methods for mass production of selected superior *Hypsipyla*-tolerant clones	System for mass production and mahogany hedge garden available	-Progress reports -Scientific papers -visits to propagation center	Coppicing of superior clones
Output 2. Seed production orchards established for each *Khaya* and *Entandrophragma*	**3 hectares orchard of superior clones establish by the end of the second year**	-reports from field visit. -progress report -Technical papers	Superior clones available for all species
Output 3. Our silvicultural "tool kit" refined to optimize planting of mixed stands in the 4 major ecological zones	**By the end of year 1: 20 hectares of mixed mahogany stand trials will be established**	-Data from field -Progress reports -Technical papers -Scientific publications	Species in the mixed stand are compatible and favours sustain growth of mahogany
Output 4. Wood quality and lumber properties from mature plantation-grown mahoganies	**At least 3 plantation grown mahogany trees are logged and processed from 40-year old plantation**	-Sawn lumber and cookies to analyzed -Technical report -Scientific papers	Comparable size trees available in plantation
Output 5. Socioeconomic impacts of integrated agroforestry plantations of mixed mahoganies with various short-term crops are determined	**Socioeconomic benefits and associated impacts determined in five participation communities**	-reports from workshop -Progress report -list of participants -completion report	Sustain interest of the collaborating communities
Output 6. A practical "how to cultivate mahogany" in plantations manual is produced and International Workshop	**By the end of year 3 International workshop organized and by middle of year 4 draft Handbook for cultivation of native mahoganies out**	-Progress report -Project completion report -workshop report -Participants list	Co-operation between project participants

List of Quantity and Unit Cost of Inputs

Outputs and Activities	Inputs		Unit Costs	Quarter Year	Budget component	Total Amount
	Units and Quantities	No.				
Output 1						
Activity 1.1 1.1 Selection of *Hypsipyla*-tolerant	1) Forest Entomologist	3	600	Y1-Y2	11.1,	1,800
	2) Days-Daily Subsistence	15	40	Y1-Y2	31.1	600
	3) Geneticist	2	600	Y1-Y2	11.2	1,200
	4) days- Daily Subsistence	15	40	Y1-Y2	31.1	600
	5) Forestry Technicians	4	250	Y1-Y2	11.3	1,000
	6) Days- Daily Subsistence	45	40	Y1Y2	31.1	1,800
	7) Casual labour	200	5	Y1-Y2	54	1,000
	8) Maintenance of truck	6	400	Y1-Y2	55	2,400
	9) Lab. Supplies			Y1-Y2	52	1,000
	10) Fuel and Lubricants				56	1,600
Activity 1.2 1.2 Establishment of new selection plots	1) Silviculturist	4	600	Y1-Y2	11.1	2,400
	2) Days-Daily Subsistence	25	40	Y1-Y2	31.1	1,000
	3) Geneticist	3	600	Y1-Y2	11.2	1,800
	4) Days- Daily Subsistence	30	40	Y1-Y2	31.1	1,200
	5) Foresters	5	600	Y1-Y2	11.2	3,000
	6) Days- Daily Subsistence	50	40	Y1-Y2	31.1	2,000
	7) Forestry Technicians	7.2	250	Y1-Y2	11.3	1,800
	8) Days- Daily Subsistence	45	40	Y1-Y2	31.1	1,800
	9) Seeds collection	2	2000	Y1-Y2	21	4,000
	10) Capital Item				41,45,48	20,000
	11) Nursery supplies (Polypots, insecticides, labels, Soil etc)			Y1-Y2	53	2,500
	12) Office supplies (papers)	25	20	Y1-Y2	51	500
	13) Casual Labour	300	5	Y1-Y2	54	1,500
	14) Fuel and lubricants			Y1-Y2	56	1,300
	15) Truck Maintenance	4	400	Y1-Y2	55	1,200
1.3 Cloning *Hypsipyla*-tolerant mahoganies by rooting cuttings	1) Forest Entomologist	1	600	Y1-Y4	11.1	600
	2) Days-Daily Subsistence	15	40	Y1-Y4	31.1	600
	3) Plant Breeder	2	600	Y1-Y4	11.1	1,200
	4) days- Daily Subsistence	40	40	Y1-Y4	31.1	1,600
	5) Technicians	5	240	Y1-Y4	11.3	1,200
	6) Days- Daily Subsistence	20	40	Y1-Y4	31.1	800
	7) Nursery establishment	12	500	Y1-Y4	22	6,000
	8) Capital Item				41,44,45	18,500
	9) Rooting media	25	80	Y1-Y4	53	2,000
	10) Casual labour	400	5	Y1-Y4	54	2,000
1.4 Establish hedge garden	1) Silviculturist	3	600	Y1-Y4	11.1	1,800
	2) Days-Daily Subsistence	15	40	Y1-Y4	31.1	600
	3) Plant Breeder	3	600	Y1-Y4	11.2	1,800
	4) Days- Daily Subsistence	20	40	Y1-Y4	31.1	800
	5) Forestry Technicians	3.6	250	Y1-Y4	11.3	900
	6) Days- Daily Subsistence	15	40	Y1-Y4	31.1	600
	7) Raising Seedlings	10	500	Y1-Y4	22	5,000
	8) Pegging and Planting	10	100	Y1-Y4	23	1,000
	9) Capital Items				41,43,44,45,47,4	10,000
	10) Office supplies (paper,ink,etc)			Y1-Y4	8	1,000
	11) Nursery supplies (labels, Hormones, etc)	400	5	Y1-Y4	51 53	1,000 2,000
	12) Casual labour				54	
1.5 Establish seedling production center	1) Forest Entomologist	1	600	Y1-Y4	11.1	600
	2) Days-Daily Subsistence	3	40	Y1-Y1	31.1	120
	3) Plant Breeder	1	600	Y1-Y4	11.2	600
	4) days- Daily Subsistence	3	40	Y1-Y2	31.1	120
	5) Technicians	3	250	Y1-Y4	11.3	750
	6) Days- Daily Subsistence	4	40	Y1-Y4	31.1	160
	7) Capital Items			Y1-Y4	47	20,000
	8) Lab. Supplies			Y1-Y4	52	1,000
	9) Nursery supplies			Y1-Y4	53	3,000

OUTPUT 2						
2.1 Orchard with diverse genetic sources	1) Silviculturist	4	600	Y1-Y4	11.1	2,400
	2) Days-Daily Subsistence	15	40	Y1-Y2	31.2	600
	3) Plant Breeder	5	600	Y1-Y4	11.2	3,000
	4) Days- Daily Subsistence	10	40	Y1-Y2	31.2	400
	5) Forestry Technicians	4.4	250	Y1-Y4	11.3	1,100
	6) Days- Daily Subsistence	12.5	40	Y1-Y4	31.2	500
	7) Pegging & Planting	10	100	Y1-Y4	23	1,000
	8) Raising seedlings	6	500	Y1-Y4	22	3,000
	9) Capital Items			Y1-Y4	41,43, 44,48	10,000
	10) Truck maintenance	3	400	Y1-Y4	55	1,200
	11) Casual labour	300	5	Y1-Y4	54	1,500
	12) Fuel and Lubricants			Y1-Y4	56	1,500
	13) Office supplies			Y1-Y4	52	800
2.2 Convert 5h trial plots into orchard	1) Silviculturist	2	600	Y1-Y4	11.1	1,200
	2) Days-Daily Subsistence	5	40	Y1-Y4	31.2	200
	3) Geneticist	2	600	Y1-Y4	11.2	1,200
	4) Days- Daily Subsistence	10	40	Y1-Y4	31.2	400
	5) Forestry Technicians	4.4	250	Y1-Y4	11.3	1,100
	6) Days- Daily Subsistence	7.5	40	Y1-Y4	31.2	300
	7) Capital Items			Y1-Y4	41,43,44,48	6,100
	8) casual labour	200	5	Y1-Y4	54	1,000
	9) Truck Maintenance	2	400	Y1-Y4	55	800
	10) Fuel			Y1-Y4	56	1,200
OUTPUT 3.0						
3.1 Different densities of mahogany	1) Silviculturist	2	600	Y1-Y4	11.1	1,200
	2) Days-Daily Subsistence	15	40	Y1-Y4	31.3	600
	3) Forest Ecologist	3	600	Y1-Y4	11.2	1,800
	4) Days- Daily Subsistence	15	40	Y1-Y4	31.3	600
	5) Forestry Technicians	4	250	Y1-Y4	11.3	1,000
	6) Days- Daily Subsistence	45	40	Y1-Y4	31.3	1,800
	7) Seeds Collection	1	2000	Y1-Y4	21	2,000
	8) Raising Seedlings	4	500	Y1-Y4	22	2,000
	9) Pegging & Planting	30	100	Y1-Y4	23	3,000
	10) Capital Items			Y1-Y4	41, 43, 44, 48	18,500
	11) Casual labour	800	5	Y1-Y4	54	4,000
	12) Fuel			Y1-Y4	56	1,000
3.2 Mixture of mahogany with food crop	1) Insect Ecology consultant	1	4,000	Y1-Y4	14.1	4,000
	2) Airticket Y-class	1	2,500	Y1-Y4	33	2,500
	3) Silviculturist	1	600	Y1-Y4	11.1	600
	4) Days-Daily Subsistence	40	40	Y1-Y4	31.3	1,600
	5) Forest Ecologist	3	600	Y1-Y4	11.2	1,800
	6) Days- Daily Subsistence	15	40	Y1-Y4	31.3	600
	7) Forestry Technicians	4.4	250	Y1-Y4	11.3	1,100
	8) Days- Daily Subsistence	32.5	40	Y1-Y4	31.3	1,300
	9) Seeds Collection	1	2000	Y1-Y4	21	2,000
	10) Raising Seedlings	4	500	Y1-Y4	22	2,000
	11) Pegging & Planting	30	100	Y1-Y4	23	3,000
	12) Capital Items			Y1-Y4	41, 43,44,46	18,500
	13) Casual labour	1000	5	Y1-Y4	54	5,000
	14) Fuel			Y1-Y4	56	1,000
3.3 Pruning effect on shoot borer incidence	1) Forest Entomologist	1	600	Y2-Y4	11.1	600
	2) Days-Daily Subsistence	10	40	Y2-Y4	31.3	400
	3) Silviculturrist	2	600	Y2-Y4	11.2	1,200
	4) Days- Daily Subsistence	15	40	Y2-Y4	31.3	600
	5) Forestry Technicians	3	250	Y2-Y4	11.3	700
	6) Days- Daily Subsistence	37.5	40	Y2-Y4	31.3	1,500
	7) Casual labour	200	5	Y2-Y4	54	1,000
	8) Pruning equipments			Y2-Y4	52	2,000
	9) Fuel			Y2-Y4	56	1,000

3.4 Thinning and spacing studies	1) Forest Entomologist	1	600	Y1-Y3	11.1	600
	2) Days-Daily Subsistence	10	40	Y1-Y2	31.3	400
	3) Silviculturrist	3	600	Y1-Y2	11.2	1,800
	4) Days- Daily Subsistence	20	40	Y1-Y2	31.4	800
	5) Forestry Technicians	4.4	250	Y1-Y2	11.3	1,100
	6) Days- Daily Subsistence	20	40	Y1-Y2	31.4	800
	8) Casual labour	400	5	Y1-Y2	54	2,000
	9) Truck maintenance	3	400	Y1-Y2	55	1,200
	10) Fuel			Y1-Y2	56	800
3.5 Weaver ants, biological control agents	1) Insect ecology consultant	1	4,000	Y1-Y3	9.1	4,000
	2) Days-Daily Subsistence	10	40	Y1-Y3	31.3	400
	3) Forest entomologist	2	600	Y1-Y3	11.2	1,200
	4) Days-Daily Subsistence	10	40	Y1-Y3	31.3	400
	5) Technicians	3.2	250	Y1-Y3	11.3	800
	6) Days-Daily Subsistence	15	40	Y1-Y3	31.3	600
	7) Office supplies			Y1-Y3	51	400
	8) Maintenance of field plots			Y1-Y3	54	800
	9) Truck maintenance			Y1-Y3	55	800
	10) Fuel			Y1-Y3	56	1,000
3.6 System for introducing weaver ants	1) Insect ecology consultant	1	4,000	Y1-Y3	9.1	4,000
	2) Days-Daily Subsistence	10	40	Y1-Y3	31.3	400
	3) Forest entomologist	4	600	Y1-Y3	11.2	2,400
	4) Days-Daily Subsistence	20	40	Y1-Y3	31.3	800
	5) Technicians	4.4	250	Y1-Y3	11.3	1,100
	6) Days-Daily Subsistence	20	40	Y1-Y3	31.3	800
	7) Capital item			Y1-Y3	44,45	3,900
	7) Office supplies			Y1-Y3	51	400
	8) Maintenance of field plots			Y1-Y3	54	600
	9) Truck maintenance			Y1-Y3	55	1,000
	10) Fuel			Y1-Y3	56	2,000
Output 4.0						
4.1 Harvest 40-year old *Khaya* species	1) Silviculturist	1	600	Y1-Y2	11.1	600
	2) Days-Daily Subsistence	10	40	Y1-Y2	31.4	400
	3) Wood anatomist	1	2,000	Y1-Y2		2,000
	4) Days-Daily Subsistence	5	40	Y1-Y2		200
	3) Forester	1.5	600	Y1-Y2	11.2	900
	4) Days-Daily Subsistence	10	40	Y1-Y2	31.4	400
	5) Technician	4	250	Y1-Y2	11.3	1,000
	6) Days-Daily Subsistence	12.5	40	Y1-Y2	31.4	500
	7) Logging and conveyance			Y1-Y2	24	10,000
	8) Laboratory supplies	100	10	Y1-Y2	53	3,000
	11) Fuel			Y1-Y2	56	2,000
4.2 Determine sawing characteristics	1) Wood anatomist	1	2,000	Y1-Y2	9.4	2,000
	2) Days-Daily Subsistence	20	40	Y1-Y2	31.4	800
	3) Wood scientist	3	600	Y1-Y2	11.2	1,800
	4) Days-Daily Subsistence	20	40	Y1-Y2	31.4	800
	5) Laboratory technicians	4.8	250	Y1-Y2	11.3	1,200
	6) Days-Daily Subsistence	22.5	40	Y1-Y2	31.4	900
	7) Sawing of logs			Y1-Y2	24	4,000
	8) Laboratory supplies (chemicals, microtome blades, labels, etc)			Y1-Y2	52	2,400
	11) Fuel			Y1-Y2	56	1,600
4.3 Compare anatomical properties	1) Wood anatomist	1	2,000	Y1-Y4	9.4	2,000
	2) Days-Daily Subsistence	15	40	Y1-Y4	31.4	600
	3) Ph.D Student	1.7	600	Y1-Y4	11.2	1,000
	4) Days-Daily Subsistence	15	40	Y1-Y4	31.4	600
	5) Laboratory technicians	6	250	Y1-Y4	11.3	1,500
	6) Days-Daily Subsistence	20	40	Y1-Y4	31.4	800
	7) Sawing			Y1-Y4	24	3,500
	8)Laboratory supplies (chemicals, microtome blades, labels, etc)			Y1-Y4	52	8,200
	9) Fuel			Y1-Y4	56	1,200
	10) Capital items			Y1-Y4	42	3,300
4.4 Mechanical and strength properties	1) Wood anatomist	1	2,000	Y1-Y4	9.4	2,000
	2) Days-Daily Subsistence	20	40	Y1-Y4	31.4	800
	3) Wood scientist	2.5	600	Y1-Y4	11.2	1,500

	4) Days-Daily Subsistence	25	40	Y1-Y4	31.4	1,000
	5) Ph.D Student	2.5	600	Y1-Y4	11.2	1,500
	6) Days-Daily Subsistence	20	40	Y1-Y4	31.4	800
	7) Laboratory technicians	4	250	Y1-Y4	11.3	1,000
	8) Days-Daily Subsistence	25	40	Y1-Y4	31.4	1,000
	9) Sawing			Y1-Y4	24	4,500
	10)Laboratory supplies (chemicals, microtome blades, labels, etc)			Y1-Y4	52	5,000
	11) Fuel			Y1-Y4	56	3,000
4.5 PhD training in wood technology	1) PhD studies	1	94,500	Y2-Y4	15.1	94,500
Output 5.0						
5.1 Comparative socio-economic analysis	1) Socio-economic consultant	1	2,000	YI-Y4	9.3	2,000
	2) Days-Daily Subsistence	10	100	Y1-Y4	31.5	1,000
	3) Forester	1.7	600	Y1-Y4	11.2	1,000
	4) Days-Daily Subsistence	20	40	Y1-Y4	31.5	800
	5) Technician	4	250	Y1-Y4	11.3	1,000
	6) Days-Daily Subsistence	30	40	Y1-Y4	31.5	1,200
	7) Capital items			Y1-Y4	41,43,44	2,100
	8) Office supplies (paper,ink,etc)			Y1-Y4	51	800
	9) Truck maintenance			Y1-Y4	55	1,000
	10) Fuel			Y1-Y4	56	3,200
5.2 Viability of smallholder plantations	1) Socio-economic consultant	1	2,000	YI-Y4	9.3	2,000
	2) Days-Daily Subsistence	5	100	Y1-Y4	31.5	500
	3) Forester	1.7	600	Y1-Y4	11.2	1,000
	4) Days-Daily Subsistence	10	40	Y1-Y4	31.5	400
	5) Technicians	4	250	Y1-Y4	11.3	1,000
	6) Days-Daily Subsistence	7.5	40	Y1-Y4	31.5	300
	7) Capital items			Y1-Y4	41,43,44	2,000
	8) Office supplies (paper,ink,etc)			Y1-Y4	51	700
	9) Truck maintenance			Y1-Y4	55	800
	9) Fuel			Y1-Y4	56	2,000
5.3 Economic analysis of propagation	1) Socio-economic consultant	1	2,000	YI-Y4	11.2	2,000
	2) Days-Daily Subsistence	10	40	Y1-Y4	31.5	400
	3) Technicians	6	250	Y1-Y4	11.3	1,500
	4) Days-Daily Subsistence	15	40	Y1-Y4	31.5	600
	5) Office supplies (paper,ink,etc)			Y1-Y4	51	1,000
	6) Truck maintenance			Y1-Y4	55	500
	7) Fuel			Y1-Y4	56	2,000
5.4 Economic assessment of Mahogany plantations	1) Socio-economic consultant	1	2,000	YI-Y4	9.3	2,000
	2) Days-Daily Subsistence	10	100	Y1-Y4	31.5	1,000
	3) Forester	2	600	Y1-Y4	11.2	1,200
	4) Days-Daily Subsistence	10	40	Y1-Y4	31.5	400
	5) Technicians	7.2	250	Y1-Y4	11.3	1,800
	6) Days-Daily Subsistence	15	40	Y1-Y4	31.5	600
	7) Office supplies (paper,ink,etc)			Y1-Y4	51	1,000
	8) Maintenance of field plots			Y1-Y4	54	1,200
	9) Truck maintenance			Y1-Y4	55	1,000
	10) Fuel			Y1-Y4	56	2,000
Output 6.0						
6.1 Prepare a handbook for establishment of Mahogany plantation	1) Project leader	7	600	YI-Y4	11.1	4,200
	2) Days-Daily Subsistence	20	40	Y1-Y4	31.6	800
	3) Genetic/ Ecology consultants	1	4,000	Y1-Y4	9.1	4,000
	4) Air-fare (international expert)	1	2,500	Y1-Y4	33	2,500
	5) Silviculturist/ Plant breeder/Economist	4	600	Y1-Y4	11.2	2,400
	6) Days-Daily Subsistence	10	40	Y1-Y4	31.6	400
	7)Technicians	5.6	250	YI-Y4	11.3	1,400
	8) Days-Daily Subsistence	7.5	40	Y1-Y4	31.6	300
	9) Office supplies (paper, ink, manual publication, etc)			Y1-Y4	51	3,000
6.2 Organize an International Workshop	1) Local participants (transport)	40	400	Y2-Y4	15.3	14,000
	2) Days-Daily Subsistence	35*4	100	Y2-Y4	15.3	14,000
	3) International participants (air fare)	3	3,000	Y2-Y4	15.3	9,000

	4) Days-Daily Subsistence	3*5	200	Y2-Y4	15.3	3,000
	5) Workshop secretariat			Y2-Y4	51	4,000
	6) Field trip			Y2-Y4	31.6	2,000
	7) Dinner	60	30	Y2-Y4	15.3	1,800
	8) Conference facility			Y2-Y4	15.3	3,000
	9) Contingency			Y2-Y4	15.3	1,200
10. Steering committee meetings	1) Traveling cost and per diem					11,000
	2) Internal monitoring and evaluation					3,600
11. Technology transfer	1) Conferences and seminars					24,500
	2) International workshops and proceedings					5,000
	3) Driver					6,000
12. Administrative costs	1) Administrative and secretariat services					9,000
	2) FORIG Administrative cost					20,000

6.0 Work plan

Project Activities	Responsible Party	Year 1												Year 2												Year 3												year 4											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Output 1. Practical methods for mass production of selected superior Hypsipyla-tolerant clones																																																
1.1 Selection of *Hypsipyla*-tolerant from existing provenance trials	PL, PI, Co-Pis, PC																																															
1.2 Establishment of new provenance/genotype selection plots	PL, PI, Co-Pis, PC,RA, Ts																																															
1.3 Cloning *Hypsipyla*-tolerant mahoganies	PL, PI, Co-Pis, PC, RA																																															
1.4 Establish hedge garden	PL, PI, Co-Pis, PC, RA																																															
1.5 Establish superior mahogany seedling production center	PI, Co-Pis, PC, RA, SEC																																															
OUTPUT 2.0 Seed production orchards established for each *Khaya* and *Entandrophragma*																																															
2.1 Mahogany seed orchard with diverse genetic sources will be established	PI, Co-PIs, RA,Ts																																															
2.2 Convert 5h of existing trial plots into orchard	PI, Co-PIs, RA,Ts																																															
OUTPUT 3.0 Silvicultural "tool kit" refined to optimize planting of mixed stands																																															
3.1 Examine different densities of mahogany in mixture stand	PI, Co-Pis, PC, RA, SEC																																															
3.2 Effect of the mixture of mahogany with food crop farming	PI, Co-Pis, PC, RA, SEC																																															
3.3 Pruning effect on shoot borer incidence and tree form	PI, Co-Pis, PC, RA, Ts																																															
3.4 Thinning and spacing effect on shoot borer attack in mahogany stands	PI, Co-Pis, PC, RA, Ts																																															
3.5 Examine the activity of weaver ants as biological control agents	PI, Co-Pis, PC, RA, Ts																																															
3.6 Develop a system for introducing weaver ants as biological control agent	PI, Co-Pis, PC, RA, Ts																																															
OUTPUT 4.0 Wood quality and lumber properties of plantation grown mahogany																																															
4.1 Harvest a number (3-5) 40-year old *Khaya* species	PI, Co-PIs, PhD.S, Ts,																																															
4.2 Determine sawing characteristics	PI, Co-PIs, PhD.S, Ts,																																															
4.3 Compare anatomical properties	PI, Co-PIs, PhD.S, Ts,																																															
4.4 Establish the mechanical and strength properties	PI, Co-PIs, PhD.S, Ts,																																															
4.5 PhD training in wood technology	PI, Co-PIs, PhD.S, Ts,																																															
OUTPUT 5.0 Socioeconomic impacts of integrated agroforestry plantations of mixed mahoganies																																															
5.1 comparative socio-economic analysis	SEC, PI, Co-Pis, PC, RA																																															
5.2 Evaluate the economic viability of smallholder plantations	SEC, PI, Co-Pis, PC, RA																																															
5.3 Economic analysis of vegetative propagation	SEC, PI, Co-Pis, PC, RA																																															
5.4 Economic assessment of the basis for Mahogany research	SEC, PI, PC, RA																																															
OUTPUT 6.0 Mahogany plantations handbook and an International Workshop																																															
6.1 Prepare a handbook for establishment of Mahogany plantation	PI, Co-PIs, PhD.S, Ts,																																															
6.2 Organize an International Workshop	PI, Co-PIs, PhD.S, Ts,																																															

Legend

PL - Project Leader
PI - Principal Investigator
Co-PI - Co-Principal Investigator
RA - Research Assistant
SEC - Socio-economic Consultant
Ts - Technicians
PhD.S - PhD Student
PC – Participating Communities

Budget

7. 1 OVERALL PROJECT BUDGET BY ACTIVITY

	BUDGET COMPONENT							
Outputs/Activities + Non-Activity Based Expenses	**10 Personnel**	**20 Sub-Cont**	**30 Duty travel**	**40Capital Item**	**50 Consumables**	**60 Miscellaneous**	**Years**	**Project Total**
Output 1. Practical methods for mass production of selected superior clones								
1.1 Selection of *Hypsipyla*-tolerant	4000		3000		6000			13000
1.2 Establishment of new selection plots	9000	4000	6000	20000	7000			46000
1.3 Cloning *Hypsipyla*-tolerant mahoganies	3000	6000	3000	18500	4000			39000
1.4 Establish hedge garden	4500	6000	2000	10000	4000			26500
1.5 Establish seedling production center	1950		400	20000	3000			25350
Subtotal 1	**22450**	**16000**	**14400**	**68500**	**24000**			**149350**
OUTPUT 2.0 Orchards for Seed production								
2.1 Orchard with diverse genetic sources	6500	4000	1500	10000	5000			27000
2.2 Convert 5h trial plots into orchard	3500		900	6100	3000			13500
Subtotal 2	**10000**	**4000**	**2400**	**16100**	**11000**			**40500**
OUTPUT 3.0 Silvicultural "tool kit" refined to optimize mixed plantations								
3.1 Different densities of mahogany	4000	7000	3000	18500	5000			37500
3.2 Mixture of mahogany with food crop	3500	7000	3500	18500	6000			38500
3.3 Pruning effect on shoot borer incidence	2500		2500		4000			9000
3.4 Thinning and spacing studies	3500		2000		4000			9500
3.5 Weaver ants, biological control agents	2000		1400		3000			6400
3.6 System for introducing weaver ants	3500		2000	3900	4000			13400
Subtotal 3	**19000**	**14000**	**14400**	**43900**	**28000**			**114300**
OUTPUT 4.0 Wood quality and lumber properties of plantation mahogany								
4.1 Harvest 40-year old *Khaya* species	2500	10000	1500		5000			19000
4.2 Determine sawing characteristics	3000	4000	2500		4000			13500
4.3 Compare anatomical properties	2500	3500	2000	3300	10000			21300
4.4 Mechanical and strength properties	4000	4500	3600		8000			20100
4.5 PhD training in wood technology	94500							94500
Subtotal 4	**106500**	**22000**	**9600**	**3300**	**27000**			**168400**

Outputs/Activities + Non-Activity Based Expenses	**10 Personnel**	**20 Sub-Cont**	**30 Duty travel**	**40Capital Item**	**50 Consumables**	**60 Miscellaneous**	**Years**	**Project Total**
OUTPUT 5.0 Socioeconomic impacts of integrated agroforestry plantations								
5.1 comparative socio-economic analysis	**2000**		**3000**	**2100**	**5000**			**12100**
5.2 Viability of smallholder plantations	**2000**		**1200**	**2000**	**3500**			**8700**
5.3 Economic analysis of propagation	**1500**		**1000**		**3500**			**6000**
5.4 Economic assessment of Mahogany plantations	**3000**		**2000**		**5200**			**10200**
Subtotal 5	**8500**		**7200**	**4100**	**17200**			**37000**
OUTPUT 6.0 Mahogany plantations handbook and an International Workshop								
6.1 Prepare a handbook for establishment of Mahogany plantation	**8000**		**4000**		**3000**			**15000**
6.2 Organize an International Workshop	**46000**		**2000**		**4000**			**52000**
Subtotal 6	**54000**		**6000**		**7000**			**67000**
9.CONSULTANTS								
9.1 Insect Ecology Consultant	**16000**							**16000**
9.3 Socio Economics	**8000**							**8000**
9.4 Wood Technology/Anatomy	**8000**							**8000**
Subtotal 9	**32000**							**32000**
10. Steering Committee meetings								
10.1 Traveling cost and per diem	**6000**		**5000**					**11000**
10.2 Internal monitoring and evaluation			**3600**					**3600**
Subtotal 10	**6000**		**8600**					**14600**
11. Technology Transfer								
11. 1 Conferences andSeminars	**22500**				**2000**			**24500**
11.2 International Workshop and Proccedings			**5000**					**5000**
11.3 Driver			**6000**					**6000**
Subtotal 11	**22500**		**11000**		**2000**			**35500**
12. Administrative Costs								
12.1 Administrative and Secretariat Services	**9000**							**9000**
11.3 FORIG Administrative cost						**20000**		**20000**
Subtotal 12	**9000**					**20000**		**29000**
Total	**289,950**	**56,000**	**73,600**	**132,900**	**113,200**	**20, 000**		**685,650**

7.2 CONSOLIDATED PROJECT BUDGET –GOV'T OF GHANA, MTU, SAMARTEX, ITTO CONTRIBUTION

Budget Components		Months/ qty	Unite rate	Gov't of Ghana	MTU	Samartex	ITTO	Total
10	**Project Personnel**							
	11 National Experts							
	11.1 Project Leader	48	600	20,000			8,800	28,800
	11.2 Researchers (3)	54	600	24,300			8,100	32,400
	11.3 Technicians (5)	75	250	11,250			7,500	18,750
	13 Administrative Personnel							
	13.1 Accountant	12	400	4,800				4,800
	13.2 Auditor	12	350	4,200				4,200
	14 Consultants							
	14.1 External Consult. Insect Ecologist	4	4,000				16,000	16,000
	14.2 Local Consult.: Socio-economics	4	2,000				8,000	8,000
	14.3Local Consult. Wood Tech/Anatomy	4	2,000				8,000	8,000
	15 Training and workshop							
	15.1 PhD training (fees & stipends) x3	Year	31,500		94,500			94,500
	15.2Masters Research	60	100	6,000				6,000
	15.3 International Workshop	20	2,000	20,000			20,000	40,000
	15.4 Steering committee meetings	6day	750	6,000				6,000
	15.5 Attending Conferences and Seminars	3x3	2,500				22,500	22,500
	19 Component Total			**96,550**	**94,500**		**98,900**	**289,950**
20	**Sub-contract**							
	21 Seeds collection	4	2,000				8, 000	8,000
	22 Nursery Establishment and management	36	500			7,200	10,800	18,000
	23 Pegging and planting	100 ha	100			2,000	8,000	10,000
	24 Logging, transporting, and sawing of logs					20,000		20,000
	29 Component Total			-		**29,200**	**26,800**	**56,000**
30	**Duty Travel**							
	31 Daily Subsistence Allowance (DSA)							
	31.1 D.S.A. Output 1 (x4)	120 MD	40				14,400	14,400
	31.2 D.S.A. Output 2	60 MD	40				2,400	2,400
	31.3 D.S.A. Output 3 (x4)	120 MD	40				14,400	14,400
	31.4 D.S.A. Output 4 (x4)	80 MD	40				9,600	9,600
	31.5 D.S.A. Output 5 (x4)	60 MD	40				7,200	7,200
	31.6 D.S.A. Output 6 (x4)	50 MD	40				6,000	6,000
	32 Internal monitoring & evaluation (x3)	30 MD	40	3,600				3,600
	32.1 Drivers	300 MD	20				6,000	6,000
	33 Air fare, Inter. Experts,	4	2,500				10,000	10,000
	39 Component Total			**3,600**			**70,000**	**73,600**
40	**Capital Items**							
	41 Vehicle 4x4 drive	1	37,000				37,000	37,000
	42 Microscope	1	2,200				2,200	2,200
	43 Computers (2) and printer	2	2,100				4,200	4,200
	44 Digital Camera	1	1,000				1,000	1,000
	45 Li-Cor for monitoring seedling physiology	1	28,500				28,500	28,500
	47.Propagation Facility	1	20,000				20,000	20,000
	48 Land	200 ha	200	20,000		20,000		40,000
	49 Component Total			**20,000**		**20,000**	**92,900**	**132,900**
50	**Consumable Items**							
	51 Office supplies	Year x4	2,000	2,000			6,000	8,000
	52 Laboratory supplies	Year x4	6,000	3,000	7,000		14,000	24,000
	53 Nursery supplies	Year x4	3,000	2,000			10,000	12,000
	54 Maintenance of field plots	year x4	7,500			12,000	18,000	30,000
	55 Spare parts	Year x4	2,300				9,200	9,200
	56 Fuel and Lubricants	Year x4	7,500				30,000	30,000
	59 Component Total			**7,000**	**7,000**	**12,000**	**87,200**	**113,200**
	60 Miscellaneous							
	61 FORIG administrative cost			**20,000**				**20,000**
	SUBTOTAL			**147,150**	**101,500**	**61,200**	**375,800**	**685,650**
80	**ITTO M & E and Administration**							
	81 Monitoring and Evaluation x4	Year	10,000				40,000	40,000
	82 ITTO Ex-Post Evaluation						15,000	15,000
	82 Program Support Costs (8%)						34,464	34,464
	89 Component Total						**89,464**	**89,464**
	GRAND TOTAL			**147,150**	**101,500**	**61,200**	**465,264**	**775,114**

MD – Man-days ha – hectare

7.3 YEARLY CONSOLIDATED PROJECT BUDGET

Budget Components		TOTAL(US)	Year 1	Year 2	Year3	Year4
10	**Project Personnel**					
	11 National Experts					
	11.1 Project Leader	28,800	7,200	7,200	7,200	7,200
	11.2 Researchers (3)	32,400	8,100	8,100	8,100	8,100
	11.3 Technicians (5)	18,750	4,687.5	4,687.5	4,687.5	4,687.5
	13 Administrative Personnel					
	13.1 Accountant	4,800	1,200	1,200	1,200	1,200
	13.2 Auditor	4,200	1,050	1,050	1,050	1,050
	14 Consultants					
	14.1 External Consult. Insect Ecologist	16,000	4,000	4,000	4,000	4,000
	14.2 Local Consult.: Socio-economics	8,000	2,000	2,000	2,000	2,000
	14.3Local Consult. Wood Tech/Anatomy	8,000	2,000	2,000	2,000	2,000
	15 Training and workshop					
	15.1 PhD training (fees & stipends) x3	94,500	31,500	31,500	31,500	
	15.2Masters Research	6,000	1,500	1,500	1,500	1,500
	15.3 International Workshop	40,000			20,000	20,000
	15.4 Steering committee meetings	6,000	1,500	1,500	1,500	1,500
	15.5 Attending Conferences and Seminars	22,500	5,625	5,625	5,625	5,625
	19 Component Total	**289,950**	**70,362.5**	**70,362.5**	**90,362.5**	**58,862.5**
20	**Sub-contract**					
	21 Seeds collection	8,000	5,000	3,000		
	22 Nursery Establishment and management	18,000	4,500	4,500	4,500	4,500
	23 Pegging and planting	10,000	2,500	2,500	2,500	2,500
	24 Logging, transporting, and sawing of logs	20,000	10,000	5,000	5,000	
	29 Component Total	**56,000**	**22,000**	**15,000**	**12,000**	**7,000**
30	**Duty Travel**					
	31 Daily Subsistence Allowance (DSA)					
	31.1 D.S.A. Output 1 (x4)	14,400	3,600	3,600	3,600	3,600
	31.2 D.S.A. Output 2	2,400		800	800	800
	31.3 D.S.A. Output 3 (x4)	14,400	3,600	3,600	3,600	3,600
	31.4 D.S.A. Output 4 (x4)	9,600	3,200	3,200	3,200	
	31.5 D.S.A. Output 5 (x4)	7,200	1,800	1,800	1,800	1,800
	31.6 D.S.A. Output 6 (x4)	6,000			3,000	3,000
	32 Internal monitoring & evaluation (x3)	3,600	900	900	900	900
	32.1 Drivers	6,000	1,500	1,500	1,500	1,500
	33 Air fare, Inter. Experts,	10,000	2,500	2,500	2,500	2,500
	39 Component Total	**73,600**	**17,100**	**17,900**	**20,900**	**17,700**
40	**Capital Items**					
	41 Vehicle 4x4 drive	37,000	37,000			
	42 Microscope	2,200	2,200			
	43 Computers (2) and printer	3,600	2,100	2,100		
	44 Digital Camera	1,000	1,000			
	45 Li-Cor for monitoring seedling physiology	28,500		28,500		
	47.Propagation Facility	20,000	10,000	10,000		
	48 Land	40,000	10,000	10,000	10,000	10,000
	49 Component Total	**132,900**	**62,300**	**50,600**	**10,000**	**10,000**
50	**Consumable Items**					
	51 Office supplies	8,000	2,000	2,000	2,000	2,000
	52 Laboratory supplies	24,000	6,000	6,000	6,000	6,000
	53 Nursery supplies	12,000	3,000	3,000	3,000	3,000
	54 Maintenance of field plots	30,000	7,500	7,500	7,500	7,500
	55 Spare parts	9,200	1,000	2,000	3,000	3,200
	56 Fuel and Lubricants	30,000	7,500	7,500	7,500	7,500
	59 Component Total	**113,200**	**27,000**	**20,000**	**29,000**	**29,200**
	60 Miscellaneous					
	61 FORIG administrative cost	**20,000**	**5,000**	**5,000**	**5,000**	**5,000**
	SUBTOTAL	**685,650**	**203,762.5**	**186,862.5**	**167,262.5**	**127,762.5**
80	**ITTO M & E and Administration**					
	81 Monitoring and Evaluation x4	**40,000**				
	82 ITTO Ex-Post Evaluation	**15,000**				
	82 Program Support Costs (8%)	**34,464**				
	89 Component Total	**89,464**				
	GRAND TOTAL	**775,114**				

7.4 YEARLY CONSOLIDATED PROJECT BUDGET -ITTO

Budget Components		TOTAL(US)	Year 1	Year 2	Year3	Year4
10	**Project Personnel**					
	11 National Experts					
	11.1 Project Leader	8,800	2,200	2,200	2,200	2,200
	11.2 Researchers (3)	8,100	2,025	2,025	2,025	2,025
	11.3 Technicians (5)	7,500	1,875	1,875	1,875	1,875
	13 Administrative Personnel					
	13.1 Accountant					
	13.2 Auditor					
	14 Consultants					
	14.1 External Consult. Insect Ecologist	16,000	4,000	4,000	4,000	4,000
	14.2 Local Consult.: Socio-economics	8,000	2,000	2,000	2,000	2,000
	14.3Local Consult. Wood Tech/Anatomy	8,000	2,000	2,000	2,000	2,000
	15 Training and workshop					
	15.1 PhD training (fees & stipends) x3					
	15.2Masters Research					
	15.3 International Workshop	20,000			10,000	10,000
	15.4 Steering committee meetings					
	15.5 Attending Conferences and Seminars	22,500	5,625	5,625	5,625	5,625
	19 Component Total	**98,900**	**19725**	**19,725**	**29,725**	**29,725**
20	**Sub-contract**					
	21 Seeds collection	8, 000	5,000	3,000		
	22 Nursery Establishment and management	10,800	2,700	2,700	2,700	2,700
	23 Pegging and planting	8,000	2,000	2,000	2,000	2,000
	24 Logging, transporting, and sawing of logs					
	29 Component Total	**26,800**	**9,700**	**7,700**	**4,700**	**4,700**
30	**Duty Travel**					
	31 Daily Subsistence Allowance (DSA)					
	31.1 D.S.A. Output 1 (x4)	14,400	3,600	3,600	3,600	3,600
	31.2 D.S.A. Output 2	2,400		800	800	800
	31.3 D.S.A. Output 3 (x4)	14,400	3,600	3,600	3,600	3,600
	31.4 D.S.A. Output 4 (x4)	9,600	3,200	3,200	3,200	
	31.5 D.S.A. Output 5 (x4)	7,200	1,800	1,800	1,800	1,800
	31.6 D.S.A. Output 6 (x4)	6,000			3,000	3,000
	32 Internal monitoring & evaluation (x3)					
	32.1 Drivers	6,000	1,500	1,500	1,500	1,500
	33 Air fare, Inter. Experts,	10,000	2,500	2,500	2,500	2,500
	39 Component Total	**70,000**	**16,200**	**17,000**	**20,000**	**16,800**
40	**Capital Items**					
	41 Vehicle 4x4 drive	37,000	37,000			
	42 Microscope	2,200	2,200			
	43 Computers (2) and printer	4200	2100	2100		
	44 Digital Camera	1,000	1,000			
	45 Li-Cor for monitoring seedling physiology	28,500		28,500		
	47.Propagation Facility	20,000	10,000	10,000		
	48 Land					
	49 Component Total	**92,900**	**52,300**	**40,600**		
50	**Consumable Items**					
	51 Office supplies	6,000	1,500	1,500	1,500	1,500
	52 Laboratory supplies	14,000	3,500	3,500	3,500	3,500
	53 Nursery supplies	10,000	2,500	2,500	2,500	2,500
	54 Maintenance of field plots	18,000	4,500	4,500	4,500	4,500
	55 Spare parts	9,200	1,500	2,000	3,000	3,200
	56 Fuel and Lubricants	30,000	7,500	7,500	7,500	7,500
	59 Component Total	**87,200**	**20,500**	**21,500**	**22,500**	**22,700**
	60 Miscellaneous					
	61 FORIG administrative cost					
	SUBTOTAL	**375,800**	**118,425**	**106,525**	**76,925**	**73,925**
80	**ITTO M & E and Administration**					
	81 Monitoring and Evaluation x4	40,000				
	82 ITTO Ex-Post Evaluation	15,000				
	82 Program Support Costs (8%)	34,464				
	89 Component Total	**89,464**				
	GRAND TOTAL	**465,264**				

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7.5 YEARLY PROJECT BUDGETS BY OTHER SOURCES

7.5 GHANA GOVERNMENT (IN KIND)

Budget Components	Total	Year 1	Year 2	Year 3	Year 4
10 Project Personnel	96,550	24,137.5	24,137.5	24,137.5	24,137.5
20 Sub-contract					
30 Duty travels	36,000	9,000	9,000	9,000	9,000
40 Capital Equipment	20,000	5,000	5,000	5,000	5,000
50 Consumables Items	7,000	1,750	1,750	1,750	1,750
60 Miscellaneous	20,000	5,000	5,000	5,000	5,000
Total	**147,150**	**44,887.5**	**44,887.5**	**44,887.5**	**44,887.5**

7.6 SAMERTEX (IN KIND)

Budget Components	Total	Year 1	Year 2	Year 3	Year 4
10 Project Personnel					
20.Sub-contract	29,200	7,300	7,300	7,300	7,300
30 Duty travels					
40 Capital Equipment	20,000	5,000	5,000	5,000	5,0000
50 Consumables Items	12,000	3,000	3,000	3,000	3,000
Total	**61,200**	**15,300**	**15,300**	**15,300**	**15,300**

7.7 MICHIGAN TECHNOLOGICAL UNIVERSITY PHD TRAINING + (IN KIND)

Budget Components	Total	Year 1	Year 2	Year 3	Year 4
10 Project Personnel	94,500	31,500	31,500	31,500	31,500
30 Duty travels					
40 Capital Equipment					
50 Consumables Items	7,000	1,750	1,750	1,750	1,750
60 Miscellaneous					
Total	**101,500**	**33,250**	**33,250**	**33,250**	**33,250**

PART III: OPERATIONAL ARRANGEMENT

1. Management Structure

1.1 Principal Investigators:

Dr. Emmanuel Opuni-Frimpong: : Project Leader and Principal Investigator, will provide scientific advice on project design, planning and implementation. Responsible for managing and coordinating all project activities, including preparations and submission of project reports to ITTO, responsible for monitoring and assessment of project activities on the field. Develop handbook for cultivation of mahogany in West Africa.

Mr. Emmanuel Ebanyenle:Co-Pi Research Scientist, will be responsible for wood anatomy and wood technological properties studies. He will design, plan and implement the wood quality and lumber properties activities of the project.

Dr. Beatrice Darko Obiri: Research Scientist, will advice on community plantation issues, socio-economic analysis on community plantations, developing collaborative forestry for community plantations

Mr. F.S. Amoah: Director Forest Plantations, Forest services Division, Forestry Commission, Ghana. Will be responsible for design, planning and implementation of industrial plantations. Also he will be a key person in stakeholder workshops and interactions.

***Professor Andrew J. Storer**: Co-Principal Investigator, Forest Ecology/Entomology Consultant, Michigan Technological University will advise on a project design, Biological control methods, capturing and introducing of weaver ants, design training manuals and will be major professor for the Ghana Ph.D. candidate. He will be involved in preparation and review of the handbook.

1.2 Scientists:

Mrs Lucy Amissah: Research Scientist in Biodiversity, Environment and Land Use. Community needs assessment, Gender related issues in community participation.

Mr. Lord Ameyaw: Silviculturist/Project Research Assistant, candidate for graduate studies, will work closely with Principal and Co-Principal Investigators.

Ms. Sandra Acheampong Owusu: Project Research Assistant will assist in vegetative propagation, candidate for graduate studies in plant breeding

1.3 Institutions Involved in the Project

Country	Institution
Ghana	Forestry Research Institute of Ghana (FORIG)
	Samartex Timber and Plywood Company limited
	Swiss Lumber Company Limited
	ABTS Company Limited
	Kranka Community Famers
USA	School of Forest Resources and Environmental Science, Michigan Technological University (MTU)

2. Monitoring, Reports and Evaluation

2.1 Monitoring

The project will be subject to periodic technical monitoring in accordance with the policies and procedures laid down by ITTO.

2.2. Reports

Progress reports will be prepared according to ITTO guidelines and submitted to ITTO every six months.

2.2 Evaluation

The project will be evaluated yearly by Project Technical Committee (Steering Committee) meeting to assess its overall orientation and organization and determine whether the project is achieving its objectives. The organization, terms of reference and periodic evaluation will be determined by consultation between project scientists, directors of implementing institutions and ITTO.

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* Note: The co-principal investigator is budgeted in this proposal as external consultants.

2.3 Steering Committing

The Steering Committee will be comprised of :

- ***Government of Ghana/Forest Commission representative*** **will chair the steering committee to support the project implementation with policy advice**
- ***Director of the Forest Research Institute of Ghana,*** **will supervise the over all implementation of the project as the director of the executing agency**
- ***Timber Industry Association representative*** **will provide advice on the expectations of the timber industry and also be the link to inform the industry the research outputs**
- ***SAMARTEX*** **is a collaborating timber organization in the implementation of the project. Samartex will be involve in most of the project activities so their contribution at the steering committee meeting will help to direct the research and execution of the activities to make the results user friendly to the timber industry**
- ***Michigan Technological University*** **is a collaborating organization. The Expert from Michigan Technological university will provide funds and train One FORIG staff in wood Technology at PhD level. His participation as a consultant at the steering committee meetings will help to improve project implementation**
- ***ITTO representative*** **will guide the steering committee to implement the project as defined in the project document as part of the Technical monitoring role of ITTO.**
- ***Kranka Community Farmers representative*** **will serve the interest of the community farmers involve in the implementation of the project at the steering committee level to make sure the project takes care of concerns of farmers.**

Project Directorate will be made up of Project Leader, Co-Principal Investigators, and Ghana Forest Commissions.

3. Future Operations and Maintenance

The Forestry Research Institute will be responsible for the maintaining and releasing resistant genotypes. It will also be responsible for the maintaining the hedge garden, Orchards and conservation plantation through the Ghana government annual budgetary allocation for running of the Institute. All the other plantations will be established on lands belonging to the Forest Service of Ghana,Timber Industries (SAMARTEX, ABTS, Swiss Lumber and others who will join the program later) and community farmers land. Their maintenance will be the responsibilities of the organizations involved with technical assistance from Forestry Research Institute of Ghana.

PART IV. TROPICAL TIMBER FRAMEWORK

1. Compliance with ITTA 2006 objectives

This project is related to 6 of 19 ITTA objectives of the successor agreement to the ITTA, 1994 (UN, 2006):

Objective c. This project contributes to sustainable community forestry development and it seeks to alleviate poverty for over 2,000 rural poor people of Ghana.

Objective d. This project promotes sustainable production, via community forestry, of some major timber species of Ghana.

Objective (f). The project will promote and support research and development with a view to improving forest management and efficiency of wood utilization and the competitiveness of wood products relative to other materials, as well as increasing the capacity to conserve and enhance other forest values in timber producing tropical Ghana.

Objective g. This project will seek to add CDM component with potential for CDM financial resources to an already well-established community forestry programs in Ghana.

Objective q. This project has a strong agroforestry component promoting sustainable forest management via production of short-term agricultural crops and medium-term horticultural crops in addition to longer-term timber production. All key institutions promoting sustainable forest management in Ghana including Forest Commission, Forest Service, Game and Wildlife Department, Forestry Research Institute of Ghana, timber industries and community tree growers are integrated in this project.

Objective r. This project has a strong "forest-dependent indigenous and local community" component and we are using novel strategies such as profit-sharing and land-ownership sharing that we have shown are successful (in the original OCAP project) in enhancing participation by farmers, villagers, and especially by young people and women.

Objective s. This project is dealing with capacity building a key new emerging issue in Africa: forestry

2. Compliance with ITTO Action Plan

This project addresses a number of goals and actions recommended in the ITTO Action Plan (ITTO, 2002):

Goal/Action 3.1.2.1 We are promoting increased reforestation with important timber species in Ghana.

Goal/Action 3.2.1.3 We are examining the role of newly established forests for mitigation of the effects of climate change by examining the amount of carbon being sequestered.

Goal/Action 3.2.1.5 We are promoting non-timber food products for both short-term agricultural crops and mid-term horticultural crops which would be planted among longer-term forest crops. Thus, the project reduces the use of slash and burn agriculture.

Goal/Action 3.2.2.3 The project promotes restoration of degraded forests in the area's non-reserve forests were largely converted to cocoa plantations in the 1960s. These plantations have largely been abandoned in recent years.

Goal/Action 3.2.2.6 The project has strong social and economic implications for the poor rural communities involved and stresses the benefits of sustainable forest management. Furthermore, we have a substantial training component in our project for the community farmers to enable them to intelligently manage their forest resources.

Goal/Action 3.2.2.10 The project promotes intensive forest management (including weed control, pruning, and thinning of plantation-grown tropical timber) to promote reforestation of degraded forest lands. We also promote multiple uses of the forests.

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ANNEX A: PROFILE OF THE EXECUTING AGENCY

A.1 Expertise of the Executing Agency FORIG

The mission of FORIG, Ghana's forestry research institute and the executing agency is to conduct use-focused research that generates scientific knowledge and appropriate technologies to enhance sustainable development, conservation, and efficient utilization of

Ghana's forest resources. FORIG also disseminates forestry information for the improvement of social, economic and environmental well being of the people of Ghana. Completed and ongoing ITTO assisted projects are as found below.

A.2 Infrastructure of the Executing Agency FORIG

The Institute's permanent offices and laboratories are located at Fumesua, near Kumasi. It has research centers at Bobiri and Amantia both in the Moist, Semi-Deciduous Forest Zone, Benso in the Wet Evergreen Zone, and Bolgatanga in the Savanna Zone. There are also research stations at Subri, Afram, Pra-Anum Area, Main Northern Grassland and BiaTano and Asenanyo. The laboratories of the Institute have a wide range of equipment for research and development. They include impregnation plants, seasoning kilns, wood testing machines, steam generators, microscopes, growth chamber and UV spectrophotometer. The Institute's library facilities include a CD-ROM workstation and The CD compiled by CAB International.

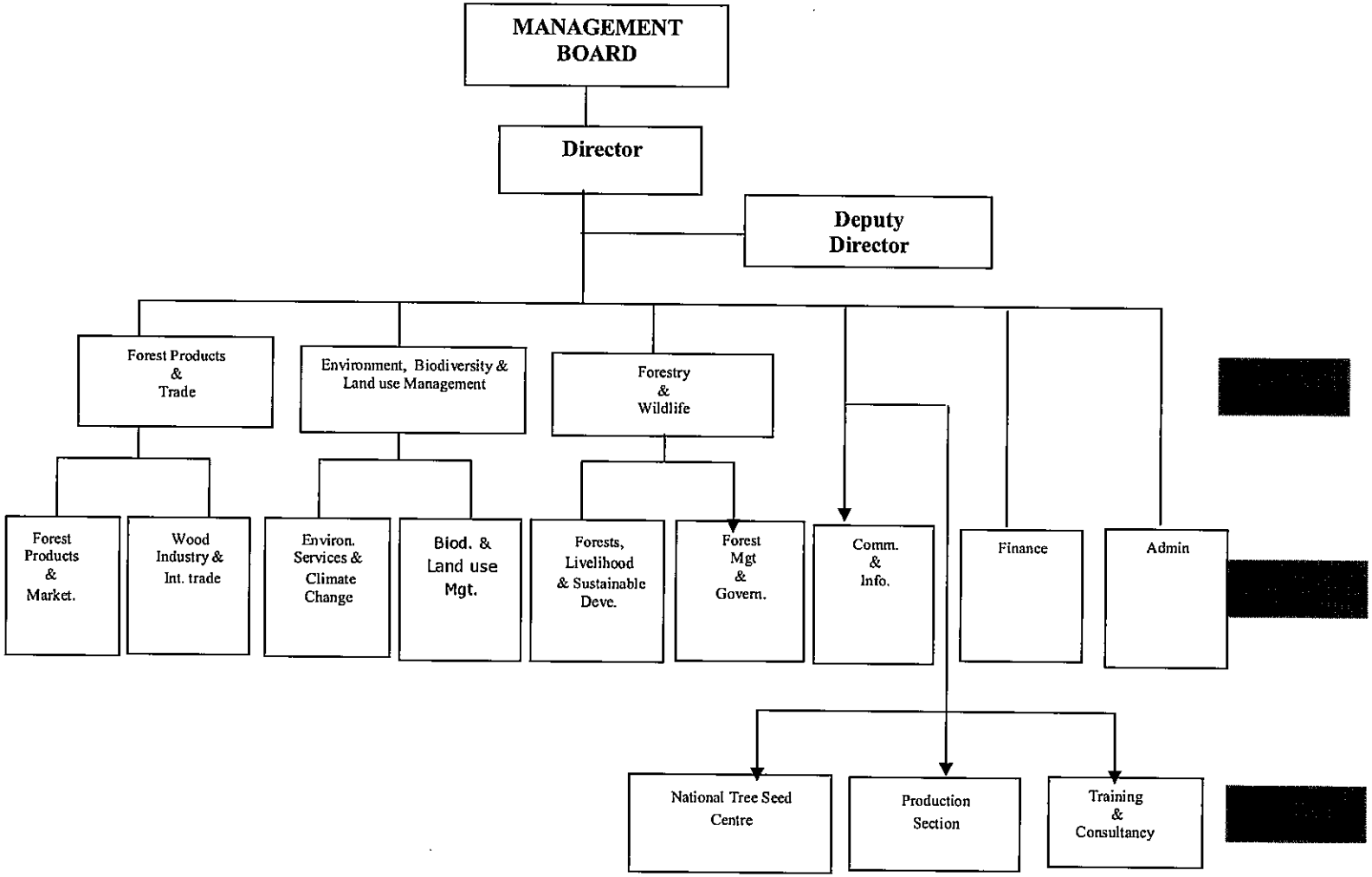
A.4 FORIG Personnel

Quantitative experts with post-graduation degrees	-	29
Quantitative experts with graduation degrees	-	9
Quantitative of middle level technicians	-	33
Quantitative of administrative personnel	-	21
Total number of FORIG personnel in forestry-related fields	**-**	**71**

RECENTLY COMPLETED AND ON-GOING ITTO ASSISTED PROJECTS AT FORIG

PROJECT TITLE	Project Number	VALUE OF PROJECT	COLLABORATING INSTITUTIONS	Status
1. Handbook on tree and wood identification of 100 lesser-used and lesser-known timber species from Tropical Africa with notes on Ethnography, silviculture and uses.	PD044/98 Rev. 2	$287,000	Swiss Federal Institute of Technology, Zurich (SFIT).	Completed
2. Silviculture and economics of improved natural forest management in Ghana ITTO PD 41 98 Rev. 1 (F)	PD0 41/98 Rev.1 (F)	$428,006	Forestry Department, Institute of Renewable Natural Resources (IRNR), Ghana Timber Millers Organization, University of Aberdeen, Scotland, Ghana Fire Service	Completed
3. Rehabilitating degraded forest through local community collaboration	PD030/97 Rev. 6 (F)	$272,000	Forestry Department Institute of Renewable & Natural Resources, UST.	Operational
4. Development of energy alternatives for the efficient utilization of wood processing residue: Co-Generation and Briquette production	PPD053/02 Rev. 1 (I)	$87,802		Completed
5. Investment promotion and enterprise development of the timber industry in Ghana	PPD063/02	59.300	FORIG, GTA, GTMO, Forestry Commission, FAWAG	Operational
6. Fire-management and post-fire restoration with local community collaboration in Ghana	PD284/04 Rev. 2(F)	731,925	IUCN, FORIG	Operational
7. Alternative mixed plantation systems and restoration strategies for conservation and sustainable production of native timber species in Ghana	Pd256/03 Rev. 1(F)	433,964	FORIG, Northern Arizona University	Operational
8. Towards sustainable timber production in Ghana: Stage 1. Improving shoot borer resistance and developing silvicultural systems to maximize mahogany plantation success.	PD105/01 Rev. 3 (F)	588,601	FORIG, Michigan Tech	Operational
9. Timber of tropical Africa Part1: Group7(1) within the PROTA programme	PD 264/04 Rev. 2(M.I)	1,654,487	PROTA, Government of Ghana, Gabon, The Netherlands, France and UK	Operational

ORGANIZATION STRUCTURE



Annex B
Curriculum Vitae

1. Name	**EMMANUEL OPUNI-FRIMPONG**
	Principal Investigator (Forest Entomologist/Ecologist, Project Leader)
Address	Forestry Research Institute of Ghana, UST, P.O. Box 63, Kumasi, Ghana
Position:	Research Scientist

Education

B.Sc. (Hons) Natural Resources	University of Science and Technology, Kumasi, Ghana (1994)
M.Phil Siviculture & Forest Mgt.	University of Science and Technology, Kumasi, Ghana (Awarded 2001)
	Awarded AAS Research Grant for M.Phil research in mahogany shoot borer (1997-2000)
Ph.D. (Forest Science)	Michigan Technological University, USA (2006)

Research Experience

Co-Principal Investigator of ITTO Project PD105/01Rev.3: "Towards Sustainable Timber Production in Ghana: Stage I. Improving Shoot Borer Resistance and Developing Silvicultural Systems to Maximize Mahogany Plantation Success"2005-2009. Principal Investigator on African Forestry Research Network Project entititled "Development of an integrated strategy for reduction of shoot borer impact on African mahogany in the tropical humid forest of Africa" 2000-2002. Butterfly diversity in sacred forest groves of Ghana. Funded by The National Geographic. 2001-2003.The potential use of insect pathogenic viruses to control mahogany shoot borer in the genus *Hypsipyla* (Lepidoptera: Pyralidae). Funded by ODA. 1995-1997. Shoot borer; *Hypsipyla robusta* (Lepidoptera: Pyralidae) damage to growth and survival of native Meliaceae (African Mahogany). Funded by the African Academy of Sciences. 1997-1999. Survey of plants with potential insecticidal properties used for traditional preservation of grains and legumes in the moist-semideciduous zone of Ghana. Funded by ODA.

Selected Publications

Opuni-Frimpong, E., Karnosky D.F., Storer A.J., Abeney E.A., and Cobbinah J.R. 2008. Relative susceptibility of four species of African mahogany to the shoot borer *Hypsipyla robusta* (Lepidoptera: Pyralidae) in the moist semi-deciduous forest of Ghana. Forest Ecology and Management, 255: 313-319.

Opuni-Frimpong E., Karnosky D.F., Storer A.J., and Cobbinah J.R. 2008. Silvicultural systems for plantation mahogany in Africa: Influences of canopy-shade on tree growth and pest damage. Forest Ecology and Management, 255: 328-333.

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Ofori, D.A. **Opuni-Frimpong, E.** and Cobbinah, J.R. (2007). Provenance variation in Khaya species for growth and resistance to shoot borer *Hupsipyla robusta*. Forest Ecology and Management. 242: 438-443

Opuni-Frimpong E. (2006) Improving productivity and conservation of African mahogany: genetic selection, propagation and silvicultural management of *Hypsipyla robusta* (moore). Ph.D. Thesis submitted to the Graduate School of Michigan Technological University, September 2006,176pp.

Bossart, J. L., **E. Opuni-Frimpong**, S. Kuudaar and E. Nkrumah (2006) Richness, abundance, and complementarity of fruit-feeding butterfly species in relict sacred forests and forest reserves of Ghana. *Biodiversity and Conservation*.. 15: 333-359.

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Apetorgbor, M. M., Darkwa, N.A., **Opuni-Frimpong. E.** and Agyman, V.K. (2004). Biodeteriorating agents associated with three tropical timber species. Forest Ecology and Management. 195 311-323

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2. Name ANDREW STORER (Co-Principal Investigator)

Address: School of Forest Resources and Environmental Science, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan, 49931

EDUCATION:

D.Phil. Department of Zoology, University of Oxford. Forest Entomology.
M.A. St. Anne's College, University of Oxford.
B.A. (Hons) Pure and Applied Biology. St. Anne's College, University of Oxford.

CURRENT POSITION:

2001 – Present Assistant Professor, Forest Insect Ecology, School of Forest Resources and Environmental Science, Michigan Technological University

Teaching: Forest Entomology and Pest Management, Insect Ecology

Research: Insect/fungus/plant interactions in forest ecosystems
Impacts of exotic species on forest ecosystems
Interactions among fire, insects and disease in forests
Urban forest health.

Service: Curriculum Committee, Charter Revision Committee (Chair), Ecosystem Sciences Search Committee (Chair), School of Forestry and Wood Products

EXPERIENCE:

1998 - 2001 Assistant Research Entomologist, Division of Insect Biology, University of California, Berkeley.
1999 - 2001 Instructor, Department of Landscape Horticulture, Merritt College, Oakland.
1992 - 1997 Postdoctoral Researcher, Division of Insect Biology, University of California, Berkeley.
1990 - 1991 School Teacher, Oundle School.
1986 - 1991 Research Student, University of Oxford. Thesis title: Host exploitation in Scolytidae
1986 - 1990 University Teaching, Department of Zoology, University of Oxford.
1988 - 1989 Wiener-Anspach Research Fellowship, University of Brussels, Belgium.
1984 - 1986 Forestry Consultant, Crichton-Maitland and Co., Hereford, England.

Relevant Papers (of nearly 70)

Opuni-Frimpong, E., Karnosky D.F., Storer A.J., Abeney E.A., and Cobbinah J.R. 2008. Relative susceptibility of four species of African mahogany to the shoot borer *Hypsipyla robusta* (Lepidoptera:

Pyralidae) in the moist semi-deciduous forest of Ghana. Forest Ecology and Management, 255: 313-319.

Opuni-Frimpong E., Karnosky D.F., Storer A.J., and Cobbinah J.R. 2008. Silvicultural systems for plantation mahogany in Africa: Influences of canopy-shade on tree growth and pest damage. Forest Ecology and Management, 255: 328-333.

Opuni-Frimpong E., Karnosky D.F., Storer A.J., and Cobbinah J.R. 2008. Key roles of leaves, stockplant age, and auxin concentration in vegetative propagation of two African mahoganies: *Khaya anthotheca* Welw. and *Khaya ivorensis* A. Chev. New Forests 36, 115123

Storer, A.J., D.L. Wood and T.R. Gordon. 2002. Effects of pitch canker pathogen on gallery excavation and oviposition by *Ips paraconfusus* (Coleoptera: Scolytidae). *The Canadian Entomologist.* 134: 519-528.

McNee, W.R., D.L. Wood, A.J. Storer and T.R. Gordon. 2002. Insect and pathogen survival in intact and chipped Monterey pine (*Pinus radiata*) branches infected with the pitch canker pathogen, *Fusarium circinatum. The Canadian Entomologist* 134: 47-58.

Bonello, P., T.R. Gordon and A.J. Storer. 2001. Systemic induced resistance in Monterey pine. *Forest Pathology.* 31: 99-106.

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Bonello, P., W.R. McNee, A.J. Storer, D. L. Wood and T. R. Gordon. 2001. Role of olfactory stimuli in host location by twig beetles (Coleoptera: Scolytidae). *Ecological Entomology.* 26: 8-15.

McNee, W.R., D.L. Wood and A.J. Storer. 2000. Pre-emergence feeding in bark beetles (Coleoptera: Scolytidae). *Environmental Entomology* 29: 495-501.

Storer, A.J., P. Bonello, T.R. Gordon and D.L. Wood. 1999. Evidence of resistance to the pitch canker pathogen (*Fusarium subglutinans* f. sp. *pini*) in native stands of Monterey pine (*Pinus radiata*). *Forest Science* 45: 500-505.

Storer, A.J., D.L. Wood and T.R. Gordon. 1999. Modification of co-evolved insect-plant interactions by an exotic plant pathogen. *Ecological Entomology* 24: 238-243.

3. Emmanuel EBANYENLE
POSTAL ADDRESS: P.O. Box 63, KNUST, Kumasi-Ghana, (official)
P.O. Box 937, KNUST, Kumasi-Ghana, (Private)
TELEPHONE: (233) 0208121968
EMAIL ADDRESS: ebanyenle@csir-forig.org.gh

EDUCATIONAL QUALIFICATIONS

1999-2003 M. Phil., (Wood Science) Institute of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
1993-1997 B.Sc. (Natural Resources Management, Forestry option), University of Science and Technology, Kumasi, Ghana.

OTHER TRAINING

I have undertaken several short courses including scientific data management, wood anatomy, bamboo technology, project management and computer soft ware applications in Japan, France, Germany, Holland, China and Nigeria.

MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS

- Member of International Association of Wood Anatomists (IAWA)
- Member of Ghana Institute of Foresters (GIF)

WORK EXPERIENCE

2005 to present Participating scientist for plant resources of tropical Africa (PROTA) on timbers
2003 to present Research Scientist, Forest Products and Marketing Division, FORIG.
1999-2002 Research Assistant, Wood Anatomy Section, Forestry Research Institute of Ghana, (FORIG) Kumasi, Ghana.

POSITION OF RESPONSIBILITY

Feb-June, 2008: Acting Head, Forest Products and Marketing Division, FORIG
October 2007 to date: Acting Head, Wood Anatomy Laboratory
April' 2006 to present: Scientific Liaison Officer to Ghana national Bamboo and Rattan Development Programme (BARADEP), ministry of lands, forestry and mines (MLFM),
2005-2007 ***National Secretary***, Ghana Institute of Professional Foresters

WORKSHOP/SERMINAR ATTENNDED

I have attended 20 local and international workshops.

RESEARCH EXPERIENCE

1. Towards Sustainable Timber Production in Ghana: Stage I. Improving Shoot Borer Resistance and Developing Silvicultural Systems to Maximize Mahogany Plantation Success. (Sponsored by ITTO)

2. Clark Sustainable Resources Developments (CSRD) Wood Identification Project (sponsored by CSRD, 2007 to date): Identification of submerged wood in the volta lake of Ghana
3. Sustainable Development of Bamboo Resources of Ghana and Togo (Sponsored by AFORNET, 2004 -2006)
4. Tree and Wood Identification of 100 Lesser-Used and Lesser Known Timber Species from Tropical Africa with Notes on Ethnography, Silviculture and Uses (sponsored by ITTO, 2000-2007)
5. African Rattan Research Programme (ARRP), R7636 Forestry Research Programme (sponsored by DFID, 2000-2004)
6. A Socio-Economic Survey of Rattan Producion-to-Consumption Systems in Ghana (sponsored by INBAR, 1999)
7. Protection of Lesser-Used Promotable White Timbers of Ghana against Sapstain and Borer Infestation. (Sponsored by TEDB, 1999)

PUBLICATIONS

I have 22 publications which include referee journal papers, contribution to books, conference papers and posters.

Annex C: Terms of Reference for Consultants

Forest Entomologist/Forest Health Consultant

A Forest Entomologist/Forest Health consultant with expertise in integrated pest management and chemical ecology will be engaged by the executing agency to assist with and among other responsibilities, the planning of project activities, design of field experiments, insect behavioural analysis, revision of reports/publications and serve as Co-Principal advisor of PhD student on the project.

Experience: The consultant will be a senior professional with at least 5-10 years teaching/research experience in forest health. He or she should have at least 1-3 years experience in research in tropical Africa and have fair knowledge on the mahogany shoot borer problem.

Duties:

1. Assist with planning, design and execution of all project activities
2. Serve as co-principal investigator on the project and take a lead role in planning and development of protocol for assessing field experiment.
3. Help develop integrated pest management strategy for mahogany pest
4. Provide expertise in chemical ecology.
5. Provide expertise on statistical analysis of project data.
6. Assist in the preparation and/or revision of technical reports and publications.
7. Serve as the co-principal investigator of PhD student

Duty Station, Cost, Duration, etc: He/She will be paid a consultancy fee of USD4, 000.00 per month in addition to USD2,500.00 to cover round trip airfare from the USA each year during the project period. He will be required to travel to Ghana during project initiation to meet with the project team, assist with planning and design of field plots, involve in identifying project sites, recommend interventions for project shortfalls and provide expert advice for smooth running of the project. The project leader shall give additional assignments, which may require his input that may come up as the project is being implemented.

Socio Economic Consultant

A Socio Economic consultant will be engaged to assist with and among other responsibilities, identify the socio economic implications of the project to the stakeholders, the planning of

project activities and how it can benefit the people of Ghana, revision of reports/publications. And the best way to disseminate project results in so as to have maximum impact

Experience: The Socio Economic consultant with 5-10 years research/teaching experience in Ghana. The person should have good knowledge of the Ghanaian social structure and has demonstrated that she/he can interact with the local communities in Ghana.

Duties

1. To design activities for evaluation of socio economic implication of the project
2. Develop strategies for dissemination of project results to the people
3. Provide expertise in economics of community plantation establishment
4. Assist in the preparation and/or revision of technical reports and publications.
5. Economic analysis of project implementation

Duties station, cost duration, etc: He/She will be paid on a contract bases with maximum of $4000 per year through out the project period. She will be responsible for evaluating the socio-economics of the integrated plantation establishment strategies used, dissemination of project results, economics of project implementation, planning and design of project to have impact. The project leader shall give additional assignments, which may require his input that may come up as the project is being implemented.

ANNEX D. Brief Profile of SAMARTEX

Samartex was created in 1995 when the company was formed and purchased the assets of African Timber and Plywood Ltd (A.T. &P), which at the time were operating under state ownership. A.T. &P had existed under various owners since its creation in 1947 under the UAC group of companies. At the time of acquisition the company was literally in ruins, and there followed an intense period of investment, renewal and recruitment, which continues to this day. Indeed, looking at the company today it is almost impossible to visualize the tremendous change that has been brought about.

The forest operations have also advanced tremendously. Changes in technology and equipment as well as investment in personnel have resulted in massive improvements in production levels and planning. There is now much more emphasis on environmental and social considerations. Samartex Timber and Plywood Company Ltd (SAX) concessions, in which log production takes place, take the form of concessions leased for a period of forty years. These former A.T. & P. concessions were renewed over the first two years of SAX existence, and are now in the process of being converted to Timber Utilization Contracts (TUCs). The concessions are a mixture of Forest Reserves and Off-Reserve concessions. The Forest Reserves are contiguous blocks of forest cover, which were demarcated and set aside for silvicultural use by the then colonial Forest Service. There Forest Reserves consist of fourteen separate leases for separate (albeit sometimes adjoining) forests totaling 158,960ha. The Off-Reserve concessions have not been managed for silvicultural use; instead the national policy has been of conversion to farmland. These concessions (of which SAX has four) do not have the same contiguous cover or stocking levels as the Reserves, and the area is much smaller (32,269ha). The company has maintained these leases with a view to long-term agro forestry projects being implemented in these areas to try and safeguard existing forest estate currently under threat from farming activities.

The company is located in the small town of Samreboi (which is in the center of the concessions). This is the headquaters of the company and comprises the administration center, as well as the timber processing facilities of Ply mill, Sawmill, Veneer Mill, Kiln Drier sheds and Carving section. A garden furniture line is also being implemented. The company also maintains offices in Takoradi and Accra for shipping, importing, banking and logistical purposes.

SAX employs around 2,500 workers in total, the overwhelming majority of whom are living and working in Samreboi town. These workers are largely housed in company accommodation with access to healthcare and educational facilities as well as portable water and electricity all of which is provided by the company. The area is extremely rural and isolated and a lot of development functions in the area are borne by the company (road infrastructure maintenance etc.).

As mentioned earlier, SAX does not own the concessions but rather leases them from the Ghana Government who in turn administers the land on behalf of the owners (Chiefs who own the land on behalf of their people). The Forestry Commission (FC) executes the administration of these concessions. The company pays royalties from timber production to the FC who in turn takes off monies for administration and then pass the remaining proceeds down to the District Assemblies (Local Government) and to the 'Stool'. In addition Social Responsibility Agreements (a statutory obligation under the Timber Resources Management Act) must be in place between the traditional owners (i.e. community) of each concession and the company. These agreements ensure that an additional 5% of the royalty revenue is paid by the company and channeled into local development projects.

The company exports products all over the world as well as limited local sales and overland exports to other West African countries. From almost the inception of the company, it was recognized that it is not in the company's interests to stake the future entirely on traditional timber products. This ethos has led to the establishment of a unique carving section making use of waste tree parts as well as other natural materials. The company also is pioneering artificial sweetener extraction from *Thaumataucoccus danielli* (a local abundant NTFP fruit) as well as actively researching essential oil and medicinal plant usage. Fruit production and processing are also areas that Samartex envisages as areas of future diversification, as are eco-tourism ventures. Long-term timber resource security is also a priority and is based on the success of the Agro-forestry project set up by the company in a nearby village. Plantation development (under planted with NTFPs) is also an area of activity. All these diverse activities aim to safeguard the future viability of the company, which is so vital to the local economy of the area. The Samartex strategy is simply sustainability in an environmental, social and economic context.

Expert Panel Recommendations and Actions Taken

Specific recommendation	Response
1. Improve the problem tree by redefining the core problem as follows: *"existing silvicultural toolkit is inadequate to promote quality indigenous mahogany plantations through the production of quality planting stock and reduction of damages by shoot borer and"* and other relevant elements of the problem tree;	The problem tree has been improved by redefining the core problem as recommended. (page 10)
2. Subsequently to the first specific recommendation, develop an objective tree in accordance with the redefined problem tree in order to clearly picture the link between the problem to be addressed and the outputs and activities. The core problem, main causes, and sub-causes should correspond to the specific objective, outputs and activities respectively;	An objective tree has been developed in accordance with the redefined problem tree and it clearly pictures the link between the problem to be addressed and the outputs and activities. The core problem, main causes, and sub-causes correspond to the specific objective, outputs and activities respectively. (page 11)
3. Further elaborate the social aspects by explaining how the communities will benefit from the outcomes of the project and will be involved in the project implementation;	The social aspects have been explained by explaining how the communities will benefit from the outcomes of the project and their involvement in the project implementation. (page 21)
4. Improve the risk analysis by taking the assumptions mentioned in the logical framework matrix into account and identify related mitigation measures;	The risk analysis has been improved. (pages 21, 22)
5. Improve the logical framework matrix by adding measurable indicators for outputs 2 through 6;	The logical framework matrix has been improved. (page 24)
6. Present the work plan table in accordance with the *ITTO Manual for Project Formulation*, while mentioning the entire title of each activity;	The work plan table has been presented as recommended. (page 30)
7 Further elaborate the section regarding the project steering committee (PSC), in the operation arrangement, by describing the role of each member of the PSC;	The project steering committee (PSC) section in the operation arrangement has been elaborated by describing the role of each member of the PSC. (page 38)
8. Indicate clearly Michigan Technological University (MTU) and SAMARTEX Company as collaborating agencies, as they are contributing to the project budget and activities;	Michigan Technological University (MTU) and SAMARTEX Company have been clearly indicated as collaborating agencies. (cover page)
9. Revise the ITTO budget in accordance with the above overall assessment and specific recommendations and also in the following way:	The ITTO budget has been revised as recommended. a) A list of quantity and unit costs of

a) Include a list of quantity and unit costs of inputs (see page 22 of the *ITTO Manual for Project Formulation*), b) Reduce the costs regarding the vehicle and the maintenance of field plots, c) Recalculate the ITTO Programme Support Costs (Sub-component 83) specified in the budget so as to conform with new standard rate of 8% of the total ITTO project costs, as decided by the 35th ITTC Session; and	inputs has been included. (pages 25 to 29) b) The costs regarding the vehicle and maintenance of field plots have been reduced. c) The ITTO Programme Support Costs (Sub-component 83) specified in the budget has been recalculated to conform with the new standard rate of 8% of the total ITTO project costs, as decided by the 35th ITTC Session; and (pages 31 to 35)
10. Include an Annex that shows the overall assessment and specific recommendations of the 37th Expert Panel and respective modifications in tabular form. Modifications should also be highlighted (**bold and underline**) in the text.	This table. Modifications are highlighted as recommended except for the list of quantity and unit costs of inputs which is only in bold.

MEMORANDUM OF UNDERSTANDING

Between

FORESTRY RESEARCH INSTITUTE OF GHANA (FORIG)

And

SAMARTEX TIMBER AND PLYWOOD COMPANY

1. AGREEMENT TITLE:

Implementation of ITTO project: PD105/01/Rev.3 (F): entitled: 'Towards Sustainable Timber Production in Ghana: Stage1: Improving Shoot Borer Resistance and developing silvicultural Systems to maximize mahogany Plantation Success".

2. CO-OPERATION ORGANIZATIONS

The Forestry Research Institute of Ghana (hereafter referred to as FORIG) and SAMARTEX Timber and Plywood Company (hereafter referred to as SAMARTEX).

3. COMMENCEMENT AND DURATION

The agreement shall remain in force for a period of four (4) years commencing by the signing of this document, with the option of renewal and variation prior to the termination by joint consent of both parties.

4. BACKROUND OF THE AGREEMENT

In 2004, the International Tropical Timber Organization (herein after refer to as ITTO) approved project No. PD105/01/Rev. 3(F) submitted by the Government of Ghana to be executed by FORIG, in collaboration with Michigan Technological University, SAMARTEX and Swiss Lumber Company Limited on improving Shoot borer resistance and developing silvicultural systems to maximize Mahogany Plantation success.
Additionally, the cooperation between FORIG and SAMARTEX will help to train one FORIG staff in Tropical Forest Entomology and Biotechnology. The implementation of this project coupled with the experiences gained in previous co- operations will help strengthen and develop long- term cooperation between scientists at Ghana (FORIG) and SAMARTEX

5. OBJECTIVES OF THE AGREEMENT

The objectives of the current agreement are:

1. To improve the sustainability of mahogany timber supply in Ghana by developing an integrated pest management system to minimize the adverse effect on young mahogany plantations.
2. To facilitate the training of FORIG and SAMATEX Forestry Team and technicians by qualified international researchers in Ghana, USA and third country, taking account of the need to promote North- South research co-operation and co-operation between Research and Industry to strengthen Research and Development.

3. To use the implementation of this project to strengthen the understanding between FORIG and SAMARTEX on research network so as to further formulate research needs and receive financial support from ITTO, Industry and other international donor agencies for relevant research in Ghana.

6. FINANCIAL ARRANGEMENTS.

ITTO, MICHIGAN Technological University and Government of Ghana are funding the Project. The project started January 2005 and ending February 2009.

7. RESPONSIBILITIES

1. FORIG will be responsible for all scientific and technical aspects of the co-operation to execute this project.
2. SAMARTEX will be contributing land in the Moist /Wet Evergreen Forest Zone for all experiments that will be conducted in this forest zone. Since the experiments will be on SAMARTEX property, SAMARTEX will be required to see to day-to-day maintenance of the plots during and after the 4-year period of the project life.
3. FORIG will provide all the planting material
4. FORIG project implementation team will see to planting and quarterly evaluation of all project experiments.
5. In addition to the Land and maintenance of the experiments, SAMARTEX will be expected to extend the needed support and co-operation that will make the FORIG research team feel welcome to their premises.
6. SAMARTEX will support 4 personnel of the FORIG project team to assess and evaluate the mahogany plantations once every year for a period of 4 years after the ITTO project funds is exhausted.

8. SHARING OF BENEFITS

1. FORIG will have total ownership of any scientific finding that will be gained in this study.

2. SAMARTEX will own the trees that will be planted on their land.

3. FORIG can have access to these experimental plots to collect plant material and data till the trees will be ready for harvest as will be agreed by FORIG and SAMARTEX

9. VARIATION TO AGREEMENT

Variation to this agreement will be made in writing and be signed for and on behalf of both parties to the agreement.

Signed in Kumasi (Ghana)

..... Date... 24 - 10 - 06

DIRECTOR
FORESTRY RESEARCH INSTITUTE OF GHANA
UNIV. P. O. BOX 63
KUMASI, GHANA

Director/ Project Leader

FORESTRY RESEARCH INSTITUTE OF GHANA (FORIG)

..... Date..... 13/11/06

Managing Director

SAMARTEX TIMBER AND PLYWOOD COMPANY

SAMARTEX Timber & Plywood Co. Ltd.
PO Box 1 - Samreboi
Ghana – West-Africa

Letter of Support - SAMARTEX

Samartex
Timber and Plywood Company Ltd

8th October 2008

Dr. Emmanuel Opuni-Frimpong
Forestry Research Institute of Ghana
University, P. O. Box 63
Kumasi, Ghana

Dear Emmanuel,

It is my pleasure to write this letter of collaboration on behalf of SAMARTEX to assist you in the examination of wood properties for a 40 year-old mahogany plantation grown trees at FORIG experimental station at Amantia. It is our intention to provide the personnel and equipment necessary to log the trees, bring them to our sawmill at SAMARTEX and saw them lengthwise to determine the sawing characteristics and heartwood qualities of the trees which were severely attacked by *Hypsipyla* (shoot borer) when thegwere young. We will co-operate with your project scientists to examine all the wood qualities including structural, physical and anatomical properties that we know is associated with natural forest mahogany.

We estimate that SAMARTEX contribution to your ITTO proposal for the project entitled "Towards Sustainable Timber Production in Ghana: Stage II. Improving Shoot Borer Resistance and Optimizing Silvicultural Systems to Maximize Mahogany Plantation Success" will be about $30,000

We are happy with the four years collaboration with you on the provenance and silvicultural improvement program of the African mahogany for plantation development in Ghana. We appreciate the MOU developed between SAMARTEX and the Mahogany project, which has led to a broader MOU between SAMARTEX and FORIG for our mutual benefit and sustainable forest management of Ghana's forest resources. We will support your project scientist to continue with monitoring and assessment of the research plots established under this collaboration possibly until harvesting of these trees.

Long live our co-operation.

Best regards,

.....
Mr. Kwaku Nsenkyire,
Deputy General Manager

MichiganTech
Michigan Technological University

School of Forest Resources and Environmental Science
Noblet, Hesterberg, and Horner Halls
1400 Townsend Drive
Houghton, Michigan 49931-1295
906/487-2454 1-800-WOODS-MI
Fax 906/487-2915
www.forest.mtu.edu

Andrew J. Storer
storer@mtu.edu

November 20, 2008

Dr. Emmanuel Opuni-Frimpong
Forestry Research Institute of Ghana
UST, P. O. Box 63
Kumasi. Ghana

Dear Emmanuel,

It is my pleasure to be involved in this collaborative Mahogany Plantations proposal. I am pleased that we will be able to support a PhD student involved in this project at Michigan Tech for three years as my contribution to our project (valued at $94,500). We have all the necessary laboratory access and expertise here at Michigan Tech to conduct the anatomical and wood properties analyses portion of the work as we have done similar research with observation of anatomical and wood properties of several North American tree species.

I look forward to working with you and colleagues from FORIG on this valuable project and can give you my best assurances that the Ghanaian Ph.D. student associated with my lab in this project will develop the necessary anatomy and wood properties knowledge which are key ingredients for the success of this project.

I look forward to our continued productive collaborations

Best regards

Andrew J. Storer
Associate Professor