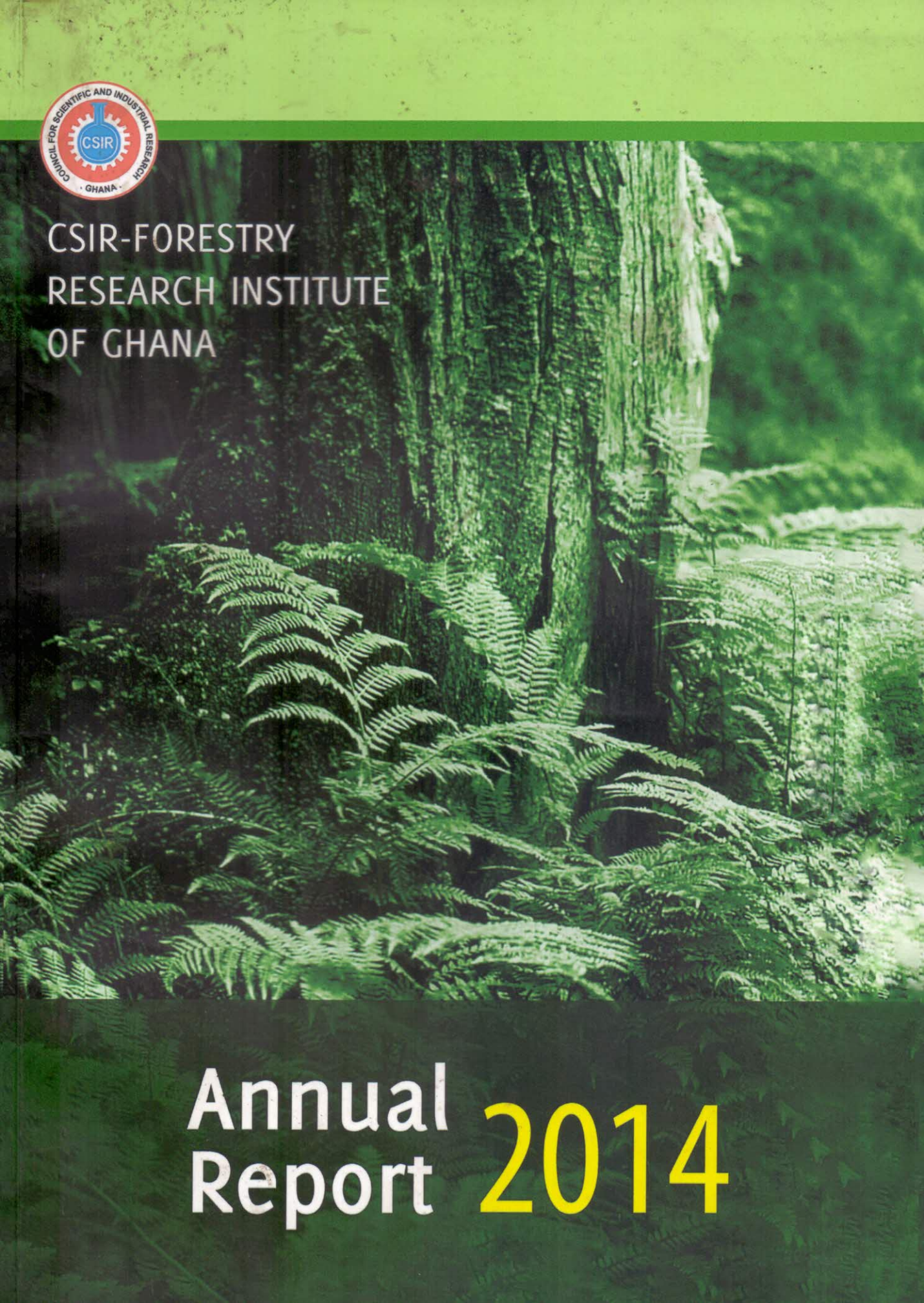

CSIR-FORESTRY RESEARCH INSTITUTE OF GHANA

Annual Report 2014

Executive Summary

In 2014, CSIR-FORIG contributed towards addressing challenges in the forestry sector by undertaking projects through multi-disciplinary teams within its core Divisions. The findings have been published in eight books and twenty two Journal papers. The total number of projects and consultancies during the year under review was twenty eight (28). The highest number was executed by the Forests and Wildlife Division followed by the Forest Industry Development Division. The focus of research activities by the former Division was primarily wildlife conservation, REDD+, DNA timber tacking, CDM forestry, *Allanblackia parviflora* and carbon use efficiency.

Forest Industry Development Division, promoted the use of bamboo and African rosewood to augment the dwindling levels of timber resources. The other major activity by the Division was to initiate the preparatory phase towards the set up of an accredited wood and furniture testing laboratory at the Institute.

Conservation and management of pollinators and measuring impact of the chainsaw milling were the two main projects implemented by the Ecosystem Services and Climate Change Division. Equally, Biodiversity and Land Use Division' focus among others included quantification of yield of *Allanblackia* from three ecological zones. Other research activities involved estimation of Ghana's wood fuel potential and the effect of climate change on regeneration and distribution of tree species in tropical forest.

Forests, Livelihood and Governance Division was primarily involved in the setting up of a national benefit sharing scheme for REDD+. The Division, in addition, studied 1. Overland export of timber from Ghana and Burkina Faso; 2. Sustainable supply system for *Allanblackia* planting material using rural resource centres.

Further studies on *Allanblackia* were handled by the Forest Products Trade and Marketing Division to aid in the identification of male and female seedlings through anatomical and morphological characteristics. Apart from *Allanblackia*, Sustainable wood fuel production and climate change mitigation in the forest-savanna transition zone was another activity that was initiated in 2013 and continued in 2014.

Commercialisation and Information Division performed a dual role of co-ordinating commercial activities and implementing a digitisation of indigenous knowledge project with the goal to identify, capture, document and digitize indigenous knowledge on forest foods and medicinal plants and to create a database. The Division also sold high quality seeds and seedlings, wood by-products, doors, windows and door frames, honey and prekese syrup etc.

In terms of training and developing the human resource of Ghana, CSIR-FORIG/UEF Graduate School which was established in 2012, currently, has a student population of twenty five (25). The School has seasoned lecturers and professors in Ghana and Finland and graduates are expected to receive a dual degree in MSc. Bio-Economy and Natural Resources Management and an Executive Master of Business Administration (EMBA). The CSIR Basic School which was also established jointly by CSIR-FORIG, CSIR-CRI and CSIR-BRRI in September 2009 could boast of a student population of four hundred and seven (407). All the above activities were carried out by the Institute through its staff strength of two hundred and sixty six (266).

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COMPOSITION OF CSIR-FORIG MANAGEMENT BOARD

1	Mr. Edward O. Nsenkyire *Former Chief Director (MESTI)*	Chairman
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4	Nana Dwomoh Sarpong *President, Ghana Timber Millers' Organisation*	Member
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6	Mr. Afari Dartey *Chief Executive, Forestry Commission*	Member
7	Ms. Comfort Darkwaah Konto *Head of Administration, CSIR-FORIG*	Secretary

1.0 INTRODUCTION

The Forestry Research Institute of Ghana of the Council for Scientific & Industrial Research (CSIR-FORIG) is one of the 13 research institutes of the CSIR. It is located at Fumesua, near Kumasi in the Ashanti Region. The mandate of CSIR-FORIG is to undertake forest, forest products and related research, disseminate and commercialize research outputs and services. To be able to successfully carry out this mandate, we have set ourselves a VISION to **"be a centre excellence and networking hub for forest and forest products research in the humid tropics"** and our MISSION is **"to conduct forest and forest products research for the social, economic and environmental benefits of society"**.

Research is primarily organized under three main programmes namely; Forestry and Wildlife, Forest Products and Trade, and Environment, Land-Use and Biodiversity. This Annual Report outlines our Institute's research activities carried out during the year 2014. It also presents key summaries on supporting activities undertaken during the year, consultancies and commercialization efforts, as well as current information on the Institute's human resource capacity, administrative and financial standing.

Twenty eight (28) on-going research projects and consultancies have been reported, all of which were executed with donor funds. Dissemination of research results were undertaken through publication in scientific journals, technical reports, books, book chapters, conference proceedings, flyers and posters. Additionally, scientists and staff of the Institute participated in a number of radio and television programmes to educate the general public on issues of forest conservation, forest management, and climate change.

In addition to research and dissemination of research results, CSIR-FORIG has been actively involved in other development activities, of which the production and supply of quality tree seeds and seedlings for plantation establishment is of significance to national development. We are a leading supplier of planting materials for forest plantation development in Ghana. We also provide technical backstopping for various aspects of forest management, especially in the areas of plantation production and rehabilitation of degraded forest areas. Further information on projects and research activities in this Annual may be obtained from the Director of the Institute or through the various publication channels.

2.1 Toward sustainable supply system of *Allanblackia* planting material: An assessment of the Rural Resource Centres (RRC) Model

Project Team: Dumenu, W.K., Ofori, D.A., Mensah, M., and E.A. Opoku
Start Date: December 2013
Expected Completion Date: March 2014

Introduction

Currently, the prospective market demand for *Allanblackia* oil is estimated at over 100,000 tons/year with the potential to exceed 200,000 tons a year. Harvesting fruits of wild *Allanblackia* species only in countries within its endemic zones such as Ghana, Nigeria, and Tanzania cannot meet this demand. Present estimates show that these countries together supply a paltry total of 210 tons/year. To address this and the challenges of over-exploitation and decreasing *Allanblackia* abundance in the forests, ICRAF and its partners from the public and private sector have been domesticating the species since 2002 using a participatory tree domestication approach. The program includes community sensitization, exploration, participatory selections of superior mother trees, conservation in field gene banks, development of agroforestry systems with *Allanblackia* (AB) and market development. The objective is to establish a sustainable supply system of quality AB planting materials for domestication and support of rural livelihoods using participatory tree domestication approach modelled by the Rural Resource Centre. The RRC model has been piloted in the above mentioned producing countries. After several years of application of the model, it is necessary to assess the performance of the model in meeting the intended objectives. For instance, answers to the following questions are imperative:

- What is the level of knowledge on the quality of germplasm production?
- Is the current mode of germplasm distribution efficient?
- What is the role of gender in AB germplasm production and distribution?
- What are the challenges encountered in the use of RRCs as a hub of AB germplasm dissemination?

Objectives

- Determine the level of knowledge of AB chain of production (propagation, cultivation, germplasm source).
- Assess the role of RRCs in AB planting materials supply system.
- Provide recommendation for improving the efficiency of AB planting materials supply system.

Methodology

The study was conducted in ten communities in Ghana namely: Dikoto, Samang, Wassa-Kumasi, Konkoso, Krofofrom, Awona, Gyedua, Dikoto-Junction, Amoakokrom and Adjeikrom. The communities are located in New Edubiase and Wassa Akropong political districts where

RRCs were established. In all, 84 respondents took part in the study. Participatory research approach namely; key informant interviews, focus group discussions and administration of questionnaires were used in data collection. The key informant interviews explored information on the role of RRCs in AB planting materials supply system, training of farmers, gender involvement in the production and supply of AB planting materials, and challenges encountered in the implementation of the RRC model. The questionnaires together with the focus group discussions sought information on knowledge of AB planting materials production, effectiveness of the RRCs, challenges faced, and benefits or otherwise of the role of RRCs.

Results

Role of RRC in building capacity for AB propagation and cultivation: the role of RRCs was prominent in building the capacity of farmers in AB propagation and cultivation particularly in selection of quality planting materials, seedlings management and how to establish and operate independent (satellite) nurseries. As many as five different knowledge-based/ practical skills were acquired by about 200 farmers during several training and capacity building workshops conducted at the RRCs in New Edubiase and Wassa Akropong. Overall, ten satellite nurseries were established within New Edubiase and Wassa Akropong Districts.

Efficiency and effectiveness of RRC in supply of AB planting materials: RRCs were less efficient in the supply of adequate planting materials to farmers. In terms of supply of AB planting materials, only 16% (about 10,000 planting materials) of the demand for planting materials by farmer groups in participating communities was met by the RRCs. Logistical constraint and ineffective planning contributed to RRCs inability to adequately supply planting materials to farmers.

Gender involvement in the production of AB planting materials and cultivation: more men than women were involved in AB propagation and cultivation. The main reason limiting women's participation was land tenure system. Ownership of farmlands influenced access to farmlands as well as who has the final say as to what can be cultivated on the land. In the project areas, more men had ownership rights to land than women. As a result, women's limited position in relation to land ownership constrained them from engaging in AB cultivation particularly when the male authority in the household did not consent to its cultivation.

Challenges encountered in supply of AB planting materials: the most frequent challenges encountered in supply of AB planting materials were inadequate production of planting materials by RRC nurseries, lack of incentives, limited financial assistance and limited communication between farmers and domestication officers as the project wore on.

Toward a sustainable supply system of AB planting materials: for sustainable supply system of AB planting materials, it is important that the operation of RRC is modified in response to the challenges encountered. Other necessary steps such as diversification of seedling production at the RRCs and provision of services with the view to securing additional funds for its operation, provision of incentives to AB farmers and development of an operational plan for seedling production are critical in ensuring sustainable supply of AB planting materials.

Conclusion

Overall, RRC has been instrumental in training and capacity building of farmers in AB propagation and cultivation. However, its effectiveness in supply of AB planting materials for cultivation on farms and establishment of satellite nurseries needs to be improved. Limited financial capacity, inadequate planting materials production to meet farmer demand and limited communication with farmers were factors that influenced RRC ineffectiveness in the supply of AB planting materials.

2.2 Setting up a national architecture/scheme on benefit sharing for REDD+ implementation process in Ghana

Project Team: Dumenu, W.K., Obeng, E.A., Samar, S.B., Oduro, K.A., Mensah, J.K., Derkyi, M. and S. Pentsil

Start Date: December 2013

Expected Completion Date: March 2014

Introduction

Reducing Emissions from Deforestation and Forest Degradation (REDD+) including the role of conservation and sustainable management of forests is an effort to offer incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ activities do not only contribute to emission reductions, but brings about financial and other co-benefits which need to be distributed across a wide range of stakeholders linked to deforestation and degradation, sustainable forest management and forest regeneration. Ghana's REDD+ Readiness Preparation Proposal (R-PP) emphasizes among others equitable benefit sharing as a critical component in the preparation toward effective REDD+ implementation. The challenges facing Ghana in developing an effective, efficient and equitable benefit sharing mechanism for REDD+ are those that relate to land/tree tenure, carbon rights definition, determination of benefit distribution mechanism, management of the benefit sharing process (transparency and accountability), determination of beneficiary stakeholders and dispute/conflict resolution mechanism. To address these issues, the Institute was commissioned by the Forestry Commission of Ghana to undertake a study with the goal of providing recommendations to address issues of land/tree tenure, carbon rights and benefit sharing critical for the implementation of REDD+ in Ghana.

Objectives

Conduct an in-depth literature review, with a particular focus on:

- Mapping institutional and legal framework for REDD+ implementation and recommendations.
- Linkages between carbon rights, and land and tree tenure and mechanisms on how to address the allocation of derived rights and their allocation (for tenant farmers and sharecroppers).
- Review of current benefit sharing and incentive programmes promoting forest management and conservation in Ghana.
- Develop Options paper on benefit sharing mechanisms and social accountability for Ghana taking into consideration the analysis conducted under Phase 1 and present an overall guidance on how to establish such benefit sharing arrangements.

Methodology

Two main approaches were adopted for executing the study namely: desk and field studies. The desk study focused on gathering existing relevant literature and background information on benefit sharing mechanisms in Ghana, gaps and challenges of implementing an equitable benefit sharing mechanism, access-right system and other institutional arrangements critical for implementing a benefit sharing mechanism. It also reviewed experiences and lessons from voluntary partnership agreement (VPA) process, mining sector and management

of local development funds. The objective of the field study was to determine stakeholders' perspectives on options of equitable benefit sharing schemes, safeguards to prevent elite capture, potential areas for inter/intra community conflicts and resolution mechanisms.

Results

Review of existing benefit sharing mechanisms: Four different forms of benefit sharing arrangements exist in Ghana's forest sector. These include; Constitutional Timber Revenue benefit sharing, Modified Taungya System benefit sharing, Commercial Plantation benefit sharing and Community Resource Management Area (CREMA) benefit sharing variants. Other forms of benefit sharing arrangements in the agricultural sector are: Traditional share contract (sharecropping) benefit namely, Abunu and Abusa.

Land/tree tenure, derived and carbon rights in Ghana: Ghana's land tenure regime is complex and legally pluralistic. It is such that land is owned by one entity but ownership and access to some resources such as trees are held by another entity. Also, both customary and statutory laws govern land tenure in Ghana. The legally pluralistic governance system governing land tenure in Ghana and the vesting of naturally occurring timber trees in the State pose some difficulties for REDD+ implementation. For effective implementation of REDD+, land and tree ownership should be aligned while harmonization or legal integration of the two land tenure regimes (customary and statutory) is pursued. The existing tree tenure should be reformed such that ownership of naturally occurring timber trees are vested in persons or entities with management, exclusion and alienation rights to trees and land. A category of stakeholders whose activities are critical to the implementation of REDD+ in Ghana are *tenant farmers* and *sharecroppers* in off-reserve areas. Tenant farmers and sharecroppers do not exercise full range of property rights like their respective landowners unless their land holdings were acquired through outright purchase. Rather, they exercise *derived rights or secondary rights* as a result of their tenancy or contract. To address the challenges that *derived right* holders (tenant farmers and sharecroppers) face in the implementation of REDD+, there should be strive toward legal documentation of tenancy or contract between tenant farmer/sharecropper and the landowner. The agreement should acknowledge the derived rights of the tenant or sharecropper and stipulates the formula for sharing REDD+ benefits between the landowner and the tenant farmer/sharecropper. The same would apply to benefits that accrue from existing trees maintained by a tenant farmer or sharecropper. The role of forests in climate change mitigation has brought about a new form of property right – carbon rights. There is no legislation in Ghana that defines and allocates rights to carbon hence the need to consider definition of carbon rights for REDD+. Consistent with the proposed tree tenure reform where ownership of naturally occurring timber trees are vested in persons or entities with management, exclusion and alienation rights to trees and land, carbon should be defined as tied to sinks (trees, soil or land). Consequently, persons or entities that exercise the aforementioned range of rights would be vested with carbon right.

Proposed REDD+ benefit sharing mechanism (BSM) and its institutional framework: Benefit sharing mechanisms involve a variety of institutional means, governance structures and instruments for distributing finance and other benefits. The various institutions to deliver and manage REDD+ benefits under the proposed REDD+ benefit sharing mechanism include: *Multi-stakeholder Governing Body (MGB); Project Implementation Body (PIB); Independent Monitoring and Audit Group (IMAG); National Carbon Fund* and *REDD+ Registry*. The broad institutional set-up fashioned after a *nested approach,* description of role/functions and proposed membership of the institutions are intended to guide the establishment of BSM for REDD+ implementation in Ghana.

Benefit sharing models for REDD+: Three existing benefit sharing schemes and a proposed fund-based benefit sharing scheme were recommended for adoption for REDD+. The existing benefit sharing models include CREMA, MTS and Commercial forest plantation development benefit sharing. These benefit sharing models address elements of equity, effectiveness, co-benefits and safeguard measures that can support REDD+ benefit sharing mechanism. Community revolving fund was proposed as a fund-based benefit sharing scheme for REDD+. It has the potential to support participating stakeholders in planting and maintenance of trees and to enable beneficiaries to engage in economically viable income generating activities.

REDD+ conflicts/disputes and resolution mechanism: The potential of REDD+ funding to increase the value of standing forests may fuel already on-going conflicts over land ownership in forest areas. Hence, strong safeguards and formal complaint mechanisms linked to REDD+ would help ensure good results for all. The establishment of independent grievance and redress mechanisms at local and national levels would foster accountability and may help reduce conflicts among stakeholders. REDD+ conflict resolution process at the local level should adapt the existing traditional system of mediation at the Chiefs' palace. The Chiefs will need support from a conflict management team composed of representatives of farmer groups, unit committee/assemblyman, the Forestry Commission (FC), religious leaders and a legal person from the government. The Traditional Authority (i.e. chief and elders) must lead in the entire conflict management process with assistance from the unit committee/assembly person and the FC official.

Conclusion

Lessons and experiences from the forest and mining sectors among others have indicated that Ghana could effectively implement REDD+ by addressing key governance gaps such as those relating to tenure, carbon rights, conflict/dispute resolution, accountability and transparency.

2.3 Overland export of timber from Ghana: studies from Ghana and Burkina Faso

Project Team: Marfo, E., Owusu, F.W., Karambiri, M., Adeyiga, G. and S. Akpalu

Start Date: January 2014

Expected Completion Date: December 2014

Introduction

The policy context for this study is that there is increasing efforts in Ghana to address illegal logging and milling and to secure the supply of legal timber to the domestic market. Ghana and the EU under the FLEGT VPA have a commitment to ensure that not only timber exported but those on the domestic markets are also sourced, processed and traded legally. TBI-Ghana, the Forestry Commission and CSIR-Forestry Research Institute of Ghana have also been collaborating under two EU-funded projects to address the issue. The policy actions, especially in formulating strategies for resource allocation depends on credible data on the domestic demand and supply of timber. Estimating the actual lumber demand in Ghana has been faced with two major difficulties; the inability to conduct a 100% survey and to track products which never reach the market (domestic consumption) and the lack of reliable statistics on overland export of chainsaw lumber. This study, commissioned under the TBI/Forestry Commission/CSIR-FORIG chainsaw project, aimed at studying overland export of lumber, particularly to neighbouring

sahelian countries with the view to estimating the size of the trade and its implications for policy attempts at supplying legal timber to the domestic market.

Methodology

This study used a more direct and empirical approach to estimating the overland export of lumber in Ghana. The general approach was to track lumber export from local markets, through key barriers all the way to exit borders. The study was conducted both in the supply and demand end of the trade. The main timber markets in Burkina Faso, the Ouagadougou markets, were studied to assess the inflows of chainsaw timber, particularly from Ghana. Three main data collection techniques were employed, i.e., interviews (traders and custom officers), desk study (official trade records) and two-weeks direct monitoring of timber imports to the local markets. In addition, official records from FC-TIDD on overland exports were obtained to triangulate reliability of empirical data collected. In this case both national and northern regional trade statistics were obtained from FC-TIDD.

Results

About 62% of the volume of timber traded in these two major markets has been determined to be exported overland mainly to Burkina Faso, Niger and Mali. About 54% of the lumber exported overland from these two markets was transported to Burkina Faso. The study estimates that lumber products transported overland to Ouagadougou markets alone in a year total about 46,031m³.

The study also reveals that Burkina Faso is the main destination of overland export trade of lumber accounting for 54% of trade. Ouagadougou is the main trade destination in Burkina Faso, receiving at least 66% of lumber exported from Ghana. The study shows that official trade statistics, especially in Ghana is very limited and unreliable to provide accurate estimates about overland trade of timber.

Table1: *Summary of overland lumber export estimations based on several data sources and approaches*

Data source	Indicated estimate of lumber exported overland (m³)	Comment
Ghana statistics	20,503	Discount illegal trade. Annual average to Burkina Faso is 9,340m³
Burkina Faso Statistics	34,669	Captures only official lumber imports to Burkina Faso from Ghana. study could not obtain import data from other countries
Ghana timber market study	130,269	Relies on only 2 major markets; annual projection based on 2 weeks market data
Burkina Faso timber market study	46,031	Projection based on 2 weeks data obtained from10 major markets in Ouagadougou
Ghana-Burkina border monitoring	249,956	Relies on 1 month data for annual projection; provides minimum export estimate to Burkina and other destinations

Conclusion

The study has confirmed observations of huge timber exports to neighbouring Sahelian countries, making the overland trade an important subject affecting the domestic timber situation in Ghana. At least 130,000m³

of timber stocked in local markets are exported overland, potentially reducing the volume of timber available to local consumers. It is also important to realise that almost all the timber traded is chainsaw lumber and so the overland export trade could become a major driver of illegal chainsaw operations in Ghana. The study has established that annually, Ghana exports 250,000m^3 of lumber to the overland market.

3.1 Population size and population genetics of the critically endangered Togo slippery frog (*Conraua derooi*) in Ghana

Project Team: Ofori-Boateng, C. and Kankam, B.O.
Start Date: January 2014
Expected Completion Date: December 2015

Introduction

The Togo slippery frog (*Conraua derooi*) is listed as critically endangered on the basis of it rapidly declining in forest habitat, restricted geographic range and severely fragmented distribution. So far, only two isolated populations are known in Ghana. One population inhabits the Atewa Hills in the eastern part of Ghana whilst the other occurs in the Togo-Volta Hills (along the Ghana-Togo border). This study aims at testing the hypothesis that the two isolated populations of the Togo slippery frog represent two distinct species and to further provide information on habitat preferences and population size of the frog in the Togo-Volta Hills for conservation planning.

Methods

We used a mark-recapture technique to estimate the population size of the Togo slippery frog in the Togo-Volta Hills. A total of 10-repeat mark-recapture visits were made to each preselected sampling site. We analysed the data using Schnabel's formula (method). To determine species habitat preferences, we selected and characterized the environmental conditions within 50 sampling plots (25x25m) selected based on a stratified random design. In each sampling plot site, habitat data were collected as well as count data on the target species. We analysed habitat preference data by developing single season patch occupancy models using the software PRESENCE. We determined the genetic composition between the two isolated populations by extracting and comparing different genetic markers (e.g. CO1) from the two target sub-populations.

Results

The census population size of the slippery frog on the Ghanaian side of the Togo-Volta Hills is now determined. Habitat suitability models developed using modelling software showed that forest condition and human presence are the major drivers of the frog's distribution. The genetic data gathered so far reveal that the two populations of the Togo slippery frog are genetically highly differentiated.

Conclusion

The Togo slippery frog is far more threatened than previously assumed due to the small estimated population size and the restricted distribution revealed by the genetic component of this study (possible occurrence in a single site in Ghana). Future work must focus on implementing measures for the long term protection of the frog's habitat in the Togo-Volta Hills.

3.2 Baseline ecological survey: Akyem Mine Reforestation Plot of Mamang River Forest Reserve

Project Team: Kankam, B. O.

Start Date: July 2014

Expected Completion Date: October 2014

Introduction

The cause of deforestation in Africa includes commercial logging, agriculture, mining, bushfire and opening of new areas for settlements. This forest loss impacts flora and fauna biodiversity.

The operations of Newmont Golden Ridge Limited (NGRL) disturbed 76hectares (ha) out of 101 ha of forest cover of Adjenjua Bepo Forest Reserve (ABFR), therefore the company is obligated to establish 303 ha, which is three times the size of the area acquired. This is one of the requirements for acquiring portions of the ABFR for its operation. Furthermore, to fulfil the requirements of Section 111 of the Minerals and Mining Act 2006, Act 703, NRGL has acquired a 60 ha plot off Mamang River Forest Reserve as phase one of the biodiversity programme to reforest 303 ha of degraded land. The pre-project flora, fauna, soil and carbon stock data is used to estimate the baseline information.

Objectives

1. Identify the fauna and flora in the project area.
2. Determine the condition score of the remnant forest within the project area.
3. Assess the soil types and its characteristics in the project area.
4. Estimate the carbon stocks already present in the project area prior to tree planting activities.
5. Identify natural areas that need to be protected (important forest areas or individual trees which need to be maintained or conserved in a landscape) in the project area.

Methodology

Mammals: Three observational methods namely: (1) direct observation, (2) identification of dung, tracks and other signs, and (3) camera-trapping, were used to survey medium-sized and large mammals. These methods were used due to their effectiveness of detecting animals. The camera trapping method was discontinued 24 hours after installing the cameras. We walked using transects and access routes (e.g. trails/footpaths, cut trails) to directly identify mammals and also to identify them using signs (e.g. footprints, dung/faecal pellets, feeding signs, trails/tracks and burrows, animal calls especially nocturnal animals) between 0700 hours and 1800 hours. Field guides were employed to aid with tracks identification.

Birds: They were surveyed repeatedly in two periods 05.30 am to 12.30 pm; and 14.30 pm to 1730 pm, using access routes (e.g., trails/footpaths) and transects to record the presence of birds in the area (i.e. overview of the bird diversity at the site) with a pair of binoculars. We identified birds by song or visual contact using binoculars during the survey.

Butterflies: They were collected from 07:45 am to 12:00 noon; and 14:30 pm to 17:30 pm. We used 23 plots (50 x 50 m plot) and 25 transects to record the presence of butterflies in the area. The plots and transects covered all land types in the area. Majority of the specimens were captured with hand held nets (an average of 4 people for 8 hours/survey for 7 days). Baited traps with rotten fruits were also used to trap

the butterflies. Trapped specimens were placed in a glassware container until their species could be identified.

Amphibians and Reptiles: In line with the dictates of 'time constrained search methodology', we searched for frogs using an equal sampling intensity (i.e. sampling effort) in each land use type (i.e. 12-man-hours/land use type. Amphibians were detected opportunistically using both visual and acoustic techniques. The surveys were undertaken during the day (8 am to 12 noon and 2 pm to 5 pm) and night (7 pm to 9pm). Captured frogs were identified in the field and released at the site of capture.

Flora: Twenty-three plots (50 m x 50 m) were established to help identify different plants in all the land use types. A stratified random sampling technique was used where at least one 50 m x 50 m plot (0.25 ha) was placed in each land-use type. Also, 10 m x 10 m sub-plots were laid at the corners of the plots (50 m x 50 m) to collect data on woody trees >10 cm. A transponder and a vertex meter were used to measure the height of the tree. Breast height of trees was measured at 1.3 m above ground. Saplings (2 – 9 cm dbh) were measured in a randomly placed subplot (4 m x 4 m), within the original 10 m x 10 m sub-plots. Seedlings (<2 cm dbh) were measured in 1 m x 1 m sub-plots within the sapling (4 m x 4 m) sub-plots. Climbers and lianas were identified and counted.

Land Cover Map and Natural Areas: The team walked through the entire proposed plantation area to identify the different land use areas and individual important trees in the area. A Garmin 62CX Geographical Position system (GPS) was used in the floristic mapping of the area. Individual plants and/or areas that needed to be left intact were marked. Classified satellite imagery was used to indicate the different land use in the area.

Vegetation Condition: The overall vegetation condition of the study site was assessed based on Hawthorne and Abu-Juam (1995) to summarize the general condition of the area.

Soil: Ninety-two soil samples were collected from the 23 plots (50 m x 50 m). For each plot eight samples of soils were collected: four soil samples at depth 0-20 cm and another four at depth 20-40 cm respectively. The composite soil samples for each depth were mixed very well and bagged in labelled large Ziploc plastic bags. The Council for Scientific and Industrial Research–Soil Research Institute (CSIR-SRI) in Kumasi analyzed the soil samples.

Key Results and Conclusion

Four mammal species belonging to 4 families and 4 genera were recorded in the study area. Same number of species, family and genera were recorded for reptiles. A total of 65 species of birds representing 26 families and 48 genera were also recorded during the survey. For amphibians, a total of 11 species, belonging to 5 families and 6 genera were recorded. Twenty species, representing 3 families and 17 genera were recorded for butterflies within the same 60 ha area. A total of 113 species belonging to 42 families and 93 genera were recorded within the study area.

The mean number of stems (trees including saplings: 2 – 9 cm dbh) per hectare was 2,880 ± 531.1. [1]No Black star or Gold star plants species

1 Star Rating: Species are grouped into star rating to reflect genetic conservation value. The primary factor used in the classification is rarity. This classification deals only with the conservation of those species in Ghana's forest that would decline if all forest were to be removed. Weedy species or savannah species found only at the margin of forest are not star- rated. (i.e. they are non-star species)

The allocation of Green, Blue, Gold and Black stars to species has been made by consideration of variety of factors concerning the ecology, taxonomy and distribution at all levels, with most significance given to the latter.

Species rated Black star, Gold star, Blue star and Green star are done in order of decreasing conservation priority.

- Green star species are species of no particular conservation concern.
- Common or widespread species that would otherwise be allocated green stars, but heavily

were recorded; however, 89 plants that were recorded at the site had different star ratings: 2 Red stars, 5 Blue stars, 69 Green stars, 9 Pink stars and 4 Scarlet stars. The condition score for the study area was 6 (i.e., no significant forest left); the forest was very disturbed and less than 2% remained intact. The total aboveground and belowground tree C stored per hectare was 73,994.2 ± 7,881.8 kg C ha^{-1} (≈ 73.99 t ha^{-1}) and 8,046.2 ± 905.7 kg C ha^{-1} (≈ 8.05 t ha^{-1}) respectively. The extrapolated aboveground and belowground tree C sequestration for the entire 60 ha was estimated at 413,936.6 ± 78,011.2 kg C (≈ 413.94 t) and 43,259.5 ± 5,460.2 (≈ 43.23 t) respectively. The soil texture is largely sandy loam (75.0%). The loam is 12.5%, sandy clay loam (6.25%) and silty loam (6.25%). The bulk density was higher (20-40 cm soil depth: 1.65 g cm^{-3}) in the open or secondary forest and lower (0-20 cm soil depth: 0.99 g cm^{-3}) in the cola stand.

Achievement: Final report submitted.

exploited or show exceptional economic potential in Ghana are rated as "Reddish star" (i.e. Scarlet, Red and Pink star) species.

- Black or Gold star are species that have high conservation rating.

3.3 Reforestation Action Plan Phase I for 60 Ha plot off Mamang River Forest Reserve

Project Team: Kankam, B. O.
Start Date: January 2014
Expected Completion Date: April 2014

Introduction

As a result of the operations of Newmont Golden Ridge Limited (NGRL) within the southern end of the Ajenjua Bepo Forest Reserve (ABFR) approximately76hectares (ha) of tree cover out of 101ha acquired has been affected. NGRL needs to establish 303 ha of tree plantation as a requirement for acquiring 101ha of land within the southern end of the ABFR as specified in the Final Environmental Impact Statement. Therefore, Newmont's commitment to replant three trees for each merchantable timber-quality tree removed from the ABFR area is obligatory. Again, according to section 111 of the Minerals and Mining Act 2006, Act 703, NRGL is also mandated to ensure that the proposed plantation area could be utilized as a buffer and developed as part of its biodiversity programme for future integration with the Mamang River Forest Reserve (Minerals Commission Approval of Mining Area letter, Reference PL.5/126/Vol.2).

Aims and Objectives

The main goal was to reforest 303 ha of degraded forest area as required by the Ghana Government for acquiring hectares of vegetation at the southern end of the ABFR. The objective of the assignment was to develop a work plan to reforest 60 ha of land (i.e. Reforestation Action Plan (RAP)) adjacent to the Mamang River Forest Reserve in the Kade forest district.

Methodology

1. **Desk study:** Relevant literature and documents on study sites characteristics, reforestation action plans and many other related topics were compiled prior to consultations and field visits.
2. **Consultations with NGRL and Forestry Commission (FC):** The NGRL environmental team was consulted to provide relevant information such as company profile, site preference and management agreements;

the consultation (with NGRL, FC and CSIR-FORIG) and formalization of site selection for establishing the plantation; and likely roles for NGRL, FC and CSIR-FORIG were defined and responsibilities of each institute/company identified.

3. **Field visits and basic data gathering at the proposed plantation sites**: Data gathered on site include the flora, fauna, soil characteristics, weather, etc. to obtain information on current forest condition.

4. **Writing the Plan**: Professionals were recruited to assist with the write up of the plan.

Key Results

The RAP has been developed. The main operations included land acquisition, species selection and site matching, planting materials, establishment operations, protection operations, biodiversity improvement, silviculture operations, and monitoring and evaluation. NGRL reforestation plan took into consideration several operations and activities in the planning, establishment and management phases. The RAP also identified institutions that will play critical roles to make this activity a success. This RAP developed will be valid for ten years and would be reviewed at the end of five years. Detailed operational plans based on the plan would be prepared annually to guide implementation of activities.

Achievement: Final Report submitted

3.4 Wildlife Monitoring: reducing entrapment and road-kills during mineral extraction stage at the Ajenjua Bepo Forest Reserve

Project Team: Kankam, B. O.
Start Date: August 2013
Expected Completion Date: January 2014

Introduction

Newmont Golden Ridge Limited (NGRL) initiated research programs to mitigate the effect of mining operations of the company on wildlife in the proposed mining site at the Ajenjua Bepo Forest Reserve (ABFR). NGRL exploratory and preparation phases of the mining operation required the construction of networks of haul roads and many facilities; the result has created "islands" of small forest fragments that would entrap wildlife in the concession area within ABFR. Roads passing through wildlife habitats become death traps for wildlife due to high vehicular movements; this sometimes leads to wildlife-vehicle collision or cars running over wildlife. Urgent need was therefore required to reverse these trends of wildlife entrapment and road-kills in the forest fragments within NGRL concession area through monitoring programmes.

The goal of this research was to rescue accidentally entrapped wildlife in small forest fragments within NGRL concession area; and to prevent/reduce road-kills of wildlife as a result of collisions with vehicles.

Specific objectives were to:

1. Identify fauna species within the NGRL footprint (especially, in the concession area within ABFR).
2. Capture and translocate entrapped wildlife in small fragments within the NGRL concession area to release sites.
3. Identify road zones frequently used by wildlife within the NGRL concession area in the Ajenjua Bepo Forest Reserve.

4. Assess wildlife mortality in the NGRL concession area.

Methodology

Amphibians, Reptiles, Birds and Mammal surveys: A reconnaissance survey was first conducted to locate and assess the remaining fragments and familiarize with the road network. The research team, were taken round the study area by NGRL Environment staff. Methods to survey amphibians and reptiles, birds and mammals is the same one used for "Baseline ecological survey: Akyem Mine Reforestation plot off Mamang River Forest Reserve" survey in this Annual Report.

Capture and Translocation of Wildlife: In our capture attempt we used equipment such as a dart gun with appropriate tranquilizers for darting and capturing of fauna, and a net for trapping mammals. Primarily, frogs were collected by hand, and snakes were captured using snake tongs and restrained in cotton bags/sacks. All captured frogs' species were identified and released in the interior forest of ABFR outside the NGRL footprint. For monitoring purposes, all snakes that were captured were marked with semi-permanent Testor's model paint at the distal half of the tail end before they were released to the relocation site. The captured species were then translocated to Kajease Forest Reserve, and the Owabi Wildlife Sanctuary (OWS). Post release wildlife monitoring was conducted for signs of mortality within a 1 Km radius from the point/place of release for eight weeks. The new habitats have similar conditions as ABFR.

Road Zones frequently used by Wildlife: We identified wildlife concentrated areas (directly or indirectly) within the NGRL concession area in both wet and dry seasons by walking along the road network (access roads and haul roads) and also by driving our vehicle slowly to identify wildlife signs (e.g., footprints, dung/faecal pellets, feeding signs, trails/tracks) on the road and around the edges. Approximately 1 round trip per day for 4 continuous days in a month for 4 months was done. Opportunistically, we observed animal behaviour in response to approaching truck along the hauling roads. We mapped the road zone where wildlife frequently crossed using NGRL base road maps and GPS coordinates. We designed standard wildlife road signs using information from road zones frequently used by wildlife and also indicated where the wildlife road signs would be erected along the roads within ABFR.

Wildlife Mortality: We assessed wildlife mortality/road-kill by walking along NGRL hauling roads located within the concession area of ABFR for 16 days in total. We conducted the research in both dry and wet seasons, as seasons influence wildlife activities. The search for wildlife mortality was complemented with observations from the wildlife presence surveys. The CSIR-FORIG research team also assessed NGRL environmental department logbook on wildlife mortality from 2012-2013 to gather information on wildlife mortality or road-kills in the NGRL concession area. In addition, we used questionnaires and interviews to complement our data on wildlife mortality or road-kills at the site.

Key Results

A total of 72 individual amphibians belonging to 3 families, 3 genera and 4 species were encountered and captured. For reptiles, a total of 46 individuals belonging to 6 species, 6 genera were distributed in 6 families. One thousand one hundred and ninety-four (1,194) individual birds representing 42 families, 88 genera and 122 species were recorded; whereas 99 individual mammals belonging to 5 families, 8 genera and 8 species were recorded at the study site. All four amphibians recorded were uncommon according to the species encounter rate. Fifty percent of reptiles recorded were in the least concern category, 16.7% was data deficient and 33.3% were yet to be evaluated or assessed. A greater percentage (79.2%) of birds encountered could be considered uncommon, whereas the rest (20.8%) were considered rare. Majority

(62.5%) of mammal species encountered were uncommon and 37.5% were rare. No taxa met the frequent, common or abundant classification category. Birds frequently encountered in and around the Tailing Storage Facility (TSF) were the Common sandpiper, Black kite, Yellow-billed kite, and the Pied crow. Eighty-two individuals comprising 5 snakes, 4 tortoises, 72 amphibians and 1 savannah monitor were successfully re-located to release sites. One bird species (hooded vulture, *Necrosyrtes monachus*) listed as endangered according to IUCN Red List of threatened species and four forest tortoises, *Kinixys erosa*; listed as Data Deficient were the species of concern according to IUCN in this survey. Wildlife such as duikers, cusimanse mongoose, Bushbuck, African civet and the stripped ground squirrel frequently used access roads. Only one pied crow (*Corvus albus*) was found dead in the Tailing Storage Facility but generally, wildlife mortality was low.

3.5 Mycorrhizal association and its benefits to *Allanblackia parviflora* seedlings in the nursery

Project Team: Apetorgbor, M.M., Peprah, T. and D. Ofori
Start Date: June 2013
Expected Completion Date: June 2015

Introduction

Allanblackia spp. (Family Clusiaceae) is a high value multipurpose indigenous fruit tree in Central, East and West African regions. Importantly, their seeds contain edible oil that have long been used by local communities in the above regions for food, medicine and animal feed. In recent times, *Allanblackia*(AB) seed oil has become a foreign exchange earner in Cameroon, Ghana, Nigeria and Tanzania and rural-based enterprises are being developed for their production and commercialization. However, wild harvesting alone cannot sustain their supply to industry therefore domestication was focused on developing propagation techniques, selecting and collecting elite planting material, initiating central and community nursery activities. However, little emphasis has been placed on the soil nutrient requirement of the *Allanblackia* spp. which will be important for realizing the full harvesting potential in domesticating them. Preliminary results on management of *Allanblackia* at the nursery showed that seedlings grown in soil collected under its natural trees have good growth performance; suggesting possible plant-microbial interactions. Research on *Allanblackia stuhlmannii* in Tanzania, indicated that the tree species form an association with vesicular arbuscular mycorrhiza. The objectives of the study were to examine whether *Allanblackia parviflora* trees form mycorrhizal associations and also to determine its benefits to seedlings raised at the nursery.

Methodology

The sampling of wildlings and soil from around *Allanblackia* trees was done in New Edubiase, Dikoto and Benso in the Ashanti, Central and Western Regions of Ghana respectively. Around five AB older trees were pooled and stored in plastic bags at 4°C prior to processing. Fine roots of wildlings and those extracted from soil rhizosphere were stored in ethanol for assessment of mycorrhizal colonization. Germinated seeds of AB were potted in eight soil treatments: rhizosphere soil collected from the AB roots, 50% soil from AB roots, humus, and top soil, soil from AB roots plus top soil, soil from *Tetrapleura tetraptera* roots, humus soil, humus and top soil, top soil and soil from *T.*

tetraptera roots combined with top soil. Seedling growth were measured monthly for six months. Seedlings were harvested after the sixth month, oven dried and weighed (shoots and roots) while fresh roots of the other half were stored for assessment of mycorrhizal colonization. AB soil collected under natural trees and top soil were then mixed in different ratios of 1:0, 1:0.75, 1: 1, 1:0.25, 1:0.125 and filled into black polythene bag of sizes 25cm x 25 cm. Germinated seeds of AB were potted in poly bags with one germinated seed per bag of six soil treatments. The height and girth were measured once every month for six months.

Determination of Arbuscular Mycorrhizal (AM) root colonization: Young wildlings and seedlings raised in the eight soil treatments of AB soil were carefully excavated. A minimum of ten fine root tip of seedlings were excised, prepared (cleared with Potassium hydroxide, and then stained with acidic Trypan blue and stored in acidic glycerol). Samples of root fragments from each plant species were examined microscopically to identify AM fungal colonization and presence of arbuscular mycorrhizal structures e.g. vesicles and arbuscular.

Soil analysis: Rhizosphere soils were randomly collected at three locations from a plot and mixed separately. They were air-dried and analyzed for their chemical properties: soil pH, soil organic carbon, total nitrogen, cation exchange capacity (CEC), calcium, magnesium, potassium and sodium, available phosphorus and potassium

Results

Determination of AM root colonization: microscopic examination of the stained roots revealed that vesicles, arbuscular structures, hyphal coils and intercellular hyphae were present on root tips of wildlings collected from around AB trees and seedlings grown in all treatment containing AB soil. Root colonization in *Allanblackia* was largely in the form of extensive cell-to-cell growth of hyphal coils characteristic of Paris-type morphology (Plate 3.1a and 3.1b). The frequency of vesicles, arbuscular structures, hyphal coils and intercellular hyphae reduced in roots of seedlings grown in treatment containing AB soil. The association observed was vesicular arbuscular mycorrhizal type.

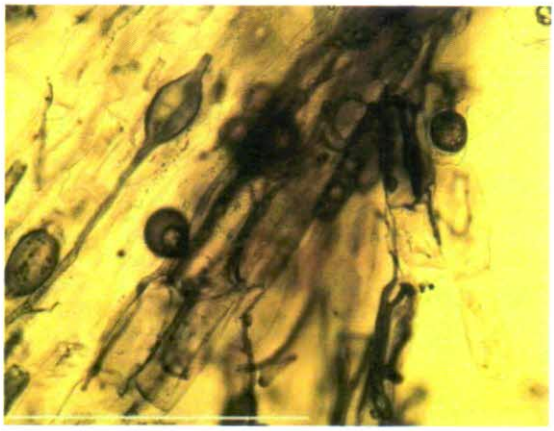


Plate 3.1a: Roots from wildlings collected **under AB tree showing vesicles**

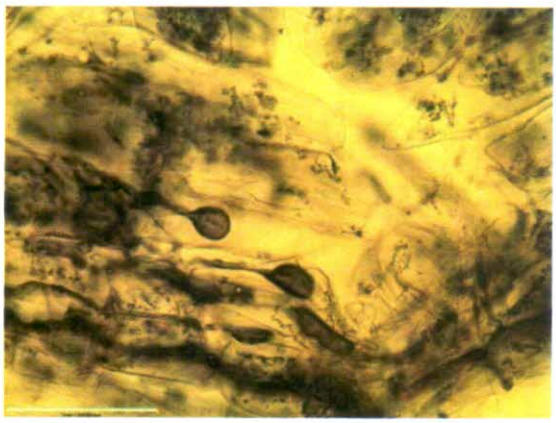


Plate 3.1b: **Roots of AB germinated seeds sown in AB soil showing vesicles**

Seedling height growth was highest in AB soil. Addition of Top soil (Ts) or Humus + Top soil (H+Ts) to AB could not improve height growth of seedlings. While combination of H+Ts decreased the diameter of seedling growth but when added to AB soil increased the expansion of seedling diameter. Seedling height increased with age in AB soil followed by combination of 75% AB soil and 25% Topsoil, 50% AB soil and 50% Top soil. Combinations of AB and Top soil at concentrations below 25% AB soil have no effect on seedling height growth.

Soil analysis: Interestingly, low nitrogen content of *Tetrapleura tetraptera* soil and top soil (Tts + Ts) (0.09%) is accounted for by the low organic

carbon content (1.31) as well as that of H (carbon, 1.31% and nitrogen, 0.10%). The high total N in H+Ts is accounted for by the high organic carbon content an indication of high fertility in H+Ts. Addition of H+Ts to AB increased the nitrogen and carbon contents. Available P is highest in Ts (220.84ppmP) followed by H+Ts (210.48ppmP) and low in AB soil (6.54ppmP). Addition of H+Ts increased the available phosphorus in AB soil to 145.10ppmP.Similarly, available K in Ts when added to AB increased K level to 267.37ppmK (60%) and H +Ts to AB increased K level to 341.34ppmK. Addition of H+Ts or Ts alone to AB decreases the Ca, Mg, K and Na levels available in soil.

Conclusion

Application of 25% and above AB soil (soil collected under matured AB tree) to any soil media in raising AB seedlings had an effect on growth (height and diameter). The effect on growth is due to both vesicular arbuscular mycorrhizal fungi and soil chemical composition of AB soil.

3.6 Kumasi Urban Forestry Project

Project Team: Adu-Bredu, S.A., Apetorgbor, M.M., Ebanyenle, E., Asomaning, J.M. and T. Peprah

Start Date: January 2014

Expected Completion Date: December 2017

Introduction

Kumasi has been known as the Garden City of West Africa due to the presence of numerous trees in the city and a forest reserve at Ahodwo, a suburb of the city. These trees provide a conducive environment for streams and other water bodies in the metropolis. However, indiscriminate felling of trees, farming close to water bodies, fuel wood collection and other activities in the watershed area has contributed to the disappearance of vegetation along many small rivers and streams in the metropolis. Therefore, Kumasi urban forests have reduced significantly in quality and quantity. In view of the apparent trend of forest degradation in the city, the Chief Executive of Kumasi Metropolitan Assembly, Hon. Kojo Bonsu, outlining his vision for metropolis indicated of plans to restore the city to its former status as the "Garden City of West Africa" through planting of 1,000,000 trees by 2017. CSIR-FORIG was therefore tasked to undertake this exercise. The objective of this project among other benefits were to provide shade, improve air and water quality as well as beautify the metropolis through the planting of trees along the major driveways, water bodies, parks, school compounds and communities in the metropolis by 2017.

Methodology

Reconnaissance survey was done by a team of CSIR-FORIG scientists who considered selected tree species for planting along the major driveways. Spaces along the major driveways of the metropolis for planting the seedlings were identified and mapped (Plate 3.2)[with support of staff of the Department of Parks and Gardens and a representative of the Department of Urban Roads].

Tree species considered for planting were *Blighia sapida* (Akye), *Terminalia montaly* (Montalis), *Salix babylonica* (Weeping willow, female), *Senna siamea* (Cassia), *Milletia thonningia* (Milletia), and *Garcinia* sp. (Candle tree). One hundred and twenty selected teachers and representatives of communities were trained by CSIR-FORIG on tree planting.

Plate 3.2: Staff scouting for favourable places to plant trees

Selected Basic Schools were involved in a special competition dubbed "Me and My Tree Competition" to motivate them to plant and nurture trees. The awareness to re-green the city was launched through radio and television programmes, posters, stickers and other educational materials. Assemblymen and women, chiefs and the media helped to sensitize the general public. LINTA Company presented posters and souvenirs while CSIR-FORIG designed the flyers.

Results

Tree seedlings were planted on both sides of major roads from Bebre to Anloga Junction to Suame Roundabout, Anloga Junction through Asokwa Interchange to Guinness Junction at Kaase, Ahodwo Roundabout through Sokoban to Opoku Ware Senior High School in Santasi, and to Anyinam. A total of 6174 seedlings (*Blighia sapida* (Akye), *Millettia thonningii* (Taatso), *Roystonea regia* (Royal palm), *Polyalthia longifolia* (Weeping willow), *Techoma* sp. and *Cassia floribunda*) were planted. CSIR-FORIG produced bamboo cages to protect the tree seedlings. Plate 3.4 shows some of the seedlings planted by CSIR-FORIG staff.

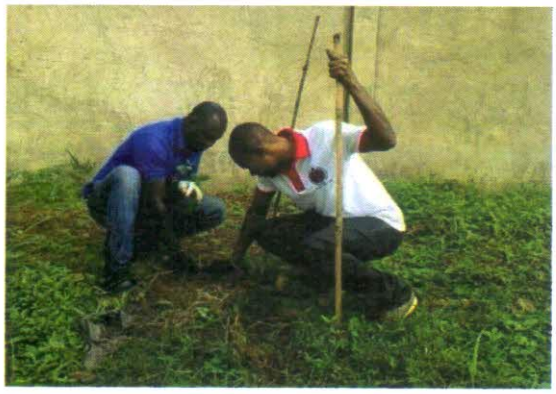


Plate 3.3: Tree planting by staff

Plate 3.4: Planted seedlings along a highway

Conclusion

The re-greening initiative is a worthy venture that should be sustained but there is also the need to expand the scope to include more Basic and Junior High Schools to help inculcate the importance of trees to society.

3.7 Advancing REDD+ in Ghana: preparation of REDD+ Pilot schemes in Off-Reserve Forests and Agroforests

Project Team: Oduro, K.A., Agyeman, V.K., Kyereh, B., Bamfo, R., Damnyag, L., Foli, E.G., and Y. Kwakye

Start Date: April 2013

Expected Completion Date: July 2014

Introduction

The international community is aware of the climate-regulating role of forests and trees and has created a mechanism aimed at reducing tropical deforestation and forest degradation and enhancing the conservation and sustainable management of forests and forest carbon stocks, a mechanism usually known as REDD+. Under REDD+, tropical countries will be financially compensated for accomplishing objectives in reducing deforestation and forest degradation, sustainably managing forests, conserving and enhancing forest carbon stocks. Around 65 countries have engaged in REDD+ preparations and are at different stages between policy development and national programme development under various multilateral frameworks. The multiple advantages that increased tree density can provide is clearly recognized in Ghana's national strategy for REDD+, which goes beyond forest boundaries to include trees and woodlots outside forests in agricultural landscapes (off-reserve areas). This approach of seeking REDD+ opportunities outside official forest boundaries makes sense in a country where agricultural zones traditionally include a relatively high density of tree cover and where agricultural and forest zones are understood as parts of a continuum. The opportunity to increase tree density in agricultural and agroforestry systems means that the forest and agricultural sectors need to collaborate and work together at a landscape scale. It also means that increasing tree stocks on farms must be endorsed by the women and men of farming communities and by both the agricultural and forest services. The preparation of off-reserve REDD+ activities in Ghana needs to provide realistic solutions for people who rely heavily on the land for their livelihoods. This project aimed to contribute to the development of approaches that generate short-term revenues in combination with longer-term gains from tree resources; and explored the potential of off-reserve REDD+ in Ghana. Specifically, the project aimed at providing Ghana with proposals for the enhancement of sustainable off-reserve production systems under REDD+ schemes with a focus on local livelihood improvement. The project was carried out in the framework of REDDES, a programme of the International Tropical Timber Organization (ITTO) that aims to strengthen capacities in selected countries to maintain and enhance the environmental services provided by tropical forests.

Methodology

The approach adopted by the project involved empirical and theoretical literature studies, all of which took reference of the potential pilot areas defined in the REDD+ readiness preparation proposal for Ghana under the framework of the Forest Carbon Partnership Facility.

Key Results/Achievements

A major output of the project was the publication of a book on "*REDD+ in agricultural landscapes: evidence from Ghana's REDD+ process*" that describes the core results of all the studies carried out under the project. Two of the studies assessed farmers' views on the potential effects of REDD+ in their areas and the incentives that would motivate farmers to include (more) trees

in their systems—thus allowing the development of concrete proposals for REDD+ implementation in Ghana. Other studies compared the performance of different land-use systems in increasing carbon stocks and farmer income; analysed the costs and benefits of potential pilot projects focusing on shea trees and essential-oil production; and assessed the extent to which experiences in cocoa certification standards could be applied to the introduction of REDD+ projects in cocoa-growing areas. Concerning the distribution of potential REDD+ benefits, for example, farmers (households), in all the project study districts, believe that they are the most important beneficiaries of REDD+ benefits because they work directly on the land where emission reductions are achieved. Distribution of REDD+ benefits should therefore involve (1) identifying the actors/beneficiaries, (2) determining existing processes that could be used in the allocation of REDD+ benefits, and (3) deciding the most appropriate means for delivering benefits. Benefits should be weighted on the basis of the performance of households involved in REDD+ activities.

Conclusion

Ghana's readiness preparation proposal suggests that one of the major weaknesses of the forest management framework is the lack of an appropriate mechanism to incentivize the conservation of native trees in off-reserve areas. REDD+ offers an opportunity for the requisite policy reforms and incentive scheme to be put in place to confront and overcome the driving factors that account for forest loss in off-reserve areas. Thus, this ITTO project sought to identify strategies that simultaneously reverse agriculture's adverse effects on forests and trees (and therefore carbon emissions) and enhance the environmental services that off-reserve forests and trees provide.

3.8 Evaluation of *Ocimum sanctum* as a repellent against Mahogany shoot borer, *Hypsipyla robusta*

Project Team: Mensah, J.K., Bandoh, W.K.N., Ofori, E., and E. Opuni-Frimpong

Start Date: April 2013

Expected Completion Date: October 2016

Introduction

Khaya ivorensis and *Khaya grandifoliola* locally known as mahogany are among the valuable timber species in the tropics but over-exploitation due to high demand of the wood in both local and international markets has led to a continuous decline of mahogany species in natural stands over the years. In an attempt to address the shortfall in supply of the wood, plantations are being established to cater for the increasing demand. However, establishing mahogany plantations has been a major challenge as result of incessant attacks by *H. robusta* (mahogany shoot borer). The shoot borer attacks and destroys the apical shoot, causing deformation or branching of the tree, and significantly reducing the economic value of the timber. Several attempts have been made in controlling the shoot borer using silvilcultural, biological and chemical methods. Although none of these interventions have proved successful in reducing shoot borer damage to an appreciable level, biological and silvilcultural interventions have been favoured over the use of chemicals in controlling the shoot borer due to cost and environmental concerns. The current study focuses on using *Ocimum sanctum* as

a biological means of managing shoot borer attacks on *Khaya* spp.

Ocimum sanctum belongs to the family Laminaceae and it is one of the most popular herbs grown in the world because of its medicinal and insecticidal values. It is native of Asia and could be found growing in the wild in tropical and sub-tropical regions of the world. *Ocimum sanctum's* ability to repel insects has been demonstrated through mixing the dried leaves with stored grains to ward off insects. The oil from the leaves has also been reported to possess anti-bacterial properties and acts as an insecticide. Moreover, it has marked repellent action and insecticidal activity against mosquitoes. The main objective of this preliminary study was to determine whether *O. sanctum* can significantly reduce the incidence of the shoot borer attacks in mahogany experimental plots.

Method

Six experimental plots of two variants were used to assess the influence of *Ocimum* sp. on the incidence of shoot borer attack in mahogany trial plots. Each plot (25m x 25m) was demarcated, cleared and pegged at 3m interval. *Ocimum* sp. seedlings were planted 3 months earlier on the first variant plot at 1m interval before planting *Khaya* spp. seedlings in an alternating trend at 3m interval. The design was such that every mahogany seedling was surrounded by 4 well established *Ocimum* sp. seedlings. The second variant plot was without *Ocimum* sp. seedlings and each plot was replicated three times.

Results

One year after planting, no incidence of shoot borer attack has been recorded in any of the two variants plots.

Plate 3.5a and 3.5b: Assessment of shoot borer activities on trial plots

However, it would be pre-mature to make any conclusion since assessment of plots for incidence of shoot borer attack and measurement of growth parameters such as diameter and height are still on-going.

Plate 3.6: Assessment of growth on established plots

3.9 Capacity Building for CDM Forestry in the Framework of SFM Emphasizing Community Forests and Poverty Alleviation in Ghana

Project Team: Opuni-Frimpong, E., Agyemang, V.K., Darko-Obiri, B., Opoku, E.O., Nyarko Duah, N.Y., Beniako, K.N., Yeboah, D. and A.D. Andrew Burton

Start Date: February 2011

Expected Completion Date: September 2015

Introduction

The potential of forestry-related Clean Development Mechanism (CDM-Forestry) in Ghana is very significant as large areas of Ghana's forests have been degraded via over-aggressive, non-sustainable logging practices, slash-and-burn agricultural practices, and conversion of forests to alternative crops such as cocoa production and many more. Based on these reasons, Ghana is eligible for CDM reforestation projects. There is therefore the need to develop capacity to conduct CDM forestry projects with special emphasis on poverty alleviation.

The project intends to develop the capacity for CDM-Forestry in Ghana via a community rehabilitation of degraded forests targeted at poverty alleviation in conjunction with sustainable forest management (SFM). The specific objective is to improve capacity for CDM-Forestry in Ghana through a community forest initiative targeted at poverty alleviation in conjunction with SFM. The expected outputs of the project are:

1. Carbon stocks of the Oda-Kotoamso Community Agro-forestry Project will be determined using GPS supported comprehensive and complete measurement of all trees in the project.
2. Mass spectro-photometric analysis will be done on wood samples from up to 5 trees each of the 19 tree species planted.
3. A degraded forest (450 ha) will be reforested with the OCAP model using highly productive timber species.
4. Comprehensive socio-economic studies will be conducted in the communities involved in the project.
5. Capacity to conduct CDM-Forestry will be built with post graduate training of Ghanaian students.

Activities undertaken in the fourth year of the CDM project focused on strategies to complete what was yet to be done in order to achieve the overall goals of the project. Maintenance, monitoring and evaluation of the previously established stands at OCAP and Pamu Berekum were undertaken to assess their growth performance. Mapping of farmers' fields within the demarcated areas of the project was conducted by the project team. Carbon sequestration estimation and analysis of the plantations were carried out successfully as part of the year's activities. Training of students in carbon stock estimation was done. Planting of indigenous and exotic species in mixtures using different planting designs were intensified at the Pamu Berekum Forest Reserve.

Plate 3.7: Plantations on a degraded landscape

Workshops to sensitize communities on CDM forestry and its role in mitigating climate change impacts were undertaken in the Dormaa Forest District to arouse interest in plantation development. Farmers within the fringe communities in Pamu Berekum were trained on fire management strategies to safeguard their plantations against wildfires.

Plate 3.8: An agroforestry plot at Pamu Berekum

Also, inventory of natural resources and evaluation of participatory strategies was carried out in communities. In addition, the project team continued with effort to develop simple community-based CDM methodologies for tree growers to facilitate easily adaptation of CDM-Forestry. Trees and crop production, socio-economic and environmental surveys were completed at the reporting period.

The implementation of the project has been successful with capacity building of students, farmers and improvement in the livelihoods of target communities involved in the project. Furthermore, project findings were presented at the XXIV IUFRO world congress held at Salt Lake City, Utah, U.S.A. in 2014. The CDM project's execution has been interesting and viable, it has attained its main objective of attracting other communities to willingly participate in the project.

Plate 3.9: Two year old *Khaya grandifoliola* in a mixed community agroforestry trial

3.10 Towards sustainable indigenous Mahogany timber production in Ghana: Phase II, Refining the Silvicultural "Tool Kit" and Practical Training for Industrial-Foresters and Community Farmers

Project Team: Opuni-Frimpong, E., Obiri-Darko, B., Tekpetey, S., Appiah-Kubi, E., Essien, C., Opoku, S.M., Nyarko Duah, N.Y., Owusu, S.A. and E.M. Opoku

Start Date: February 2010

Expected Completion Date: November 2015

Introduction

Sustainable supply and conservation of mahogany (*Khaya* spp.) is threatened by over-exploitation of natural mahogany forests. Exacerbating the situation is the inability to establish mahogany plantations in their native range as a result of the incidence of *Hypsipyla robusta* (mahogany shoot borer) pest. Mahogany

shoot borer mostly kills the main stem of the young trees, causing excessive forking and branching, contributing to tree mortality. As a consequence of the destructive activities of mahogany shoot borer, some entomologists have classified it as the most important pest in tropical forestry. This project sponsored by ITTO focuses on developing an integrated pest management strategy for mahogany shoot borer via plantation culture to restore and conserve the African mahogany. 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 to expand collaboration with industrial and community tree farmers. The specific objectives seek to refine the 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 through a practical "how to" cultivate indigenous mahoganies manual.

Project implementation in the fifth year targeted at the completion of all activities in order to attain the objectives set within the specified duration. Establishment of superior mahogany seedling production centres and hedge gardens were undertaken successfully. Methods of producing progenies from *Hypsipyla* sp-tolerant genotypes was intensified through the application of biochar (soil amendment) mixed with soil. Grafting experiment of different mahogany species continued effectively during the reporting period. Maintenance of existing seed orchards with diverse genetic sources of *Khaya* spp. and *Entandrophragma* spp. in community nurseries were undertaken to facilitate access to seedlings for planting. Silvicultural "tool kit" was refined to optimize planting of mixed stands in the 4 major ecological zones. Monitoring and maintenance of experimental plots was equally carried out in the different ecological zones namely: Benso, Bobiri, Mesewam and Abofour in the Wet Evergreen, Moist and Dry semi-deciduous forest zones respectively. Survival rate and growth performance of planted trees was evaluated in each eco-zone.

New provenances and mixed species plantations were established at Abofour and Mesewam (Plate 3.10) in the moist semi-deciduous forest zone to determine growth performance and tolerance to pest attack by the mahogany species.

Plate 3.10: Experimental trials of mahogany showing *Swietenia macrophylla* attacked by insects at Mesewam

Plate 3.11: Superior mahogany trees in a plantation trial in Bobiri Forest

Wildfire management strategies was improved with the construction of fire belts and planting of fire resistant trees by the project field crew at Abofour in the semi-deciduous forest zone of Ghana to mitigate erratic fires. Evaluation was also conducted on the spacing, pruning, mixed stands of neem and mahogany trial plots and

provenance trials. Initiatives to introduce weaver ants as biological control agents in mahogany plantations were undertaken by the project staff. The project team also established strong collaboration with the Osiem Savior church as partners to raise ninety thousand (90,000) seedlings of different indigenous tree species including *Khaya* species, *Entandrophragma*, *Terminalia superba*, *Terminalia ivorensis*, *Ceiba petundra*, and *Nauclea diderrichii* to commemorate their 90th anniversary which is a major achievement of the project. The farmers were trained in best nursery management techniques to enhance the production of seedlings for planting. Wood quality and lumber properties studies to determine the sawing characteristics of mature and plantation-grown mahoganies which involved harvesting of a number (3-5) 40-year old *Khaya* species were completed during the period under review. Anatomical, mechanical and strength properties determination were also completed successfully. Moreover, comparative socio-economic studies on economic viability of smallholder plantations are still on-going. Economic assessment of vegetative propagation and the basis for Mahogany research was completed within the period. Preparation of a practical "how to cultivate mahogany" in plantations manual is on course. It is important to state that all the major research activities conducted during the period was undertaken by under graduate students as part of their final dissertation. The implementation of the mahogany project has demonstrated that mahoganies can be grown in plantations despite problems with pests. Activities carried out so far shows much progress has been made to achieve the developmental objectives of the project. The project has strengthened collaboration with communities and encouraged many to venture into planting of more native species like mahogany to sustain Ghana's forest estate.

Plate 3.12: *Khaya* mixed stand intercropped with plantain

3.11 Development and implementation of a species identification and timber tracking system in Africa with DNA fingerprints and stable isotopes

Project Team: Degen, B., Noel-Bouda, H., Opuni-Frimpong, E., Bandoh, W.K.N., Mensah, J.K., Kuudaar, S., Govina, J.K., Opoku, E.M. and S. Anane

Start Date: April 2011

Expected Completion Date: August 2015

Introduction

Illegal logging and associated trade are the cause of many economic and ecological problems both in timber producer and consumer countries. Although many legal instruments (EU timber trade regulation, US Lacey Act etc.) have been established to combat illegal logging and trade of illegally sourced timber, practical control mechanisms to identify the tree species and geographic origin of wood and wood products are still lacking. DNA fingerprints and stable isotope techniques use characters inherent in the timber (impossible to falsify) and the combination of both methods guarantee a high spatial resolution and a strong statistical power at higher cost efficiency for the control of origin of wood and wood products. This is a three-year regional project on species identification and timber tracking system with DNA fingerprints and stable isotopes for several important timber tree species in the following countries in Africa: Cameroon, Central African Republic, Democratic Republic of Congo, Republic of Congo, Gabon, Ghana and Kenya. The specific objectives of the project are to undertake genetic studies of African tree species, develop stable isotopes to track illegal extraction of timber, use DNA markers to control origin of African tree species and DNA fingerprints for the chain of custody. The expected output of the project for Ghana includes:

- Capacity building of African Scientists.
- Sampling 400 *Khaya* trees from SAMARTEX concession at Yoyo FR
- Sampling 200 wood and veneer samples of *Khaya*.
- Establishment and running of Genetic Reference Laboratory at CSIR-FORIG
- Training of a CSIR-FORIG Biotech Lab Person at VTI, Germany

The project kick-start meeting was held in CSIR-FORIG and this was subsequently followed by a study on genetic species identification and chain of custody of *Khaya anthotheca* and *Khaya ivorensis* at a concession controlled by SAMARTEX. Besides, four hundred and forty-four (444) *Khaya* trees were sampled for cambium, leaves and wood from Yoyo Forest reserve (Plates 3.13, 3.14, 3.15). The samples used to develop this database comprised of 170 and 274 different trees of *Khaya anthotheca* and *Khaya ivorensis* respectively. From these samples, genetic results were provided for 359 individuals on 6 gene markers (microsatellites).

Plate 3.13: Field team at Yoyo forest reserve

Plate 3.14: Matured tree at the reserve

The genetic data showed very strong genetic differences among the two species with little evidence for hybridisation among the species. It could as well be shown that microsatellites are very useful gene markers to follow chain of custody of individual *Khaya* trees.

A training workshop and seminar on wood anatomy and state of the art technologies for tracking legal timber was organized to equip scientists together with staff of Forestry Commission, TIDD and the timber industry on systems to track the origin of timber. The establishment and running of a Genetic Reference Lab in CSIR-FORIG has been initiated and one scientist has been trained in Kenya.

Plate 3.15: Extraction of samples on site

3.12 DNA based species identification in the genus *Khaya*

Project Team:	Degen, B., Paulini, M., Opuni-Frimpong, E., Pakull, B. and A. Hoeltken
Start Date:	January 2012
Expected Completion Date:	August 2015

Introduction

In Ghana, two species i.e. *Khaya ivorensis* and *Khaya anthotheca* are sympatric in the same tropical forests. Only a few morphological traits such as leaflets, laterals, fruits and bark are used to distinguish them. During forest inventories, tree spotters use mostly the shape of the tree crown and the bark to distinguish them: *Khaya anthotheca* is often smooth and pale with scattered scales while *Khaya ivorensis* is rough, scaly and appears smooth when younger. However, all these morphological traits show an overlapping distribution of phenotypes among the two species. The wood quality of *Khaya ivorensis* and *Khaya anthotheca* is different and the timber market prefers *Khaya ivorensis*. Moreover, the EU-timber regulation and the USA Lacey Act require precise declaration of the botanical species for imports to the EU and the USA.

The project therefore seeks to developed DNA makers for the two *Khaya* spp. to facilitate genetic timber identification

Methodology

In cooperation with SAMARTEX Timber Company in Ghana, we conducted a pilot study demonstrating the performance of DNA-markers to distinguish the two species. Cambium

samples from 444 trees (*Khaya ivorensis and Khaya anthotheca*) were collected in the logging zone of the SAMARTEX concession in 2013 and 2014. For each tree, the species was assigned according to its morphological traits. The collection was constituted of 170 *K. anthotheca* and 274 *K. ivorensis*. The samples were stored in plastic bags or tubes with silica gel for quick dehydration and DNA conservation. Several sets of microsatellites have already been developed for different genera of the Meliaceae family such as *Khaya, Swietenia* and *Entandrophragma*. After testing a lot of these published primer pairs, six loci were assessed to be suitable for our project. We further optimised these six gene markers for the two *Khaya* species and genotyped 359 samples with an ABI DNA capillary sequencer.

Results

The genetic results came up with two completely separate groups. Furthermore, we found very little evidence for hybridisation, as less than 5% of the trees were classified as hybrids. Only 5% of the *K. ivorensis* were classified genetically as *K. anthotheca*, whereas 40% of the *K. anthotheca* were classified as *K. ivorensis*.

Conclusion

It could be shown that the microsatellites are also useful gene markers to follow the chain of custody of individual *Khaya* spp. It could also be inferred that DNA fingerprints can distinguish between two species which show similarities in their morphological traits as characteristics inherent in the timber are used for identification.

Way forward

The project seeks to establish DNA database of other valuable tree species including *Khaya* spp., *Nauclea diderrichi, Cylicodiscos gabonensis, Pericopsis elata* and *Lophira alata*. The outcome of this project would enhance better enforcement of forest laws and regulations, monitoring of chain of custody through improved verification and documentation of existing timber resources for sustainable management of Ghana's forest estate.

3.13 Does shifting carbon use efficiency determine the growth rates of intact and disturbed tropical forests? Gathering new evidence from African forests (NERC, UK Project)

Project Team: Adu-Bredu, S., Owusu-Afriyie, K., Djagbletey, G.D., Duah-Gyamfi, A., Addo-Danso, S.D., Amponsah-Manu, E., Dabo, J., Opoku-Ameyaw, A. and M. Boakye

Start Date: September 2012

Expected Completion Date: August 2015

Introduction

Tropical forests play a major role in the global carbon cycle, both by storing a substantial amount of carbon in biomass and soil, by regulating the transfer of this stored carbon into the atmosphere as a greenhouse gas, carbon dioxide (CO_2). Tropical forests in Amazonia and Africa appear to be increasing in biomass, absorbing around 12±3 % of current anthropogenic CO_2 emissions (and the rate of rise of atmospheric CO_2 would be about 17% higher without this tropical sink), but the continuity of this biomass carbon sink is uncertain. Improved understanding of productivity, carbon cycling and carbon use efficiency (*the ratio of net primary production to gross primary production*), and their controlling factors is essential to improve attempts to accurately

model tropical forest carbon cycling, and potential responses to future environmental changes. The project therefore seeks to address the relative importance of photosynthesis and autotrophic respiration in determining forest function in intact and disturbed tropical African forests. To achieve this comprehensive carbon cycle, assessment plots have been established and replicated across two contrasting countries in Africa namely: Ghana (West Africa) and Gabon (Central Africa). In Ghana, the project is being implemented in different ecological zones namely: the Bobiri Forest Reserve (moist semi-deciduous zone), Ankasa Forest Reserve (wet evergreen zone) and the Kogyae Strict Nature Reserve (dry semi-deciduous zone).

Hypotheses

The underlying hypotheses being explored are that (i) there is no significant site-to-site variation in the Gross Primary Production (GPP) (forests within Ghana in comparison to Gabon), despite variation is soil properties, climate and tree species composition; (ii) there is substantial site-to-site variation in Net Primary Productivity (NPP), and this is mainly driven by shifts in carbon use efficiency (CUE, the proportion of photosynthetic carbon converted to biomass), and (iii) forest CUE increases substantially after disturbance (logging and fire) and subsequently declines over time. Methods and results presented here are from two sub-studies under the project jointly titled: Necromass carbon stock and carbon dioxide efflux in a moist semi-deciduous forest of Ghana under recovery from selective logging.

Methodology

Coarse woody debris (CWD) and forest ground litter (FGL), together called necromass, are important characteristics of tropical ecosystems and play important role in global carbon (C) cycle. Studies on CWD and FGL in tropical forests are not widespread, and the few reported cases focused on the Amazon. Therefore, there has been no comprehensive description of C stocks and fluxes pertaining to tropical African forests. This results in uncertainties in quantifying the overall aboveground C stocks of tropical forest stands. The study aimed at quantifying FGL and CWD C stocks and CWD carbon dioxide efflux of Bobiri Forest Reserve, a moist semi-deciduous forest, under recovery from selective logging represented in a chronosequence of post-logged-years sites. Sites included 12 – (Y12), 22 – (Y22), 55 – (Y55) post-logged-years' sites and a Strict Nature Reserve (SNR), with no logging history. In the above-mentioned chronosequence of post-logged sites, sampling and analysis were done using standard (published) field and laboratory methods.

Results/Achievements

- The CWD C stocks showed the least decomposed categories (DC) dominating in relatively recent logged sites, whiles highly decayed DC was dominant in relatively older logged sites.
- The larger-sized diameter class stocks of CWD exhibited highest contribution towards total CWD across sites.
- Generally, CWD biomass stock followed a U-shaped trend across the chronosequence.
- Total Forest Ground Litter (FGL) C stocks ranged from 0.28 (± 0.02) to 0.44 (± 0.03) Mg C ha-1.
- The CO_2 efflux rates were estimated for CWD using Infra-red gas analyser and soil respiration chamber.
- Efflux levels were high in highly decomposed categories for the relatively old logged sites, but low for the relatively recently logged sites.
- Comparing total CO_2 effluxes across the chronosequence, efflux rate was highest in SNR.

Conclusion

- The CWD stocks reported in this study were comparatively lower than the stocks reported in other forest biomes.
- The study serves as a baseline for litter and debris assessment hence contribute to the prediction of C stock and cycle of forests under recovery from logging.

4.1 Bamboo lamination and capacity building for promotion and utilization of bamboo for housing in Ghana

Project Team: Owusu, F.W., Appiah-Kubi, E., Tekpetey, S.L. and C. Essien

Start Date: July 2013

Expected Completion Date: June 2014

Introduction

The rapid development of the global economy and constant increase in population has resulted in an increasing demand for housing and utilisation of wood-based products. The increased use of the available local materials will considerably reduce the import bill on building materials as well as retain capital, provide affordable housing, generate revenue to the state, provide employment for the youth and hasten infrastructural development in Ghana. Bamboo, which is one of the locally available raw materials, is a good substitute for wood. It could be used for different useful products, which include furniture, paper, bikes and construction of houses. But the full potential of bamboo resources in Ghana and some other developing countries where the resources abound remain untapped. This is because the capacity of bamboo users especially artisans, builders, and architects is very low in Ghana. As a result of the rather low level of diversified bamboo products in Ghana compared countries like China, Philippines and India, trade in bamboo products is almost negligible. The main objective of this activity was to increase the utilization of bamboo in the construction industry by enhancing the capacity for research into the use of bamboo. The specific objectives are to:

- Produce bamboo laminated boards from different species and binding media.
- Determine the mechanical strength properties of three different bamboo species
- Build the capacity of bamboo stakeholders for efficient utilization bamboo in Ghana

Methodology

Desk study was conducted to identify bamboo sites (natural and plantations) in Ghana. Based on the ecological zones and access to the bamboo culms, four areas, which include, Bobiri Forest Reserve at Kubease, Oil Palm Research Institute at Kade and Subri Industrial Plantation Limited at Daboase were selected. Bamboo culms of various species from both natural and plantation stands were identified, extracted and processed into strips. These were further processed into laminated boards of various thicknesses and widths which were then used to determine the mechanical strength properties on species basis and the manufacture panel doors. Telephone/ internet communication and visits were also used to identify bamboo research and processing institutions and organizations, bamboo users/ artisans and companies in order to have data on bamboo stakeholders.

Results

1. Mechanical properties of laminated boards from some bamboo species determined

Table 2: *Mean MOR and MOE values for the species with 3 different glue types*

Species	PVA		FWC		5PU	
	MOR N/mm²	MOE N/mm²	MOR N/mm²	MOE N/mm²	MOR N/mm²	MOE N/mm²
Bambusa vulgaris	94,3 (17,22)	9794 (2967)	91,54 (20,08)	9923 (1098)	62,58 (11,95)	9915 (1647)
Dendrocalamus brandisii	84,52 (13,17)	9778 (1162)	90,19 (13,04)	11797 (1669)	99,73 (20,62)	11594 (1433)
Guadua chacoensis	78,2 (17,09)	6629 (747)	81,26 (12,93)	7787 (1137)	80,25 (18,12)	7861 (872)

Note: Figures in parenthesis are standard deviations from the sample mean

Dendrocalamus brandisii (DB) had the highest mean MOR of 99.73 N/mm² (Table 2) with the application of the 5-minute hardening polyurethane glue and *Bambusa vulgaris* (BV) had the least mean MOR with the application of the same 5-minute hardening polyurethane glue. *Bambusa vulgaris* recorded a good mean MOR of 94.3 N/mm² with the application of the polyvinyl acetate white glue and 91.54 N/mm² with the use of the formaldehyde adhesive. *Guadua chacoensis* seemed to have consistent results with all the 3 different adhesives. For PVA and FWC, which are available and popular in the Ghanaian market, *Bambusa vulgaris* recorded the best results in terms of the MOR.

Dendrocalamus brandisii had the highest mean MOE of 11,797 N/mm² with the application of the formaldehyde adhesive whilst *Guadua chacoensis* had the least MOE of 7,861 N/mm² with the application of the PVA. The mean MOE results of *Bambusa vulgaris* were consistent for all the three different adhesives [9794 – 9923 N/mm²]. With the application of the PVA and FWC adhesives, which are readily available in the Ghanaian market, *Dendrocalamus brandisii* recorded the best mean MOE results.

Table 3: Mean compressive strength results for the three species with 3 different glue types

Species	PVA	FWC	5PU
	N/mm²	N/mm²	N/mm²
Bambusa vulgaris	50,71 (6,55)	52,41 (6,57)	47,71 (5,66)
Dendrocalamus brandisii	47,79 (4,07)	49,6 (4,98)	52,51 (5,24)
Guadua chacoensis	37,89 (3,82)	37,21 (3,22)	37,78 (4,84)

PVA = Polyvinyl acetate emulsion white wood glue, FWC = Formaldehyde based adhesive resin, WoodChem, 5PU = 5-minute curing Polyurethane wood adhesive

Bambusa vulgaris had the highest compressive strength with the application of the FWC (52.41 N/mm²) and PVA (50.71 N/mm²). However, out of the three species, *Dendrocalamus brandisii* had the highest compressive strength with the application of the 5PU glue (Table 3).

Meetings and training workshops were held to discuss the way forward for efficient bamboo utilization and promotion. Additionally, some prototype products were developed from bamboo (Plate 4.1 & 4.2).

Plate 4.1: Laminated panel door

Plate 4.2: Laminated furniture

A national bamboo colloquium on the theme "Bamboo utilization for a greener construction and future in Ghana" was held at Fumesua-Kumasi to generate and share information on bamboo for the preparation of publications for public education.

Some bamboo products and structures identified in some regions of Ghana are as follows:

Plate 4.3: Bamboo bikes

Plate 4.4: A roof truss made from bamboo

Plate 4.5: Bamboo out house

Conclusion

From the results, there is clear indication that, bamboo could be a good substitute for the dwindling timber species. It could be used as a tool to alleviate poverty and at the same time ensure environmental sustainability. Currently, efforts being made to promote bamboo utilization are very minimal but the government could do more by utilising bamboo resources to encourage more people to use bamboo in the near future.

4.2 Set up and accreditation of Wood and Furniture Testing Laboratory at CSIR-FORIG

Project Team: Appiah-Kubi, E., Owusu, F.W., Damnyag, L., Tekpetey, S.L., Ebanyenle, E., Essien, C., Ofori, J. and Sekyere, D.

Start Date: 2013

Expected Completion Date: 2016

Introduction

Trade in timber and timber products contribute significantly to the GDP of Ghana. In 2008, for instance, over 187 million Euros was realized from the sale of timber products from Ghanaian sawmills. More than sixty per cent of the timber trade values are from exports to Europe and other consumer countries, an indication that the timber market in Ghana is export-oriented. Increased trade values or higher income from timber products can be achieved through value addition.

Value addition typically involves passing a given product through some processing stages (primary, secondary and tertiary) to increase its worth, thereby, improving the utility and economic value of the product. The timber industry in Ghana, has over the years been largely characterized by primary and secondary processing primarily for export. Past government policy interventions to encourage further processing to ensure more efficient use of forest resources for higher returns, especially at the tertiary level have failed to achieve the desired results.

The magnitude of tertiary processed products and equivalent foreign exchange earnings has consistently declined over the years. It decreased from 11.35% in 2004 to 4.03% in 2009 with regard to the volume of tertiary products exported, equivalent to 16.05% in 2004 to 6.56% in terms of the foreign exchange earnings to Ghana. In terms of value, it decreased from USD 34,846,969 in 2004 to USD 12,631,065 in 2009. Moreover, the timber industry is currently challenged with dwindling wood supplies from the national forest estate coupled with pressure of demand for wood by the informal processing sector particularly for domestic consumption. Under the present circumstances, there is the need to redirect industry's focus for higher value processing. This will ensure sustainable use of the resources and safeguard the timber industry and the Ghanaian economy.

The developmental objective is to enhance the export performance of Ghana by creating conditions for strengthening supply capacity in the wood industry. The specific objectives are to:

- Undertake the value chain analysis of the wood sector in Ghana.
- Upgrade the existing test laboratory at CSIR-FORIG and accredit it according to the international standard ISO 17025.
- Build the capacity of personnel and promote test laboratory to key stakeholders within the Ghanaian wood industry and boost the export and use of wood products through value addition that meets required standards.
- Set up a national technical committee for standards and to ensure compliance by the industry.

Methodology

Desk study, stakeholder meetings/workshops, visit to some sawmills and furniture companies and engagement of consultants.

Results

Specific objective 1: To undertake the value chain analysis of the wood sector in Ghana.

A value chain analysis of the wood sector in Ghana was completed and a final report submitted to UNIDO. Wood products selected by stakeholders include:

- Plywood and veneer value-added
- Mouldings, profile boards, dowels, finger-jointed products and parquet
- Outdoor chairs and tables

Specific objective 2: To upgrade the existing test laboratory at CSIR-FORIG and accredit it according to the international standard ISO 17025.

The scope and the extent of accreditation of the laboratory have been defined. The different tests that will be conducted and the sort of equipment and devices for the testing at the laboratory have also been determined. Equipment list has been provided to UNIDO for procurement. Personnel to man the laboratory have already been identified. An organogram and a management structure of the testing centre have also been set up.

Specific objective 3: To build capacity of personnel and promote test laboratory to key stakeholders in the Ghanaian wood industry and boost the export and use of wood products through value addition by meeting standards.

The capacity of identified personnel for the laboratory has been built through training workshops.

Specific objective 4: To set up a national technical committee for standards and to ensure compliance by industry. A review of the national and international standards in the wood and furniture industry has been done by the project team. The team will liaise with the Ghana Standards Authority (GSA) to set-up a national technical committee to develop standards for the industry.

Conclusion

Most of the aforementioned activities depend on the set up of the laboratory. This involves the renovation of the existing building to a standard which can accommodate the new equipment for the accreditation. According to UNIDO's policy on project implementation, beneficiary institutions are required to contribute to the project funding through the provision of infrastructure to accommodate the equipment. UNIDO's main role involves the acquisition of equipment, capacity building of personnel and payment of accreditation services as well as the set-up of the national technical committee and standards development. CSIR-FORIG is therefore required to provide funding for the renovation of the existing building to the standard required for accreditation.

4.3 The size of the domestic timber market in Ghana

Project Team: Owusu, F.W., Damnyag, L., Marfo, E., Nutakor, E., Adjei, F., Antwi-Baawuah, E., Adjei, R., Asiedu-Opoku, E. and J. Adutwum-Oppong

Start Date: June 2014

Expected Completion Date: March 2015

Introduction

Supplying legal timber to the domestic market of Ghana is increasingly recognized as a critical policy intervention for the sustainability of forest resources and good forest governance in Ghana. This is because the domestic timber

market is flooded with volumes of chainsaw lumber, which are illegally extracted from forests and farmlands. A number of studies have looked into the supply of chainsaw lumber into the domestic timber market to estimate the annual inflows to enable policy makers know the trend of supply. Taking cognizance of the fact that most of the timber resources have been deforested or degraded, the current volumes of timber inflows (supply) and outflows (demand) on the domestic market may be at variance with those stated by these earlier studies. This may likely affect policy decisions on the timber industry. Again, the actual volume of consumption of sawn wood in the domestic market is not clear due to increasing overland export to other countries. Moreover, Ghana has joined the European Union in adopting the FLEGT-VPA process, which imposes a short or medium-term obligation to ensure the traceability and legality of all products from forest operations, whether for the national market or for export. With these challenges it is therefore necessary for the actual size of the domestic market and the current illegal lumber inflows to be determined in order to plan for legal, sustainable, regulated and cost-efficient supply of lumber to meet growing demand. The main purpose of this study, therefore, was to explain the functioning of the domestic timber sector in an effort to contribute to finding ways to make it legal and secure. The specific objectives of the study were; i) to identify all the domestic timber markets in the country and their sizes ii) to display the identified timber markets on a map of Ghana iii) to determine the supply pattern of wood with respect to volumes, values, species and products available on the domestic market

Methodology

The study used structured questionnaires and personal interviews in addition to desk study information on the domestic timber market in Ghana.

Results

1. A total of 109 timber markets in Ghana with different market sizes have been identified.
2. A draft map of Ghana with the surveyed timber markets displayed has been prepared.
3. Timber inflows (volumes and values) estimated on regional basis, and the national volume is being computed.
4. Volumes and values of species and products identified have been determined.
5. Inflows for chainsaw and sawmill lumber from different regions have also been estimated.

Conclusion

The introduction of a map on the domestic timber market in Ghana will make it possible for various markets to be easily identified. Analysis of the results is on-going after which the trend of chainsaw lumber inflow will be made known.

4.4 Some machining characteristics of African Rosewood (*Pterocarpus erinaceus*) grown in Ghana

Project Team: Owusu, F.W., Owusu-Ansah, J. Jnr., Arthur, P.L., Boakye, F., Zorve, G.K., Adutwum, O.J. and R. Boamah

Start Date: November 2013

Expected Completion Date: July 2014

Introduction

There is over exploitation of timber species in Ghana due to some factors like illegal logging, bush fires, farming and urbanization, resulting in dwindling of timber resources. This has made it difficult for wood workers to have enough timber to work with. There is the need to find other alternative wood species (lesser-used or lesser-known timber species) to replace the fast diminishing timber species thereby increasing the resource base. One of such alternatives is *Pterocarpus erinaceus* (rosewood). Rosewood is mostly available in the three Northern regions of Ghana and some parts of Brong Ahafo region. High volumes of the species have been exported from the country in billet form until 2014 when it was prohibited. The less use of rosewood in Ghana could be attributed, among other factors, to the inability of wood users to utilize it fully because of little knowledge on machining properties of the species and its high demand on the international market. This tends to impede the promotion and efficient utilization of the species. One of the properties that affect the general utilisation of any wood is machining. This includes the standard operational processes such as planing, boring, lathing, sanding and shaping. Adding value to the species by way of developing its machining properties will increase revenue, provide employment and keep the furniture industry in business. The specific objectives of the project were to establish the planing, shaping, boring, lathing and sanding properties of rosewood.

Methodology

Ten trees were extracted from Kintampo in the Brong Ahafo region. Using a chainsaw, these were cross-cut into logs of length 2.5 m, labelled, and transported to CSIR-FORIG campus. Both 'plain' and 'cannot' methods were used to mill the logs into lumber of thicknesses 25 mm and 38 mm using a wood-mizer. These were stacked and air dried to an average moisture content of 15%. Planing, shaping, boring, turning and sanding machines were used for the tests. ASTMD 1666-87 and ASTMD 143-94 were used to prepare the test samples, tested, evaluated and graded (excellent = without any defect; good with defects that can be eliminated; and poor with defects that cannot be eliminated without affecting the thickness of the sample).

Plate 4.6a: Sanding of *Pterocarpus erinaceus*

Plate 4.6b: Lathing of the sample at a workshop

Results

Feed speeds ranging from 6m/min and 9m/min with 15° cutting angle gave the best planing quality followed by the same feed speed with a 20° cutting angle. There was no blade and chip marks on the planed surfaces. The degree of ease of planing was classified as Easy. With shaping, a spindle speed of 6,500 rpm developed a higher percentage of good to excellent (100%) samples than 4,500 rpm and 5,000 rpm. Yet all the spindle speeds could be used to work on the wood as both speeds recorded 90% surface quality. Shaping activity was slightly difficult. The quality of boring was 100% (Excellent) but the process was slightly difficult. The smoothness of the surface after sanding was excellent. The percentage surface quality after turning (lathing) increased with increasing spindle speed.

Conclusion

The study has shown that rosewood is machineable and that cutters used for processing should be sharpened intermittently.

4.5 Investigating surface quality of African Mahogany from Ghana using Stylus and Deflectometry Techniques

Project Team: Tekpetey, S.L., Opuni-Frimpong, E., Riegel, A. and K. Dekomien

Start Date: July 2014

Expected Completion Date: December 2015

Introduction

Surface quality evaluation has been described as one of the most difficult issues in wood research. Wood is heterogeneous, anisotropic and reacts differently under changed machining processes. Its evaluation and the relationship between different techniques have been the subject of interest to many researchers over the years. The visual and tactile techniques which are commonly used in surface evaluation are subjective and need experienced assessors. More objective and quantitative techniques such as stylus and deflectometry are needed. There is, however, paucity of data and information on the surface quality of tropical hardwood species like African Mahogany. The objective was to evaluate the surface quality of machined wood of African mahogany (*Khaya ivorensis*) from both natural and plantation forest using different quantitative techniques.

Methodology

Natural and plantation grown mahogany trees harvested from Pra-Anum Forest Reserve at Amantia were transported to Logs and Lumber Limited (LLL), Kumasi for primary processing with a vertical band mill. Oven dried boards were also transported to the University of Applied Science, Lemgo, Germany for surface quality evaluation. The stylus instrument: Hommelwerke with a tip type of TK 300 and a Gaussian Regression filter – DIN ISO 11562 was used for surface roughness

of the samples. The roughness parameters were then taken with scan length 15mm and a cut-off length of 2.5 mm. Each sample was measured 10 times on the tangential surfaces. The Optimap device was used for the texture measurement. The Optimap™ Phase Stepped Deflectometry (PSD) camera of 1.3 Megapixels, image resolution 1296 x 966with setting of extra dull and multiband was used. The measurement area was 95mm x70 mm with lateral resolution of 75µm texture values at different wavelength.

Results

Analysis of results revealed that roughness parameters varied significantly at different height levels of wood samples at 95% confidence level for both plantation and natural samples. Roughness parameters for plantation samples (Figure 4.2) were relatively lower than the natural samples (Figure 4.1) at the middle and bottom but not the top portions. Texture values at different wavelength (Ta, Tb, Tc, Td and Te) using the Optimap device showed statistically significant variation along the stem for both natural and plantation samples of mahogany at 95% confidence level.

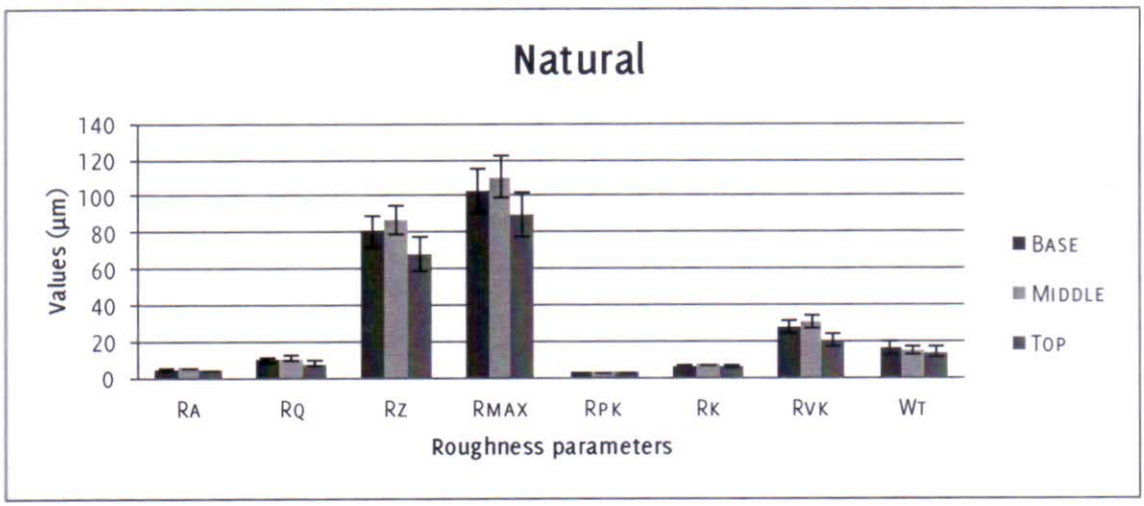


Figure 4.1: Roughness parameters for natural samples

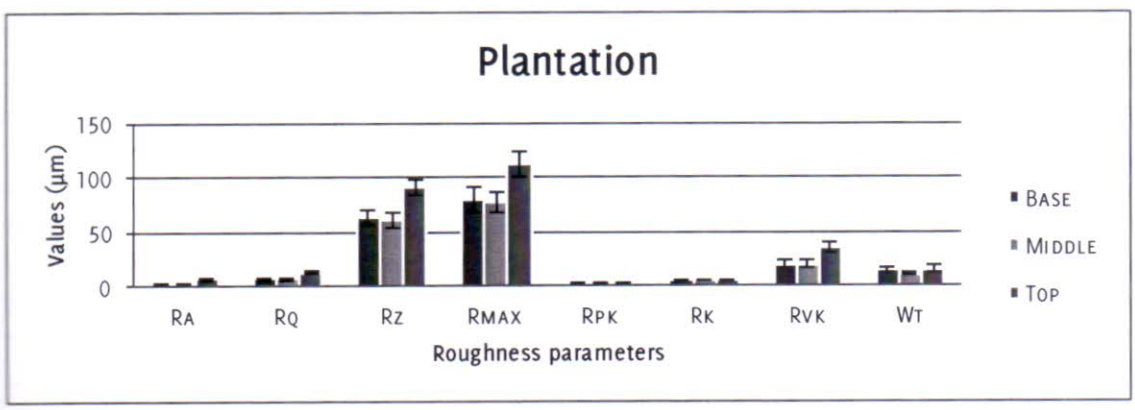


Figure 4.2: Roughness parameters for plantation samples

Conclusion

Tropical hardwood species like *Khaya ivorensis* have characteristics that make it suitable for commercial use. The results of the study showed average values for the selected roughness and texture parameter estimates. Further work on the filtering process such as the use of 'love filter' on the surface profiles obtained will be necessary to eliminate the effect of deep valleys which occur as a result of vessel openings on the surface of the material. Wetting and coating of the surfaces of samples are also being fully tested to understand their influence on surface quality assessment.

5.1 Identification of male and female seedlings of *Allanblackia parviflora* A. Chev. using anatomical and morphological characteristics

Project Team: Ebanyenle, E. and D.A. Ofori
Start Date: December 2014
Expected Completion Date: August 2015

Introduction

Allanblackia spp. belongs to the family Clusiaceae. Nine tree species within the genus are limited to Africa. *Allanblackia parviflora* A. Chev. occurs within the forest zone of Guinea to Ghana. Traditionally, local people use oil extracted from the seeds for cooking and soap making. However, in the recent times, the potential of the oil from the seed in agribusiness is acknowledged. Unilever Ghana has identified the oil to be of high value and being developed as rural enterprise economic schemes in Cameroon, Ghana, Nigeria and Tanzania. Nevertheless, only 5% of the demand for *Allanblackia* oil can be supplied sustainably from natural populations. Hence a programme for cultivation of *Allanblackia* was initiated by Novella Africa in 2003. *Allanblackia parviflora* is a dioecious tree and its sex characterization appears impossible until maturity and flower formation. Typically, it reaches maturity stage between 5 to 12 years. Furthermore, accurate identification of its male and female at the juvenile stage (before reproductive maturity stage) is essential for its establishment in plantations or agroforestry systems. Anatomical and morphological characteristics of different plants parts have been useful in plants systematic and sex determination of a number of plant species. Nonetheless, investigations of the anatomical and morphological characteristics of *A. parviflora to* aid in distinguishing male and female trees at the juvenile stage including seedlings to our knowledge have not be fully explored. It is against this background that this project seeks to determine the anatomical and morphological properties of the leaves of *A. parviflora* with the aim of identifying characteristics of diagnostic value for identification of male and female trees especially at the juvenile stages.

Methodology

Tree sampling: A total of six 10-year-old trees with known sex (females and males) were randomly sampled from an *Allanblackia* demonstration site at CSIR-Forestry Research Institute of Ghana. The trees were established from seedlings in June 2004 and the average diameter at breast height (DBH) was 9.0 and 11.5 cm for male and female trees respectively.

Morphological investigation: For the morphological studies, 5 leaves were collected from each tree at approximately the 6th and 7th node from the eastward, westward, northward, southward and a fifth one from the apical position. All leaves sampled were scanned using an HP scanner and the images were analysed using image J software (National Institute of Health, Bethesda, MD, USA). Features measured include petiole length, leaf length, leaf width (measured at the widest portion), and leaf area. In addition, six leaves were randomly selected from each tree and the leaf lamina (blade) thickness was measured using a digital

micrometer. Two measurements were taken from each leaf lamina.

Anatomical investigation: Imprints of stomata at abaxial side of all sampled leaves were made using plain nail polish and cellotape and transferred onto glass slides. Microphotographs were made from the imprints with a digital camera attached to a national compound microscope. Stomata characteristics analysis was done on the microphotographs using Image J software (National Institute of Health, Bethesda, MD, USA). Five 366 × 274 µm size images at 200 x magnifications at 1024 × 768 pixels resolution were captured randomly from each imprint for stomata density measurements (number of stomata per mm^2).

Results

Leaf morphology: Leaf characteristics such as area, length, width, and petiole length and leaf lamina thickness appear not to differ significantly with respect to sex. Hence may not be useful descriptors for female and male *Allanblackia parviflora*.

Leaf petiole anatomy: In general, the petiole is oval in cross section and consist of epidermis, hypodermis, conducting tissues (xylem and phloem) located centrally and pith consisting of parenchyma cells. Crystal sands were found in parenchyma cells in the cortex and pith of both female and male trees. Intercellular canals (spaces filled with secretory products including oil) are located in the cortex of the petiole. Larger cavities of 1–2 in number were found at the adaxial side whereas the smaller canals are located at the abaxial region of the petioles. Female trees tend to have higher number of secretory cavities than males in the cross sections of the leaf petiole. On the average female trees had 26 ±1 canals, whereas males had 23±2 canals.

Leaf lamina anatomy: Stomata were present only on the abaxial region of the leaves but absent in the adaxial. Stomata were longer and wider in females than the male type. However, stomata density did not differ with respect to sex. In cross section, the general leaf lamina anatomy of female and male *Allanblackia parviflora* was distinctly made up of epidermis covered with cuticle and palisade and spongy mesophylls below the epidermis. The mid vein of the lamina consists of xylem tissues which are located towards the pith whereas the phloem tissue is located towards the periphery. Internal phloem fields were observed in the pith. Crystal sands in parenchyma cells were common in both female and male trees. Unlike the petiole anatomy, male trees tend to have more intercellular canals than the female trees in the cross sections of the leaf lamina. Male trees have mean canals of 15 ±1 and Females had 13±1.

Conclusion

Leaf morphological characteristics i.e. area, length, width, thickness, and petiole length may not be useful descriptors of female and male *Allanblackia parviflora*. Qualitatively, anatomical properties of female and male *Allanblackia parviflora* appear similar. However, some quantitative characters such as stomata length and width, number of intercellular canals in leaf lamina and leaf petiole appear to be promising diagnostic characteristics. Nonetheless, these preliminary observations need to be confirmed or rejected through further intensive sampling and analysis. More reliable and valid conclusions will be made after studies have been replicated using large number of male and female trees from the *Allanblackia* gene bank at Benso. Additionally, more quantitative anatomical investigations of the leaf petiole and leaf lamina which is currently ongoing could aid in corroborating the current observations. Further quantitative anatomical investigations include the nature of the intercellular canals (area, diameter, frequency); cuticle thickness, veins and veinlets density, crystal sand density, epidermal cell sizes, cortex width etc. Intensive sampling of trees at the *Allanblackia* gene bank at Benso will be done for further investigations on the morphology and anatomy of female and male *A. parviflora* to aid in confirming or rejecting current observations.

5.2 Rehabilitation of degraded forests for sustainable wood fuel production and climate change mitigation in the forest-savanna transition zone of Ghana

Project Team: Darko-Obiri, B., Oduro, K.A., Peprah, T., Damnyag, L., Korang, J., Opuni-Frimpong, E., Nutakor, E., Adjei, R. and K. Asumadu

Start Date: May 2013

Expected Completion Date: April 2016

Introduction

The objective of this study was to contribute to the sustained socio-economic development of forest dependent communities and reduction in forest degradation in the forest savanna transition zone of Ghana through the promotion of smallholder and commercial tree plantations that could ensure sustainable resource base for charcoal and other wood energy production, marketing and carbon sequestration.

Methodology

Baseline studies

1. Participatory and quantitative methodology for characterization and value chain analysis of the wood fuel sector.
2. Wood fuel tree resource inventories with communities' involved using one hectare sized plots to determine species abundance/richness and description of characteristics of dominant and key species.
3. Assessing vulnerability of wood fuel dependent livelihoods/communities to climate change effects using socio-economic indicators and wood fuel species availability and use trends.

Preparatory stakeholder dialogue meetings

1. Local and district level workshops with communities and technical experts in the wood energy sector was organized to thoroughly discuss and screen options for sustainable wood fuel resource development.

Experimentation

1. Prioritized wood fuel development options were planted on demonstration plots to be managed by volunteer experimenters on their privately owned lands.
2. Scientists and FSD technical experts assisted experimenters with technical knowledge to plant and manage their test plots using appropriate rotation strategies and planting (block, strip, mixed, boundary) patterns. Farmers were also supported with material incentives including quality fast growing planting materials to enhance survival and growth. Wood fuel species used, determined by stakeholders comprised a mix of both indigenous and well researched and tested exotics species that could easily be managed by both smallholder and larger scale experimenters. Consideration was given to fire tolerance and nitrogen fixing species and also planting regimes that would ensure compatible agri-silvicultural or tree-agricultural crop mixes in temporal and/or spatial sequences.

Monitoring and evaluation of test plots

A monthly monitoring schedule was followed after establishment of the trial plots and necessary technical backstopping provided to maintain test plots. During this period, data was collected for the following analyses:

1. Tree performance i.e. survival and growth (vegetative, stem and girth) for estimating biomass production potential of trial wood fuel species.

2. Carbon dynamics and vegetation carbon cycle modelling approaches was employed for initial carbon stock assessment.
3. Silvicultural management regimes

Laboratory chemical analysis of wood fuel species on test plots using standard tests

1. Determination of calorific value.
2. Life cycle analysis of charcoal
3. Carbonization methods and charcoal yield

Potential cost and benefits of wood fuel plantations

1. Ex-ante economic analyses of the options experimented to access viability using the cost benefit methodology

Potential impact on livelihoods and environment

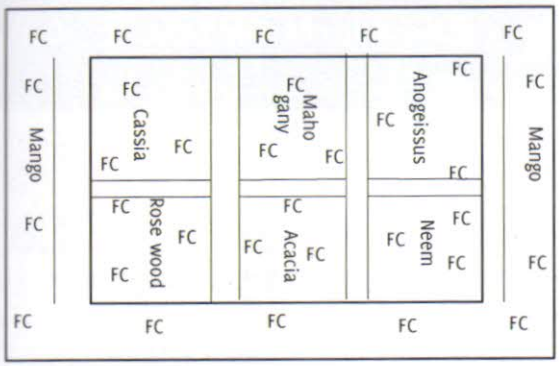
1. Determine social, economic and environmental impacts on local livelihoods of wood fuel plantations.
2. Gender analyses framework which takes into account access and control profiles and social and economic inequity will be used for gender mainstreaming

Planning for sustainability through stakeholder forums and publicity

1. Local, district and national level workshops of stakeholders in the wood energy, environment and forest sectors have been engaged to thoroughly discuss, design and draft a plan for wood fuel resource development and management.
2. The media will be invited to publicize results from the project

Results

1. Baseline surveys and reports have been completed. Key results indicate the following:
    - Wood fuel species have multiple uses: fuel, timber for construction and furniture, medicine, utensils, etc.
    - Majority of the species are currently harvested from secondary forests and fallow lands.
    - Species have declined in stocks.
    - Erosion of traditional conservation measures, hence wood fuel resources hardly managed /regulated while the species are highly susceptible to wildfire.
2. Germination trials of selected and preferred wood fuel test species to be planted in wood fuel demonstration plantations have been conducted. Preliminary data has been gathered on the germination requirements on seeds of *Anogeissus leiocarpus* (Kane), *Pterocarpus erinaceus* (Rose wood – Krayie), *Khaya senegalensis*, *Azadirachta indica* (Neem), *Senna siamea*, *Acacia mangium*, and *Acacia cracicarpa* (Exotic) to be planted in demonstration trials. Results indicate that seeds began germination after 6 days with pre-treatment. However, kane and rosewood (krayie) have recalcitrant seeds that are difficult to germinate with pre-treatment media. Further pre-treatment will be applied to test whether germination will be improved in these species
3. **Establishment of nurseries:** nurseries were established at Nkranka, Babatokuma, Attakura and CSIR-FORIG to produce approximately 20,000 seedlings for establishment of wood fuel species demonstration plots. Routine monthly monitoring of these nurseries were done to ensure that they are properly maintained for production of healthy seedlings. Test plots of wood fuel species have been installed in six communities in the Kintampo North and Nkoranza Districts. Farmer plots covering 5 ha were systematically planted with seedlings in six project villages.



FC = FOOD CROP

Figure 5.1: A standard plot planted for scientific data collection with all the seven trial species

4. **Monitoring performance of planted seedlings:** As part of periodic monitoring and evaluation schedule, follow up visits were made to all wood fuel species trial plots to assess performance/survival of seedlings planted. Seedling survival was over 95% on all fields visited. Some fields need weeding for the seedlings to be protected against wild fire, especially those established on fallow land.

Ex-ante economic analyses of the wood fuel test plots being experimented is in progress. An ex-ante financial analysis of the viability of wood fuel plantations based on species selected for planting in the test plots is in progress. Based on field monitoring reports and farmer interactions and preferences for tree species, 3 wood fuel woodlots models are being analysed (Table 4). These are as follows:

Table 4: *Wood fuel woodlots model*

District	Tree-crop woodlot model	Reason for choice	Expected products
Kintampo North	*Senna siamea*-Yam-Maize	All species browsed by livestock and susceptible to wild fire damage except *Senna siamea*	Food crops Leaf biomass to improve soil fertility Wood for charcoal Poles for construction Stakes for trailing yam vines
Kintampo North	*Senna siamea-Khaya senegalensis-Anogeissus leioccarpus-Acacia* sp-Yam-Maize	Where livestock browsing and wildfire can be controlled	Food crops Leaf biomass to improve soil fertility Wood for charcoal Timber for sawing Poles for construction Stakes for trailing yam vines
Nkoranza	*Khaya senegalensis-Acacia* sp. *Terminalia ivorensis*–Yam-Maize	Preference for multipurpose woodlots that can produce wood for both timber and charcoal	Food crops Leaf biomass to improve soil fertility Wood for charcoal Timber for sawing Poles for construction Stakes for trailing yam vines

5. **Questionnaires preparation:** questionnaires have been developed and are being tested for data collection on the assessment of the potential impact of wood fuel plantations on the livelihood and environment of households.

6. **District and national stakeholder dialogue meetings:** meetings have been held and draft wood fuel resource management plan prepared.

6.0 ECOSYSTEM SERVICES AND CLIMATE CHANGE DIVISION

6.1 Conservation and management of pollinators for sustainable agriculture, through an ecosystem approach (Bobiri STEP Site)

Project Team: Bosu, P.P., Anim-Frimpong, K., Adjaloo, M., Braimah, H. and W. Oduro

Start Date: September 2010

Expected Completion Date: December 2014

Introduction

The GEF/UNEP/FAO project, "Conservation and Management of Pollinators for Sustainable Agriculture, through an Ecosystem Approach", or Global Pollination Project-Ghana (GPP-Gh) aims to build local, national, regional and global capacities among farmers, agricultural researchers, extension agents, and policy-makers to design and implement management practices that secure the pollination services of wild pollinators for crop production. The primary focus is to develop pollination management plans for priority cropping systems with a high dependence on pollinators, which also have important links to human livelihood and sustainable development, in selected STEP (Study, Training, Extension and Promotion) sites. STEP sites are areas designated by the Project for the demonstration of pollinator-friendly practices. There are three STEP sites in Ghana, namely Mankessim (vegetable cultivation), Dodowa/ Somanya (mango cultivation) and Bobiri/ Kubease (cocoa cultivation). The Bobiri/ Kubease STEP site is located within the catchment of the Bobiri Forest Reserve (BFR) in the Ejisu-Juaben Municipality of the Ashanti Region.

The objectives of the project were to:

1. Strengthen the knowledge base on pollinators and pollination systems in Ghana.
2. Build and/or enhance the capacity of stakeholders in the conservation and efficient management of pollinators to enhance agricultural production.
3. Identify, test and promote the application of pollinator-friendly best practices.
4. Increase public awareness and mainstreaming of issues on the conservation and sustainable management of pollinators.

Methodology

The STEP site activities were carried out primarily with farmers at the village of Wuraponso, which lies on the fringes of the Bobiri Forest Reserve. Other farmers from Kubease, Krofrom, and Duapompo were also included. A desktop review of literature on cocoa pollination was conducted, followed by a public awareness survey in the Ashanti Region to evaluate the level of awareness of key stakeholders on the subject of pollination. In addition, a survey was carried out within selected farming communities to identify indigenous and local farming practices that promote the management and/ or conservation of pollinators. The pollinator management practices identified were tested in the field, in collaboration with farmers. Also, training and public awareness activities were undertaken to educate the general public on the importance of pollinator conservation.

Results

A number of pollinator-friendly best practices have been identified, tested and promoted among cocoa farmers within the Project catchment area. The Project has among others, confirmed that an insect belonging to the midge group *Forcipomya* spp. is the primary pollinator of cocoa in Ghana. Farmers from the Wuraponso village have nick-named this insect "kookoo kunu" (literally "husband of cocoa") to distinguish it from similar insects found in the cocoa agro ecosystem. Farmers were also given training in para taxonomy to help with identifying the midges and other pollinators, as well as insects that are pests, predators or other groups.

Conclusion

A number of publications (scientific articles, fliers, bulletins, handbooks, and many more) have been produced through this Project. However, opportunity still exists for further studies on the pollinator complexes in other cropping systems. Studies are also required to understand the dynamics of various pollinator complexes following disturbances in the ecosystem.

6.2 Measuring the impact of the chainsaw project in three critical areas: Knowledge generation, MSD process and policy outcomes

Project Team: Bosu, P.P., Appiah, N. and E. Marfo
Start Date: January 2014
Expected Completion Date: December 2014

Introduction

The first phase of the EU Chainsaw project titled "Developing alternatives for illegal chainsaw milling (CSM) through Multi-Stakeholder Dialogue (MSD) in Ghana and Guyana" aimed at developing alternatives to unsustainable chainsaw milling practices. The project was implemented in Ghana from 2007 to 2012 by Tropenbos International (TBI), in collaboration with the Forestry Commission and the Council for Scientific and Industrial Research-Forestry Research Institute of Ghana (CSIR-FORIG). In 2013, a baseline assessment of the first phase of the project (2007 - 2012) was undertaken to determine the extent to which the project achieved its set objectives and to provide an outline of baseline indicators for assessment at the end of the second phase of the project. This report is the outcome of an empirical impact assessment of the project conducted in three critical areas of "Knowledge Generation, MSD process and Policy Outcomes". The study focused on these three areas based on claims made by the Project Management Team and reports regarding its implementation and expected impacts. Specific objectives of the study were to ascertain the actual impact of the MSD process in terms of stakeholder participation in policy dialogue, the impact of knowledge generated on the policy environment, and actual policies that have emanated to address illegal chainsaw milling in Ghana.

Methodology

Methods/tools used largely consisted of surveys and interview of key stakeholders, evaluation of records/statistics, and inspection of products and on-going activities linked directly or indirectly to the project. Regarding evaluation of the impact of the MSD component, key stakeholders interviewed include operators and actors of chainsaw lumbering, policy makers and regulators, civil

society, traders and researchers. Information was gathered from a cross-section of members using semi-structured questionnaires, one-on-one interviews and focused group discussions. Additional data to validate information gathered from interviews were obtained from official records and observation of tangible outputs or products. Where empirical data was not available, we interviewed relevant officers or institutions for their opinion. Assessment of the impact of the project on knowledge generated and the policy environment was done concurrently. We interacted with key policymakers and stakeholders to assess whether there has been an increase in their current understanding of the CSM situation compared to the pre-project situation. We then measured policy impact by examining records/documentation to knowledge generated and recommendations arising out of the policy briefs, official statements, and minutes of meetings that discussed these issues. Key stakeholders who participated in this evaluation included staff from the Forestry Commission and its four main Divisions, law enforcement agencies, local government agencies, researchers, traders, chainsaw operators and local communities.

Results

Key findings of the assessment showed that after nearly seven years of implementing the EU CSM Project in Ghana, the following impacts /changes have occurred:

1. Knowledge in the contribution of chainsaw lumber to the domestic market has increased considerably; with over 78% of respondents indicating a significant improvement in knowledge gained.
2. Sixty-six percent (66%) of respondents directly attributed knowledge gained to the implementation of the EU-CSM Project, Tropenbos International-Ghana (the project implementing agency), or other key project partners.
3. Almost sixty percent (60%) of respondents have one or more project documents available and majority of respondents (82%) considered available data as good or better.
4. There has been a general increase in awareness with regard to the MSD platform as a means to building consensus to resolve the CSM menace. Additionally, TBI-Ghana, the EU-Chainsaw Project, the Forestry Commission, and CSIR-FORIG are organizations rightly considered to be at the forefront of the process. Even though participation of actors in the private sector was greater than other sectors, the MSD has been accepted as a more effective platform for discussing forest related issues.

Conclusion

The EU-Chainsaw Project has generated a discourse and options to address chainsaw milling, provided strategies to supply legal timber to the domestic market and consolidated efforts at institutionalizing the culture of MSD in the forestry sector. A major breakthrough of the project is the change in policy direction in terms of integrating artisanal milling in the formal industry to produce and supply timber to the domestic market.

6.3 Domestication of *Tetrapleura tetraptera* for Livelihood Improvement in Tropical Africa: Assessment of Provenances from Ghana, Nigeria and Uganda

Project Team: Bosu, P.P., Owusu, E.O., Elusiyan, C.A. and E. Kemigisha
Start Date: February 2014
Expected Completion Date: February 2017

Introduction

Tetrapleura tetraptera (common name: Aidan tree, local name: prekese) is a native tropical African tree commonly found throughout the high forest zone. It occurs in many African countries, including Ghana, Nigeria, Uganda and Tanzania. In addition, it is recognized as a highly useful tree due to its nutritional and medicinal properties in these countries. The fruits and seeds are commonly used to flavour soups and stews. The leaves, bark, roots and the kernels are used extensively in traditional medicine; and as mosquito repellent. Analysis of phytochemical composition of *T. tetraptera* shows it contains alkaloids, flavonoids, saponins, tannins, phenols and glycosides.

In spite of its importance, *T. tetraptera* is still underutilized in many African countries and to some extent neglected. Throughout Africa, fruits are collected from the wild in an unsustainable manner, for household use or sold in local markets. Pressure on land for settlement, slash and burn agriculture, and cash crop production, have contributed to the decline in population size and genetic diversity. At the current rate of deforestation, the role of *T. tetraptera* as a nutrient resource and a supplementary source of income will be lost or significantly reduced. In addition, information to facilitate the domestication of the species is lacking. Better understanding of the existing potential and opportunities for *T. tetraptera* will facilitate the domestication of the species in Africa and beyond. This will help reduce poverty and improve livelihoods in local communities, increase biodiversity, and help in climate change adaptation and mitigation processes.

The objective of the study is to screen *T. tetraplera* germplasm from across the continent, identify and select progenies/provenances that are high yielding, have high fruit quality, low fruit toxicity, and with other desired characteristics, as well as enhancing planting and conservation of the species.

Methodology

Tetrapleura tetraptera germplasm (fruit and seed samples) were collected from the distribution range in Ghana, Nigeria and Uganda, and the samples were shared among project partners in the three countries for various studies. The samples included one accession of *T. chevalieri* (local name: Ntim prekese), which is a rare species of the genus *Tetrapleura*. Seeds obtained were raised at the Mesewam nursery for the establishment of progeny/provenance plot.

Results

Twenty eight (28) samples of *Tetrapleura* species were collected for progeny/provenance trials. In Ghana, samples were collected from the Moist semi-deciduous forest zone (areas around Suhum, Oda, Asarekwae, Adantem, Kubease, Amantia), Dry semi-deciduous forest zone (areas around Abofour), Transition zone (areas around Dogojani), Upland Evergreen Forest (Mpraeso), and the Wet evergreen forest zone (areas around Elubo). Another set of four (4) and eight (8) progenies were received from Nigeria and Uganda, respectively. Only one out of the 28 progenies was *T. chevalieri*, with the remaining 27 being *T. tetraptera*.

Conclusion

Site for the progeny/provenance trials has been selected at the Mesewam nursery. The plot will be set up during the planting season in June/July. The provenance trial will be replicated by the project partner in Uganda. A socioeconomic assessment on collection, uses and marketing of Tetrapleura in being undertaken in the three countries. Strategies for vegetative propagation is currently been studied at the CSIR-Plant Genetic Resources Research Institute (Ghana), whiles analysis of the nutritional content of the fruit is on-going at the Obafemi Awolowo University in Nigeria.

7.1 Flowering, fruiting phenology and quantification of seed yield of *Allanblackia parviflora* from three ecological zones in Ghana

Project Team: Asomaning, J.M., Peprah, T. and D.A. Ofori
Start Date: January 2013
Expected Completion Date: December 2015

Introduction

Plant phenological studies are of great significance because it does not only provide knowledge about plant growth pattern but it also gives an idea of the effects of environment and selection pressure on flowering and fruiting behaviour. It is used for characterization of vegetation type. In addition, it provides valuable data for land-use planning and crop zonation, control of agricultural, forestry and domestic pest species, protection of species of conservation interest, and information on pollen release and its implications for human health. The knowledge of timing of phenological events and their variability can help to get more stable crop yields and quality through improved and sustainable crop management providing dates for timely irrigation, fertilizing, and crop protection. *Allanblackia* species of the family Clusiaceae are a high value multipurpose indigenous tree species in the Central, East and West African regions notably Cameroon, Ghana, Nigeria, and Tanzania. *Allanblackia* spp. unlike others is not likely to be affected by climate change due to high genetic diversity among the species and their ability to thrive in different habitats ranging from wet evergreen to dry semi-deciduous forest zones. Some benefits derived from *Allanblackia* spp. include shade, timber, medicine and seed oil. The kernel when dried contains about 67-73% of solid white fat.

Objectives

To investigate and document time of flowering, fruiting as well as seed yield in *Allanblackia parviflora* across three provenances in Ghana.

Methodology

Forty-five (45) trees (accessions) of the species comprising of 30 females and 15 males were sampled from each of the three ecological zones within its distribution range, namely: Benso Pataho in the Moist Evergreen Forest; Wassa Akropong Dikoto in the Moist Semi Deciduous Rainforest and New Edubiase Anwona in the Semi Deciduous Rainforest ecological zones. Thus a total of 135 accessions comprising of 90 females and 45 males were used for the study. Trees were marked with white paint and were given distinctive identification numbers after which their global positioning coordinates were taken using a GPS. Marked trees were visited monthly for the measurement/counting of quantitative traits such as tree height, tree diameter, flower numbers, number of fruits at maturity, fruit weight, fruit size and number of seeds per fruit. However, visits were done at 2 week intervals during the period of flower bud formation, flowering and fruiting.

Flower colour and count: This qualitative/descriptive trait was also assessed and categorized as white (W), pink (P) or pale pink (PP) {this has been done only at the Benso Pataho in the Moist Evergreen Forest Ecozone}.

Assessment at the other two ecological zones will be done in the coming flowering season.

Total number of matured fruits per tree: This was assessed by collecting, counting and recording the number of fallen matured fruits under each tree during each visit. Fruits were removed from the ground after each count. The number of fruits remaining on each tree was then counted during the final visit and these figures were added to the previous values already collated to get the total number of fruits per tree.

Fruit weight, length and circumference: Thirty fruits were collected from every marked female tree from each of the 3 ecological zones between December 2013 and March 2014. Fruit weight, length and circumference were measured and recorded.

Total number of seeds per fruit: After the measurement of fruit weight, length and circumference, each fruit was then opened with the hand and seeds extracted, cleaned, weighed and number of seeds recorded.

Results

Flower colour: Flower colour assessment carried out at the Benso Pataho provenance showed that Pink was the most dominant colour amongst flowers of *Allanblackia parviflora* with 23 counts. This was followed by Pale Pink and White with 15 and 7 counts respectively.

Fruit weight: Mean fruit weight indicated that fruits from the New Edubiase Anwona provenance were the heaviest with a weight of 1.3 kg per fruit. This was followed by fruits from Benso Pataho and Wassa Akropong Dikoto with weights of 1.2 kg and 1.1 kg respectively.

Fruit length: Fruits from the Wassa Akropong Dikoto provenance were the longest with a value of 27.8 cm. This was followed by fruits from Benso Pataho provenance and New Edubiase Anwona provenance with 27.7 cm and 27.1 cm respectively.

Fruit circumference: Fruits from New Edubiase Anwona provenance had the biggest circumference of 33.2 cm. This was followed by fruits from Benso Pataho provenance and New Edubiase Anwona provenance with 31.6 cm and 30.7 cm respectively.

Mean number of seeds per fruit: Seeds per fruit from Wassa Akropong Dikoto provenance were 24.2 seeds. This was the highest compared to 23.6 and 23.1 seeds per fruits from the New Edubiase Anwona and Benso Pataho provenances respectively.

Mean number of fruits per tree: Benso Pataho provenance had 187.4 fruits per tree which was the highest compared with 176.7 and 167.8 respectively recorded from trees from the Wassa Akropong Dikoto and New Edubiase Anwona provenances respectively.

Conclusion

Pink was the most dominant flower colour at the Benso Pataho provenance. In terms of mean fruit weight and fruit length, the differences between provenances may not be significant. For the mean number of fruits per tree, differences between provenances may be significant.

7.2 Estimates of wood fuel potential for wood fuel supply in Ghana as part of a wider review of Ghana's Strategic National Energy Plan

Project Team: Owusu-Afriyie, K., Mensah, J.K., Opoku, E.A. and I. Nunoo

Start Date: September 2013

Expected Completion Date: September 2015

Introduction

Wood-fuel dominates Ghana's energy equation as in most African countries. As urbanisation continues unabated and forests become further depleted, the real cost of domestic energy is set on a rising trend. Wood being a renewable resource, a well-thought out national wood energy planning, reflecting both demand and supply characteristics, and backed up with sustainable management of forests, forest resources and adequate investment into the sustainable production and use of wood energy could be a more sustainable long-term solution to the rising domestic energy requirements. The solution needed is one that takes better account of the socio-economic dimension of the energy equation of the country, and is also more likely to promote inclusive green growth in Ghana. The two broad objectives of the project were to:

- Estimate direct wood-fuel resource per land use system in three political regions in Ghana.
- Estimate the annual generation of indirect wood-fuel resource from waste wood systems from economic sectors in Ghana annually.
- Establish wood-fuel supply and demand balance for Ghana annually.

Methodology

The study was carried out in three political districts, one each in the forest, transition, and Northern Savannah ecological zones. It was designed as a pre-project to explore and unearth the major issues that need to be considered in order to fully address the problems associated with wood-fuel demand and supply in the country. Literature review was followed by qualitative and quantitative methods to obtain relevant data. Triangulation of data collection by using multiple methods and information/ data sources including secondary sources (i.e. information from literature), and primary data (talking to experts, interviewing field practitioners, as well as direct measurements in the field (using standard forest inventory techniques) ensured credibility of the process.

Results

- Wood-fuel demand and supply balance at the national level is currently favourable (i.e. supply exceeds demand) but looks uncertain to be sustained in the long-term future.
- Dwindling wood-fuel supply sources (resource base) need to be actively managed to ensure sustainability of supply.

Conclusion

Poor record keeping by institutions and the private sector, probably as a result of delay in execution of governmental and private sector projects, makes estimation of the annual generation of indirect wood-fuel resource from waste wood systems from economic sectors in Ghana challenging. Further research needs to be carried out to upscale the results.

7.3 The effect of climate change on regeneration and distribution of tree species in Tropical Forest of Ghana

Project Team: Amissah, L., Mohren, F., Poorter, L., Kyereh, B., and S. Sportel

Start Date: January 2010

Expected Completion Date: 2014

Introduction

Natural tree species distributions in Ghana are strongly related to environmental factors such as rainfall and soil fertility. Over the last four decades' precipitation in West Africa has decreased at a rate of 4% per decade and current climate change predictions indicate a drier climate for West Africa. General Circulation Models and Simple Models also predict a 20% annual rainfall reduction in the rain forest zone of Ghana by 2050. Additionally, air temperatures between 1960 and 1990, have increased by 0.26°C per decade over the tropical biome, which was twice the rate of increase 0.12°C per decade reported for global temperatures for the period 1951-2012 (IPCC 2013). These developments will have major effects on tree seedling growth and survival and consequently influence the distribution of tree species. Presently, the potential response of tree species to predicted climate change remains poorly understood. Understanding species response to temperature and especially drought becomes critical for understanding the potential impact of climate change on forest ecosystems. It will also help in the selection of suitable tree species for afforestation and plantation programme.

Research aim and questions

The aim of the research was to determine species response to drought and the mechanisms underlying drought response. Four research questions were addressed: (1) what is the relative importance of rainfall and temperature on tree species distribution?; (2) How do tree species acclimatise to drought and shade in terms of their physiology, morphology, growth and survival?; (3) What morphological and physiological traits determine species drought performance and distribution?, and (4) How do seedlings of different species perform in dry and wet forests, and does species survival under drought, and growth determine species distribution along the rainfall gradient?

Methodology

Field work was carried out from December 2009 to November 2013. The study involved analysis of Ghana forest inventory data and climatic data to determine tree species response to rainfall and temperature. A greenhouse experiment was also conducted to determine the drought survival of 24 tree species under shade and light. Plant functional traits (morphological and physiological characteristics) that predict the ability of species to survive drought were determined. Finally, reciprocal transplanting experiments were conducted in a dry forest (Afram Headwaters Forest Reserve) located at Abofour in the Offinso district and wet forest (Neung South Forest Reserve) located at Bonsa in the Tarkwa district sites to determine the drought survival, growth and physiological acclimatisation of 23 out of the 24 selected tree species. The planted seedlings in the field were monitored for two years. Seedling height, diameter, leaf water potential, stomatal conductance, photosynthetically active radiation (PAR) reaching the seedlings, temperature and relative humidity during the dry seasons (January - March 2012, 2013) and wet seasons (June 2012) were measured. Soil samples were also taken during the dry and wet seasons and processed in the laboratory using the filter paper technique to estimate soil matric potential. A greenhouse

experiment was also conducted to assess the effect of soil from dry-forest and wet-forest on survival and growth of 18 species out of the 23 species. Herbivory damage on the 23 species of the reciprocal transplanting experiment was assessed to determine herbivory effects on the distribution of species along the rainfall gradient in Ghana.

Key results/achievements

An analysis of the country inventory data showed that rainfall and rainfall seasonality are the main factors influencing the distribution of tree species in Ghana; whereas temperature was found to affect the distribution of certain species only. This suggests that a reduction in rainfall will likely cause a shift in the distribution of tree species in the forest of Ghana. In the greenhouse experiment, shade facilitated drought tolerance of seedlings, an indication that when forests are conserved the impact of drought will be reduced. Majority of species tested showed moderate tolerance to drought. A list of species that are drought tolerant has been provided based on performance in the greenhouse and in the field. These species can be used for plantation development programme in Ghana.

Conclusion

Water availability and shade tolerance were found to be stronger drivers of species distribution along the rainfall gradient than soil nutrients and pests. Majority of species tested showed moderate tolerance to drought which suggests that a further decline in rainfall due to climate change as well as forest fragmentation may lead to a shift in the distribution of tree species in Ghana.

8.0 COMMERCIALIZATION AND INFORMATION DIVISION

The Commercialization and Information Division comprises of the Library and Publications, Computer, Statistics and Marketing sections. The activities undertaken by these sections during the period under review are reported in the ensuing paragraphs.

The Division is also responsible for coordinating all commercial activities of the Institute. These are:

- Sale of high quality forest seeds and seedlings
- Sale of mushroom spawns
- Sale of wood by-products
- Consultancy services
- Training Workshops (mushroom and snail farming).
- Production of honey
- Production of Prekese syrup
- Production of wood products

Sale of High Quality Forest Tree Seeds

CSIR-FORIG continues to generate income from the collection and processing of various forest tree seeds for sale to prospective plantation developers in the country. Major clients of the Institute are the Forestry Services Division (FSD) and private developers. Several FSD plantations have been established with seedlings produced at CSIR-FORIG using superior seeds. Seeds are collected, pretested, treated and supplied on demand. The seeds are stored under optimum conditions to ensure their viability. The most popular species collected during the period under review included ofram, emire, cedrela, teak and mahogany. A major challenge with this activity is the rapid depletion of seed trees through illegal logging.

The Institute is trying to avert this by establishing seed orchards throughout all the ecological zones. This activity is however very slow and expensive. Two seed orchards have already been started at two sites and they are progressing slowly. A lot more orchards need to be set up with Ghana Government support to minimise loss of planting material for future forest establishments.

Production and Sale of Seedlings

Seedling production is another source of income for the Institute. During the period under review, the Institute continued with the production of high quality seedlings from tested and treated seeds. The most popular species patronised by clients were ofram, cedrela, teak and emire. Monitoring activities conducted by the Institute shows that plantations established using seedlings produced tend to grow well. Furthermore, the Institute is able to take orders from clients before the planting season to ensure that clients do not experience a break in their plantation activities.

Sale of Wood by-products

CSIR-FORIG sold wood thinned from research plots at Pra-Anum research station located at Amantia and Afram Headwaters research station located at Abofour as research by-products. Even though this activity is beneficial, it is not sustainable because these by-products can be sold only at specified periods and for a specific time because they are dependent on available research plots. Without the establishment of research plots therefore, it is not possible to have thinnings as by-products. However lack of funds has significantly slowed down the establishment of more research plots.

Contract Research

The Institute thrives on consultancy services and contract research from various stakeholders as a commercial activity. However, in 2014, very few consultancies and contract research activities were undertaken. Efforts are being made to contact various stakeholders who may need the services of the Institute in a consulting capacity.

Training Workshops Organised

A four-day mushroom training course for improved livelihoods (oyster and oil palm mushrooms) was organized for participants with Dr. (Mrs.) Mary Apetorgbor as the main resource person. These training courses have proved to be useful for local communities, church and youth groups as alternative sources of income. Several more such courses are planned for the coming year.

Library Section

The library provides essential information services to support research activities at the Institute and to cater for the general information needs of the entire forestry sector. The library subscribes to online journals and databases which are valuable sources of information. Databases such as AGORA, EBSCOHOST and JSTOR provide access to full text, peer reviewed articles. It also has in stock an extensive collection of bulletins, reports and annual reports from various organisations and institutes in and outside Ghana. Other services provided include Selective Dissemination of Information (SDI) to various stakeholders. During the period under review, about 100 database and CD-ROM searches were conducted.

In addition to online databases, the library also has access to stand-alone CD-ROM databases including PROSPECT, WOODS of the WORLD, FORESTRY COMPENDIUM and FOREST SCIENCE DATABASE.

AGRIS

CSIR-FORIG is one of the nodes of FAO AGRIS project. A repository has been created with full text of CSIR-FORIGs publications. This is an on-going activity.

TEEAL

CSIR-FORIG has signed a Memorandum of Understanding (MOU) with ITOCA, an International Information training and outreach centre headquartered in South Africa to establish academic and research relations with ITOCA in order to promote direct co-operation and communication in the disciplines of electronic library resources, (e-resources), research, information access and related fields. ITOCA is a reputable organisation recognised and sponsored by international donors such as Cornell University, USA. The two organisations will collaborate in joint trainings on TEEAL and AGORA and other research 4life e-resources and conduct research activities within fields to be mutually agreed upon and subject to the availability of funds.

Computer Section

Some of the major responsibilities of the computer section are to administer systems and services related to the Local Area Network (LAN) for the purpose of ensuring availability of services to staff. In addition, it is also in charge of the maintenance and update of the Institute's website as well as that of the Forestry Research Network for Sub-Saharan Africa Information Systems (FORNIS). During the year under review, the activities of the section were performed satisfactorily.

Ten computers and five scanners were donated to the Institute by the Ministry of Lands and Natural Resources. These computers and scanners were distributed to the Graduate School, each of the three Units, the library, administration and finance divisions. Dr. Opuni-Frimpong also purchased two 24-port switches for the Institute to replace the faulty switches in the last block. In January 2014, the bandwidth for the Institute's dedicated internet connectivity was upgraded from 2MB to 4MB at the same cost to ensure fast internet connectivity. However, there were

some challenges with the email service. These challenges include users having their email passwords missing on the system which had to be reset each and every time, flooding of emails with spam and unfriendly email interface. This discouraged most staff from using the Institute's email client with the domain csir-forig.org.gh and resorted to their private email addresses. The section hopes to resolve these challenges in the year 2015.

Marketing Section

The marketing section coordinates marketing activities of all commercial products and services of the Institute. The 2014 Marketing Plan outlined key marketing strategies that would enable the Institute increase its Internally Generated Fund; and generate a projected net income of GH¢ 184,500 over a 12-month period.

Promotional activities undertaken during the year included the following: organization of two radio talk shows, publication of one volume of *Ghana Journal of Forestry*, two issues of CSIR-FORIG Newsletter, a flyer on *"Growing Oyster Mushrooms on Sawdust"*; and also coordinated the organization of two training workshops on *"Mushroom Production"* with Dr. (Mrs.) Apetorgbor as the main resource person.

The Marketing Section nominated and presented a total of ten customers/users of CSIR-FORIG technologies who attended a one-day business seminar organized by the Technology Development and Transfer Centre (TDTC) of the Council for Scientific and Industrial Research (CSIR). Clients were selected from various organizations such as FORM Ghana, SOLIDARIDAD, MOFA, TIDD, as well as private investors and businessmen.

Public Relations Section

CSIR-FORIG was represented at the "Launching of the National Climate Change Policy" and "National Environment Policy" held at the International Conference Centre in Accra on the 2nd of July, 2014.

The Institute also mounted an exhibition at the Osu Castle in Accra which was attended by the Council of State. The Director-General of the Council for Scientific and Industrial Research who attended the ceremony made a presentation to the Council of State on the subject: *"Potential and Strategic Role of the CSIR in the Structural Transformation of Ghana's Economy"*.

8.1 Digitisation of indigenous knowledge in the forestry sector in Ghana

The library submitted a proposal to Elsevier Foundation entitled "Digitisation of Indigenous Knowledge (IK) in the Forestry Sector in Ghana" Indigenous knowledge is increasingly discussed by all as a commodity of value, something that can be value-added, exchanged, traded, appropriated, preserved, excavated and mined. In some jurisdictions, IK is treated as normal library material, so it is collected, recorded, processed and preserved. In Ghana however, there is hardly any system of recording, documenting and preserving indigenous knowledge (IK) or information, let alone a mechanism for capturing IK to cope with dynamic world needs. This project seeks to identify IK for what it is worth and for the IK so captured to be digitized and stored for later use. Digitization is ideal for sharing, exchanging, educating, and preserving indigenous knowledge and cultures. This requires a clear design for metadata standards and procedures, multimedia technologies, and appropriate structures for access and use.

Research Objectives

- Identify, capture, document and digitize indigenous knowledge on forest foods and medicinal plants.

- Create a database of indigenous knowledge so identified.
- Share knowledge of useful IK practices and their usage and thereby preserve the information to promote their wider application.
- Establish a relationship between the knowledge identified and modern science.
- Develop a manual of procedures and best practices to document the knowledge so identified.
- Train researchers, librarians and information management personnel in the management of indigenous knowledge.
- Explore the importance of indigenous knowledge systems in livelihood and socio-economic development in Ghana.
- Assess the contribution of indigenous knowledge to scientific research.

This project which is funded by Elsevier Foundation will be executed in two years with a budget is $47,000. Actual research work will start in earnest in 2015.

9.0 ADMINISTRATION DIVISION

The main objectives of the Division are to:

- Ensure implementation of policies, procedures, rules and regulations of the CSIR at the Institute level by providing support services to facilitate effective and efficient performance of work by all Divisions.
- To provide administrative machinery for the implementation of institutional initiatives and activities.

2.0 Staff Strength

Senior members:	57
Senior staff:	89
Junior staff:	120
Total:	**266**

3.0 New Appointments

Research Scientists:	4
Senior Staff:	5
Junior Staff:	2
Total:	**11**

The names of officers recruited during the period under review are as follows:

- **Dr. Mark Appiah**, Principal Research Scientist, FWMD
- **Dr. James Korang**, Research Scientist, FPMD
- **Dr. Ernest Kwaku Kraka**, Scientific Secretary, CID
- **Ms. Sandra Acheampong Owusu**, Research Scientist, BLUD
- **Mr. Willam Hagan-Brown**, Senior Technical Officer, FWMD (Abofour)
- **Mr. Adu Gyamfi Asamoah**, Senior Technical Officer, FWMD (Oda)
- **Ms. Safia Ibrahim**, Senior Technical Officer, Administration Division
- **Ms. Mavis Agyenkumwaa Bamfo**, Senior Technical Officer, CSIR Basic School
- **Ms. Hamdia Mahama Wumbeidow**, Senior Technical Officer, FWMD
- **Mr. Daniel Ofori Oppong**, Senior Technical Assistant, CID
- **Ms. Joyce Fosu**, Labourer, Grounds & Garden/Graduate School

4.0 Training

A total of 26 members of staff were beneficiaries of further training. The breakdown of the number of officers who completed or are undergoing training programmes at the Institute is presented in the Table 5 below:

Table 5: *Training of staff*

LEVEL	COMPLETED	ON-GOING
PhD	1	12
MPhil/M.Sc./MA	-	2
B.Sc./BA		2
Short courses (Security) In house training	9	-
TOTAL	**10**	**16**

5.0 Promotions and Upgrading

In all, a total of 41 members were promoted/ upgraded during the 2013 promotions exercise. The breakdown is as follows:

Senior Members:	8
Senior Staff:	13
Junior Staff:	20
Total	**41**

The names of Senior Members promoted are as follows:

- Dr. Victor Agyeman, Director, CSIR-FORIG promoted to Chief Research Scientist
- Dr. Mary Apetorgbor promoted to Principal Research Scientist
- Dr. Paul P. Bosu promoted to Principal Research Scientist
- Dr. Lawrence Damnyag promoted to Senior Research Scientist
- Dr. Joseph M. Asomaning promoted to Senior Research Scientist
- Mr. Francis Osei Amofah promoted to Senior Administrative Officer
- Mrs. Gloria D. Djagbletey promoted to Senior Research Scientist
- Mrs. Evelyn Owusu Agyeman promoted to Accountant
- Ms. Bridget Brentuo promoted to Chief Technologist

6.0 Awards

Dr. Emmanuel Marfo, a Senior Research Scientist of the Institute was adjudged one of the top 100 Scientists in the World by the International Biography Centre (IBC) during its 2014 award year.

Retirements

Eight (8) staff members retired from service of the Council during the year 2014. The breakdown is as follows:

Senior member:	None
Senior staff:	3
Junior staff:	5

7.0 Resignation

Mr. Akwasi Bempah Owusu, an accounting assistant resigned from the Institute on 1st September, 2014.

8.0 CSIR-FORIG/UEF Graduate School

The school was established in September 2012 to run a Master of Science (MSc). in Bio-Economy and Natural Resources Management course. This degree programme is conducted by the CSIR and is implemented jointly by the University of Eastern Finland and CSIR-FORIG. All studies take place in Ghana and it is an interactive 2-year modular programme delivered through taught courses, seminars, and thesis. The Programme is delivered by seasoned lecturers and professors in Ghana and Finland leading to the award of a dual degree in MSc. Bio-Economy and Natural Resources Management, and Executive Master of Business Administration (EMBA). The course is run using both face-to-face lectures and on-line programming. Furthermore, the programme operates the European Credit Transfer System (ECTS) and the certificates are awarded by the University of Eastern Finland (UEF) after completing 120 ECTS.

The aim of the MSc. Bio-Economy and Natural Resource Management Programme is to build capacity for development and to meet the environmental challenges in Africa by equipping participants with management skills and specialised knowledge in natural resources. The School currently has a student population of twenty-five (25) of which eight candidates form the first of students expected to graduate in 2015.

9.0 CSIR Basic School

The CSIR Basic School was established jointly by CSIR-FORIG, CSIR-CRI and CSIR-BRRI in September 2009. The current student population of the school is four hundred and seven (407).

The aim was to have high quality functional school for the children of CSIR staff and other people within the catchment area of CSIR Institutes in Kumasi. This was to afford the community access to quality education at an affordable cost.

The School has classes from nursery to Junior Secondary School (JHS). The first batch of JHS pupils would be writing their BECE exams in 2016.

10.0 Bereavement

The Institute lost two (2) members of staff during year under review. They are:

- Mr. Stephen Baah – Supervisor Grade I
- Mr. Seidu Mohammed Hamidu – Security Grade II

Major Events

• Visit by the CSIR's Council Chairman

The CSIR Council Chairman, Mr. Abe Inkoom visited CSIR-FORIG on 10th of February, 2014. He entreated staff to work very hard to enable the Institute increase revenue and avoid waste. He also urged staff to avoid lackadaisical attitude towards work.

• Bamboo colloquium hosted by CSIR-FORIG

The FIDD of CSIR-FORIG in collaboration with Ministry of Environment Science, Technology and Innovation (MESTI) organized a first Bamboo Colloquium from 29th to 30th April 2014. The colloquium was held to discuss and share knowledge on the extent of research work on sustainable utilization of bamboo resources in Ghana especially for housing. In all, about one hundred and eighty people attended.

• Tree Planting Training at CSIR-FORIG

There was tree planting exercise for teachers jointly organized by CSIR-FORIG and Kumasi Metropolitan Assembly on 13th May, 2014 at CSIR-FORIG to educate the public on the need to plant trees. The general public was encouraged to plant and nurture trees in Kumasi as well as preserve its rich heritage and legacy.

• First National Forestry Conference

The conference was organized jointly by the Forestry Commission (FC), CSIR-FORIG, College of Agriculture Natural Resources (CANR), KNUST and Tropenbos International Ghana with support from Ministry of Lands and Natural Resources (MLNR), Ministry of Environment, Science Technology Innovations (MESTI), Ghana Timber Millers Association (GTMO), Ghana Timber Association (GTA) and the Furniture and Wood Workers Association of Ghana (FAWAG). The Conference was held from 16 to 18th September, 2014 at CSIR-FORIG.

The objective was to highlight the role of forests and woodlands on livelihoods, environmental management and economic development in the country and the expected future contribution in the light of current challenges. This conference was held to commemorate 100 years of forestry practice and 50 years of forestry research in Ghana.

• Hosting of DMC by CSIR-FORIG

CSIR-FORIG hosted the 241st DMC meeting on the 20th and 21st November, 2014. As part of the programme, DMC members had a durbar with CSIR-FORIG staff.

• CSIR College of Science and Technology (CCST)

The CSIR College of Science and Technology is scheduled to take off in 2016. It is affiliated to the University of Cape Coast (UCC) and the Kwame Nkrumah University of Science and Technology (KNUST).

Human Resource

One major asset of CSIR-FORIG is the number of highly qualified staff in all the Divisions. The names of Senior Members and Senior Staff in each of the nine (9) Divisions are as follows:

Table 6: *List of Senior Members*

ADMINISTRATION DIVISION	
Victor K. Agyeman	B.Sc. Nat. Res. Mgt., MPhil Silviculture, PhD Forest Ecology, LLB, QC (BL), *Chief Research Scientist*, **Director**
Comfort Konto (Ms.)	B.A. (Hons) Economics, Dip. Education, MBA Strat. & Consultancy Mgt. **Head *of Administration Division***
Francis O. Amofah	B.A. Secretaryship, Dip. Ed., Master of Public Administration (MPA), *Senior Administrative Officer*
Georgia Coffie (Mrs.)	B. Ed. Secretarial & Mgt., MSc E-Comm. & Marketing, *Administrative Officer*
FOREST, LIVELIHOODS AND GOVERNANCE DIVISION	
Emmanuel Marfo	BSc. Nat. Res. Mgt., MSc. Tropical Forestry, PhD Environmental Science, *Senior Research Scientist*, **Head of Division**
Eric E. Nutakor	B.A. Social Science, MPhil. Silv. & Forest Mgt., *Research Scientist*
Elizabeth Obeng (Mrs.)	BSc. Agric., MSc. Sustainable Res. Mgt., *Research Scientist*
William Dumenu	BSc. Nat. Res. Mgt., MSc. Forest Ecol. & Mgt., *Research Scientist*
FORESTS AND WILDLIFE MANAGEMENT DIVISION	
Theresa Peprah (Mrs.)	BSc. Nat. Res. Mgt., MPhil. Tree Improvement, *Senior Research Scientist*, **Head of Division**
Stephen Adu-Bredu	BSc. Nat. Res. Mgt., MSc. Silv. Mgt., PhD Silv. Mgt./Ecophysiology, *Principal Research Scientist*, **Deputy Director**
Mary M. Apetorgbor (Mrs.)	BSc. (Hons) Botany, PhD Plant Pathology/Mycology, *Principal Research Scientist*
Emmanuel Opuni-Frimpong	BSc. Nat. Res. Mgt., MPhil. Silv. Mgt., PhD Forest Entomology *Senior Research Scientist*
Bright O. Kankam	BSc. Nat. Res. Mgt., MPhil. Wildlife and Range Mgt., PhD Primatology, *Senior Research Scientist*
Kwame Antwi Oduro°°	BSc. (Hons) Nat. Res. Mgt., MSc. Forestry and its relation to Land Use, *Research Scientist*
Akwasi Duah Gyamfi°°	BSc. Nat. Res. Mgt., MPhil. Ecology & Mgt., *Research Scientist*
John K. Mensah	BSc. Botany, MSc. Plant Pathology, *Research Scientist*
Caleb Ofori Boateng	B.Sc. Nat. Res. Mgt., PhD Wildlife & Range Management, *Research Scientist*
FOREST INDUSTRY DEVELOPMENT DIVISION	
Francis W. Owusu	BSc. Agric. Engineering, MPhil. Wood Technology, *Senior Research Scientist*, **Head of Division**
Joseph Ofori**	BSc. Chemical Tech., MSc & DIC Timber Tech., PhD Wood Technology, *Chief Research Scientist*

Daniel Sekyere**	BSc. Chemistry, MSc. Chemistry, PhD Pulp & Paper Tech., *Principal Research Scientist*
Charles Essien	BSc. Nat. Res. Mgt., MPhil Wood Technology, *Research Scientist*
Stephen Tekpetey Lartey	BSc. Nat. Res. Mgt., PhD Wood Science, *Research Scientist*
Emmanuel Appiah-Kubi	BSc. Civil Engineering, MPhil. Civil Engineering, *Research Scientist*
Bridgette Brentuo	BSc. Physical Science, MPhil Wood Technology, *Chief Technologist*
FOREST PRODUCTS TRADE AND MARKETING DIVISION	
Emmanuel Ebanyenle	BSc. Nat. Res. Mgt., MPhil. Wood Science, PhD Forest Science, *Senior Research Scientist*, **Head of Division**
Lawrence Damnyag	BA. Economics, MPhil. Economics, PhD Forest Economics, *Senior Research Scientist*
Andrew Oteng Amoako**	BSc. Wood Technology, MSc. Wood Science, PhD Wood Products & Eng., *Chief Research Scientist*
Beatrice Darko-Obiri (Mrs.)	BSc. Agric., MSc. Agroforestry, PhD Agroforestry, *Senior Research Scientist*
Sarah Pentsil (Mrs.)	BSc. (Hons) Nat. Res. Mgt., MSc. Dev. Policy & Planning, *Research Scientist*
Samar B. Sparkler°°	BA. Arts (Econs. & Geog.), MA. Geog. & Rural Dev., *Research Scientist*
ECOSYSTEM SERVICES AND CLIMATE CHANGE DIVISION	
Ernest G. Foli	BSc. Nat. Res. Mgt., MPhil Forest Men/Inventory, PhD Silv. & Mgt., *Principal Research Scientist*, **Head of Division**
Paul P. Bosu	BSc. Biological Science, MPhil. Biological Science, PhD Forest Entomology, *Principal Research Scientist*
Joseph Cobbinah**	BSc. Biological Science, PhD. Forest Entomology, *Chief Research Scientist*
Stephen E. Akpalu	BSc. Agric., MPhil. Env. Science, *Research Scientist*
Gloria D. Djagbletey (Mrs.) °°	BSc. Nat. Res. Mgt., MPhil. Silv. & Forest Mgt., *Senior Research Scientist*
George K. Ametsitsi°°	BSc. Nat. Res. Mgt., MSc. Env. Res. Mgt., *Research Scientist*
Shalom Addo-Danso°°	BSc. Nat. Res. Mgt., MSc Forest Ecol. and Mgt., *Research Scientist*
Gloria Kukurije Adeyiga	B.Sc. Nat. Policy & Legislation, M.Sc. GIS & Remote Sensing, M.Phil. Tree Physiology, *Research Scientist*
BIODIVERSITY AND LAND-USE DIVISION	
Luke C.N. Anglaaere	BSc. Nat. Res. Mgt., MSc. Silv. & Forest Biology, PhD. Agroforestry, *Senior Research Scientist*, **Head of Division**
Daniel A. Ofori*	BSc. Agric., MPhil. Tree Improvement, PhD. Forest Genetics (Molecular Biology), *Chief Research Scientist*
Joseph Asomaning	BSc. Agric., MSc. Seed Technology, PhD Seed Science and Technology, *Senior Research Scientist*
K. Owusu-Afriyie	BSc. Nat. Res. Mgt., MSc. Forest Mgt., PhD Plant Science, *Research Scientist*

Lucy Amissah (Mrs.)	BSc. Nat. Res. Mgt., MPhil. Silv. & Forest Mgt., PhD. Forest Ecology and Forest Management (Functional Ecology), *Research Scientist*
Francis Dwomoh °°	BSc. Nat. Res. Mgt., MSc. GIS & Earth Obs., *Research Scientist*
William K. N. Bandoh °	BSc. Biochemistry., *Asst. Research Scientist*
COMMERCIALIZATION AND INFORMATION DIVISION	
Darimani Bukari	BA. Publishing Studies, MPhil. Art and Culture, Information Officer, **Head of Division**
Stella Britwum Acquah (Mrs.) °	BSc. Computer Science, MBA. Mgt. Info. Systems, *Senior Research Scientist*
Margaret Sraku-Lartey (Mrs.) °°	BA. Social Science, Post. Grad. Dip. Lib. Studies, MA. Industrial Mgt., *Principal Librarian*
Naomi Appiah (Mrs.)	BA. Publishing Studies, MBA Marketing, *Marketing Officer*
FINANCE DIVISION	
Osei Yaw Agyei	BSc., MBA, ACCA, *Accountant*, **Head of Division**
K. Agyeman Prempeh	ICA, *Accountant*
Evelyn Owusu Agyemang	MBA (Accounting), *Accountant*

*Sabbatical Leave
**Post Retirement Contract
°°PhD Student
°MSc/MPhil Student

Table 7: *List of Senior Staff*

Name	Rank
John Agbozo	Chief Technical Officer
Leticia Asamoah	Chief Technical Officer
Michael Mensah	Chief Technical Officer
Prempeh Bandoh	Chief Technical Officer
Godson K. Zorve	Chief Technical Officer
Paul Kankam	Chief Technical Officer
Maud M. Prempeh	Chief Technical Officer
Samuel A. Kyei	Chief Technical Officer
Asiamah Yeboah Konadu	Chief Administrative Assistant
C.C. Acheampong	Chief Accounting Assistant
J.J. Mensah	Chief Accounting Assistant
Mavis Serwah Kwarteng	Chief Accounting Assistant
Isaac Boahen	Chief Accounting Assistant
John Sackey	Chief Works Superintendent
Paul Adusei	Chief Works Superintendent (Traffic)
Samuel Appiah	Chief Works Superintendent (Traffic)
Albert Nyeha	Principal Technical Officer
Peter L. Arthur	Principal Technical Officer
Philip T. Boampong	Principal Technical Officer
Sarfo Kwame Bonsu	Principal Technical Officer
Jacqueline Twintoh	Principal Technical Officer
Frank Baffour Asuming	Principal Technical Officer
Elizabeth Ampah	Principal Technical Officer
Richard Adjei	Principal Technical Officer
Awurama Andoh	Principal Administrative Assistant
Anastasia Duah-Gyamfi	Principal Administrative Assistant
Margaret Adugbire	Principal Administrative Assistant
Ernest Osei Boakye	Principal Technical Officer
Eric Frimpong	Principal Technical Officer
Kwaku Asumadu	Principal Technical Officer
Jemima Owusu	Principal Technical Officer
Daniel Debrah	Principal Technical Officer
Osei Tutu Boateng	Principal Technical Officer
Dorothy Asare Akoto	Principal Technical Officer
Akwasi Baah Acheamfour	Principal Technical Officer

Name	Rank
Govina J. Kudjo	Principal Technical Officer
Samuel Atusong	Principal Accounting Assistant
Francis Asare Abetia	Principal Administrative Assistant
Jane Nketiah	Principal Administrative Assistant
Ebenezer Frans Mensah	Senior Technical Officer
Michael Ampah	Senior Technical Officer
Daniel Peprah	Senior Technical Officer
Jonathan Dabo	Senior Technical Officer
Emmanuel Manu	Senior Technical Officer
Sandra Owusu	Senior Technical Officer
Ezuame Constant	Senior Technical Officer
Samuel Larbi	Senior Administrative Assistant
Rebecca Okyere Darko	Senior Stores Superintendent
Wendy O. Amankwa	Senior Accounting Assistant
Elvis Nkrumah	Senior Technical Officer
George K. Nyantakyi	Senior Security Officer
Osei Boateng	Senior Security Officer
Anthony Boateng	Senior Asst. Transport Officer
Mohammed Awal Issa	Senior Transport Officer
Jackson Nti	Senior Transport Officer
Sampson Adonteng	Senior Transport Officer
Gabriel Lumor	Technical Officer
Mark Debrah Marfo	Technical Officer
Sylvester Kuudaar	Technical Officer
Daniel Damte	Draughtsman
Emmanuel Sarpong	Library Assistant
Isaac Donkor	Administrative Assistant
Kester Mensah	Administrative Assistant
Joseph Sebuka Kwaku	Administrative Assistant
Michael Atitsugbui	Security Officer
Agnes Mantey	Superintendent Telephonist
Thomas Avarison	Assistant Transport Officer

10.0 FINANCE DIVISION

Objectives of the Finance Division are to:

- Provide suitable financial information to management for the daily management of the Units of the Institute;
- Assist in short and long-term planning;
- Help establish internal control measures to safeguard assets of the Institute and ensure the completeness, accuracy and reliability of financial records.

Table 8: *Summary of Financial Results for 2014*

Government of Ghana	Inflows (GH¢)	Outflows (GH¢)	Variance (GH¢)
Personnel Emoluments (Note 1)	8,582,075	8,582,075	
Administrative Expenditure (Note 2)	43,250	677,548	(634,298)
Service Expenditure (Note 3)		91,411	(91,411)
Internally Generated Funds	185,831	104,165	81,666
Guest Houses	153,939	49,231	104,708
Production Unit	28,705	26,061	2,644
Total	8,993,800	9,530,491	(536,691)
Donor (Note 4)	2,881,720	3,096,243	(214,523)

Note 1: Personnel Emoluments figure represents staff emoluments paid directly by the Controller and Accountant General's Department to staff. The Institute has no control over the expenditure

Note 2: The Administrative grant was accrued and received in 2015.

Note 3: For some time now, service grants are not forth coming from the Central Government. Expenditure under service is entirely financed from IGF and accumulated resources.

Note 4: Donor funds were received in Dollars, Euros, Pounds and Ghana Cedis. Annual average exchange rates were used (USD/GHS=3.2001 and ¢/GHS=3.8959 and £/GHS=4.9791) to convert them into Ghana Cedis.

Note 5: This report is a draft one, the Division is yet to finalise the 2014 financial report for the External Auditor's attention.

11.0 APPENDICES

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Acheampong, E., Dawoe, E., Bosu, P. P. and Asante, W. 2014. Baseline Carbon quantification in Small holder cocoa farms in Ghana. Technical Report submitted to SNV-Ghana Cocoa-Eco Project, August 2014, 108 p.

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Dumenu, W.K., Derkyi, M., Samar, S., Oduro, K.A., Mensah, J.K., Pentsil, S., Nutakor, E., Foli, E.G and Obeng, E.A. 2014. Benefit sharing mechanism for REDD+ implementation in Ghana. Consultancy Report. Forestry Commission, Accra, Ghana.

Ebanyenle, E., Adu-Bredu, S., Apetorgbor, M., Peprah, T., and Asomaning, J.M. 2014. Kumasi Urban Forestry Project. A report on production of knock down bamboo cages 4 p.

Ebanyenle, E. and Ofori, D.A. 2014. Identification of female and male seedlings of *Allanblackia parviflora* using anatomical and morphological characteristics. A preliminary report submitted to ICRAF, Nairobi, Kenya

Kankam, B.O. and Ofori-Boateng, C. 2014. Akyem Gold Mining project at Ajenjua Bepo Forest Reserve: Baseline survey of amphibians and reptiles in proposed plantation site. Report # xxx (Submitted to Newmont Golden Ridge, Company-Akyem, Ghana).

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Obiri, D.B., Nunoo, I., Obeng, E., Owusu, F.W. and Marfo, E. 2014. The charcoal industry in Ghana: an alternative livelihood option for displaced illegal chainsaw lumber producers. Tropenbos International, Wageningen, the Netherlands, 132 p.

Obiri, D.B. and Nutakor, E. 2014. Ethno-botany survey of important forest/fuel wood species in transition zone of Ghana: Kintampo Forest District. Project report submitted to ITTO, Japan.

Owusu, F.W., L. Damnyag, Marfo, E. and Boateng Nantwi, G. 2014. Supply of chainsaw lumber to the domestic market: a validation study. Wageningen, Tropenbos International, 30 p.

Ofori-Boateng, C. 2014. Conservation of the critically endangered Togo slippery frog (Conraua derooi) in Ghana (Report No. F14AS00144, 10 p). Submitted to Conservation Leadership Program, Arlington, VA USA.

Owusu-Afriyie, K. 2014. Assistance to the Energy Commission of the Ministry of Energy to update the Estimates on The National Wood Fuel Potential for Wood Fuel Supply in Ghana as part of a Wider Review of Ghana's Strategic National Energy Plan (SNEP). TCP/GHA/3401 (BABY04). Draft Final Report. October 2014.

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Owusu, F.W., Tekpetey, S.L., Essien, C., Appiah-Kubi, E. and Appiah, J.K. 2014. Technological properties of some selected bamboo species grown in Ghana for housing. Technical report for submission to MESTI.

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Wüthrich, K., Brunner, M., Appiah-Kubi, E., Damnyag and Owusu, F.W. 2014. Value chain analysis of the wood sector in Ghana. Technical report submitted to UNIDO, Vienna, Austria, on 31st March 2014. 86pp

Supervision of Students

By Dr. Emmanuel Marfo

1. **Betty Boante Abeyie** (2013-2014) Assessing the social impacts of forest certification: comparative study in the high forest zone, Ghana. Technische Universitaet Dresden, Germany.

2. **Jacqueline Joyce Twintoh** (2013-2014) Reducing the incidence of illegal operations: an assessment of the impact of the Multi-stakeholder dialogue approach in Juaso Forest District University of Eastern Finland.

3. **Stephanie Ayambo** (2013-2014) Analysis of media reportage of natural resource and in environmental issues in Ghana: a case study of the Ghanaian Times from 1994- 2012.

By Dr. Emmanuel Opuni-Frimpong

1. **Kwawuvi, D.** 2014. Relative susceptibility of four species of African mahogany to the shoot borer *Hypsipylarobusta* in the moist semi-deciduous forest of Ghana, pp54. BSc. Thesis submitted to the Faculty of Forest Resources Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

2. **Peprah, D.** 2014. Effects of spacing on growth and *Hypsipyla robusta* attacks on *Khaya grandifoliola* stands in moist semi-deciduous Forest in Ghana. pp 39. BSc. Thesis submitted to the Faculty of Forest Resources Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

3. **Osei, S.** 2014. Silvicultural systems for plantation mahogany in Africa; the influence of canopy shade on tree growth and pest damage pp 52. BSc. Thesis submitted to the Faculty of Forest Resources Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

By Dr Stephen Adu-Bredu

1. **Asiedu, D.S.** 2014. Carbon stock of fine litter for different age logged forest stands in Bobiri Forest Reserve, Ghana. BSc Thesis submitted to the College of Agriculture and Natural Resources, Faculty of Forest Resources Technology, Kwame Nkrumah University of Science and Technology, Kumasi. 50p.

2. **Boakye, M.** 2014. Necromass carbon stock and carbon dioxide efflux in a moist semi-deciduous forest of Ghana under recovery from selective logging. MSc Thesis in Bio-Economy and Natural Resource Management submitted to the University of Eastern Finland, Faculty of Science and Forestry and CSIR-FORIG/UEF Graduate School. Kumasi Campus, CSIR-Forestry Research Institute of Ghana, Kumasi. 83p.

Workshops/ Conference Attended

Acquah, S.B. Regional workshop on Tree Volume and Biomass Allometric Equation in West Africa. August 4-7, 2014, CSIR-FORIG, Kumasi, Ghana.

Acquah, S.B. Technical workshop on Regional Forest Monitoring. June 3-5, 2014, CSIR-FORIG, Kumasi, Ghana

Acquah, S.B. First National Forestry Conference, "The Contribution of Forests to Ghana's Economic Development." September 16-18, 2014, CSIR-FORIG, Kumasi, Ghana.

Agbozo, J. International seminar on technologies for tracking legal timber, Thünen Institute of Forest Genetics and International Tropical Timber Organization (ITTO); May 26-29, 2014, CSIR-FORIG, Kumasi, Ghana.

Apetorgbor, M.M. Plantation forestry diseases in Ghana: Causes and management strategies. Presented at the Tenth International Congress of Plant Pathology (ICPP). August 25-30, 2014, Beijing, China. Pp 272.

Apetorgbor, M.M. Training Workshop on CABI's Invasive Species Compendium. December 16-18, 2014. Nairobi, Kenya.

Apetorgbor, M.M. Council for Scientific and Industrial Research-Research Staff Association. 25th Annual General Meeting. 'Revitalising agricultural productivity for food security and economic empowerment in Ghana: Pivotal role of CSIR. CSIR-Crops Research Institute, October 21-23, 2014, Kumasi, Ghana.

Apetorgbor, M.M. First National Forestry Conference on "The contribution of forests to Ghana's economic development". September 16-18, 2014, Kumasi, Ghana.

Apetorgbor, M.M. Training Workshop for Research Scientist, CSIR-Technology Development and Transfer Centre Project. July 2-3, 2014. BRRI, Kumasi, Ghana.

Apetorgbor, M.M. AWARD Women's Leadership and Management Course. May 4-10, 2014. Speke Resort & Conference Centre, Munyonyo, Kampala, Uganda.

Apetorgbor, M.M. Soil Fertility Management Training Workshop, Soil Research Institute. January 27-28, 2014. Kumasi, Ghana.

Appiah-Kubi, E., Owusu, F.W. and Damnyag, L. Stakeholders Validation Workshop on selected wood value chains for export. Organized by UNIDO and CSIR-FORIG. Held at Excelsa Lodge, Kumasi on January 30, 2014.

Appiah-Kubi, E. World Wood Day Symposium organized by the International Wood Culture Society (IWCS). Xianyou County, China. March 20-22, 2014.

Appiah-Kubi, E. and Tekpetey, S.L. Training workshop in Wood Identification and Anatomy. Organized by the Thunen Institute, Germany. Held at the Forestry Research Institute of Ghana, Kumasi, Ghana from June 6-7, 2014.

Appiah-Kubi, E. Research Stay at the Georg-August-University of Goettingen, Germany. DAAD Doctoral Research Fellowship Award, 2014. Held from July 1, 2014-December, 31, 2014.

Appiah, N. International Seminar on Technologies for Tracking Legal Timber. CSIR-FORIG, Thünen Institute of Forest Genetics and International Tropical Timber Organization (ITTO). May 26-29, 2014, CSIR-FORIG, Kumasi, Ghana.

Appiah, N. First National Forestry Conference: "The Contribution of Forests to Ghana's Economic Development". September 16-18, 2014, CSIR-FORIG, Kumasi, Ghana.

Appiah, N. Training Workshop for Selected Scientists to Support the Technology Transfer Drive of the Council for Scientific and Industrial Research (CSIR). Organized by the CSIR-Technology Development and Transfer Centre (TDTC). July 2-3 2014, CSIR-Building and Road Research Institute, Kumasi, Ghana

Appiah, N. Business Seminar for Potential Private Investors / Users of CSIR Technologies. Organized by the CSIR-Technology Development and Transfer Center (TDTC). July 4, 2014, CSIR-Building and Road Research Institute, Kumasi, Ghana.

Bosu P.P. IFS Collaborative Research Workshops. December 8-11, 2014, Benin Diaspora Hotel, Ouidah, Benin.

Bosu, P.P. 50th Session of the International Tropical Timber Council. Yokohama, Japan. November 3-8, 2014. (Invited Participantto present a "Success Story" as recipient of ITTO Fellowships.

Bosu, P.P. XXIV IUFRO Congress. October 5-11 2014, Salt Lake City, Utah, USA.

Bosu, P.P. Butterfly Rearing and Ecotourism Development. Training of local communities within the catchment of the Missahoe Forest Reserve, Kpalime. September 22-26, 2014, Togo.

Bosu, P.P. Workshop on The Role of the Media in the Conservation of Pollinators. September 10-11, 2014, Somanya. (Participated as a Resource person)

Bosu, P.P. Second National Seminar on Conservation of Pollination. March 26, 2014, British Council Hall, Accra. (Participated as a Resource person).

Bosu, P.P. Training Workshop on Cartegena Protocol and Related Regulations. Organized by the National Biosafety Committee. January 30, 2014, Crops Research Institute – Kumasi –Ghana.

Marfo, E. The illusion of representation under REDD+ Readiness consultation in Ghana. International Conference on Carbon-Land-Property, July 1-4, 2014, Copenhagen.

Marfo, E. Strengthening African forest governance in the perspective of the implementation of FLEGT-VPA process, October 20-24, 2014, Yaounde, Cameroun.

Marfo, E. First National Forestry Conference, Kumasi, CSIR-FORIG.

Marfo, E. International Conference on Land-Property-Carbon. July 1-4, 2014, Copenhagen, Denmark.

Marfo, E. International Conference on Policy Mixes in Environmental and Conservation Policies. February 25-27, 2014, Leipzig, Germany

Obiri, D.B. Meeting of the Collaborative Partnership on Forests (CPF), Global Forest Expert Panels (GFEP). November 23-25, 2014, New Dehli, India.

Obiri, D.B. XXIV IUFRO World Congress, October 5-11, 2014, Salt Lake City, UTAH, USA.

Obiri, D.B. National Forestry Conference. September 16-18, 2014, CSIR-FORIG, Kumasi, Ghana.

Obiri, D.B. Meeting of the Collaborative Partnership on Forests (CPF), Global Forest Expert Panels (GFEP). July 16-19, 2014, Cambridge, UK.

Obiri, D.B. National Bamboo Colloquium. April 29-30, 2014, CSIR-FORIG, Kumasi, Ghana.

Obiri, D.B. Meeting of the Collaborative Partnership on Forests (CPF), Global Forest Expert Panels (GFEP). March 13-16, 2014, Bogor, Indonesia.

Oduro, K.A. Information literacy and introduction to Endnote. October 28-29, 2014. Wageningen University, the Netherlands.

Oduro, K.A. Mobilising your scientific network. October 17-23, 2014, Wageningen University, the Netherlands.

Oduro, K.A. XXIV IUFRO World Congress. October 5-11, 2014, Salt Lake City, Utah, USA.

Oduro, K.A. Companion modelling course. September 21-26, 2014, Wageningen University, the Netherlands.

Oduro, K.A. Final Project Completion Workshop for ITTO project on Advancing REDD+ in Ghana: Preparation of REDD+ pilot schemes in off-reserve forests and agroforests. Sponsored by International Tropical Timber Organization. August 12, 2014, Kumasi, Ghana.

Oduro, K.A. Round table discussion workshop on carbon reference emission levels and measurement, reporting and verification system in Ghana. June 17, 2014, Forestry Commission, Accra, Ghana.

Oduro, K.A. Technical workshop on regional forest monitoring in West Africa. June 3-4, 2014. CSIR-FORIG, Kumasi, Ghana.

Owusu-Afriyie, K. and Mensah, J.K. (Official Rapporteurs). Proceedings of the regional technical workshop on Tree Volume and Biomass Allometric Equations in West Africa. UN-REDD Programme. August 4-7, 2014, CSIR-Forestry Research Institute of Ghana, Kumasi, Ghana.

Owusu-Afriyie, K. Understanding the Supply Information Form (SIF). A presentation at a Workshop on Training in the use of Database Information Systems for Stakeholders in Wood-fuels. Organised by Energy Commission of Ghana and Food & Agriculture Organization of the United Nations, July 7-11, 2014, NODA Hotel, Kumasi, Ghana.

Owusu-Afriyie, K. Understanding the Demand Information Form (DIF). A presentation at a Workshop on Training in the use of Database Information Systems for Stakeholders in Wood-fuels. Organised by Energy Commission of Ghana and Food & Agriculture Organization of the United Nations, July 7-11, 2014, NODA Hotel, Kumasi, Ghana.

Owusu-Afriyie, K. Estimating the national Wood-fuel potential for Wood-fuel supply in Ghana. A presentation to Stakeholders at the Inception of the project: Assistance to the Energy Commission of the Ministry of Energy to update the Estimates on The National Wood Fuel Potential for Wood Fuel Supply in Ghana as part of a Wider Review of Ghana's Strategic National Energy Plan (SNEP). TCP/GHA/3401 (BABY04). 14 March 2014. Forestry Commission, Accra.

Owusu, F.W., Appiah-Kubi, E. and Tekpetey S.L. Participated in the 1st National Forestry Conference with the theme: "The contribution of Forests to Ghana's Economic Development". Held at CSIR-FORIG, Fumesua-Kumasi from 16-18th September 2014.

Owusu, F.W. SSE-pay (E-SPV) validation workshop held at CSIR-CRI and organized by Controller and Accountant General's Department (CAGD) on 7th March 2014.

Owusu, F.W. 4th KNUST summer school with the theme "Advancing Science and Technology through effective communication" held at College of Science Auditorium – KNUST by Quality Assurance and Planning Unit (QAPU)-KNUST from 18th to 22nd August, 2014.

Owusu, F.W. National Project Steering Committee meeting of UNIDO/MOTI trade capacity building project phase 2, held on 24th September 2014 at Affram hall-Alisa Hotel, North Ridge-Accra and organized by UNIDO. Theme: "Improving sustainable value chains for exports from Ghana".

Owusu, F.W. Workshop organized by TBI at Forest Hotel, Dodowa from 2nd – 6thJuly, 2014 and 23rd to 25th September, 2014. Theme: Training on Business plan writing for key stakeholders of EU-chainsaw project "Supporting the integration of legal and legitimate domestic timber markets into voluntary partnership agreements"

Owusu, F.W. Workshop organized by TBI at Bedtime Hotel, Koforidua from 28th to 29th August, 2014. Theme: Overland export of timber in Ghana and policy on the supply of legal lumber to the domestic lumber.

Owusu, F.W. Workshop organized by MESTI on 10th July 2014 at MJ Grand Hotel Accra with the theme "Evaluation of the activities of phase 2 of the action plan on the use of local building materials in the construction industry in Ghana"

Owusu, F.W. Project Development and Financing Workshop organized by CTI/PFAN and held in Nairobi, Kenya on the 5th – 6thMay 2014.

Owusu, F.W., Appiah-Kubi, E. and S.L. Tekpetey First National Bamboo Colloquium in Ghana. Theme: "Bamboo utilization for a greener construction and future in Ghana". Organized by CSIR-FORIG and the Ministry of Environment, Science, Technology and Innovation (MESTI). Held at the CSIR-FORIG Conference Room, Fumesua-Kumasi, from 29th – 30th April, 2014

Sraku-Lartey, M. GLA 2014 BIENNIAL CONGRESS & AGM," *Information Literacy and a Changing Landscape*", November, 13 – 14, 2014, University of Cape Coast.

Sraku-Lartey, M. First National Forestry Conference, "The Contribution of Forests to Ghana's Economic Development", September 16 – 18, 2014, CSIR-FORIG, Kumasi, Ghana.

Sraku-Lartey, M. XII World Congress on Computers in Agriculture, and Natural Resources, WCCA 2014, "Reducing risk and improving sustainability" July 27 – 30, 2014, San José, Costa Rica.

Tekpetey, S.L. 4thInternational Conference of Production Engineering and Management. September 25-26, 2014 Lemgo, Germany.

Tekpetey, S.L. Workshop on Generation Z, a challenge in Didactics and Education, University of Applied Science 24th September, 2014, Lemgo, Germany.

Tekpetey, S.L. Sensitization Workshop for CSIR-TDTC focal persons 12-13 May 2014 CSIR-Technology Development and Transfer Center, COTVET GSTDP-COMPONENT 2 Project, Mensvic Hotel, Accra, Ghana