CSIR-FORESTRY RESEARCH INSTITUTE OF GHANA

2015 Annual Report

Executive Summary

The Forestry Research Institute of Ghana (FORIG) is one of the 13 research institutes under the Council for Scientific and Industrial Research (CSIR). CSIR-FORIG has the mandate to undertake forestry and forest products research, disseminate the results as well as commercialize relevant research outputs and services. The Institute has six research divisions and three support divisions. As at December 2015, the Institute had a total staff of 253 comprising 59 senior members, 89 senior staff and 109 junior staff.

In this 2015 Annual Report, we highlight outputs from key research and development-oriented activities. We also present highlights from key commercialization and administrative activities during the period. Our research activities during the year fell within three of the seven CSIR Research Programme areas namely; *'Food Security and Poverty Reduction', 'Climate Change, Environmental Management and Green Technology' and 'Science and People'*. However, there are overlaps and it is usually not easy to place particular projects under distinct programme areas.

Allanblackia parviflora (*novella*, local name *sonkyi*) is an indigenous tree species which produce fruits with high oil content useful for vegetable oil production. For some years now, fruits of *A. parviflora* are collected from the wild, however, increasing demand for industrial processing by Unilever and other food processing companies has resulted in a situation where demand is far outstripping supply. CSIR-FORIG has partnered the World Agroforestry Centre (ICRAF) to promote cultivation of *Allanblackia* by especially local farmers, and in the process help improve their livelihoods. Research efforts in the past were focused on seed germination and silvicultural production techniques. However, a crucial aspect of the plantation process is to be able to distinguish between male and female plants, as *A. parviflora* naturally has separate male and female plants (dioecious). This is to ensure that the right ratio of male and female seedlings are used during plantation establishment. A study was thus conducted to identify anatomical and morphological features that could be used to distinguish between the sexes. The study showed, however, that anatomical and morphological properties alone may not be good sex descriptors for *A. parviflora*, and as such further experiments using DNA markers to confirm sex characteristics has been recommended.

A number of projects that fall under the Climate Change and Environmental Management and Green Technology Programme were also implemented. These were largely projects in the area of tree improvement and plantation development techniques to enhance timber production, as well as enhance climate change mitigation and adaptation. Among these were, a project funded by International Tropical Timber Organization (ITTO) to enhance the capacity of local communities to establish plantations under the clean development mechanism (CDM) which could lead to poverty reduction in local communities. In another study, we are collaborating with ITTO to develop stable isotopes that will enable the tracking of timber extracted and sold illegally on the international timber market. This study involves the use of DNA markers to control the origin of tree species that enter the international market as well as use of DNA fingerprints and stable isotopes for the chain of custody.

In other projects to promote plantation development, we continued with research efforts to promote mahogany as a plantation species in tropical Africa through development of integrated pest management and silvicultural strategies. Inclusive of these were, the evaluation of 18 provenances of *Acacia* species to promote agroforestry development and 24 provenances of *Tetrapleura*

tetraptera (prekese) for quality fruit production. Our ability to produce high quality prekese fruits will substantially increase the supply of raw materials for our Prekese Syrup Production Center as well as increase supply to the local market.

During the year under review, we continued to work on the EU Chainsaw project, with Tropenbos International as one of the key partners. The project is aimed at working with timber markets and chainsaw millers. Surveys on national timber markets and trade established that 70% of lumber sold on the domestic market was found to be supplied by illegal chainsaw operators resulting in huge losses to the state and forest degradation. A number of recommendations to help curb the chainsaw menace, improve sustainable forest management, and livelihoods of operators and actors have been proposed.

Apart from illegal chainsaw operations, the wood industry sector is currently faced with many challenges, which include inefficient downstream processing and absence of standards to regulate the production and marketing of furniture in Ghana and the subregion in general. With funding from the United Nations Industrial Development Organization (UNIDO), CSIR-FORIG is establishing a Wood and Furniture Testing and Accreditation Laboratory at Fumesua, which will serve as a center for testing and certifying wood and finished wood products for the domestic and export markets. When completed and fully operational, the facility will become the only furniture testing and accreditation laboratory in the entire West African subregion.

Another key project with potential to promote the timber industry is adoption of high quality cassava flour (HQCF) as an extender in plywood production. This product which originated from our Chemistry Section in 2003 was to replace the more expensive wheat flour currently used by the industry. Various tests have been conducted at industry level with promising outcomes. Collaborators to produce the cassava flour on large scale are being sort for whiles further studies on plywood bond quality continues.

In the year under review, we engaged ourselves in several capacity building programmes, which included training of selected local communities in mushroom cultivation and snail farming techniques. In addition, we engaged in a number of commercialization and marketing of research by-products as part of our efforts to increase internally generated funds. Through radio talk shows, distribution of flyers and one-on-one visits to clients, we promoted the sale of prekese syrup, quality seeds and seedlings, wood thinnings from research plots, and undertook consultancy services.

Many of our research results and outputs were published in various forms to make them available to our stakeholders and the general public. These include a book, twenty-five (25) refereed journal articles, 14 technical reports, eight posters, two policy briefs and several workshop and conference presentations and reports. CSIR-FORIG will continue to work closely with the Ministry of Environment, Science, Technology and Innovation, the Forestry Commission and all its partners and collaborators to address the social, environmental and economic aspects of Ghana's forest resources.

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COMPOSITION OF CSIR-FORIG MANAGEMENT BOARD

1	**Mr. Edward O. Nsenkyire** *Former Chief Director (MESTI)*	Chairman
2	**Dr. Daniel A. Ofori** *Director, CSIR-FORIG*	Member
3	**Dr. Lawrence M. Aboagye** *Director, CSIR-PGRRI*	Member
4	**Nana Dwomoh Sarpong** *President, Ghana Timber Millers' Organisation*	Member
5	**Mr. Baffour Awuah Agyeman** *Furniture and Wood Products Association*	Member
6	**Mr. Afari Dartey** *Chief Executive, Forestry Commission*	Member
7	**Mr. Francis O. Amofah** *Head of Administration, CSIR-FORIG*	Secretary

1.0 INTRODUCTION

1.1 Establishment

The Forestry Research Institute of Ghana is one of the 13 Research Institutes of the Council for Scientific and Industrial Research (CSIR-FORIG). It is located at Fumesua, near Kumasi in the Ashanti Region. The Institute started as a research unit within the Forestry Department in 1962 and later established as a Research Institute in 1964 by CSIR Act 521.

The mandate of CSIR-FORIG is to undertake forest, forest products research, disseminate and commercialize research outputs and services. Thus arising from its mandate, the Institute continued to collect data, analyze, educate and market outputs and services for the benefit of society.

1.2 Vision

To be a center of excellence in forestry research in the humid tropics.

1.3 Values

Our core values include professionalism and excellence, creativity and innovation, discipline and punctuality, teamwork and inclusiveness and networking and partnership.

1.4 Mission

To undertake demand-driven research, build capacity and promote the application of technologies for sustainable management of forest resources for the benefit of society.

1.5 Key Objectives

The key objectives of the Institute are:

- Develop technologies for sustainable management of natural forests, biodiversity conservation, climate change adaptation and mitigation;
- Develop technologies for plantation forestry;
- Generate, mobilize, process and disseminate information critical to the management of Ghana's forest resources;
- Strengthen capacity to enhance the commercialization drive of research output;
- Contribute through research to social economic and environmental wellbeing of Ghanaians.

1.6 Divisions

The Institute's core research activities are implemented by 6 Divisions and 3 Non-Core Research Divisions. The Core Divisions are:

- Biodiversity Conservation and Ecosystems Services
- Forest and Climate Change
- Forest Policy, Governance and Livelihoods
- Forest Improvement and Productivity
- Forest Products and Marketing
- Wood Industry and Utilization

The Non-Core Research Divisions are:

- Administration
- Commercialization
- Finance

2.0 FOOD SECURITY AND POVERTY REDUCTION PROGRAMME

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

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

Introduction

Allanblackia spp. belong to the family Clusiaceae and there are nine species within its genus that are limited to Africa. *Allanblackia parviflora* A. Chev for example, occurs from the forest zone of Guinea to Ghana and the local people use the oil extracted from the seeds for cooking and soap making. Recently, Unilever Ghana has acknowledged the high value and quality of the oil extract and its potential for improving rural livelihood. Nevertheless, the oil is in high demand and only 5% of this can be supplied sustainably from natural populations. Novella Africa in 2003 therefore initiated a project to cultivate *A. parviflora* on a large scale to augument the demand gap from the natural forest. However, *A. parviflora* is a dioecious tree and its sex characterization could be misleading until it reaches maturity (5 to 12 years) and flower formation stage. Yet, accurate identification of its sex at the juvenile stage before reproductive maturity stage is essential for its establishment in plantations. Its been established that both anatomical and morphological characteristics can help in identifying the sex of *A. parviflora* and therefore the project seeks to use both characteristics of its leaves at juvenile stages for the sex determination.

Methodology

A total of 66 matured trees with known sex (females and males) were randomly sampled from *Allanblackia* genebank at Benso and a demonstration site at CSIR-Forestry Research Institute of Ghana. For the morphological studies, 5 leaves were collected from each tree at approximately the 6th and 7th nodes of all trees from the eastward, westward, northward, southward and a 5th from the apical positions. All leaves sampled were scanned using HP scanner and the images were analyzed using image software (National Institute of Health, Bethesda,MD, USA). Features measured include; petiole length, leaf length, leaf width, and leaf area.

Key results and the way forward

The results of our investigation suggest that leaf area, leaf length, petiole length and anatomical properties may not be good sex descriptors for *A. parviflora*. However, leaf width and stomata width could be useful descriptors of female and male *A. parviflora*. It is recommended that an experiment should be designed to test and confirm our hypothesis using a DNA marker system.

2.2 Development and implementation of a species identification and timber tracking system in Africa with DNA fingerprints and stable isotopes/large scale genetic timber verification project

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

Start Date: April 2011

Expected Completion Date: August 2017

Introduction

Illegal logging and associated trade are the cause of many economic and ecological problems both in timber producer and timber 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 use DNA fingerprints for the chain of custody:

The expected outputs for the project in Ghana are as follows:

a. Kick off meeting will be held.
b. Capacity building of African Scientists in Nairobi.
c. Sampling of 400 *Khaya* trees from SAMARTEX concession at Yoyo FR.
d. Sampling of 200 wood and veneer samples of *Khaya*.
e. Establishment and running of Genetic Reference Lab.
f. Training of a FORIG Biotech Lab Person at VTI, Germany.

The project kick off meeting was held in CSIR-FORIG. Training of CSIR-FORIG scientists in Nairobi; Kenya and Germany has been undertaken. The study on the genetic species identification and chain of custody study of *Khaya anthotheca* and *Khaya ivorensis* at the SAMARTEX concession is completed. The genetic data showed very strong genetic differences among the two species. Sampling of 200 wood and veneer samples of Khaya was successfully carried out by the project field team in CSIR-FORIG. A training workshop and seminar on wood anatomy, state of the art technologies for tracking legal timber was organized to equip scientists, Forestry Commission staff, TIDD and the timber industries on systems to track the origin of timber. Activities involved in the genetic timber verification project are sampling of high quality DNA samples and blind test of some economic timber species to develop markers to track country of origin and identification of timber species.

As part of the project implementation activities, sampling has been conducted in Ghana, Cote D'Ivoire and Nigeria for the key species involved in the project including *Cylicodiscos gabonensis, Khaya ivorensis, Nauclea diderrichi, Lophira alata* and *Entandrophragma utile*. Sampling training workshop was done in Ghana, Cote D'Ivoire and Nigeria to build capacity of project field crew on sampling protocol to enhance validity of data from the field. Samples collected have been collated and shipped to Germany for blind and ring tests for high quality DNA samples. The project leader attended a project steering committee meeting in Douala and presented the state of the project, achievements and challenges in the West African region to the lead executing agency; Thunen Institute of Forest Genetics, Germany. DNA sequencing equipment was installed in the Biotech reference laboratory at CSIR-FORIG. A solar system was also installed to maintain regular power supply for the sequencer and lab. Ring test of some of the samples was done in Ghana to assess the authenticity of the sequencer and also for validity of results. The equipment was launched and made operational to facilitate research activities in West Africa sub region which is a major achievement of the project.

Plate 1: Samples of plant materials used for DNA extraction

Plate 2: Scientist engaged at reference lab using the DNA sequencing equipment

3.0 CLIMATE CHANGE, ENVIRONMENTAL MANAGEMENT AND GREEN TECHNOLOGY

3.1 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: January 2018

Introduction

Kumasi has been known as the Garden City of West Africa due to the numerous trees in the city and a forest reserve at Ahodwo, a suburb of the city. These trees provide conducive environment for streams and other water bodies in the metropolis. Indiscriminate felling of trees, farming close to water bodies, fuel wood collection and other activities in the watershed areas have 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 Mayor of Kumasi Metropolitan Assembly, Hon. Kojo Bonsu, outlining his vision for the Metropolis indicated his plan to restore the city to its former status as the "Garden City of West Africa" through planting of one million (1,000,000) trees by 2017. CSIR-FORIG was contacted by the Kumasi Metropolitan Assembly to bring the vision to fruition.

The goals of this project among other benefits are to provide shade, improve air and water quality as well as beautify the Metropolis through planting of trees along the major driveways, water bodies, parks, school compounds and communities.

The main objective is to plant and manage one million trees along the major driveways, water bodies, parks, school compounds and communities in the metropolis by 2017.The short term objective was to plant 10,000 tree seedlings in the Metropolis by the end of 2014.

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 (with support of staff of Department of Parks and Gardens and a representative of Department of Urban Roads). Tree species considered for planting were *Blighia sapida* (Akye),*Terminalia montalis* (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 seedling planting. Selected Basic and Junior High Schools were involved in "Me and My Tree Competition" in planting and nurturing of 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 communities on tree

planting through public education. LINTA Company presented posters and souvenirs while CSIR-FORIG designed flyers.

Results

Tree seedlings were planted on both sides of major roads from Bebre to Anloga Junction, 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.FORIG produced bamboo cages to protect the tree seedlings.

Supply of seedlings

CSIR-FORIG supplied 250 seedlings to KMA for a beating up exercise which was supervised by the Chairman of the Kumasi Urban Forestry Project Planning Committee. Ten laborers were hired for the exercise.

Conclusion and Way Forward

A consultancy report was written by the team and the Institute is still waiting for funding to continue the work.

Plate 3: A section of the planted tree seedlings in wooden cages

3.2 Monitoring of wildlife presence and adaptation at the Akyem Mine, Ghana-2015

Project Team: Kankam, B. O.
Start Date: February 2015
Expected Completion Date: April 2016

Introduction

As development of mine-related facilities by Newmont Golden Ridge Limited (NGRL) advances, portions of land cover and biodiversity are removed; leading to direct loss of wildlife habitat. Loss of wildlife habitat may cause a shift in the composition of wildlife communities, particularly when the intensity of habitat disturbance is high. Consistent annual monitoring of wildlife as suggested in the NGRL Wildlife Monitoring Plan is critical to make informed decisions regarding wildlife issues in and around the concession area. Monitoring of wildlife in the NGRL concession further allows for modification or consideration to adopt new strategies in the Wildlife Monitoring Plan and Wildlife Management guideline to address wildlife-related concerns in the area. The driving question for this research is "Comparatively which of the animals has been displaced or become resilient in the Akyem mine concession area due to mine-related disturbance?" This question is imperative because different wildlife species respond differently to natural vegetation disturbance either at the same habitat or in different habitat.

This research therefore seeks to: 1) survey, document and compare the trend of wildlife observed in the NGRL concession area, especially key animal species of global concern identified in previous studies, and 2) identify areas requiring improvements to mitigate/reduce potential wildlife management risks.

Methodology

Mammals: We surveyed large mammals using (1) direct observations, (2) indirect evidence: identification of dung, tracks and other signs, and (3) camera-trapping, to detect animals. We walked transects and access routes throughout the NGRL concession area in the morning and afternoon/evening daily to increase the chances of sighting. We also identified mammals using signs (e.g. footprints, dung/faecal pellets, feeding signs, trails/tracks and burrows, animal calls especially nocturnal animals) between 06:00 hours and ended around 14:00 hours, and later from 16:00 hours to 20:00 hours.

Birds: Birds were surveyed repeatedly using access routes (e.g., trails/footpaths) and existing transects in the area in the morning (05:30 to 12:30 hours) and evening (14:30 to 17:30 hours). We identified birds either by their songs (calls) or visual contact using binoculars. We also surveyed all artificial ponds or water facilities within the survey site to record aquatic birds. We also established mist nets to capture, identify and record birds that flew low at the forest floor.

Amphibians and Reptiles: The survey was conducted from morning to noon (06:00-12:00 h), and at night (19:00-22:00 h) to detect both diurnal and nocturnal amphibian and reptile species. We searched for amphibians systematically and repeatedly by looking at potential breeding sites and hiding places. Also, we searched in bushes, lifted rotten logs, and scrapped through leaf litter. We excavated burrows, dead stumps, holes and termite mounds for reptiles. Frogs and toads were captured, identified and released at the field. In cases where frogs could not be captured, they were identified using their mating calls.

Key Results/Findings

Results indicated that at the mine site, the number of individuals, family, genera and species for amphibians and reptiles decreased in 2013 as compared to other survey periods. Mammals and birds however, did not follow a regular pattern. The number of amphibians and birds recorded between survey periods was significant ($p<0.05$) except for 2011 and 2013 respectively. There was no significant difference for reptiles and mammals. The mine take analysis showed that the number of amphibians and birds recorded in 2013 was statistically significant; but not for reptiles and mammals. The overall per cent annual average change varied among different taxa. Fewer individual species recorded an increase in per cent annual average change at the entire mine take area between 2013 and 2015. We recorded 3 species of conservation importance: *Phrynobatrachus alleni* (Near-Threatened); *Necrosyrtes monachus* (Endangered) and *Kinixys erosa* (Data Deficient). Using camera traps, we obtained 587 trap events from 792 animal photographs captured. Bushbuck (*Tragelaphus scriptus*) was the most recorded species (n=228; 26.92 detections/100 camera trap days) followed by African civet (*Civettictis civetta*: n=141; 16.65 detections/100 camera trap days).

Conclusion

The most adapting species at the Akyem mine site are mammals: Bushbuck (*Tragelaphus scriptus*), African civet (*Civettictis civetta*), and African palm civet (*Nandinia binotata*). Others include Amphibians: *Phrynobatrachus latifrons* and *Ptychadena mascarieniensis*; and Birds: *Necrosyrtes monachus, Milvus migrans, Corvus albus*. No reptile species seem to have adapted. Hunting should be discouraged in the concession area. Regular wildlife survey and monitoring is recommended at the Akyem mine. These regular checks should be conducted as specified in the NGRL Wildlife Monitoring Plan to successfully mitigate the measures proposed in the NGRL Wildlife Management Plan to minimize risks to critical animal species in the concession area.

3.3 Weathering characteristics of natural forest and plantation grown Khaya ivorensis in Ghana

Project Team: Owusu F.W., Tekpetey S.L., Appiah-Kubi, E. and Adutwum-Oppong, J.

Start Date: October 2014

Expected Completion Date: October 2017

Introduction

For the past two decades, the timber industry in Ghana has continued to decline with reduction in supplies of commercial timber supplies. This situation is impacting negatively on many timber firms leading to their closure or a decline in their operating capacity. Khaya (African Mahogany) is among this category. All the species in the genus are overexploited and threatened. For instance, *Khaya ivorensis* is one of the species from the genus *Khaya* that has both domestic and international demand due to its many structural and non-structural applications. In Europe for instance, a high percentage of African Mahogany products sold on the market comes from *K. ivorensis*. In order to increase and or maintain the resource base of the dwindling species, there was the need to establish plantations. However, the technological properties of the species from the natural forest and plantations with respect to outdoor exposure are not known. It is expedient to establish the weathering properties of *K. ivorensis* from both sources for comparison in order to efficiently promote the utilization of the plantation species.

Objectives

1. To determine selected physical properties of *K. ivorensis* timber from plantations and natural forest.
2. To establish the bending characteristics of *K. ivorensis* timber from plantations and natural forest after different periods of exposure.

Methodology

Samples were collected from six trees of *K. ivorensis* that were extracted from Pra Anum forest reserve. With three trees from each source (natural forest and plantation sources), 120 samples of dimensions 2cm x 10cm x 30cm were prepared. The initial weight of each sample was taken and recorded. The sample was then displayed on two exposure test rakes designed by Francis Wilson Owusu of CSIR-FORIG (Plate 4 and 5), one for full exposure test and the other rake for samples kept indoors as control. The British Standards, BS 373 (1957) was used for the preparation of the bending test samples with dimensions 2cm x 2cm x 30cm. The test was conducted using a Universal Instron Testing machine according to BS 373 (1957) at CSIR-FORIG and data on MOE and MOR were collected. Data was collected on MOE/MOR using the computer attached to the Universal Instron Testing machine.

Plate 4: **Wood and metal mix rake for exposure tests**

Plate 5: **Display of *Khaya ivorensis* test samples on rake**

Key results and the way forward

The colour of *K. ivorensis* samples from natural and plantation sources gradually changed at the end of the 1st month to the 12th month. The species from both sources changed from pale pinkish to a shiny tan then finally to Greyish black. The dimensional changes of the test samples affected the thickness and width while there was no significant change in the length. The estimated volumetric changes were more severe with the trees from the natural forest than those from plantations for both control and exposed samples. Again, the plantation samples under exposure experienced quite higher volumetric changes than its control samples, while it was comparatively lower with natural forest trees. The mean weight loss per month for *K. ivorensis* for the 12 months with respect to the initial weights of the samples, ranged between 3.3g to 78.3g and 12.2g to 86.65g for the control and exposed samples respectively. Trees from the natural forest exhibited higher weight loss than the plantation trees. The modulus of rapture (MOR) and modulus of elasticity (MOE) are bending properties, which are mechanical strength indicators for timber species. Consistently, the plantation trees from both the control and exposed samples recorded higher mean MOEs than the natural forest trees while the mean MORs did not show a particular trend. This implies that in utilization, the plantation trees have the ability to resist some external forces than the natural ones. Samples from plantations indicated comparatively lower deviations with respect to their initial densities than the natural forest trees.

Plantation species of *K. ivorensis* have the capacity to withstand adverse weather conditions more than those from the natural forest. Furthermore, with respect to wood from plantations, minimal exposure to weather conditions on wood from plantations makes the wood more versatile in utilization. In conclusion, the properties exhibited by the samples from plantation trees are an indication that they are good substitutes to natural forest trees of *K. ivorensis*.

However, the analysis of the complete data at end of the third year of study will help us to confirm or reject our current observations.

3.4 Processing of African rosewood (*Pterocarpus erinaceus*) into lumber using Wood Mizer portable machine

Project Team: Owusu, F.W., Appiah-Kubi, E., Tekpetey, S.L., Mensah, M. and Adutwum Oppong, J.

Start Date: December 2014

Expected Completion Date: December 2015

Introduction

African rosewood (*Pterocarpus erinaceus*), belongs to the family, Fabaceae. It is predominantly found in many African countries. The species adopts mostly to the forest savannah transitional zone, open forest and woody savannah; and parts of the northern savannah woodland ecological zone. In Ghana, Rosewood is locally known as Krayie or Kpatro, a common name for timber exploited from the species while the Chinese Rosewood buyers or traders in Ghana also refer to it as Kosso.The species is mostly found in the northern part of Ghana (Ashanti, Volta, Northern, Upper East and Upper West and Brong Ahafo regions). The major uses of the species in these areas are firewood and charcoal production. For some years now, because of its high demand on the international market, the species is processed into square lumber form and exported. Unfortunately, there is no data on its properties to enable it to be promoted on the local timber market for use. For the efficient promotion of the species, determination of the machining properties, is important and will enable the furniture industry benefit from its utilization. It will also increase the economic value of the species as well as the national revenue.

Objectives

To determine the sawmilling properties of African Rosewood grown in Ghana with available portable milling machine.

Methodology

The Logs to be used for the experiment were extracted from the Northern, Ashanti and Brong Ahafo regions of Ghana. These were felled (Plate 6) using a chainsaw machine and cross-cut into billets as shown in (Plate 7). Dimensions (butt & top diameters and length) of all the logs were taken. These were milled using LT15 Wood-Mizer. The time taken to mill each log and fuel used were recorded. The dimensions of lumber generated were also taken.

Plate 6: Rosewood tree felled

Plate 7: Billets of rosewood

Key results and the way forward

Rosewood is a deciduous small tree with height of 12m to 15m tall. Tree branches after 3-10m high but in most cases it is twisted, fluted and with a rounded crown. The tree is slightly buttressed and the maximum diameter recorded was 65cm. The bark of the tree surface is grayish black, fissured and scaly. A reddish translucent gum comes out when there is a cut through the bark. The heartwood is yellowish brown to reddish brown, often with purplish brown streaks, and distinctly demarcated from yellowish or pale cream-coloured sapwood. Freshly cut wood has an unpleasant smell. The wood was difficult to saw without nonstellite-tipped saws and the frequency of saw sharpening was high. Some flashes of light were observed during sawing, which indicates the presence of inclusions in the wood. Fuel consumption was higher and lumber production rate was lower than medium to heavy density wood species (for instance; Odum, Mansonia, Makore and Teak). The preliminary average green lumber recovery rate has been estimated to be 69.54%.

Sawing properties of Rosewood grown in Ghana have been established and this will enhance the efficient processing, promotion and utilization of the species locally. Other technological properties recommended will be developed.

3.5 Set up and Accreditation of Wood and Furniture Testing Laboratory at CSIR FORIG

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

Start Date: September 2013

Expected Completion Date: September 2017

Background

Trade in timber and timber products contribute significantly to the Gross Domestic Product (GDP) of Ghana. In 2008 for instance, over 187 Million Euros was realized from the sale of timber products from Ghanaian sawmills. 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) that increases its worth, thereby, increasing the utility and economic value of the product. One of the key challenges that affect value addition to wood and wood products is the lack of an accredited testing centre in the country to ensure that standards are complied with in the manufacture and processing of wood products. It is therefore imperative that a wood and a furniture testing laboratory accredited under ISO 17025 is set up to test and certify wood products to ensure that they comply with standards for market access both locally and internationally.

UNIDO through funding from the State Secretariat for Economic Cooperation (SECO), Switzerland is supporting CSIR-FORIG to set up and obtain an accreditation for Wood and Furniture Testing Laboratory at FORIG under ISO 17025. The laboratory will test and certify wood products for exports in order to meet standards and become competitive on the international market.

Objective

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.

- To upgrade the existing test laboratory at CSIR-FORIG and accredit it according to the international standard ISO 17025.
- To build the capacity of personnel and promote test laboratory to key stakeholders of the Ghanaian wood industry and boost the export and use of wood products through value addition by meeting standards.
- To set up a national technical committee for standards and to ensure compliance by industry.

Methodology

To fully comprehend the wood industry of Ghana and the sub-region, we conducted a desk study, organized series of stakeholder meetings and training workshops. Subsequently, we redesigned and started renovation of the existing wood and furniture testing laboratory at CSIR-FORIG. We have also identified personnel and created a management structure (organogram) for the laboratory. Furthermore, we have also developed laboratory quality management handbook, processes, manuals and templates. Acquisition of new equipment and set up of laboratory for accreditation according to ISO 17025 has been initiated.

Activity/progress since previous report

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

Personnel for the laboratory have been identified and trained in the development and writing of laboratory manuals. A management structure (organogram) for the operation of the laboratory has been set up. The scope of laboratory accreditation has been defined and the sort of equipment, devices for the testing have also been determined. Equipment list with specification has therefore been submitted to UNIDO for procurement.A re-design of the existing laboratory to accommodate the new equipment has been done and renovation is underway. New offices to relocate existing offices in the building have also been completed.

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

Guidelines and procedures for the development of documentation for the laboratory have been defined. Personnel have been trained by consultants from the Bern University of Applied Sciences (BFH), Switzerland on the write up of the laboratory quality management handbook. Write up of the handbook, processes and templates are underway.

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 on wood and wood products has been done. The Ghana Standards Authority (GSA) will lead in the set-up of a national technical committee to review and develop standards for gaps identified in the standardization of wood products in Ghana. GSA has also been contacted for calibration services for the equipment in the laboratory.

The way forward

Uncompleted activities are on-going and expected to be completed in the next quarter. Most of the 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 the policy of UNIDO on project implementation, beneficiary institutions are required to contribute to the project funding through the provision of the infrastructure to accommodate the equipment. UNIDO will be responsible for the acquisition of all the equipment, capacity building of personnel and the payment for accreditation services as well as the setup of the national technical

committee and standards development. CSIR-FORIG is therefore providing financial support for the renovation of the existing building to the standard required for accreditation. Lack of adequate funding in the Institute is a challenge in meeting the requirement of CSIR-FORIG within the project time frame.

3.6 Evaluation of 18 provenances of three Acacia species for use as agroforestry species in the Upper East of Ghana

Project Team: Cunningham, P. (WV Australia) and Akpalu, S.
Start Date: February 2014
Expected Completion Date: February 2017

Introduction

Edible Australian Acacias have been shown to have significant potential to restore degraded lands, improve food security, build farm resilience and support adaptation to climate change in semi-arid tropical regions of Africa. The three principal species that have been developed over the last 25 years are *Acacia colei, Acacia torulosa* and *Acacia tumida*. These species have been developed in the Maradi Region of Niger. The annual rainfall of the region ranges from 450-500 mm. It is also well documented that these species are adapted to higher rainfall areas. Therefore the purpose of this study is to assess the 18 provenances and identify suitable tree species to use in agroforestry in the Upper East Region of Ghana.

Methodology

Nursery and field plots with 100 x 100 m were established. The experimental design used was Completely Randomised Block Design (CRBD). The parameters assessed were: survival rates, growth rates, flower and fruit production, litter production, and techniques for incorporation into local dishes to improve nutrition.

Status

The plots were established in August 2014. Assessment of survival and height were recorded at 6 and 12 months after planting. The study would be done in 18 months. Thus, fruiting will also be assessed in February 2016. Technical reports on survival and growth rate (height) were submitted to World Vision Ghana and Australia in February and August 2015.

Way Forward: Provenances will be assessed on fruit production in February 2016.

3.7 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., Darko-Obiri, B., Tekpetey, S., Appiah Kubi, E., Essien, C., Opoku, S.M.,Nyarko Duah, N.Y., Owusu, S.A. and Opoku, E.M.

Start Date: February 2010

Expected Completion Date: November 2015

Introduction

Sustainable supply and conservation of mahogany (*Khaya* spp.) are 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 research that is being conducted aimed at developing an integrated pest management strategy for mahogany shoot borer via plantation culture to contribute to restoration and conservation of 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 expand our collaboration with industrial and community tree farmers. The specific objectives seek to refine our silvicultural "tool Kit" to improve the ability to produce economically viable indigenous mahogany in mixed plantations and to transfer this technology to Ghana's key industrial partners and community tree growers via a practical "how to" cultivate indigenous mahoganies manual. The expected outputs of the project are as follows:

a. Practical methods for mass production of selected superior *Hypsipyla*-sp-tolerant clones.

b. Seed production orchards established for each *Khaya* spp. and *Entandrophragma* spp.

c. Our silvicultural "tool kit" refined to optimize planting of mixed stands in the 4 major ecological zones.

d. Wood quality and lumber properties from mature plantation-grown mahoganies determined.

e. Socio-economic impacts of integrated agro-forestry plantations of mixed mahoganies with various short-term crops determined.

f. A practical "How to cultivate mahogany" in plantations manual produced and International Workshop Organized.

The project implementation in the fifth year focused on efforts to complete most of the activities in order to attain the target set for the project within the specified duration. Establishment of superior mahogany seedling production centers and hedge garden was 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 at 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. Our silvicultural "tool kit" was refined to optimize planting of mixed stands in the 4 major ecological zones. Monitoring and maintenance of experimental plots established since the project's implementation was 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 planting were established at Abofour and Mesewam in the dry and moist semi-deciduous forest zones respectively to determine growth performance and tolerance to pest attack by the mahogany species. Wildfire management strategies was improved with construction of fire belts and planting of fire resistant trees by the project field crew at Abofour to mitigate erratic fires. The project field crew undertook monitoring and evaluation in the spacing, pruning, mixed stands of neem and mahogany trial plots and provenance trials. Initiatives of introducing weaver ants as biological control agents in mahogany plantations were undertaken by the project field crew. The project strengthened its collaboration ties with the Osiem Savior Church to ensure efficient beating up and maintenance of the stands established in the previous year. Studies on wood quality and lumber properties to determine the sawing characteristics of mature and plantation-grown mahoganies are being finalised for publication. Comparative socio-economic studies on economic viability of smallholder plantations involving focus group discussions and participatory rural appraisals methods were completed successfully.

The project's established stands were monitored and evaluated for their growth performances and pest incidences. Different mixed stands of mahogany species with other species such as *Khaya* and *Entandrophragma species, Cedrela odorata* and *Swietinia macrophylla* which are already established at Bobiri and Mesewam research plots in the moist semi-deciduous forest zone were evaluated. Height, diameter, number of shoots, height to first branch and shoot attacks were collected on the stands per site to compare the growth and pest tolerance of the tree species. The data is being analyzed to supplement the database of the project. Major research activities of the project conducted this year were selected by undergraduate students for their thesis work. Studies on chemical and mechanical properties of plantation grown mahogany in Ghana were completed. Experimental trial of grafting four mahogany species was developed at the CSIR-FORIG nursery site with scions collected from healthy and prolific mature trees of four *Khaya species*. Evaluation of grafting success and growth performance of grafted mahogany species per the three grafting methods was done to determine the most suitable method.

Plate 8: Samples of grafted mahogany seedlings

An international conference on towards sustainable production of mahogany in tropical Africa was organized at CSIR-FORIG on the 2nd to 6th March 2015 with participants from Thunen Institute of Forest Gentics, SODEFOR, Nigeria, Togo, Benin, Malaysia, Collaborators from Michigan Technological University, USA, African Plantations for Sustainable Development; Ghana, Samartex Plywood and Timber company and academic and research institutions in Ghana. A practical handbook for managing mahogany plantations

in the tropics has been developed and presented for final editing and review. The implementation of the mahogany project has been effective and educative as valuable information has been provided for sustainable management of mahogany in plantations. Activities carried out so far shows much progress in achieving the developmental objectives of the project. The project built active community participation which has renewed the interest of other community farmers and tree growers to engage in future plantation development programme with the establishment of indigenous species such as mahogany for sustainability of the Ghana forest estate.

3.8 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 Mensah, E., Nyarko Duah, N.Y., Beniako, K.N. and Yeboah, D.

Start Date: 2011

Expected Completion Date: 2014

Objective

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, and therefore, making the country eligible for CDM reforestation projects. Undoubtedly, the need to develop the capacity to conduct CDM-Forestry projects with a strong poverty alleviation component is very high. The project intends to develop the capacity for CDM-Forestry in Ghana via a community rehabilitation of Ghana's degraded forests targeted at poverty alleviation in conjunction with sustainable forest management (SFM). The expected outputs of the project are:

a. Carbon stocks of the Oda-Kotoamso Community Agro-forestry Project (OCAP) will be determined using GPS to obtain comprehensive and complete measurements of all trees on the project site.

b. Mass spectrophotometric analysis will be done on wood samples from up to 5 trees each of the 19 tree species planted.

c. A degraded forest (450 ha) will be reforested with the OCAP model using highly productive timber species.

d. Comprehensive socio-economic studies will be conducted in the communities involved in the project.

e. Capacity to conduct CDM forestry will be built with post graduate training of Ghanaian students.

f. Community-based CDM forestry methodology will be developed for the OCAP project.

Activities undertaken in the fifth year of the CDM project focused on strategies to complete the few activities yet to be done in order to achieve the overall goal of the project. Maintenance, monitoring and evaluation of the previously established stands at OCAP and Pamu-Berekum were undertaken to assess their growth performance. Fields within the project demarcated area which were not captured in the previous mapping was continued by the

project team at the reporting period.Carbon sequestration estimation and analysis of the plantations was carried out successfully as part of the year's activities and students were trained in carbon stock estimation. Mapping of the Pamu-Berekum project site was undertaken by the project field crew and the mapping unit of the Forestry Service Division, Sunyani. Assessment of the established plantations of the different farmer groups working on the project was carried out.

A study was undertaken to evaluate the influence of farmers' participation and practices on stand productivity and carbon sequestration in plantation development. Additional surveys were conducted and questionnaires were administered in the fringe communities in Pamu-Berekum to augment the existing data to enable the team draw relevant conclusions. Social survey on farmers' socioeconomic background and its influence on silvicultural practices and stand productivity were conducted.

Silvicultural practices used by the farmers have been documented. Stakeholders at the Dormaa FSD were engaged in structured interviews to seek their opinions on management and sustainability of the established plantation. An analysis of carbon sequestration of the stands has been initiated to assess the productivity of the farms. Other fields within the project demarcated area were mapped to update the land cover of the project site. This will enhance proper documentation of the planted area and also ensure equity in benefit sharing from future carbon trade. Farmers were educated to avoid unnecessary burning on their farms which can result in severe wildfires and a boundary line was cleared to guard against fire outbreak. The attention of farmers was drawn to the relevance of integrated management approaches in fire management and they opted to act as volunteers to patrol the established stand in order to prevent losing their long term carbon benefits which is important to sustaining the CDM project. The project team continued their activities of developing simple Community-based CDM methodologies for tree growers to facilitate easy adaptation to CDM Forestry. The project has obtained immense progress with regards to expanding research focus with the overall goal of enhancing effective restoration of the degraded forest reserves. Capacity building of farmers, students and the entire project staff was prioritized in the project implementation. Nursery management techniques developed were transferred to farmers to improve their livelihoods and training of students on the project is contributing towards the development of vibrant human capacity for CDM Forestry in Ghana. The CDM project's execution has been effective and interesting, attracting other communities to participate in the project contributing to achieving the project objectives.

Plate 9: Farmers and project team members in the Pamu-Berekum Forest Reserve

4.0 SCIENCE AND PEOPLE

4.1 Capacity Needs Assessment of Smallholder Farmers for *Allanblackia* Propagation and Cultivation

Project Team: Dumenu, W.K., Ofori, D.A., Mensah, M., and Afona, D.

Start Date: June 2015

Expected Completion Date: December 2015

Introduction

Cultivation of *Allanblackia* (AB) and its processing into different products such as oil, white spreads, soap and drink has been identified as an emerging agri-business in many African countries. Currently, the potential market demand for AB oil alone is estimated at over 100,000 tons per year with the potential to exceed 200,000 tons a year. The huge demand and interest in AB cultivation calls for the building of the capacity of smallholder farmers in order to upscale AB cultivation in Ghana. However, to effectively build the capacity of smallholder farmers, capacity needs assessment is critical. Therefore, this study focuses on assessing the capacity needs of smallholder farmers in propagation and cultivation of AB.

Objectives

- Identify gaps in previous capacity building programme.
- Determine additional and emerging capacity building needs of smallholder farmers.
- Provide recommendation for capacity building programme that can address the additional and emerging needs.

Methodology

The study was conducted in ten communities in Ghana in two political districts namely; New Edubiase and Wassa Akropong. Farmers from these communities have benefited from two different capacity training programmes organized in 2008 and 2013. Participatory research approach (key informant interviews, focus group discussions and administration of questionnaires) were used in data collection.

Outputs

1. Gaps in previous capacity building programmes identified.
2. Additional and emerging capacity needs determined.
3. Capacity building programmes that can address additional/emerging needs recommended.

Work done

- Fieldwork in all ten communities has been completed with data analyzed for preliminary results.
- Data for two of the three major outputs have been collected and preliminarily analyzed namely;
  - Gaps in previous capacity building programmes identified.
  - Additional and emerging capacity needs determined.

4.2 Assessing Options for Benefit Sharing Mechanisms for REDD+ Implementation in Ghana

Project Team: Foli E.G. and Dumenu, W.K.
Start Date: January 2015
Expected Completion Date: September 2015

Introduction

Through a series of multi-stakeholder consultations and workshops, IUCN has identified three (3) benefit-sharing options with potential for implementation in Ghana. The benefit sharing options include *Community Managed Revolving Credit Scheme, Individual Payments Scheme* and a *Hybrid/Combination* of the first two schemes. The challenge is to determine which of these three options can be adopted for REDD+ implementation. Also, relevant are determination of the institutional framework for the operationalization of the identified benefit sharing mechanism. The study uses the 'Options Assessment Framework' (OAF) to determine which of the recommended benefit sharing schemes could be adopted for effective REDD+ implementation. It also assessed the institutional, monitoring and fund management capacities of the recommended benefit sharing schemes for adoption for REDD+.

Objectives

- Assess the readiness status (institutional and operational capacity, legal framework) of the recommended benefit sharing schemes for REDD+.
- Determine benefit sharing scheme(s) most ready for adoption based on the readiness assessment results.
- Propose additional benefit sharing schemes and key actions required to operationalize them for adoption for REDD+.

Methodology

A participatory research approach involving a two-phased focus group discussion was used to gather data. The first phase involved focus group discussions featuring mainly farmers, NGOs, CSOs, district assemblies and traditional authorities for the assessment of recommended benefit sharing schemes in the forest sector based on the four building blocks of the OAF (PwC, 2012). The second phase involved expert stakeholder and validation workshops.

Outputs

1. Most ready-to-be-adopted benefit sharing scheme(s) for REDD+ implementation identified.
2. Enabling actions (institutional, fund management and monitoring) for operationalization of most feasible benefit sharing scheme(s) determined.
3. Additional benefit sharing scheme(s) proposed.

Work done

- Fieldwork has been completed, all focus group discussions and expert stakeholder/ validation workshops conducted.
- The most ready-to-be-adopted benefit sharing schemes for REDD+ implementation has been identified.
- Twenty enabling actions were determined while, four additional benefit sharing schemes have been proposed.

4.3 EU Chainsaw Project: Domestic Timber Markets and Trade in Ghana Study

Project Team: Marfo, E., Owusu, F. W., Damnyag , L., Karambiri, M. and Adeyiga, G.

Start Date: January 2014

Expected Completion Date: December 2015

Introduction

This report covered two major studies thus the national timber market survey and an overland lumber export. The national timber market survey study alone covered an estimated 90% of total timber markets share in Ghana. On the other hand, the overland lumber export study involved analysis of timber trade data from Ghana and Burkina Faso, direct trade assessment from the two major overland export markets (Techiman and Sokoban-Kumasi), and monitoring of timber flows across the northern border of Ghana (Paga, Kulungugu and Hamele) as well as a timber market study in Ouagadougou, Burkina Faso.

Result and Discussion

From the study, the respective volume of chainsaw and saw mill lumber in the domestic market as of 2015 is estimated at 72% and 28% respectively. The result therefore suggests that the share of chainsaw lumber on the domestic market has dropped from 84% as reported in 2009. The average monthly sales of sawmill and bush-cut stock in the domestic market is about 82% and 53% respectively, suggesting high consumer preference for saw mill timber. The study estimates that some 1.53 million m^3 of lumber is traded annually on the Ghanaian market, leading to exploitation of some 4.9 million m^3 of logs. This is 2.9 million m^3 over and above the official AAC. The study estimates that at least 130,000m^3 of lumber is exported overland annually from timber markets in Ghana alone. Based on physical border monitoring, the conservative estimate of the annual overland export of lumber across the northern borders of Ghana alone is 250,000m^3. This implies that some 120,000m^3 of lumber may be exported overland directly from production sites and from minor timber markets. It also means that some 825,083m^3 of trees (RWE) can be said to be used in the production of lumber for the overland export trade alone. At the same time, the potential revenue from stumpage fees lost, using an average stumpage fee of GH¢ 29.41 based on the 2014 revised rate could be GH¢ 7,351,205.9(USD1.97 million). On the average, the potential stumpage revenue loss was about 44% of the actual collected stumpage revenue over the period from 2010 to 2012. Given the conservative estimate of 250,000 m^3 of overland export, some 1.2 million m^3 of lumber can be said to be consumed annually within Ghana, translating into RWE of about 3.8 million m^3. This gives per capita lumber consumption of 0.05m^3. The study suggests that in total, some GH¢ 271,924,520 (US$75.5 million) of potential stumpage revenue could have been collected based on the estimated 4.9 million m^3 RWE of logs exploited and an average stumpage rate of GH¢ 55.5 (US$15.4). Given that about 70% of lumber on the domestic market was found to be supplied by illegal chainsaw operators, the expected actual potential stumpage revenue loss is estimated at GH¢190.3 million (US$52.7 million) annually. This is significant if compared to levels of current forest revenue. For example, only US$ 2 million (GH¢ 7.2 million) was collected by the FC as stumpage fees in 2012.

4.4 EU Chainsaw Project: Impact Assessment of the EU Chainsaw Milling Project in Ghana

Project Team: Marfo, E., Bosu, P.P., Dumenu, W.K., Nutakor, E., Samar, S.B., Agyei, F. K., Appiah, D.O. and Appiah, N.

Start Date: January 2014

Expected Completion Date: December 2015

Introduction

This study evaluated the impact of the EU chainsaw project in terms of generation of knowledge, policy outcomes, promotion of multi stakeholder dialogue and the incidence of illegal chainsaw activities in the project pilot forest areas.

Results and Conclusions

The main conclusions from the study are that chainsaw milling operations are generally on the decline; there is considerable improvement in knowledge about linkages and contributions of chainsaw lumber to the domestic timber market; increased access and availability of project reports and findings to most stakeholders; there has been growing recognition and increasing legitimacy of MSD platform as a means of building consensus and solving the CSM menace. The project has also generated new insights, policy discussions and strategies for supplying legal timber to the domestic market and supporting the establishment MSD concept in the forestry sector. It was however observed that data availability and reliability on lumber confiscations is still a challenge and the FC must take steps towards effective data capture and management.

4.5 Democratic representation in Ghana's REDD+ Readiness preparation consultation process

Project Team: Marfo, E.

Start Date: 2013

Expected Completion Date: 2015

Introduction

Ghana claims to have developed its REDD Readiness Plan through a highly participatory and consultative process using the notion of stakeholder representation in designing the institutional architecture for participation. The rhetoric of democratic representation is highly visible in Ghana's constitution and forest policy statements. To what extent were the espoused democratic principles regarding representation implemented by intervening authorities who designed and implemented the REDD Readiness strategy consultative process?

Objective

The objective is to understand the democracy outcomes of forest intervention and how we can achieve greater impacts on environmental citizenship, democratic representation and equitable benefit sharing. The Ghana REDD+ consultation process through expert interviews and documentary reviews, produced a peer-

reviewed paper published as CODESRIA Working Paper.

Result and Discussion

The study explored democratic representation of REDD actors, by examining espoused visions of democracy against actual commitments in practice. The paper argues that representation is an illusory feature of the REDD participatory process in Ghana because it is used symbolically rather than substantively. It shows that policy commitments to democratic representation in the R-PP consultation and participation process were largely symbolic to the extent that the allocation of resources did not reflect the depth of the espoused language of democracy. The paper also shows that there seems to be a fundamental gap on democratic notions of responsiveness and accountability between scholars and authorities of programmes like REDD+. Moreover, the paper demonstrates the struggle by REDD authorities to define the institutional architecture for the representation of local people and civil society in national processes like REDD that can deliver responsiveness and accountability in practice. In effect, current understanding of representation under institutional choices for stakeholder participation approaches seems to be very far from the desired democracy outcomes of responsiveness and accountability.

4.6 Community Training in Mushroom and Snail Production in the Bia Conservation and UNESCO Biosphere Reserve, Environmental Protection Agency-CSIR-FORIG Project

Project Team: Apetorgbor, M.M., Apetorgbor, A.K. and Bosu, P.P.
Start Date: February 2015
Expected Completion Date: June 2015

Objectives

i. To train selected community members around Bia Conservation and UNESCO Biosphere Reserve in oyster and oil palm mushroom production to improve their livelihood.

ii. To train selected community members around Bia Conservation and UNESCO Biosphere Reserve in snail farming to improve their livelihood.

Methodology

Mushroom Training

The programme was held at the premises of the Church of Pentecost at Kumkunso (Plate 10). The resource person took the 32 participants through lectures on the need to protect the National Park, need to cultivate mushrooms, importance of mushrooms and the different types of mushrooms and cultivation methods.

Practical Sessions

Supply of mushroom spawns/seeds

Sixty-four bottles each of oyster and oil palm mushroom seeds were prepared and sent to the participants at Bia for them to produce their own mushrooms. Another batch of fifty bottles of oyster mushroom seeds were sent to them to ensure that they are conversant with the production processes.

Plate 10: Participants at a lecture

Plate 11: Resource person demonstrating how to bag sawdust compost for mushroom production

Snail rearing

The following topics were covered under the training:

i. Background to Snail Farming in Ghana
ii. Brief Anatomy and Biology of Snail
iii. Selection of Snails for Rearing
iv. Consideration of site for snail farming
v. Food and feeding
vi. Breeding and Management
vii. Managing pests and diseases

Certificates of participation

Thirty-six certificates of participation were also prepared and given to the coordinator of Environmental Protection Agency (EPA) to be given to the participants.

Conclusions and way forward

The two training sessions were a success. A final report has been submitted to the Executive Director of the EPA and management of EPA has promised to continue with the collaboration to ensure the sustainability of the enterprise.

4.7 Digitisation of Indigenous Knowledge in the Forestry Sector in Ghana

Project Team: Sraku-Lartey, M., Acquah, S.B., Djagbletey, G., Samar-Brefo, S. and Appiah, N.

Start Date: January 2015

Expected Completion Date: January 2017

Introduction

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 meta data standards and procedures, multimedia technologies, and appropriate structures for access and use.

Research Objectives

1. Identify, capture, document and digitize indigenous knowledge on forest foods and medicinal plants.
2. Create a database of indigenous knowledge so identified.
3. Share knowledge of useful IK practices and their usage and thereby preserve the information to promote their wider application.
4. Establish a relationship between the knowledge identified and modern science.
5. Develop a manual of procedures and best practices to document the knowledge so identified.
6. Train researchers, librarians and information management personnel in the management of indigenous knowledge.
7. Explore the importance of indigenous knowledge systems in livelihood and socio-economic development in Ghana.
8. Assess the contribution of indigenous knowledge to scientific research.

This project which is expected to run for two years, is estimated at $47,000 and sponsorship is provided by Elsevier Foundation.

4.8 Empowerment of Selected Small Scale Mushroom Producers in the Ashanti and Greater Accra Regions of Ghana for Improved Livelihood

Project Team: Apetorgbor, M.M. and Apetorgbor, A. K.

Start Date: February 2015

Expected Completion Date: June 2015

Introduction

Mushroom growers (Alpha Mushroom Growers' Cluster and the Afigya Kwabre West-Sekyere South Mushroom Growers' Associations) who have formed associations in the Ashanti and Greater Accra Regions of Ghana have membership of 97 and 87, respectively. They were trained in the different cultivation techniques of oil palm mushroom production. They went through all the processes and had good harvest. Some growers were provided with mushroom spawns (seeds) on request and were able to grow their own mushrooms. The associations' vision is to promote the business of growing edible and medicinal mushrooms with the intention of improving health and nutrition of people and to create wealth for members. They are eager to produce mushrooms but are poor and cannot raise seed money to establish their farms. Some growers are therefore requesting for financial assistance for use as seed money to enable them establish their own farms. Furthermore, the above project is the continuation of "Training course on enhancing oil palm mushroom (*Volvariella volvacea*) cultivation technology for improved livelihood for small scale mushroom producers in the Ashanti and Greater Accra Regions of Ghana" submitted in the first quarter report for 2015.

Objective

To empower selected hardworking but resource-poor mushroom growers' associations in the Greater Accra and Ashanti Regions of Ghana to sustainably produce oil palm mushroom to improve their livelihood.

Methodology

i. A bundle of thick transparent polythene sheet required to cover substrates during incubation and cropping was purchased and cut into equal sizes and distributed to association members who formed groups numbering between seven and eight. Participants were given money to buy the following items: drums and aluminum bowls for soaking substrates. They also purchased tools such as pick axes, hoes, shovels and rakes to construct beds. Growers were also expected to prepare trapezoid wooden moulds for constructing low beds.

ii. The Afigya Sekyere-Afigya Kwabre Association of Ashanti Region has received 75 bottles of oil palm mushroom spawns while Alpha Mushroom Cluster in the Greater Accra Region had 90 bottles out of 300 bottles meant for each.

Results

i. Growth and yield of V. volvacea

The mushroom growers had very good harvest from the mushroom beds.

ii. Provision of mushroom spawn

The mushroom farmers made up of 10 farmer groups in each of the Ashanti and Greater Accra Regions were provided with 30 bottles of oil palm mushroom seeds (spawn).

iii. Monitoring and evaluation of farmer groups in mushroom production

The farmer groups started growing their own mushrooms. They (70%) mentioned that the oil palm mushroom was readily purchased when available and was preferred to the oyster mushroom. Some growers trained others in their communities and beyond (Akosombo, Akwamu and Nigeria) while others have started purchasing their own mushroom seeds for production.

Others have expressed their desire to expand production of the mushroom by employing more hands, acquiring more space/land, advertising the importance of this mushroom and working on the processing and storage.

Way forward

Mushroom seeds would be prepared for sale to enthusiastic farmers of the two associations.

4.9 The Size of the Domestic Timber Market in Ghana

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

Start Date: April 2014

Expected Completion Date: April 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 market is flooded with volumes of chainsaw lumber, which are illegally extracted from both the forests and farmlands. This illegal operation has impacted negatively on the country since its introduction. For the past two decades especially, a number of efforts, led by both Government and Non-Governmental actors have been made to ensure that illegal production and trade of timber is curbed. Yet the supply of the required volumes of legal wood and wood products to the domestic market continues to be a major challenge to the nation.

Due to this challenge facing the country, a number of studies have examined 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 (forests) 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 is likely to affect policy makers in their decision on the timber industry. Again, the actual size of the consumption of sawn wood in the domestic market is not clear due to the increasing overland export to other countries in the sub-region. Moreover, Ghana has joined the European Union in adopting the FLEGT-VPA process, which imposes a limited period of obligation to ensure the traceability and legality of all products from forest operations, whether for the local market or for export. Therefore, legal lumber trade needs to be enforced but in the right direction. With these challenges it is therefore necessary for the actual size of the domestic market to be determined in order to plan for legal, sustainable, regulated and cost-efficient supply of lumber to meet the growing demand.

Objectives

The main purpose of this study, therefore, was to increase the supply of legal timber on the domestic market of Ghana at the disadvantage of illegally produced timber and wood products. The specific objectives of the study were to:

1. Determine the supply pattern of timber to the domestic market.
2. Outline the challenges in the domestic timber supply and consumption.
3. Identify effective measures for enhancing legal timber supply on the domestic market.

Methodology

Desk study was undertaken. Structured questionnaires, amidst personal interviews, were used to collect data on inflows and outflows of lumber. There were initial discussions between the research team and the Domestic Lumber Trade Associations (DOLTA) and or leaders of the various timber markets, thereby sensitizing their members of the exercise prior to data collection. The timber merchants interviewed per market were randomly selected, taking into consideration willingness of the merchants to grant audience for interviewing. The timber market study consisted of a survey of wood merchants or suppliers on timber markets (i.e. the supply side) in the domestic timber markets across Ghana. Trained enumerators used 14 days to collect the data across the country during the peak (dry) season.

Key results and the way forward

A total of one hundred and eight (108) different timber markets of various sizes were identified in Ghana. A map of timber markets of Ghana has been created (Fig. 1).

The total annual national volume of timber consumed was estimated at 1,532,199 m^3, which corresponds approximately to 4.9 million m^3 round wood equivalent (RWE). Out of this volume, 63% was bush cut while 37% could be classified as sawmill products (lumber and boards). Meanwhile the annual stock volume nationwide was 2,513,429 m^3 (8 million m^3 RWE). The survey recorded a total of 99 timber species at all the domestic markets in the country. These timber species have been grouped under three utilization categories of small, medium and large sizes. The introduction of the map on the domestic timber markets in Ghana will make it possible for various markets to be identified easily. Current data is available to support policy makers in decision-making. Periodically, such data is recommended to assess the trend of legal/illegal timber inflows to the domestic market.

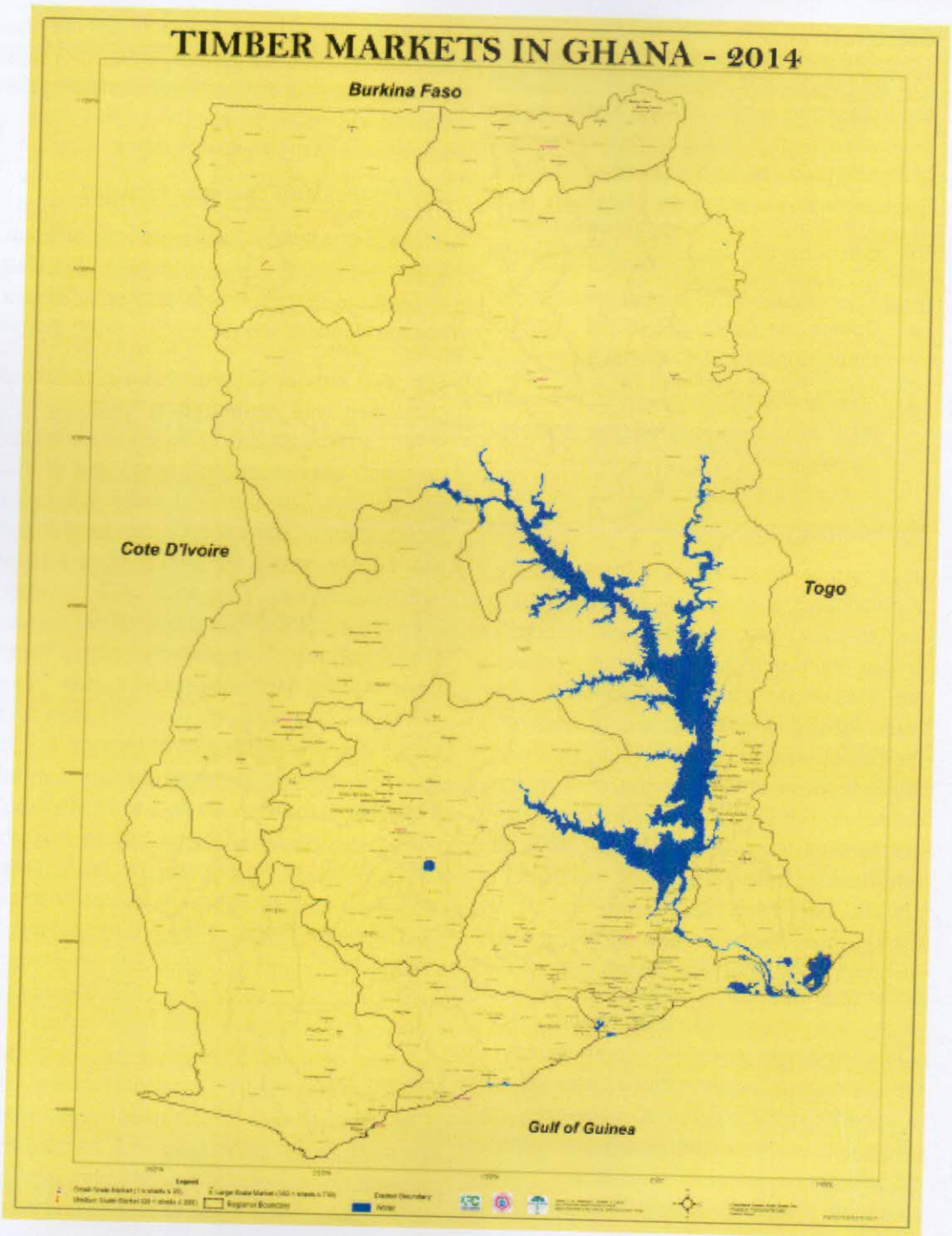

Figure 1: Map of Timber markets in Ghana

Source: Owusu, F.W., Damnyag, L. and Marfo, E. 2015

4.10 Capacity building of artisanal millers on portable machines for efficient sawmilling of logs into lumber

Project Team: Owusu F. W., Agyenim Boateng, A., Mensah, E.S., and Mckeown, J.P.

Start Date: July 2015

Expected Completion Date: January 2016

Introduction

Illegal logging has gained prominence in national, regional and international forestry debates over the past decade. Illegal logging has negative environmental, economic and social effects. In 2007, Tropenbos International (TBI) and its partners, CSIR-FORIG and FC initiated the EU chainsaw milling Project to bring together all relevant stakeholders on a platform to dialogue on the illegal chainsaw milling issues and supply of legal lumber to the domestic market to help meet the VPA requirement of the domestic market. Again in 2008, TIDD of the FC under the NREG programme also initiated a programme to help meet the VPA requirement of supplying legal lumber to the domestic market. From independently commissioned studies, findings from both initiatives proposed similar policy directions as follows:

- Saw millers only to supply legal lumber to the domestic market.
- Saw millers and Artisanal millers to supply the domestic market with legal lumber.
- Artisanal millers only to supply the domestic market with legal lumber.

The three proposed policy directions have been discussed by stakeholders since November 2009. In September 2010, stakeholders reached consensus on a viable policy direction: Sawmillers and artisanal millers to supply the domestic market with legal timber obtained from sustained yields. In June 2011, the joint TIDD-EU CSM process submitted a draft policy for operationalization of the agreed policy option to the MLNR. The policy was approved by government of Ghana in March 2012. Policy proposal for supply of legal lumber to the domestic market has concentrated on sensitization of the policy to prepare for the transformation of illegal chainsaw milling operations into legal artisanal milling in keeping with the principles of sustainable forest management. Activities to support communities to prepare for transformation of illegal chainsaw milling activities into legal artisanal milling operations has focused on capacity building to form community artisanal milling/mobile recovery teams/associations.

It is upon this background that a technical training programme was organized for the Sankore group, which is legally registered by the Registrar General's Department. This was to ensure safety, optimal milling efficiency, good equipment maintenance, and factory hygiene.

Objectives

The main objective of the training was to build the technical capacities and skills of the potential artisanal millers to efficiently and effectively process legal timber for the domestic market in support of the VPA.

The specific objectives were to:

- Develop the skills of potential Artisanal millers in the operation and maintenance of Wood-Mizer milling machine for optimum lumber production.
- Equip potential Artisanal millers with knowledge in sawmill hygiene and safety practices.

Methodology

Two portable types of machines, Wood-Mizer LT 15 / 20 (Plate 12) and Lucas mill, (Plate 13) were used for the training. Basic principles in sawmill operation were highlighted, which formed about 25% of the training programme while the practical aspect was 75%.

Plate 12: Log processing using Wood-Mizer

Plate 13: Log processing using lucas mill

Key results and way forward

Twenty-five (25) "converted illegal chainsaw operators" (known as Artisanal millers) have been trained in two communities (Insu Siding near Bogoso and Apori near Oda) in the operation and maintenance of Wood-Mizer to supply legal lumber to the domestic market.This has reduced the number of illegal chainsaw operators in the country.

4.11 The Use of High Quality Cassava Flour (HQCF) from two Sources as an Extender for Plywood Production

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

Start Date: October 2015

Expected Completion Date: October 2019

Introduction

The use of High Quality Cassava Flour (HQCF) as an extender in plywood production to substitute for wheat flour was developed by CSIR-FORIG in 2003. This success story was achieved in collaboration with CSIR-FRI and Renewable Natural Resources Institute. To upscale this technology, CSIR-FORIG has searched for funds and or business partners for a pilot plant to produce HQCF. By the close of 2014, CSIR-FORIG identified DADTCO Ghana, which is a company located in the Volta Region. The company is a subsidiary of DADTCO Netherlands and is into production of cassava paste/dough for Accra Brewery for the production of Cassava beer in Ghana. CSIR-FORIG visited the company at Hohoe in the Volta region and had discussions on partnership for production of HQCF for commercialization in Ghana. DADTCO Ghana expressed interest and agreed to have the company's cassava dough/ paste used for HQCF production. Samples of the cassava paste/dough were collected and used to prepare different grade mixes of HQCF to compare with other HQCF produced from other

sources in order to determine the usefulness of DADTCO Ghana product as possible extender for plywood production.

Objective

The objective is to develop different mix proportions of HQCF from two sources for plywood production.

Materials and method

The materials for the HQCF were collected from DADTCO Ghana factory at Hohoe, and another company at Sunyani. The veneer, glue and hardeners were from BLLC in Kumasi.

The cassava dough from DADTCO with moisture content greater than 50% was sun-dried to a moisture content below 15%. The dried meal was passed through a wire mesh of sieve size 600, 425, 250, 150um. Six (6) different adhesive mixtures of HQCF were then made for preparation of plywood production as follows: HQCF from Sunyani, Wet dough from DADTCO and filtered dried dough from DADTCO with different sieve sizes: 600µm, 425µm, 250µm, 150µm. Another mixture was also prepared from the wet dough from DADTCO but was filtered before application. The total mass of the mixture, 600g was applied to 3 surfaces of veneer each of dimensions 50mm x 100mm. The composition of the adhesive consisted of glue, HQCF, hardener 1, hardener 2 and water. The percentage composition per each type of adhesive are listed in tables 1 and 2. The prepared adhesives of different mixes were applied to the veneer surface by brushing (Plate 14). In all, seven (7) different types of adhesive were prepared. The plywood was pressed hot at BLLC Ltd, Kumasi-Ghana (Plate 15). The 7 sheets of plywood were subsequently trimmed and transported to CSIR-FORIG.

Plate 14: Brushing of plywood with adhesive

Plate 15: Pressing of plywood

Table 1: *Composition of adhesive from dried cassava dough from DADTCO*

Components	%	actual amount (g)
Glue	25.7	154.2
HQCF	17.15	102.9
Hardener 1	0.27	1.62
Hardener 2	0.27	1.62
Water	56.6	339.6
Total	100	600

Table 2: *Composition of adhesive from filtered and unfiltered wet cassava dough from* DADTCO

Component	%	amount (g)
Glue	25.7	154.2
HQCF	34.3	205.8
Hardener 1	0.27	1.62
Hardener 2	0.27	1.62
Water	39.45	236.7
Total	140	599.94

Results

Seven (7) sheets of plywood of different mixes have successfully been produced at BLLC. The bonding of plies of the various plywood sheets is to be tested using a universal Instron testing machine.

4.12 Solar Drying Technology for Food and Wood Materials in Ghana

Project Team: Korang, J.K., Jezler, U., Fromm, I., Brentuo, B., Buehlmann, U., Espinoza, O., Wuthrich, K., Ofori, J., Appiah-Kubi, E., Owusu, F.W., Ebanyenle, E., Tekpetey, S.L. and Mensah, M.

Start Date: July 2015

Expected Completion Date: January 2016

Introduction

Developing countries often fail to support their industries with reliable services such as electric power. Also, existing power generation capacities are often based on outdated and inappropriate technologies. Thus, using renewable resources with low-cost technology is beneficial for individuals (employees and business owners), society, and the environment. Solar energy allows the decentralization of the energy production and may require limited investments. For example, inexpensive, simple to build and operate solar powered dry kilns for wood exist and have been used in developing countries. Clearly, solar power can dry about anything and is not restricted to wood. The idea behind this project is to provide individuals and businesses in Ghana with *easy to build and to handle, inexpensive, clean solar technology* for drying processes by using existing technologies adapted to the Ghanaian reality. This technology will be embedded into a programme that promotes, explains, and supports the technology throughout Ghana and Africa. The programme will be driven by individuals in Ghana with proposed support from UNIDO.

Objectives

- To validate the project's objectives.
- To conduct needs assessment.
- To establish contacts with research institutions and government representatives in Ghana in areas related to the project in addition to the existing contacts with CSIR-FORIG.
- To explore opportunities for collaboration with industry in Ghana.
- To finalize the research proposal for UNIDO in collaboration with experts in Ghana.

Work done

The following activities were conducted at Bern University of Applied Sciences (BFH) Switzerland

by the project team from 11th October to 12th November, 2015.

- Reviewed relevant literature on solar drying technologies of existing research results globally on the materials, wood and the food sector.
- Assembled and documented all information on the various methods used in producing the existing solar technologies.
- Searched and created list of researchers and experts needed, including local support personnel in Ghana.
- Assigned duties and identified the most efficient communication channels.

Additionally, a fact-finding team comprising of Ghanaian and Swiss nationals performed the following activities in Ghana between November 26 and December 3, 2015.

- Conducted a needs assessment.
- Established contact with other research institutions and government representatives in Ghana working in areas related to the project.
- Explored opportunities for collaboration with the industry in Ghana.
- Finalized the research thematic areas for UNIDO in collaboration with experts in Ghana.

Key results and Way forward

Our visit to different associations, institutions and companies helped in the identification of potential users of solar kilns in Ghana. All the stakeholders and informants interviewed confirmed the need to add value to food products and wood. They however suggested that new technologies for solar kilns should be affordable, adapted to local conditions and possibly built locally with the materials available in Ghana. The potential users of solar kilns in Ghana identified include; woodworkers, carvers, food processors, producers, dried food exporters, and a wide range of entrepreneurs. A full project proposal on"Solar drying technology for food and wood materials in Ghana" has been drafted and currently under review. This will be submitted to UNIDO for possible funding in April 2016.

4.13 EU Chainsaw Project: Analysis of Transaction and Production Costs of Community-based Forest Plantation Establishment and Management in Ghana

Project Team: Damnyag, L., Darko-Obiri, B., Marfo, E. and Nunoo, I.
Start Date: January 2014
Expected Completion Date: December 2015

Introduction

Community collaborative forest concepts such as the modified taungya system is a pragmatic approach to addressing forest degradation while ensuring benefit flows in terms of income and a wide range of food products for subsistence to farm household economies in forest fringe communities in Ghana. This study, using cases study of community-based plantations, sought to establish the investment cost, and estimate the hidden transaction cost to local people in establishing such plantations. The reason being that, without factoring hidden transaction cost into the investment cost at the design phase, the sustainability of such projects may not be achieved, especially after donor or government project support phase ceases.

Result and Discussion

The transaction cost per ha per farmer ranged from US$ 48 to 147. The transaction cost/ha as a percentage of production cost/ha ranged from 7.4-9.2%. Hence an allowance of up to 10% of production cost is recommended to be factored into investment cost for community-based plantation development projects. It is observed that although transaction or hidden costs associated with the development and success of such projects may be low as compared to official estimated project costs, it constitutes a significant portion of the farm household budget. A range of socio-economic and technical factors including limited financial resources, social connections, capacity of target beneficiaries to organize social and financial capital to implement and monitor planted field successfully, conflicts, official project logistical constraints may increase these costs to the detriment of project outcomes.

5.0 COMMERCIALIZATION DIVISION

The Division coordinates marketing activities of all commercial products and services of the Institute. 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. The main income generating activities undertaken by the Division during the period under review are:

a. Sale of high quality forest seeds and seedlings
b. Sale of spawns
c. Sale of wood
d. Consultancy services
e. Training Workshops (Mushroom and snail farming)
f. Production of honey
g. Production of Prekese syrup
h. Production of wood products

5.1 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 government support if Ghana is not to lose planting material for future forest establishment.

5.2 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, Cedrella, Teak and Emire. Monitoring activities conducted by the Institute shows that plantations established using seedlings produced by CSIR-FORIG tend to grow well. CSIR-FORIG is also able to take orders from clients before the planting season to ensure that clients do not experience a break in their plantation activities.

5.3 Sale of wood by-products

CSIR-FORIG sold wood thinnings from its 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 only 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, due to lack of funds, research activities resulting in the establishment of research plots have slowed down.

5.4 Contract Research

The Institute thrives on consultancy services and contract research from various stakeholders as a commercial activity. However, in 2015, 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.

5.5 Training workshops organized

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.

5.6 Information and Communication Section

Information section comprises the Library and Publications, Computer and Statistics. 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 publications of CSIR-FORIG's 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. 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.

5.7 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 the Finance divisions. A staff 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 our 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 2016.

5.8 Public Relations Section

CSIR-FORIG participated in 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 Director-General of the Council for Scientific and Industrial Research 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. The ceremony was held at Osu Castle.

6.0 ADMINISTRATION DIVISION

6.1 Objectives

The main objectives of the Division include:

a. To ensure implementation of policies, procedures, rules and regulations of CSIR at the Institute level by providing support services to facilitate effective and efficient performance of work by all Divisions.

b. To provide administrative machinery for the implementation of institutional initiatives and activities.

6.2 Staff Strength

The total staff strength of the Institute as of December 2015 was 253. The breakdown is as follows:

a) Senior Members: 55

b) Senior Staff: 89

c) Junior Staff: 109

6.3 New Appointments

The Council approved the appointment of two key positions during the year as follows:

a) Dr. Daniel Aninagyei Ofori, a Chief Research Scientist, was appointed as the Director of the Institute, effective from 1st April, 2015.

b) Dr. Paul Pinnock Bosu, a Principal Research Scientist, was appointed as the Deputy Director of the Institute, effective from 1st July, 2015.

6.4 Staff Training

During the year, five (5) staff members were granted approval to undergo further training at different levels. This brings the total number of staff in training to 23, including those pursuing courses at various levels locally and abroad. The breakdown is presented in the Table below:

Table 3: List of staff undergoing training

Training Level	Local	Foreign	Total
PhD	6	7	13
MPhil/MSc/MA	2	1	3
BSc/BA	5	-	5
Others	2	-	2
Total	**15**	**8**	**23**

6.5 Promotions and Upgrading

A total of 45 members of staff were promoted during the 2015 promotions exercise:

a) Senior Members: 4

b) Senior Staff: 13

c) Junior Staff: 28

The Senior Members promoted during the year are as follows:

a. Dr. Mary M. Apetorgbor, was promoted to Chief Research Scientist, effective from 1st January, 2015.

b. Dr. Beatrice Darko Obiri, was promoted to Principal Research Scientist, effective from 1st July, 2014.

c. Dr. Luke Cyprian N. Anglaaere, was promoted to Principal Research Scientist, effective from 1st January, 2014.

d. Dr. Emmanuel Opuni-Frimpong, was promoted to Principal Research Scientist, effective from 1st January, 2015.

6.6 Retirements

A total of eight (8) members of staff went on compulsory retirement from the service of the Council during the year 2015. The breakdown is as follows:

a) Senior Member: 1
b) Senior Staff: 3
c) Junior Staff: 4

6.7 Resignation

During the year, two (2) junior staff resigned from the Institute. They are:

a) Mr. Peter Entsuah, Tradesman Grade I, on 13th January, 2015.
b) Mr. Kwame Mensah, Supervisor Grade I, on 1st April, 2015.

6.8 Transfer/Reposting

Following his appointment as Director-General of CSIR, Dr. Victor K. Agyeman was transferred to CSIR Head Office, effective from 1st January, 2015. Mr. Issa Awal Mohammed, a Senior Assistant Transport Officer, was also transferred on the same date.

During the year, two (2) internal auditors from CSIR Head Office were transferred to the Institute, effective from 1st August, 2015. They are:

i. Mr John K. Boateng, Internal Auditor.
ii. Mrs. Elizabeth Appiah, Chief Auditing Assistant.

Similarly, Mr. Peter Komla Gamadey, a Senior Assistant Transport Officer, was transferred from CSIR-IIR to the Institute, effective from 1st November, 2015.

Internally, Management addressed the acute shortage of staff in some Divisions/Sections through reposting and reassignments of some staff as follows:

- Two (2) staff were transferred from Mesewam Research Station to the Main Office (Security and Works & Maintenance Sections),
- One (1) staff was transferred from Works & Maintenance Section to Transport Section.
- One (1) staff was transferred from Pra-Anum (Amantia) Research Station to the Main Office (Works & Maintenance Section).
- One (1) staff was reassigned from General Administration Section to Forest Products & Marketing Division.

6.9 Sabbatical Leave

Dr. Ernest G. Foli, a Principal Research Scientist, was granted approval for a one-year sabbatical leave tenable at the Ministry of Agriculture, Forestry and Food Security in Sierra Leone, effective from 1st October, 2015.

6.10 Leave of Absence

Mrs. Dorothy Asare Akoto, a Principal Technical Officer, was granted a one-year leave of absence, effective from 1st October, 2015.

6.10.1 Bereavement

The Institute lost three (3) members of staff during the year under review. They are as follows:

a. Mr. Evans Adusei, a Senior Caretaker at Bobiri Research Station, 17th February, 2015.
b. Dr. Dominic Blay, a Principal Research Scientist (on post-retirement contract), 5th March, 2015

c. Mr. Samuel Kingsley Appiah, Chief Works Superintendent (Traffic), 7th August 2015.

Major Events

a) Head Count Exercise

A head count exercise was successfully conducted by CSIR Internal Audit Team for all staff (including those at the outstations) from 9th-27th February, 2015. A mop-up exercise became necessary and this extended the period to the first week of March 2015. The exercise helped the Head of Administration, who accompanied the Audit Team, to do the following:

- Validate and reconcile some information provided by staff and those in the personnel files.
- Brief outstation staff on current staff situation to enable them appreciate the difficulty of recruiting new staff and the need to take on additional responsibilities.
- Educate staff on the need and how to fill the *Nomination form* used in corporate CSIR.

b) Staff Work Attendance and e-Clocking System Operation

The electronic clocking system for keeping record on staff work attendance became operational in the Institute on 1st April 2015. After a test-run period of two weeks. This e-clocking system has come to replace the existing manual system.

c) Visit by CSIR Staff Audit Team

A three-member team from CSIR Staff Audit visited the Institute from 16th-18th March, 2015, to hold separate discussions with the Director, and individual Heads of Division in connection with staff employment levels and categorization earlier compiled and submitted to CSIR-Head Office. Based on the advice received from the Audit Team, staff employment levels and categorizations were revised for resubmission.

d) Appointment and Introduction of New Director

Dr. Daniel Aninagyei Ofori, a Chief Research Scientist, was appointed by Council as Director of CSIR-FORIG on 1st April, 2015. He was formally introduced to staff members by the Director-General of CSIR, at a durbar held on 27th April, 2015. Present at the ceremony were Ag. Director of Administration CSIR, Directors of CSIR-CRI, CSIR-BRRI, and CSIR-SRI.

e) Director's Vision and Divisional Changes

After the official assumption of duty, the new Director used the first three (3) months to communicate his vision to key stakeholders including the Management Board, Internal Management Committee, Research Staff Association and all categories of staff for their acceptance. The vision is focused on 5 strategic goals namely:

i. Research and Development
ii. Resource Mobilization
iii. Visibility
iv. Capacity development
v. Partnerships

The organizational structure of the Institute was reviewed and research divisions redefined to focus on the following themes:

i. Biodiversity Conservation and Ecosystem Services
ii. Forest Policy, Governance and Livelihoods
iii. Wood Industry and Utilization
iv. Forest Products and Marketing
v. Forest and Climate Change
vi. Forest Improvement and Productivity

f) Hosting of CCCLU AGM

The Institute hosted the11th Annual General Meeting of the Central Committee of the CSIR Local Unions (CCCLU) on 19th-22nd October, 2015.

g) Hosting of CSIR Workshop

The Institute hosted a workshop organized by CSIR for the Northern Sector Institutes on Electronic System for Third Party Deductions from 13-14th October, 2015.

h) Co-Hosting of CSIR Commercialisation Fair

CSIR-FORIG co-hosted the CSIR Commercialisation Fair for the Northern Sector Institutes held at CSIR-CRI, Fumesua on 20th November, 2015

CSIR-FORIG/UEF Graduate School

The School was established in September 2012 to run a Master of Science (MSc.) course in Bio-Economy and Natural Resources Management. This degree programme is conducted by the CSIR and is being implemented jointly by the University of Eastern Finland and CSIR-FORIG. All studies take place in Ghana and 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 (8), form the first batch of students of the school. These students are expected to graduate in 2016.

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 sixty eight (468).

The aim was to have a 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 affordable cost. The School has classes from nursery to Junior High School level (JHS). The first batch of 13 JHS pupils would be writing their BECE exams in 2016.

Human Resources

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 provided in Appendix III and IV.

7.0 FINANCE DIVISION

Objectives of the Finance Division are to:

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

The financial summary for the period is shown in Table 4.

Table 4: *Financial summary for 2015*

Government of Ghana	Inflows (GH¢)	Outflows (GH¢)	Variance (GH¢)
Personnel Emoluments (Note 1)	9,623,410	9,623,410	-
Administrative Expenditure (Note 2)	13,929	592,885	(578,955)
Service Expenditure (Note 3)	-	50,669	(50,669)
Internally Generated Funds	155,207	57,317	97,890
Guest Houses	134,373	55343	79,030
Production Unit	34,432	27,493	6,939
Total	**9,961,351**	**10,407,116**	**(445,765)**
Donor (Note 4)	2,472,029	2,355,468	116,561

Note 1: The 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 expenditure was financed from IGF and administrative support from projects.

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

Note 4: Donor funds were received in Dollars, Euros, Pounds and Ghana cedis.

Note 5: This report is a draft one, as we are yet to finish with the 2015 financial report for external auditor's review.

8.0 APPENDIX I: Staff Publications

Books

Kwapong, P., Aidoo, K., Annoh, C. and Bosu, P. 2015.Understanding the Concept of Pollination. University Printing Press, Cape Coast. 35pages.

Journal Papers

Abengmeneng, C.S., Ofori, D.A., P. Kumapley, R. Akromah and Jamnadass, R. 2015. Estimation of heritability and genetic gain in height growth in *Ceiba pentandra.African Journal of Biotechnology*, 14:1880-1885.

Acquah, S.B., Avuglah, R.K. and Harris, E. 2015. Impact of trade policies on wood products export in Ghana. *American Journal of Mathematics and Statistics* 5(5):221-229. doi:10. 5923/j.ajms.20150505.01

Addo-Danso, S.D., Prescott, C.E. and Smith, A.R. 2015. Methods for estimating root biomass and production in forest and woodland ecosystem carbon studies: A review. *Forest Ecology and Mangement*, 359:332-351

Aggrey-Smith, S., Preko, K., Owusu, F.W. and Gbadago, J. 2015. Measurement of Elemental Compositions of Selected Tropical Wood Species – a Case Study of Pra Anum Forest, Ghana. *International Journal of Biomedical Science and Engineering*, 3:34-43, Doi: 10.11648/j.ijbse.2015 0303.11.

Alain Tsobeng, A., D. Ofori, Z. Tchoundjeu, E. Asaah and P.V. Damme 2015. Improving growth of stockplants and rooting ability of leafy stem cuttings of *Allanblackia floribunda* Oliver (Clusiaceae) using different NPK fertilizers and periods of application. *New Forests: Doi: 10.1007/s11056-015- 9517-1.*

Amissah, L., Mohren, G. M. J., Kyereh, B., Poorter, L. 2015.The effects of drought and shade on the performance, morphology and physiology of Ghanaian tree species. *PLoS ONE* 10(4):e 0121004. doi:10. 1371/journal.pone. 0121004.

Apetorgbor, A.K., Apetorgbor, M.M. and Derkyi, N.S.A. 2015. Comparative studies on the growth and yield of oil palm mushroom, *Volvariella volvacea* (Bull. ex. Fr.) Sing. on different substrates. *Greener Journal of Agricultural Sciences* 5:177-189. DOI: http://doi.org/10. 15580/GJAS. 2015.4. 0711 15091.

Apetorgbor, M.M. and Apetorgbor, A.K. 2015. Comparative studies on yield of *Volvariella volvacea* using root and tuber peels for improved livelihood of communities. *Journal of Ghana Science Association*, 16:34-43.

Apetorgbor, M. M. and Roux, J. 2015. Diseases of plantation forestry trees in Southern Ghana. *International Journal of Phytopathology*, 4:5-13.

Dumenu W. and E. Obeng. 2015. Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications. *Environmental Science Policy,* 55: 208-217.

Hansen, C. P., M. Pouliot, E. Marfo, B.D. Obiri and T. Treue. 2015. Forest, timber and rural livelihoods: implications for social safeguards in the Ghana-EU Voluntary Partnership Agreement. *Small-Scale Forestry.* DOI 10.1007/s11842-015-9295-9.

Kyereh, D., Darko-Obiri, B., Agbenyega, O. and Opuni-Frimpong, E. 2015. Analysis of smallholder forests for poverty alleviation and climate change mitigation in the Nkoranza South District of the Brong Ahafo Region of Ghana, *Journal of Global Ecology and Environment,* 3:68-73.

Mathew, M.M., M.R. Munjuga, N.J. Cordeiro, R. Coe, D.A. Ofori, A.J. Simons, C.T. Sawe and R.Jamnadass. 2015. Early survival and growth of *Allanblackia stuhlmannii*(Clusiaceae): a threatened tropical rainforest tree of high economic value in Tanzania. *African Journal of Ecology,* 53:572–580.

Mensah J.K., Apetorgbor, M.M. and Owusu, F.W. 2015. Evaluation of natural durability of *Ficus sur* and *Cola gigantea* from two ecological zones of Ghana. *International Journal of Science and Nature,* 6:406-410.

Oduro, K.A., Mohren, G.M.J., Pe˜na-Claros, M., Kyereh, B. and Arts, B. 2015. Tracing forest resource development in Ghana through forest transition pathways. *Land Use Policy,* 48: 63–72.

Ofori, D.A., J.M.Asomaning,T. Peprah, V.K. Agyeman, P.Anjarwalla, Z., Tchoundjeu, J.G. M., and Jamnadass, R. 2015. Addressing constraints in propagation of *allanblackia* spp. through seed sectioning and air layering.*Journal of Experimental Biology and Agricultural Sciences,* 3:89-96

Owusu, F.W., Boakye, F. and Zorve, G. 2015. Timber species from Afram arm of the Volta Lake in Ghana: Planing and sanding properties. *Journal of Horticulture and Forestry,* 7: 84-93.

Paine, C.E., Amissah, L., Auge, H., Baraloto, C., Baruffol, M., Bourland, N., Bruelheide, H., Daïnou, K., de Gouvenain, R.C., Doucet, J-L., Doust, S., Fine, P.V.A., Fortunel, C., Haase, J., Holl, K. D., Jactel, H., Li, X., Kitajima, K., Koricheva, J., Martínez-Garza, C., Messier, C., Paquette, A., Philipson, C., Piotto, D., Poorter, L, Posada, J.M., Potvin, C., Rainio, K., Russo, S.E., Ruiz-Jaen, M., Scherer-Lorenzen, M., Webb, C.O., S., Wright, J., Zahawi, R.A. and Hector. A. 2015. Globally, functional traits are weak predictors of juvenile tree growth,and we do not know why. *Journal of Ecology.*103: 978-989doi: 10.1111/1365-2745.12401.

Peprah, T., Oduro, K. A., Siaw, D.E.K.A., Cobbinah, J.R., Tchoundjeu, Z., Simons, A J., Jamnadass, R. and Ofori, D.A. 2015. Domestication and Sustainable Use of Genetic Resources of a Native Tree with High Economic Potential in Ghana. *Open Journal of Forestry,* 5, 678-685. http://dx.doi.org/10.4236/ojf.2015.57060

Rockney, H. J., Ofori-Boateng, C. Natsuko, P. and Leaché, A.D. 2015. A Comparison of DNA Barcoding Markers in West African Frogs. *African Journal of Herpetology,* 10. 1080/ 2156 4574. 2015. 1114530.

Saiz, G., Bird, M., Wurster, C., Quesada, C.A., Ascough, P., Domingues, T., Schrodt, F., Schwarz, M., Feldpausch, T.R., Veenendaal, E., Djagbletey, G., Jacobsen, G., Hien, F., Compaore, H., Diallo, A., and Lloyd, J. 2015.The influence of C_3 and C_4 vegetation on soil organic matter dynamics in contrasting semi-natural tropical ecosystems.*Biogeosciences*, 12: 5041- 5059

Song, M., Djagbletey, G., Nkrumah, E.E., and Huang, M. 2015. Patterns in leaf traits of leguminous and non-leguminous dominant trees along a rainfall gradient in Ghana. *Journal of Plant Ecology*,1-8. doi: 10. 1093/jpe/rtv038.

Tekpetey, S.L., Riegel, A., and Kerstin, D. 2015. Investigating surface quality of African Mahogany *(Khaya ivorensis)* from Ghana using stylus and deflectometry techniques. Wood and Fiber Science, 47: 190-198.

Veenendaal, E.M., Torello-Raventos, M., Feldpausch, T.R., Domingues, T.F., Gerard, F., Schrodt, F., Saiz, G., Quesada, C.A., Djagbletey, G., Ford, A., Kemp, J., Marimon, B.S., Marimon-Junior, B.H., Lenza, E., Ratter, J.A., Maracahipes, L., Sasaki, D., Sonké, B., Zapfack, L., Villarroel, D., Schwarz, M., Yoko Ishida, F., Gilpin, M., Nardoto, G.B., Affum-Baffoe, K., Arroyo, L., Bloomfield, K., Ceca, G., Compaore, H., Davies, K., Diallo, A., Fyllas, N. M., Gignoux, J., Hien, F., Johnson, M., Mougin, E., Hiernaux, P., Killeen, T., Metcalfe, D., Miranda, H.S., Steininger, M., Sykora, K., Bird, M. I., Grace, J., Lewis, S., Phillips, O. L., and Lloyd, J. 2015. Structural, physiognomic and aboveground biomass variation in savanna-forest transition zones on three continents. How different are co-occurring savanna and forest formations? Biogeosciences, 12:2927–2951.

Conference papers

Appiah Kubi, E., Owusu, F.W., Tekpetey, S.L., and Essien, C. 2015. Bamboo for housing in Ghana: Challenges and prospects for the Future. *In*: Owusu *et al* (eds) 2015.Bamboo utilization for a greener construction and future in Ghana. MESTI/CSIR-FORIG Proceedings of first bamboo colloquium held at CSIR-FORIG, Fumesua-Kumasi from 29th–30th April, 2014. Pp. 131-143

Appiah-Kubi, E., Kankam, C.K., Opuni-Frimpong,E., Tekpetey, S.L. and Essien,C. 2015. Durability and mechanical strength properties of plantation grown *Khaya ivorensis* (Mahogany) in Ghana. International Conference on "Towards sustainable production of Mahogany species in plantation in tropical Africa". CSIR-FORIG, Kumasi, Ghana. 2-6 March, 2015. Pp. 165.

Appiah-Kubi, E. 2015. The physical and mechanical properties of plantation grown *Khaya ivorensis* from Ghana. Book of Abstracts. International Conference on "Towards sustainable production of Mahogany species in plantation in tropical Africa". CSIR-FORIG, Kumasi, Ghana. 2-6 March, 2015. Pp. 5.

Appiah-Kubi, E., Owusu, F.W., Tekpetey, S.L., Essien, C. and Seidu, H. 2015. Mechanical properties of some bamboo species for efficient utilization in Ghana. In: Owusu *et al* (eds) 2015. Bamboo utilization for a greener construction and future in Ghana. MESTI/ CSIR-FORIG Proceedings of first bamboo colloquium held at CSIR-FORIG, Fumesua-Kumasi from 29-30th April, 2014. Pp. 71-80.

Damnyag, L. 2015.Tenure and 'carbon rights' in local REDD + project: Insights from community-based workshops in Ankasa Conservation Area, Ghana [Conference paper presented at the ROME 2015-SCIENCE SYMPOSIUM ON CLIMATE, jointly organized with the Italian Scientific Societies, from 19-20 November 2015 in Rome, Italy, at the FAO headquarters].

Owusu, F.W., Tekpetey, S.L., Appiah-Kubi, E. and Pentsil, S. 2015. Bamboo utilization for a greener construction and future in Ghana. MESTI/CSIR-FORIG Proceedings of first Bamboo Colloquium held at CSIR-FORIG, Fumesua, Kumasi, Ghana from 29th–30th April, 2014. 271 pp.

Owusu, F. W., Appiah-Kubi, E., Tekpetey, S.L., Essien, C., Arthur, P.L. and Zorve, G.K. 2015. Product development of laminated panel door from plantation grown bamboo species in Ghana. In: Owusu *et al* (eds) 2015. Bamboo utilization for a greener construction and future in Ghana. MESTI/CSIR-FORIG Proceedings of first bamboo colloquium held at CSIR-FORIG, Fumesua-Kumasi from 29–30th April, 2014. Pp. 109-130.

Owusu, F.W., Tekpetey, S.L., Appiah-Kubi, E., Essien, C., Appiah, J. K. and Boakye, F. 2015. Ripping and planing characteristics of some exotic bamboo species grown in Ghana. *In*: Owusu *et al* (eds) 2015. Bamboo utilization for a greener construction and future in Ghana. MESTI/CSIR-FORIG Proceedings of first bamboo colloquium held at CSIR-FORIG, Fumesua-Kumasi from 29th–30th April, 2014. Pp. 81-99.

Samar, S.B., Frimpong, C., Djagbletey, G.D., Appiah, D.O. and Asiedu-Opoku, E. 2015. Local knowledge and ethnobotany survey of medicinal plants for traditional healthcare delivery in Ghana. Paper presentation at International Association for the Study of the Commons 15th Biannual Conference in Edmonton, May 25-29, 2015.

Tekpetey S.L., Appiah-Kubi, E., Owusu, F.W., and Essien, C. 2015. Bamboo for furniture and housing in Ghana: the certification and standard issues. In: Owusu *et al.* eds. 2015 Bamboo utilization for a greener construction and future in Ghana. MESTI/CSIR-FORIG Proceedings of first Bamboo Colloquium held at CSIR-FORIG, Fumesua, Kumasi, Ghana from 29th–30th April, 2014. Pp. 161-167.

Tekpetey, S.L., Riegel, A., Dekomien, K. and Opuni-Frimpong, E. 2015. Investigating surface quality of African mahogany(*Khaya Ivorensis*) from Ghana using stylus and deflectometry techniques.*In*: Appiah et al eds: International Conference on "Towards sustainable production of Mahogany species in plantation in tropical Africa". CSIR-FORIG, Kumasi, Ghana. 2-6 March, 2015. Pp. 44.

Technical and Consultancy Reports

Acquah, S.B., Oduro, K.A., and Darko-Obiri, B. 2015. Silvicultural prescriptions for management of woodfuel species. Submitted to ITTO under the project 'Rehabilitation of degraded forests for sustainable woodfuel production and climate change mitigation in the forest-savanna transition zone of Ghana'. 29pp.

Acquah, S.B. 2015. Priority Setting Results. Submitted to Management CSIR-FORIG. 15pp

Acquah, S.B. 2015. Communication Plan.Submitted to management CSIR-FORIG. 14pp

Adu-Bredu S. and Samar S.B. 2015. Strengthening the protection of forest and tree resources outside government forest reserves. Consultancy report submitted to Conservation Alliance

Adu-Bredu, S., Apetorgbor, M.M., Ebanyenle, E., Asomaning, J.M., Peprah, T. and Owusu, F.W. 2015. Greening of the Garden City of West Africa, Kumasi Urban Forestry Project. Consultancy Report submitted to Kumasi Metropolitan Assembly.17pp. CSIR-FORIG/CR/SAB; MMA; EE; JMA; TP; FWO 2015/23

Akpalu, S. and Adeyiga, G. 2015. Provenance trial report on height and survival of 18 provenances of edible Australian Acacia species. Submitted to World Vision, Ghana, Talensi

Akpalu, S. and Adeyiga, G. 2015. Baseline report on seedling survival, height population of naturally generated indigenous species on agroforestry demo plot. Submitted to World Vision, Ghana, Talensi.

Apetorgbor, M.M. and Bosu, P.P. 2015. Community Training in mushroom and snail production in the Bia Conservation Area and UNESCO Biosphere Reserve. Funded by the Environmental Protection Agency.

Apetorgbor, M.M. and Apetorgbor, A.K. 2015. Final report on enhancing oil palm mushroom (*Volvariella volvacea*) cultivation technology through training for improved livelihood for small scale mushroom producers in the Ashanti and Greater Accra Regions of Ghana. Consultancy Report submitted toCSIR-Technology Development Technical Centre, Accra

Apetorgbor, M.M., Apetorgbor, A.K. and Adablah, M. 2015. Empowerment of selected small scale mushroom producers in the Ashanti and Greater Accra Regions of Ghana for improved livelihood. In collaboration with Mushroom Cluster of the Ghana Pan African Competitiveness Forum (PACF). Ghana Skills and Technology Development Programme of the COTVET II. Funded by World Bank.

Asomaning, J.M., Ebanyenle, E., Peprah, T., Korang, J., Dabo, J., Dumenu, W.K. and Ofori, D.A. 2015. Tree crops development in Africa and Asia to benefit the poor-*Allanblackia* component. Progress report submitted to the World Agroforestry Centre. 23p.

Bosu, P.P., Appiah, N. and Marfo, E. 2015. Assessment of Impact of EU Chainsaw Milling Project. Report submitted to EU Chainsaw Milling Project.

Damnyag, et al. 2015. Participatory development of reporting and verification methods and determination of baseline carbon stock for forest carbon stocks assessment and monitoring in Ankasa Conservation Area, Ghana [Technical report of ITTO project RED PD026/09 Rev. 1(F)-Submitted in September 2015)].

Damnyag, et al. 2015. Land cover change of plantation established with local communities in degraded forest reserves in three districts, Ghana [Technical report on ITTO Degraded phase II project [PD 30/97 Rev.6 (F)].

Dumenu, W.K., Samar, S.B., Mensah, J.K., Derkyi, M., Oduro, K.A., Pentsil, S., Nutakor, E., Foli, E.G. and Obeng, E.A. 2015. Benefit sharing mechanism for REDD+ implementation in Ghana. Consultancy Report submitted to Forestry Commission, Accra, Ghana

Ebanyenle, E., and Ofori, D.A. 2015. Identification of female and male seedlings of *Allanblackia parviflora* using anatomical and morphological characteristics. A progress report submitted to ICRAF, Nairobi, Kenya.

Korang, J.K., Awuku, S. and Darko Obiri, B. 2015. Carbonization yield and calorific values of wood fuel species: Technical report submitted to International Tropical Timber Orgaization (ITTO). 5pp.

Marfo, E., Owusu, F.W., Karambiri, M. and Adeyiga, G. 2015. Overland export of timber from Ghana study. A research report submitted to Tropenbos International, Ghana. 46pp.

Marfo, E. 2015. The illusion of democratic representation in the REDD+ Readiness consultation process in Ghana. *RFGI Working Paper* No. 15

Mensah, J.K., Pentsil, S. and Samar, S.B. 2015. Effect of Climate Change on Household Food Security and Livelihood. Consultancy report submitted to AARDO.

Owusu, F.W., Damnyag, L. and Marfo, E. 2015. The size of the domestic timber market in Ghana. A research report submitted to Tropenbos International, Ghana. 107pp.

Owusu-Afriyie, K., Nutakor, E., Asiedu-Opoku, E., Dabo, J., Mensah, M., Mensah, J.K. and Kwarteng, E. 2015. Assessment of fuelwood usage and quantity flows among actors in the production and consumption areas of Ghana's coastal regions. 54pp.

Owusu-Afriyie, K., Mensah, J. K., Asiedu-Opoku, M.E. and Nunoo, I. 2015. Estimates of wood-fuel potential for wood-fuel supply in Ghana as part of a wider review of Ghana's Strategic National Energy Plan (SNEP). 88pp.

Owusu-Afriyie, K., Swaine, M.D., Agyeman, V.K., Kyereh, B. and Orgle, T.K. 2015. Recurrent fire in a moist and a dry semi-deciduous forest types in West Africa: effects on forest structure, ground cover biomass and species composition. A poster presented at the 6thInternational Wildland Fire Conference. Pyeongchang, South Korea 12-16 October 2015.

Owusu F. W. 2015. Development of Building Blocks made of stabilized Laterite and agricultural Residues as an environmentally friendly as an alternative to cement blocks in Ghana. Technical report submitted by BFH and CSIR-FORIG teams. 20pp.

Pentsil, S., Mensah, J.K., Sparkler, S.B., Appiah-Kubi, E., Essien, C., Asiedu-Opoku, E., Appiah, N. and Konto, C. 2015. Effect of climate change on household food security and livelihood, Ghana. Technical report submitted to AARDO. 35pp

Wüthrich, K., Brunner, M., Appiah-Kubi, E., Damnyag, L., Owusu F.W., Tekpetey, S.L., Essien, C. 2015. Value Chain Analysis Wood Sector, Ghana. A Report submitted to UNIDO by BFH and CSIR-FORIG teams. 86pp.

Posters

Adu-Bredu, S., Opoku-Ameyaw, A., Owusu-Afriyie, K., Djagbletey, G.D., Dua-Gyamfi, A., Addo-Danso, S.D., Moore, S., and Malhi, Y. 2015. Soil respiration studies in two sites of different post-logging ages in a moist semi-deciduous forest in Ghana. CSIR-Forestry Research Institute of Ghana, Kumasi.

Ametsitsi, G.K., Logah, V., Adu-Bredu, S., Owusu-Afryie, K., Van Langevelde, F., Oliveras, F. and Veenendaal, E.M. "The role of soils in the distribution of forest and savanna vegetation in an ecotone. Soil Science in a Changing world, Book of Abstracts. Wageningen Soil Conference. Page 204.

Appiah-Kubi, E., Owusu, F.W., Tekpetey, S. L., Ebanyenle, E., Jezler, U., Korang, J., Damnyag, L., Ofori, J. and Sekyere, D. 2015. Setup and accreditation of wood and furniture testing Lab at CSIR-FORIG, UNIDO/FORIG project. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Asomaning, J.M., Ebanyele, E., Peprah, T., Korang, J., Dabo, J., Dumenu, W.K. and Ofori, D.A. 2015. Tree crops development in Africa and Asia to benefit the poor–*Allanblackia* component. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Bosu, P.P., Owusu, E.O., Elusiyan, C.E, Kemigisha, E., Nkrumah, E., Sey, E. and Korang, J. 2015. Domestication of Prekese (*Tetrapleura tetraptera)* for Livelihood Improvement in Tropical Africa. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Damnyag, L. 2015. Curbing illegal logging in Ghana: the role of incentives to decentralized forest-fringe community institutions in a VPA world

Damnyag, L. 2015. Farmer's perception on wildfire occurrence, causes and mitigation approaches in six districts, Ghana.

Darko-Obiri, B., Awuku, S. and Korang, J.K. 2015. Indigenous tree species in sustainable wood fuel production in Ghana.CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Djagbletey, G.D., Samar, B.S., Duah-Gyamfi, A., Dabo, J., and Mensah, M. 2015. Specimens preparation for selected most frequently used medicinal plants and the disease they treat in Ghana. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Issifu, H., Ametsitsi, G., Lana J. de Vries, Djagbletey, G.D., Adu-Bredu, S., Van Langevelde, F. and Veenendaal, E. 2015. Differential seedling establishment success of congeneric tree species as influenced by woody plant canopy cover in the forest-savanna boundary.

Menanyih, A. S. and Opuni-Frimpong, E. 2015. The influence of silvicultural practices on stand productivity.CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Opoku, M.E., Opuni-Frimpong, E., Dompreh, D. and Kuudaar, S. 2015. Application of grafting technology for improving planting stock of four African mahogany species.CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Opuni-Frimpong, E., Opoku, S.M., Opoku, M.E, and Storer, J.A. 2015. Growth and productivity of *Khaya grandifoliola* in the dry semi-deciduous forest of Ghana; a comparison in pure and in diverse species stands. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Owusu, F.W., Damnyag, L. and Marfo, E. 2015. A map of Ghana with "Domestic timber markets in Ghana 2014" displayed. EU-Chainsaw Project.CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Pentsil, S., Mensah, J.K., Sparkler, S.B., Appiah-Kubi, E., Essien, C., Asiedu-Opoku, E., Appiah, N. and Konto, C. 2015. Effect of climate change on household food security and livelihood. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Sraku-Lartey, M., Acquah, S.B., Djagbletey, G.D., Samar, B.S. and Appiah, N. 2015. Digitization of Traditional Knowledge on Forest Foods and Medicinal Plants in Ghana. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Tekpetey, S.L., Owusu, F.W., Appiah-Kubi, E., Essien, C. and Pentsil, S. 2015. Bamboo, an alternative local raw material for affordable housing in Ghana. MESTI-FORIG project on the utilization of locally available raw materials in the building and construction industry in Ghana.

Tekpetey, S.L., Riegel, A., Dekomien, K. and Opuni-Frimpong, E. 2015.Evaluation of Surface Quality of Plantation Grown *Khaya ivorensis* for furniture Production in Ghana.CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Tekpetey, S.L.,Owusu, F.W., Appiah-Kubi, E. and Pentsil, S. 2015. Bamboo for affordable housing in Ghana: Phase 1 and Phase II. CSIR-Forestry Research Institute of Ghana, Annual Planning Session.

Manuals

Adu-Poku, S., Owusu, F.W., Sraku-Lartey, M. and Ofori, J. 2015. Site master file document and production manual for CSIR-FORIG Prekese syrup factory 8pp.

Adu-Poku, S., Owusu, F.W., Sraku-Lartey, M. and Ofori, J. 2015. Standard operation procedures for CSIR Prekese syrup production. 10pp.

News Papers

Amissah, L. and Ninnoni, R.K. 2015. Forest Fire Management in Ghana. ITTO Tropical Forest Update 24(2): 20-22

Media

Akpalu, S. and Adeyiga, G. Nursery establishment /management, mango grafting and honey production. Guruni Star Radio, 11th March, 2015

Akpalu, S. and Adeyiga, G. Radio program to educate public on the mandate and roles of the Institute, Guruni Star Radio, 11th March, 2015.

Apetorgbor, M.M. and Asumadu, K. 2015. Discussions on uses and cultivation of edible and medicinal mushrooms on Mercury Radio, Kumasi, 07 May, 2015.

Djagbletey, G.D. Impact of climate change on agriculture and food security on Mercury Radio, Kumasi, 16thJuly, 2015.

8.1 APPENDIX II: Workshops and Conferences attended

Abraham, J., Opuni-Frimpong, E., Weissbecker, B., Schütz, S. and Angeli., S. 2015. Exploiting the scent of trees to protect mahogany plantations from pest insects. International conference on sustainable mahogany production, 2nd – 6th March, 2105 at CSIR-FORIG, Kumasi.

Amissah, L. 2015. Wildland Fires in West Africa: Interventions and the Way Forward, 6th International Wildland Fire Conference, 12-16th October, 2015 in Pyeongchang, South Korea.

Amissah, L. and Ninnoni, R.K. 2015. Forest Fire Management Interventions in Ghana: The Role of ITTO – funded Projects. 6th International Wildland Fire Conference, 12-16th October, 2015in Pyeongchang, South Korea.

Amissah, L. 2015. Workshop on the Economics of Ecosystems and Biodiversity (TEED) study, 28th May 2015 at Alisa Hotel,Accra

Angalaaere, L.C. 2015. Results-Based Management System (RBMS) and Training of Ghana Action Site R4D platform members, 26-27 May 2015 at Hotel Kosados Arena, Accra

Angalaaere, L.C. 2015. Humid tropics Ghana Action Site Cluster 4 project inception workshop, 25-26 August, 2015 at Hotel Kosados Arena, Accra

Angalaaere, L.C. 2015. Rapid Appraisal of Agricultural Innovation System (RAAIS) of Ghana Action Site, 20-21th April, 2015, Accra

Angalaaere, L.C. 2015. Launch of the CCAFS Flagship Project 'Mainstreaming Climate Smart Cocoa', 13th May, 2015 at Mensvic Grand Hotel, East-Legon, Accra.

Angalaaere, L.C. 2015. CCAFS Open Day on 'Mainstreaming Climate Smart Cocoa.CIAT, IITA, Rainforest Alliance, Root Capital and Sustainable Food Lab with the support of the Cocoa Research Institute of Ghana, 09th October, 2015 at CSIR campus in Airport Residential Area, Accra.

Angalaaere, L.C. 2015. CCAFS Validation workshop 'Mainstreaming Climate Smart Cocoa'. CGIAR's Global 'Climate Change, Agriculture and Food Security' (CCAFS) research programme and being implemented by a project consortium CIAT, IITA, Rainforest Alliance, Root Capital and Sustainable Food Lab., 2nd October, 2015 at CRIG, Tafo.

Apetorgbor, M.M. 2015. Career and Research Output Sharefair.AWARD West Africa Regional Forum Programme, 27-30 April, 2015 at Forest Hotel, Dodowa, Accra.

Apetorgbor, M.M. 2015. CSIR–Technology Development and Transfer Center COTVET GSTDP-COMPONENT 2 Project. One Day Training for CSIR-TDTC Grant Awardees, 15 May, 2015 at CSIR-BRRI Training Center, Kumasi.

Appiah-Kubi, E. (*invited speaker*). 2015. World Bamboo Day Seminar, 18th September, 2015 at FRNR KNUST, Kumasi.

Appiah-Kubi, E. TEEAL and AGORA Programme Training – of – Trainers Workshop on the use of electronic library resources at the University for Development Studies (UDS), Tamale, Ghana. 9th – 11th November (Facilitator for ITOCA).

Appiah-Kubi, E. Training workshop for students of Pentecost University College (PUC), Accra, Ghana in wood properties and timber engineering. CSIR–FORIG, Kumasi, Ghana. 30th June – 1st July, 2015 (Resource person for timber engineering).

Appiah-Kubi, E. 1st Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 12th-16th January 2015.

Appiah-Kubi, E. DAAD Regional Alumni Conference on the theme "A world without hunger". ISSER, University of Ghana, Legon, Accra, Ghana. 7th October 2015.

Appiah-Kubi, E. International Conference on "Towards sustainable production of Mahogany species in plantation in tropical Africa" and Training workshop on sampling methods for genetic timber verification project. Organized by FORIG and Thunen Institute, Germany. Held at FORIG, Kumasi, Ghana. 2nd-6th March 2015.

Appiah-Kubi, E. 2nd Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 27th February-3rd March 2015.

Appiah-Kubi, E., Militz, H.,Gellerich, A., Kankam, C.K. and Frimpong-Mensah, K. 2015. Decay resistance of plantation-grown *Khaya ivorensis* to brown-rot and white-rot fungi. Paper submitted to the 47th Conference of the International Research Group on Wood Protection to be held in Lisbon, Portugal. May 2016.

Appiah-Kubi, E. TEEAL and AGORA Programme Training – of – Trainers Workshop on the use of electronic library resources. Organized by ITOCA and CSIR-FORIG. CSIR-FORIG, Kumasi, Ghana 8th-10th September 2015.

Appiah-Kubi, E. Training workshop for stakeholders in wood industry (TIDD, GTA, FAWAG, WAG, DOLTA, GTMO). Organized by the German Import Promotion Desk. CSIR-FORIG, Kumasi, Ghana, 24th November 2015.

Brentuo, B. Kick-starting workshop on "Solar drying technology for food and materials in Ghana" at Bern University of Applied Sciences, Switzerland from 11th October to 12th November, 2015.

Brentuo, B. Symposium on the theme "Distance opens up horizons – new rules of virtual collaboration" organized by Centre for Information (cinfo) and held on Thursday 29th October, 2015 at Bern, Switzerland under the auspices of Bern University, Switzerland.

Brentuo, B. Training workshop for students of Pentecost University College (PUC), Accra, Ghana in wood properties and timber engineering. CSIR–FORIG, Kumasi, Ghana. 30th June – 1st July, 2015 (*Resource person for wood seasonsing*).

Brentuo, B. 1st Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 12th-16th January 2015.

Brentuo, B. 2nd Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 27th February – 3rd March 2015.

Darko-Obiri, B. Opuni-Frimpong, E., Sekyere, J., Abgenyega, O. and Storer, J.A. 2015. Economics of mahogany production in Ghana. Presentation at the International Conference on Sustainable mahogany production, 2nd-6th March, 2015 at CSIR-FORIG.

Darko-Obiri, B., Owusu-Afriyie, K. and Opuni-Frimpong, E. 2015. Production and marketing of woody biomass for energy in Ghana. ECREE Workshop, Niamey, Niger. 27-29 April, 2015.

Dumenu, W. Portal Forest Estates: A model of integrated land use system in Ghana. Integrated land use system summer school. June 1-19, 2015. University of Freiburg, Freiburg, Germany

Ebanyenle, E. Training workshop for students of Pentecost University College (PUC), Accra, Ghana in wood properties and timber engineering. CSIR-FORIG, Kumasi, Ghana. 30th June – 1st July, 2015.(Resource person for wood anatomy and wood identification)

Ebanyenle, E. 1st Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 12th-16th January 2015.

Ebanyenle, E. 2nd Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 27th February-3rd March 2015.

Ebanyenle, E. CSIR Senior Researchers Forum on the Director-General's new vision for CSIR: Transformational change– 2016- 2020. Held at CSIR-Crops Research Institute on 22nd and 23rd September 2015 and organized by CSIR-Secretariat.

Ebanyenle, E. TEEAL and AGORA Programme Training – of – Trainers Workshop on the use of electronic library resources. Organized by ITOCA and CSIR-FORIG. CSIR-FORIG, Kumasi, Ghana 8th – 10th September 2015.

Ebanyenle, E. The Green Clean Charcoal Initiative –Addressing barriers to adoption of alternative and improved commercial charcoal production technologies in Ghana. Commissioning of Bamboo Charcoal Production Unit, Ankobra River Research and Training Center (ARTiC), Ankobra Beach Resort, Axim, 23 November, 2015, Axim, Ghana (invited speaker).

Ebanyenle, E. Training workshop for stakeholders in wood industry (TIDD, GTA, FAWAG, WAG, DOLTA, GTMO). Organized by the German Import Promotion Desk. CSIR-FORIG, Kumasi, Ghana, 24th November 2015.

Korang, J. K. 2015. International Conference on Sustaining Mahogany Production and Timber verification training workshop held at CSIR-Forestry Research Institute of Ghana, Fumesua from 2nd–6th March 2015.

Korang, J.K. 2015. TEEAL/AGORA Training-of-Trainer Course on electronic library resources at CSIR-Forestry Research Institute of Ghana.

Marfo, E. 2015.Democratic representation of environmental citizens under national pol icy development: lessons from REDD+ readiness consultation process in Ghana.XVth biannual conference of IASC, Edmunton, Canada, 25-29th May 2015

Ofori-Boateng, C. 2015. Biodiversity inventory organized by the Biodiversity Informatics Training Curriculum in Buea, Cameroun.

Ofori-Boateng, C. 2015. "Innovative conservation awareness programme increases stakeholder participation for the protection of a critically endangered West African frog". 3rd European Environmental Laureates Conference. International Conference Centre, Frieburg, Germany.

Opuni-Frimpong, E. 2015. International Conference on 'Towards Sustainable Production of mahogany species in plantations in tropical Africa and training workshop on timber verification project held at CSIR-FORIG 1st – 6th March, 2015. Chair of the organizing committee and presenter.

Opuni-Frimpong, E. and Noel-Bouda, H. Z. 2015. Training workshop on sampling of plant genetic materials for the Large Scale Genetic Timber verification project, 27th-31st November, 2015 in Ghana Funded by Thunen Institute of Forest Genetics.

Opuni-Frimpong, E. and Noel-Bouda, H.Z. 2015. Training workshop on sampling of plant genetic materials for the large scale genetic timber verification project, 1st-7thDecember, 2015 in Cote D'ivoire, Funded by Thunen Institute of Forest Genetics.

Opuni-Frimpong, E. 2015. Africa regional workshop on strengthening C and I for sustainable forest management policy and practice, 27-29th May, 2015 in Douala, Cameroon, Organized by ITTO.

Opuni-Frimpong, E. 2015. XIV World Forestry Congress Workshop; Forest people and the environment: some perspectives from Africa, 4-12th September, 2015 in Durban South Africa.

Opuni-Frimpong, E. 2015.Genetic variation in African mahogany with resistance/ tolerance to *Hypsipyla*. World Forestry Conference, 7-12th September, 2015 in Durban South Africa

Opuni-Frimpong, E. 2015. Final project conference 'development and implementation of species identification and timber tracking system in Africa with DNAS fingerprints and stable isotopes (PD 620/11M (Rev.1))' 29-6- 2015 to 3-7- 2015 in Douala, Cameroun. Organized by Thunen Institute of Forest Genetic, Germany.

Owusu, F.W. CSIR Senior Researchers Forum on the Director-General's new vision for CSIR: Transformational change– 2016- 2020. Held at CSIR-Crops Research Institute on 22nd and 23rd September 2015 and organized by CSIR-Secretariat.

Owusu-Afriyie, K. and Amissah, L. TEEAL/AGORA Training of Trainer Course. Organised by ITOCA, Cornell University and CSIR-FORIG and Research for Life Programme. 8-10th September, 2015. CSIR FORIG.

Owusu, F.W. Participated in Import Promotion Desk (IPD) training workshop on "Exporting Technical Wood Products to Europe" for stakeholders in wood industry, held at CSIR-FORIG on 24th November 2015 and organized by German Import Promotion under the sponsorship of German Federal Ministry for Economic Cooperation and Development (BMZ).

Owusu, F.W. Multi-Stakeholder Dialogue (MSD) on alternative livelihoods held at Assin-Fosu, Oda and Kade for converted illegal chainsaw milling actors. Amember of the Resource

persons, held from 15th – 17th April 2015. Oganized by Tropenbos International, Ghana under EU-chainsaw project "Supporting the integration of legal and legitimate domestic timber markets into voluntary partnership agreements."

Owusu, F.W. Participated in the 5th KNUST summer school with the theme "Sustainable Development of Tertiary Institutions in Ghana amidst Economic and Security Challenges" held at College of Science Auditorium – KNUST by Quality Assurance and Planning Unit (QAPU)-KNUST from 17th to 20th August, 2015.

Owusu, F.W. Resource person for multi-stakeholder meeting 12 on "Supporting the integration of legal and legitimate domestic timber markets into Voluntary Partnership Agreements", held at Assin-Fosu, Akim Oda and Kade districts; 73 people from 15th–17th April, 2015

Owusu, F.W. TEEAL and AGORA Programme Training – of – Trainers Workshop on the use of electronic library resources. Organized by ITOCA and CSIR-FORIG. CSIR-FORIG, Kumasi, Ghana 8th – 10th September, 2015.

Owusu, F.W. 1st Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 12th – 16th January 2015.

Owusu, F.W. 2nd Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 27th February-3rd March, 2015.

Owusu, F.W. 13th National Multi-Stakeholder Dialogue (MSD) workshop under the European Union-Chainsaw Milling Project "Supporting the integration of legal and legitimate domestic timber markets into voluntary partnership agreements". Oganized by Tropenbos International, Ghana and held at Forestry Commission Training Centre (FCTC), Akyawkrom-Ejisu on 16th July 2015. Paper presented: Overland timber export studies in Ghana and Ougaudougu.

Tekpetey, S.L., Owusu, F.W., Appiah-Kubi, E., Pentsil, S. and Adutwum, J. 2015. Trade and Innovation in Bamboo and Rattan Furniture Industry in Ghana. Paper accepted during the XIV World Forestry Congress, Durban, South Africa, 7-11 September 2015.

Tekpetey, S.L. World Bamboo Day Seminar held at FRNR KNUST, Kumasi. 18th September, 2015 *(invited speaker)*.

Tekpetey, S.L. EU/INBAR PhD Presentation on Bamboo BioWeb project (*Chairman*),

Tekpetey, S. L. International Conference on "Towards sustainable Production of Mahogany species in plantations in tropical Africa and Training Workshop on Timber Verification project. 2nd – 6th March, 2015 venue CSIR-FORIG, Kumasi, Ghana

Tekpetey, S.L. 2015. The role of Bamboo in climate mitigation and Adaptation RENARSA week celebration, FRNR Auditorium, KNUST 4th November (*invited Speaker*).

Tekpetey, S.L. TEEAL and AGORA Train-the-Trainer Workshop 08-10 September, 2015, conference room CSIR-FORIG, Kumasi, Ghana.

Tekpetey, S.L. 2nd Training Workshop on the development of Laboratory Quality Management Handbook. Organized by BFH, Switzerland and UNIDO. Excelsa Lodge, Kumasi, Ghana. 27th February-3rd March 2015.

Tekpetey, S.L. Training workshop for stakeholders in wood industry (TIDD, GTA, FAWAG, WAG, DOLTA, GTMO). Organized by the German Import Promotion Desk. CSIR-FORIG, Kumasi, Ghana, 24th November 2015.

Thesis supervision by Dr. Emmanuel Marfo

Nelson Owusu Ansah 2015. Transaction cost of democratic representation in an MSD process. MSc thesis, KNUST

Fullnere Omari 2015. Forest land use conflict management. MSc thesis, KNUST.

Policy Brief

Oduro, K.A., Damnyag, L. and Foli, E.G. 2015. Distribution of potential REDD+ benefits from agricultural lands in forest and forest savanna transition zones of Ghana. Policy Brief. CSIR-FORIG/FC/HAFL/ITTO/SECO.

Deppeler, A., Oduro, K.A., Damnyag, L. and Foli, E.G. 2015. Lessons Learnt from cocoa certification for REDD+ implementation. Policy Brief. CSIR-FORIG/FC/HAFL/ITTO/SECO

8.2 APPENDIX III: LIST OF SENIOR MEMBERS

ADMINISTRATION DIVISION	
Daniel A. Ofori	BSc. Agric., MPhil. Tree Improvement, PhD. Forest Genetics (Molecular Biology) *Chief Research Scientist*, **Director**
Francis O. Amofah	B.A. Secretaryship, Dip. Ed., Master of Public Administration (MPA), *Senior Adm. Officer*, **Head of Administration**
Comfort Konto (Ms.)	B.A. (Hons) Economics, Dip. Education, MBA Strat. & Consultancy Mgt. *Administrative Officer*
Georgia Coffie (Mrs.)	B. Ed. Secretarial & Mgt., MSc E-Comm. & Marketing, *Administrative Officer*
FOREST POLICY, GOVERNANCE AND LIVELIHOODS DIVISION	
Emmanuel Marfo	BSc. Nat. Res. Mgt., MSc. Tropical Forestry, PhD. Environmental Science, *Senior Research Scientist*, **Head of Division**
Kwame Antwi Oduro	BSc. Nat. Res. Mgt., MSc. Forestry and Land Use, *Senior Research Scientist*
Eric E. Nutakor	B.A. Social Science, MPhil. Silv. & Forest Mgt., *Research Scientist*
Elizabeth A. Obeng (Mrs.)	BSc. Agric., MSc. Sustainable Res. Mgt., *Research Scientist*
William K. Dumenu	BSc. Nat. Res. Mgt., MSc. Forest Ecol. & Mgt., *Research Scientist*
BIODIVERSITY CONSERVATION & ECOSYSTEM SERVICES DIVISION	
Mary M. Apetorgbor (Mrs.)	BSc. Botany, PhD. Plant Pathology/Mycology, *Chief Research Scientist*, **Head of Division**
Luke Cyprian N. Anglaaere	BSc. Nat. Res. Mgt., MSc. Silv. & Forest Biology, PhD. Agroforestry, *Principal Research Scientist*
Stephen Adu-Bredu	BSc. Nat. Res. Mgt., MSc. Silv. Mgt., PhD. Silv. Mgt./Ecophysiology, *Principal Research Scientist*
Kennedy Owusu-Afriyie	BSc. Nat. Res. Mgt., MSc. Forest Mgt., PhD. Plant Science *Research Scientist*
Lucy Amissah (Mrs.)	BSc. Nat. Res. Mgt., MPhil. Silv. & For. Mgt., PhD. Forest. Ecology & Forest Mgt. (Functional Ecology), *Senior Research Scientist*
Bright O. Kankam	BSc. Nat. Res. Mgt., MPhil. Wildlife and Range Mgt., PhD. Primatology, *Senior Research Scientist*
Akwasi Duah Gyamfi°°	BSc. Nat. Res. Mgt., MPhil. Ecology & Mgt., *Research Scientist*
Caleb Ofori Boateng	B.Sc. Nat. Res. Mgt., PhD. Wildlife & Range Management, *Research Scientist*
Francis Kwabena Dwomoh°°	BSc. Nat. Res. Mgt., MSc. GIS & Earth Obs., *Research Scientist*
WOOD INDUSTRY & UTILISATION DIVISION	
Emmanuel Ebanyenle	BSc. Nat. Res. Mgt., MPhil. Wood Science, PhD. Forest Science *Senior Research Scientist*, **Head of Division**
Francis W. Owusu	BSc. Agric. Engineering, MPhil. Wood Technology, *Senior Research Scientist*
Joseph Ofori**	BSc. Chemical Tech., MSc & DIC Timber Tech., PhD. Wood Technology, *Chief Research Scientist*

James K. Korang	BSc., MSc., PhD. Chemistry, *Research Scientist*
Daniel Sekyere**	BSc., 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 Sci., MPhil. (Wood Technology), *Chief Technologist*
FOREST PRODUCTS & MARKETING DIVISION	
Lawrence Damnyag	BA., MPhil. Economics, PhD. Forest Economics, *Senior Research Scientist,* **Head of Division**
Beatrice Darko-Obiri (Mrs.)	BSc. Agric., MSc., PhD Agroforestry, *Principal Research Scientist*
Andrew Oteng Amoako**	BSc. Wood Technology, MSc. Wood Science , PhD Wood Products & Eng., *Chief 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*
FORESTS &CLIMATE CHANGE DIVISION	
Gloria D. Djagbletey (Mrs.)	BSc. Nat. Res. Mgt., MPhil., PhD. Silv. & Forest Mgt., *Senior Research Scientist,* **Head of Division**
Paul P. Bosu	BSc., MPhil. Biological Sci., PhD Forest Entomology, *Principal Research Scientist,* **Deputy Director**
Ernest G. Foli	BSc. Nat. Res. Mgt., MPhil Forest Men./Inventory PhD Silv. & Mgt., *Principal Research Scientist*
Joseph Cobbinah**	BSc. Biological Sci., PhD. Forest Entomology, *Chief Research Scientist*
Stephen E. Akpalu	BSc. Agric., MPhil. Env. Sci. *Research Scientist*
George K. Ametsitsi°°	BSc. Nat. Res. Mgt., MSc. Env. Res. Mgt. *Research Scientist*
Daniel Shalom Addo-Danso°°	BSc. Nat. Res. Mgt., MSc Forest Ecol. and Mgt., *Research Scientist*
Gloria Kukurije Adeyiga	B.Sc. Nat. Res. Mgt., M.Sc. Sust. Env. Mgt., M.Sc. Agric Dev't., *Research Scientist*
FOREST IMPROVEMENT & PRODUCTIVITY DIVISION	
Joseph Mireku Asomaning	BSc. Agric., MSc. Seed Technology, PhD. Seed Science and Technology, *Senior Research Scientist,* **Head of Division**
Emmanuel Opuni-Frimpong	BSc. Nat. Res. Mgt., MPhil. Silv. Mgt. PhD. Forest Entomology, *Principal Research Scientist*

Mark Appiah	BSc. MSc. PhD. Agroforestry, *Principal Research Scientist*
John K. Mensah	BSc. Botany, MSc. Plant Pathology, *Research Scientist*
Theresa Peprah (Mrs.)	BSc. Nat. Res. Mgt., MPhil. Tree Improvement, *Senior Research Scientist,*
Sandra Acheampong Owusu	BSc. Nat. Res. Mgt., MSc., PhD. Plant Genetics, *Research Scientist*
William K. Nuako Bandoh	BSc. Biochemistry, *Asst. Research Scientist*
COMMERCIALIZATION AND INFORMATION DIVISION	
Margaret Sraku-Lartey (Mrs.) °°	BA. Social Science, Post. Grad. Dip. Lib. Studies, MA. Industrial Mgt. *Principal Librarian,* **Head of Division**
Stella Britwum Acquah (Mrs.)	BSc. Computer Science, MBA. Mgt. Info. Systems, MSc. Statistics *Senior Research Scientist*
Ernest Kwaku Kraka	BSc. Nat. Res. Mgt., MSc. Environ & Res. Mgt., MSc. Waste Mgt. PhD. Agric. Sci.-Weed Sci. & Entomology, *Scientific Secretary*
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*
John K. Boateng	BSc., MBA, *Internal Auditor*

*Sabbatical Leave

**Post Retirement Contract

°°PhD Student

8.3 APPENDIX IV: LIST OF SENIOR STAFF

NO	NAME	GRADE
1.	Michael Mensah	Chief Technical Officer
2.	John Agbozo	Chief Technical Officer
3.	Mavis Serwaah Kwarteng	Chief Acct. Assistant
4.	Paul Kankam	Chief Technical Officer
5.	Kwabena Prempeh Bandoh	Chief Technical Officer
6.	John Sackey	Chief Works Supt.
7.	Paul Adusei	Chief Works Supt. (Traffic)
8.	Clement Cletus Acheampong	Chief Acct. Assistant
9.	Magdalene Prempeh Agyeman	Chief Technical Officer
10.	John Justice Mensah	Chief Technical Officer
11.	Godson K. Zorve	Chief Technical Officer
12.	Samuel Kyei Yamoah	Chief Technical Officer
13.	Elizabeth Ampah	Chief Technical Officer
14.	Albert K. Nyeha	Chief Technical Officer
15.	Eric K. Frimpong	Chief Technical Officer
16.	Emmanuel Asiedu-Opoku	Chief Technical Officer
17.	Ernest Osei Boakye	Principal Technical Officer
18.	Markfred Mensah	Principal Technical Officer
19.	Francis Asare Abetia	Principal Admin. Assistant
20.	Frank Baffour Assuming	Principal Technical Officer
21.	Isaac Boahen	Chief Acct. Assistant
22.	Samuel Atusong	Chief Acct. Assistant
23.	Peter Loving Arthur	Chief Technical Officer
24.	Elizabeth Appiah	Chief Auditing Assistant
25.	Sarfo Kwame Bonsu	Principal Technical Officer
26.	Jacqueline Twintoh	Principal Administrative Officer
27.	Awurama Andoh	Principal Admin. Assistant
28.	Kwasi Baah Acheamfour	Principal Technical Officer
29.	James Oppong Amponsah	Principal Technical Officer
30.	Richard Kwadwo Adjei	Principal Technical Officer
31.	Govina James Kudjo	Principal Technical Officer
32.	Anastasia Duah-Gyamfi	Principal Administrative Asst.
33.	Daniel K. Debrah	Principal Technical Officer
34.	Dorothy Asare-Akoto	Principal Technical Assistant
35.	Felix Boakye	Principal Technical Officer

NO	NAME	GRADE
36.	Kwaku Asumadu	Principal Marketing Assistant
37.	Jemima Owusu	Principal Technical Officer
38.	Jane Nketiah	Principal Admin. Assistant
39.	Margaret Adubigire	Principal Admin. Assistant
40.	Jonathan Dabo	Principal Technical Officer
41.	Daniel Peprah	Principal Technical Officer
42.	Sandra Owusu	Principal Technical Officer
43.	Samuel Larbi	Principal Admin. Assistant
44.	Nana Yeboaa Opuni-Frimpong	Principal Technical Officer
45.	Georgina Boateng Yeboah	Principal Accounting Assistant
46.	Elvis Nkrumah	Principal Technical Officer
47.	George K. Nyantekyi-Mensah	Senior Security Officer
48.	Rebecca Okyere Darko	Senior Stores Superintendent
49.	Emmanuel Amponsah Manu	Principal Technical Officer
50.	Osei Tutu Boateng	Principal Admin. Asst.
51.	Wendy O. Amankwah	Principal Accounting Assistant
52.	Michael Ampah	Senior Admin. Assistant
53.	Gifty Wiafe Mensah-Tenkorang	Senior Accounting Assistant
54.	Haruna Seidu	Senior Technical Officer
55.	Eunice Okyere-Agyapong	Senior Technical Officer
56.	Jones Adjapong	Senior Technical Officer
57.	John Bismark Amokwandoh	Senior Technical Officer
58.	Samuel Apraku Yeboah	Senior Technical Assistant
59.	Mark Debra Marfo	Senior Technical Officer
60.	Ebenezer Ofori	Senior Technical Officer
61.	Ebenezer Frans Mensah	Senior Technical Officer
62.	Daniel Damte	Senior Draughtsman
63.	Peter Komla Damadey	Senior Asst. Transport Officer
64.	Jackson Nti	Senior Asst. Transport Officer
65.	Sampson Adonteng	Senior Asst. Transport Officer
66.	Osei Boateng	Senior Security Officer
67.	Constant Ezuame	Senior Technical Officer
68.	Gabriel Lumor	Senior Works Superintendent
69.	Isaac Donkor	Administrative Assistant
70.	Sylvester Kuudaar	Asst. Farm Manager
71.	Kwabena Achina Owusu	Accounting Assistant

NO	NAME	GRADE
72.	Michael Atitsogbui	Senior Security Officer
73.	Safia Ibrahim	Senior Technical Officer
74.	William Hagan Brown	Senior Technical Officer
75.	Mavis Agyekumwaah Bamfo	Senior Technical Officer
76.	Adu-Gyamfi Asamoah	Senior Technical Officer
77.	Hamdia Mahama Wumbeidow	Senior Technical Officer
78.	Helena Akomaning	Administrative Assistant
79.	Hilda Dokey	Administrative Assistant
80.	Kester K. Mensah	Administrative Assistant
81.	Joseph Sebukah	Administrative Assistant
82.	Joan Owusuaa Amponsah	Technical Officer
83.	Victoria Apeseku	Technical Officer/Catering
84.	Patrick Baidoo-Ansah	Technical Officer
85.	Emmanuel Sarpong	Library Assistant
86.	Maxwell Asante Boachie	Security Officer
87.	Emmanuel Kofi Antwi	Security Officer
88.	Michael Kwarteng	Security Officer
89.	George Kwabla Kpodo	Security Officer