CSIR-FORESTRY RESEARCH INSTITUTE OF GHANA

2018 Annual Report

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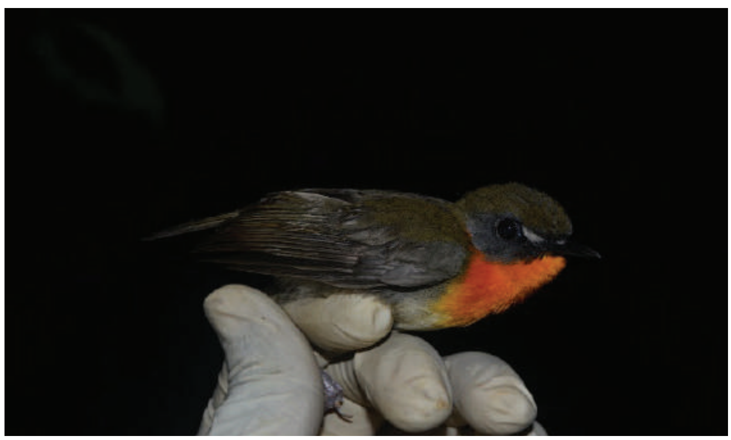

Annual Report 2018

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FOREWORD

Prof. Daniel A. Ofori (PhD)
Director, CSIR-FORIG

CSIR-Forestry Research Institute of Ghana (CSIR-FORIG) is among the 13 institutions of CSIR, mandated to undertake forest, forest products and related research and to disseminate and commercialize research outputs and services in Ghana. For CSIR-FORIG to be able to achieve this mandate, the institute undertakes demand-driven research, builds capacity and promotes the application of technologies for sustainable management of Ghana's forest resources for the benefit of society. This report presents the research outputs and outcomes for the year 2018 grouped under four (4) broad research themes namely: Food Security & Poverty Reduction, Climate Change, Environmental Management & Green Technology, Material Science and Manufacturing and Science and People.

With the high commitment of its research staff, its culture of interdisciplinary and multidisciplinary co-operation and its strength in applied research, the CSIR-FORIG is well positioned to remain as one of the top research institutes in the sub-region. On behalf of CSIR-FORIG management, I applaud and appreciate the contribution of all staff to this uplifted performance of the Institute.

EXECUTIVE SUMMARY

During the period under review, a total number of nineteen (19) projects were implemented comprising thirteen (13) pure research projects and six (6) service-oriented activities. Seven (7) of the research projects were undertaken in collaboration with other national and international institutions. The projects were linked to four (4) of the seven (7) CSIR Thematic Research Areas, namely; (a) Food Security and Poverty Reduction; (b) Climate Change, Environmental Management and Green Technology (CCEMGT); (c) Material Science and Manufacturing; and (d) Science and People.

Under the Food Security and Poverty Reduction programme, seedlings of two varieties of Pomegranate (*Punica granatum*) were planted in four different ecological zones. Monitoring for survival, growth performance and yield is on-going. On solar drying of domestic food products, initial data has been collected on various food products and are being analysed to find their drying rates/schedules, compare designs and other important parameters. Also, training programmes with respect to mushroom cultivation, Snail Farming and Beekeeping technologies were undertaken.

Under the Climate Change, Environmental Management and Green Technology Programme, a total area of 2,830.31 hectares of forest plantations of both indigenous and exotic tree species has been established. The sites are being maintained and protected from fires. One bird and one amphibian of conservation concern on the IUCN Red List of threatened species, namely, Hooded vulture (*Necrosyrtes monachus*) *and Phrynobatrachus alleni,* were recorded under the Akyem mine project at the mining sites in Ahafo. A new Wildlife Monitoring Plan titled "Newmont Golden Ridge Limited- Wildlife Monitoring Plan" was developed and accepted by the Akyem mine (Newmont Golden Ridge Limited). Field investigation of superior varieties of indigenous tree species, was conducted for enrichment of nurseries, trees on farm and plantations. The National Tree Seed Centre collected and distributed a total of 945.5kg of seeds. This quantity could produce an estimated number of 2,862,710 seedlings, that could cover an area of 2,5676.7ha, if planted at a spacing of 3m x 3m.

The proposal to UNIDO for sponsorship to build the capacities of members of staff of the new Wood and Furniture Testing Laboratory, was approved and funding has been made available for testing services to industries. Products would be expected from the companies for trial testing in January 2019. Preliminary results from the study on the phytoremediation potential of exotic and indigenous tree species for the rehabilitation of mining sites, suggest the presence of different heavy metals within the same site. A total of 33ha of new seed orchards and plantations of genetically superior planting stocks and endemic species, such as *Talbotiella genti*, have been established and are being maintained. The institute embarked on an assessment to determine the suitability of plantation-grown *Eucalyptus* species as utility pole material in Ghana, and the species has been accepted by the Energy Commission to be used as utility pole.

Under Material Science and Manufacturing theme, a timber market survey of wood merchants or suppliers was carried out at the domestic timber markets across Ashanti region and Techiman. A total of 13 emerging timber species were identified

Under the Science and People programme, land restoration and demonstration areas were established in degraded mining sites in Bibiani with the cooperation of the private sector to strengthen their involvement in supporting the mitigation and adaptation to climate change. The MSc. and MPhil programmes in Climate Change and Integrated Natural Resources Management continued to run smoothly with 15 new students admitted in 2018, making a total number of 40 students.

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COMPOSITION OF CSIR-FORIG MANAGEMENT BOARD

Prof. Robert Clement Abaidoo *CANR-KNUST*	Chairman
Prof. Daniel A. Ofori *Director, CSIR-FORIG*	Member
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Mrs. Josephine E. Geraldo *CSIR, Director-General's Representative*	Member
Mr. Lawrence K. Mensah *Head of Administration, CSIR-FORIG*	Secretary

LIST OF ABBREVIATIONS AND ACRONYMS

AGM	Annual General Meeting
BARADEP	Brong-Ahafo Regional Agricultural Development Programme
CABE	College of Arts and Built Environment
CANR	College of Agriculture and Natural Resources
CARLIGH	Consortium of Academic and Research Libraries in Ghana
CCEMGT	Climate Change, Environmental Management and Green Technology
CCST	CSIR-College of Science and Technology
CD	Commercialization Division
CFRN	Coalition for Rainforest Nations
CRD	Completely Randomized Design
CSIR-FORIG	Council for Scientific and Industrial Research-Forestry Research Institute of Ghana.
DBH	Diameter at Breast Height
DMC	Directors Management Committee
DOLTA	Domestic Lumber Traders Association
FC	Forestry Commission.
FCTC	Forestry Commission Training Centre
FIP	Forest Investment Programme
FIPD	Forest Improvement and Productivity Division
GIS	Geographical Information Systems
GNPC	Ghana National Petroleum Company
GOG	Government of Ghana
ICBR	International Centre for Bamboo and Rattan
IMC	Internal Management Committee
INBAR	International Network for Bamboo And Rattan
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
JWRS	Japan Wood Research Society
KNUST	Kwame Nkrumah University of Science and Technology
LA	Leaf Area

MC	Moisture Content
MLNR	Ministry of Lands and Natural Resources
MOU	Memorandum of Understanding
N/E	North-East
NAB	National Accreditation Board
NGGL	Newmont Ghana Gold Limited
NGRL	Newmont Golden Ridge Limited
NPA	Non- Protected Area
NTSC	National Tree Seed Centre
PA	Protected Area
PAU	Protected Area Unburnt
PGRRI	Plant Genetic Resources Research Institute
PPPs	Public Private Partnerships
RCBD	Randomized Complete Block Design.
REDD+	Reduced Emissions of Deforestation and Forest Degradation
RSA	Research Staff Association
SECO	Secretariat for Economic Cooperation
SLA	Specific Leaf Area
SSA	Senior Staff Association
SWST	Society of Wood Science and Technology
UHAS	University of Health and Allied Science
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	The United Nations Industrial Development Organization
WIUD	Wood Industry and Utilisation Division
WMP	Wildlife Management Plan

INTRODUCTION

There is an increasing need for forestry research in Ghana due to the increasing awareness of the value of trees and forests. It is expected that in general, forestry research would be able to provide adequate information and responses to the challenges of sustainable forest development in a rapidly changing world. Ghana, as most developing countries, is in the tropical zones, where higher biodiversity with complex ecosystem exists. This has created many challenges in the development of sustainable land management system. In addition, there is insufficient funding for forestry research. However, CSIR-FORIG has managed to undertake forestry research that contributes to the resolution of many developmental issues. This report highlights technologies, outputs and achievements in 2018.

1.0 FOOD SECURITY & POVERTY REDUCTION (FSPR)

Background and Highlights of Research Achievements under FSPR research theme

In 2018, CSIR-FORIG worked with other national and international research institutions on research covering important agricultural and forestry issues under the following thematic areas:

- Forest, trees, plant resources (natural products)
- Soil, mechanization and agro food processing
- Biotechnology (Germplasm collection, conservation, bio-processing) under the Biomedical and Public Health research theme of CSIR, Ghana.

Under these themes, food-related research was carried out to meet the challenge of providing Ghana's growing population with access to safe, affordable and nutritious food, using sustainable land use practices.

Activity 1.1 Pomegranate (*Punica granatum*) Species Trial in Ghana

Research Team: *D. A. Ofori, A. Antwi-Wiredu, and P. P. Bosu*

Donor: *Northstone Investment Ltd*

Pomegranate (*Punica granatum*) is a fruit-bearing deciduous shrub or small tree in the family *Lythraceae* that grows between 5 and 8 m tall. Pomegranate is known as a super food. Its jewel-like seeds (arils) and its ruby-red fruits have been used for medicinal purposes for millennia, including stomach upsets, menopausal hot flashes, haemorrhoids, conjunctivitis, osteoarthritis, lowers blood pressure, stimulates the immune system, wards off the flu, reduces inflammation, reduces risk of heart disease and lowers cholesterol. The peel is good for the heart and blood vessels, the white membrane is good for stopping diarrhoea and good for wounds and ulcers of the mouth and throat. The fruit also strengthens the brain, cleanses the body and blood from toxins, and is very good at expelling worms from the intestines.

In Ghana, it is mostly used for fruit juice and due to its importance in the beverage industry, there is a need to explore the possibility of growing pomegranate in Ghana. The study is thus, aimed at demonstrating the performance of pomegranate in the country and identifying the ecological zones where the different varieties/ provenances perform best. The specific objective seeks to assess the adaptive capacity, growth and yield of pomegranate in Ghana. The study will provide basis for future research on pomegranate in Ghana, including ecological and social impacts of pomegranate in Ghana.

Seeds of two varieties (Hicaz and Wonderful) of pomegranate imported from Turkey and South Africa respectively by Blue Skies were measured and processed for germination. Various parameters such as the weight, the height, the diameter, and circumference of each fruits, the number and, the weight of fresh pulped seed and dried weight of seeds per individual fruits were taken into consideration during the measurement.

Furthermore, the seeds were air dried for a few days and then sown in bowls (100 seeds per bowl). Completely randomized design (CRD) was used for sowing and replicated 3 times in the greenhouse. The number of leaves and height of each of the seedlings were taken.

Four separate arable lands were selected and demarcated from three (3) regions in Ghana for the provenance assessment of the pomegranate genotypes. The regions include:

1. Mpraeso in the Eastern region
2. Yenku in the Central region
3. Kumasi (Abofour & Mesewam) in the Ashanti region

Randomised complete block design (RCBD) was followed with five replications at each site, with 20 pomegranate seedlings per plot and planted at 3m x 3m within and between rows. On the selected sites, land clearing, lopping and peg cutting were performed between May and July, 2018. With regards to land preparation, zero-tillage with no bush burning was practiced before transplanting the pomegranate seedlings. This was to ensure that the soil nutrients and beneficial microbes remain intact to support the growth and development of the pomegranate seedlings. So far an area of 1.6 ha has been put into the production of pomegranate species. A plot of land in each provenance covered an area of 0.4ha.

The baseline data collected revealed that height, number of shoots and the number of leaves produced by each pomegranate seedlings in the five (5) replications were doing well. In terms of provenanace growth performance, both pomegranate cultivars showed the highest growth height at Abofour (24.50cm) followed by Mesewam (21.2cm), Mpraeso (20.22cm) and Yenku (18.16cm). On the contrary, Yenku produced the highest average number of shoots followed by Mesewam, Abofuor and then Mpraeso. Although, the rains were scarce at Yenku, the seedlings performed very well. With the number of leaves, Yenku once again out-performed the other fields. This was followed by Abofour, Mesewam and lastly Mpraeso. For the two pomegranate cultivars, the Hicaz performed significanly better than Wonderful.

For the nursery establishment, about three thousand (3000) pomegranate seedlings of both Hicaz and Wonderful cultivars were raised. Two hundred (200) Hicaz and Wonderful pomegranate seedlings were planted in each of the four fields for the provenance trials. Therefore, in all the provenances, a total of eight hundred (800) pomegranate seedling stands were planted. There was 100-percentage survivability of pomegranate seedlings after planting in the four fields. For the years ahead, data collection of the seedlings on each field will focus on parameters such as survival, growth in height, diameter, crown, and yield.

A

B

Plate 1: Hicaz (A) and Wonderful (B) seedlings growing after transplanting in the field.

Activity 1.2 Solar Drying Technology for Domestic Use in Ghana

Research Team: *B. Brentuo, E. Appiah-Kubi, and F. W. Owusu*

Donor: *CSIR-FORIG*

A survey undertaken in Ghana indicates that there are no effective and affordable solar drying kilns for domestic use. Therefore post-harvest losses are on the increase and farmers are disadvantaged as periodically they are unable to break-even because of the challenge in drying. Again, lack of adequate and efficient drying results in the production of poor quality products (for instance, artefacts). To reduce seasonal post-harvest losses and improve the quality of food and wood products especially in the rural communities, the introduction of clean solar dryer technology for drying processes is long over due. Hence, the project sought to design and construct a solar dryer for local drying of wood and food items by individuals and businesses whose characteristics include; versatility, increased affordability and effectiveness, low complexity, ease of manufacturing with limited set of local materials, ease of operation and maintenance, resilience and environmentally friendly. There is a considerable potential to develop affordable and effective solar dry kilns for high quality products in Ghana. The objective of the study is to enhance the quality of wood and food products through the use of appropriate solar dryer technology in rural communities in Ghana.

A desk study was undertaken on the various designs available, which were powered electrically or by solar. Based on this, an appropriate design was made and constructed using about 90% of local raw materials. These materials include wood, polythene, wire mesh, thermometer, hygrometer, collector and jointing/fixing items. Most of the materials are replaceable when necessary however one of the designs was without a collector. To test for the effectiveness of the designs constructed, some food items, including pepper, cassava chips, mushrooms and plantain chips have been dried and data taken for assessment.

So far, the initial data collected on the solar dryer for the various food products are being analysed to determine their drying rates/schedules, compare designs and other parameters of importance. Further testing is ongoing for other food items like okro, garden eggs and some roots and tubers. The study is expected to be completed in 2019.

Plate 2: A sample domestic solar dryer showing cassava being dried

2.0 CLIMATE CHANGE, ENVIRONMENTAL MANAGEMENT & GREEN TECHNOLOGY (CCEMGT)

Background and Highlights of Research Achievements under CCEMGT

CSIR-FORIG's research under the climate change, environmental management and green technology theme improves our knowledge of the health and environmental effects of climate change and provides sustainable solutions for communities to effectively manage and reduce the impacts of a changing climate. In 2018, the research activities under the theme were related to the following:

- Soil, Water and Biodiversity Conservation
- Climate Change Mitigation (Including REDD^{+})
- Climate Change Adaptation and Social Development
- Green Technologies for Sustainable Development

Activity2.1: Establishment of Forest Plantations to Support Reforestation of Ghana's Forests

Research Team: *R.T. Guuroh, S.Adu-Bredu, F. Asuming-Baffour, A. Asamoah, G. Djagbletey, D. A. Ofori, and E. Foli.*

Donors: *Forestry Commission/Industry Fund Board*

The Forestry Commission/ Industry Plantation Development Fund Board have set up a programme to contribute towards the reforestation of Ghana's forest estate via plantation development. The Board therefore tasked the CSIR-Forestry Research Institute of Ghana (FORIG) to establish best practice plantation of fast growing indigenous and exotic commercial species at various locations in the country. Accordingly, CSIR-FORIG has been establishing forest plantations with support from the FC/Industry Fund since 2010. These plantations have been established in the Research Working Circles of CSIR-FORIG in Pra-Anum, Opro/Afram Headwaters and Asenanyo Forest Reserves, and in degraded Forest Reserves at Mankrang, Essen-Apam and Pamu Berekum.

So far, an area of 2,784.24 ha has been planted with indigenous species including Ofram (*Terminalia superb*), Kusia (*Nauclea diderrichii*), Onyina (*Ceiba pentandra*) Wawa (*Triplochiton scleroxylon*), Mahogany (*Khaya ivorensis*), and Otie (*Pycnantus angolense*). The exotic species are Cedrela (*Cedrela odorata*), Teak (*Tectona grandis*) and Paulownia species (*P.elongata* and *P.fortunei*). Operations from the month of January to end of November 2018 centred on maintenance of plantations in the form of weeding, fire rides construction and maintenance; patrolling for detection of bush fire threat and illegal encroachments; fire fighting and fire preventive education; nursery management; peg cutting, line pegging, beating up and carrying out of census in some permanent sample plots established in the already established plantations.

Research plots of 30m x 30m are being used to study effects of hydrogel on survival and growth rate of teak stumps. Similar plots have also been established to compare growth rate of Teak, Gmelina and Rosewood in three ecological zones namely Pamu Berekum (Dry semi-deciduous zone), Asenanyo (Moist Semi-deciduous N/E zone) and Essen Apam (Moist Semi-deciduous S/E zone). The third study is focused on comparing manual weed control with herbicide application to determine effects on growth of seedlings, biodiversity of undergrowth, cost of weed control and soil microorganisms. All the research plots have been successfully established.

The target of establishing 465 ha in 2018 was achieved and the progress of work was satisfactory. The plantation presents an opportunity to implement different research components that would lead to a better understanding of plantation establishment in Ghana and this opportunity should be vigorously explored. Scientists are encouraged to make use of the sites for their research activities.

Activity 2.2 Akyem Mine Wildlife Monitoring Programme

Research Team: *B.O. Kankam, and C. Ofori-Boateng*

Donor: *Newmont Golden Ridge Limited*

Surface mining is destructive to biodiversity. The activity reduces habitat complexity and impacts negatively on plants and animals biodiversity. Consistent biological monitoring assessments increases the understanding of wildlife populations and their adaptations to vegetation changes in the area. Monitoring of wildlife by Newmont Golden Ridge Limited (NGRL) is a vital component of not losing any additional biodiversity in their operations going forward.

This monitoring activity is focused on the assignment relating to biodiversity monitoring targets relevant to Akyem mine. The Researchers' specifically surveyed and determined the trend in the number of wildlife (especially species of global concerns) observed in forest fragments and 60-ha reforestation plot, and assessed the presence and distribution of Hooded vulture (*Necrosyrtes monachus*) in and around NGRL mine boundary. The objective of this study is to provide information for adaptive management, such as identifying areas requiring improvements to wildlife management and the effectiveness of mitigation efforts aimed at reducing potential mortality risks. It will also contribute to understanding the human impacts on vultures and mammal assemblages in and around the mining community.

Fauna survey on avifauna, large mammals bats, reptiles and amphibians were conducted within the Akyem mine concession area by the research team. Also, the use of camera traps was key to this survey, especially for information on ellusive species. Information on the presence and distribution of vultures is being gathered by visiting the waste-dump sites where Newmont and the communities surrounding the Akyem mine dump their non-toxic waste materials.

A total of 104 individuals of amphibians consisting of 37 families, 3 genera and 7 species; 6 individuals of reptiles representing 3 families, 3 genera, and 6 species; 200 individuals of birds belonging to 36 families, 78 genera and 103 species; and 54 individuals belonging to 6 families, 12 genera and 14 species were recorded in the remnant forest within the Newmont concession area. An average of 4 vultures was recorded at the Akyem Mine Inert waste dump.

Two species of conservation concern on the IUCN Red List of threatened species (1 bird and 1 amphibian) have been recorded. The bird, *Necrosyrtes monachus* (Hooded vulture) is listed as critically endangered (i.e. facing an extremely high risk of extinction in the wild), whereas the amphibian, *Phrynobatrachus alleni* is listed as near-threatened. Data collection went on throughout the year under review.

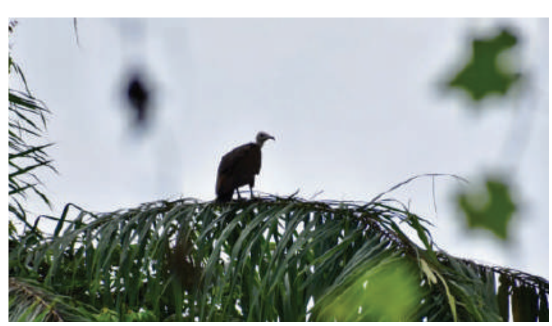


Plate 3: Hooded vulture (*Necrosyrtes monachus*)

Activity 2.3: Vegetation and Soil Erodibility Monitoring of Reclaimed Sites, Ahafo Gold Operations

Research Team: *P.P.Bosu, B.O. Kankam, L. Amissah, G. Djagbletey, G. Quansah, E. O. Adjei, and E. Gaisie.*

Donor: *Newmont Ghana Gold Limited*

Newmont Ghana Gold Limited (NGGL) is reclaiming its degraded lands within the operational sites to bring it up to a level where its ecological integrity and/or socioeconomic relevance will be enhanced. As part of this obligation, a 70 ha waste rock surface was reclaimed at the operational area using indigenous and exotic tree species from 2009 to 2015 to mitigate the impacts of environmental degradation.

The objective of this assignment is to monitor the process of restoration of the 70 ha reclaimed site at the NGGL at Ahafo Kenyase, based on selected biophysical properties (vegetation, fauna and soil). The wildlife aspect of the project was specifically conducted to determine the presence of wildlife (amphibians, reptiles, birds and mammals) in the reclaimed sites of Newmont Ghana Gold Limited.

This research will provide information for adaptive management, such as identifying areas requiring improvements to wildlife management and the effectiveness of mitigation efforts aimed at reducing potential mortality risks. It will also contribute to understanding the human impacts on vultures and mammal assemblages in and around the mining community.

Fauna survey on avifauna, large mammals including bats, reptiles, and amphibian were conducted within the Ahafo mine concession area by the research team. The use of camera traps was needful in identifying ellusive species. Six families, 6 genera and 8 species of amphibians were recorded as compared to a survey in 1999/2000 where 3 families, 3 genera and 3 species of amphibians were recorded. For birds, 31 families, 55 genera and 85 species were recorded for this survey; whereas 24 families, 52 genera and 62 species were recorded in 1999/2000. The bird *Necrosyrtes monachus* is listed as critically endangered. A new species of forest robin in the genus Stiphrornis (*Stiphrornis inexpectatus*) was recorded at the Apensu reclaimed site (Plate 4). Two families, 6 genera and 7 species were discovered for this survey as compared to a survey in 1999/2000 where one family, 5 genera and 5 species were found. The Shannon-wiener diversity for bats was relatively high (H'= 1.64) for this survey than the baseline survey (H'=1.25) in 1999/2000 in the two protected forest reserves (Boskumese and Amama Forest Reserves) and outside the forests combined. However, for small mammals (rodents), Shannon diversity was high for the baseline survey in 1999/2000 (H'=1.53) than the current survey (H'=0.56). Most of the animals were recorded at the Apensu reclaimed site, which was established in 2009.

By the end of 2018, field surveys on avifauna, small mammals including bats, large mammals, reptiles, and amphibians were completed and a draft report was been prepared.

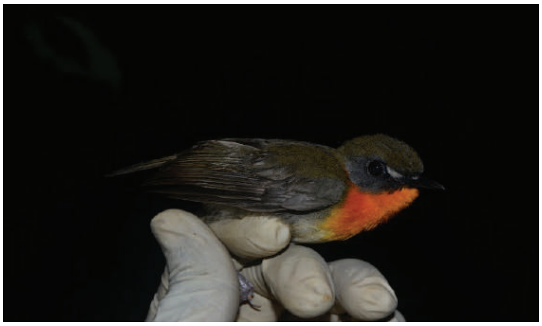


Plate 4: Ghana Forest Robin (*Stiphrornis inexpectatus*)

Activity 2.4: Newmont Golden Ridge Limited Wildlife Monitoring Plan

Research Team: *B.O. Kankam, and L. Amissah*

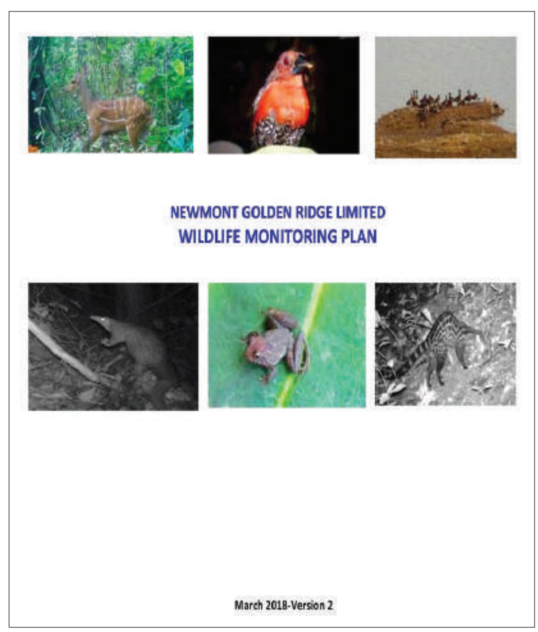
Donor: *Newmont Golden Ridge Limited*

Mine-related activities can have an impact on biodiversity and especially wildlife for the purpose of this plan. Interactions or incidents between mining operations and wildlife are anticipated because the site is sandwiched between two forest reserves (Ajenjua Bepo and Mamang River Forest Reserves). Newmont is therefore committed to protect the environment and provide long-term benefits to the country/ region/communities in which they integrate biodiversity and ecosystem services into their business. The first version of Newmont Golden Ridge Limited Wildlife Management Plan dates back to 2012. It focused on priority biodiversity and proposes the evaluation of operational impacts. It was designed to feed into site management system/operations. The revision is aimed at bringing the Wildlife Management Plan (WMP) into alignment with Newmont's corporate biodiversity standard of 2016 and good practice where the overarching goal of "no additional loss" of biodiversity at the operating sites is practiced.

The conceptual framework for biodiversity monitoring at Akyem Mine include defining monitoring objectives, identifying knowledge gaps, implementing monitoring activities, evaluation, adjustment of revision of goals if need be, reporting, and transfer of results in accordance with Newmont's corporate standards. The WMP recognizes the appropriate legal/regulatory requirements embodied in many legally and non-legally binding regulatory requirements including Ghana Wildlife Conservation Regulations 1971 and IUCN red data, which prohibits disturbing, injuring, or killing wildlife and destroying their habitats, and designated critical habitat. The plan is also responsive to the corporate, good practice, global biodiversity targets and Newmont goals, which seek to conserve species of concern, minimize disturbances and improve habitat and ecosystem services.

The current Management Plan (version 2) outlines the monitoring plans for ecosystem services and the survey threshold at which changes in the population (or encounter rate) of wildlife (especially, species considered as national (Ghana) and global species of concern) would be detected. Monitoring activities/ programmes proposed in the plan include general wildlife monitoring, performing wildlife deterrence activities (where necessarily), tailing and other facilities monitoring. Others include ecological research/monitoring of key species of conservation concern, laboratory analysis of dead wildlife, security and fence inspection/monitoring, ecosystem services, hunting activities, translocation of wildlife (when necessary), training, reporting and reviews. Section of the plan is devoted to profiling priority species recorded at the site and reviewing findings/reports to determine the last date the species were seen. Additionally, the plan provides general protocols for detection and collecting monitoring data for different taxa as well for collecting data on ecosystem services.

One major outcome from the project is a forty-two page Wildlife Monitoring Plan titled "Newmont Golden Ridge Limited-Wildlife Monitoring Plan" which was submitted to Newmont (Akyem Mine) shown in plate 5.


NEWMONT GOLDEN RIDGE LIMITED
WILDLIFE MONITORING PLAN

March 2018-Version 2

Plate 5: Cover page of "Newmont Golden Ridge Wildlife Monitoring Plan

Activity 2.5: Assessment Of Suitability of Plantation-Grown *Eucalyptus* Species as Utility Pole Material in Ghana

Research Team: *E. Appiah-Kubi, F. Wilson Owusu, E. Ebanyenle, J. Korang, M. Apetorgbor, H. Seidu, J. Govina, B. Brentuo, M. Mensah, and F, Boakye.*

Donor: *Asuboa Treatment Limited/ MIRO (Ghana) Forestry Limited*

In Ghana, there has been over-reliance on *Tectona grandis* (Teak) for the manufacture of utility poles. Inarguably, the growth rate of indigenous species is slow to fit same purpose. Close to a decade now, wooden poles from pines have been imported into the country. MIRO Forestry Company Limited, located at Asante Akyem Agogo, has for the past 7 years been growing various wood species including *Eucalyptus* in large-scale plantations. This is due to the promising growth of the Eucalyptus species in Ghana, coupled with its utilization in other countries as electricity poles.

Asuboa Wood Treatment Limited, located at Asankare, collaborated with CSIR-FORIG to investigate the suitability of the *Eucalyptus urograndis* hybrid (*E. urophylla x E. grandis*) established by MIRO (Ghana) Forestry and other established plantations for use as electricity poles. This will increase the timber resource base of the wood industry thereby contributing to sustainable resource management, green business opportunity, climate change mitigation and livelihood improvement.

The main objective was to increase the timber resource base of the wood industry through the introduction (utilization) of new wood species (*Eucalyptus* spp). Typically, the suitability of the Eucalyptus hybrid for use as electric power transmission pole was assessed by testing all the relevant technological properties including fibre crushing stress, mechanical properties, durability and treatability of the wood.

Three plantation sites were visited, Agogo (Ashanti region, which belongs to MIRO Forestry), Amantia (Eastern region, for CSIR-FORIG Plate) and Winneba-Yenku (Central region, belonging to CSIR-FORIG & Forestry Commission at different sites). Samples were selected based on tree size and defect-free status prior to extraction as shown in Plate 6. Six trees were sampled from a 4-year old *Eucalyptus* plantation at Agogo for the determination of technological properties. 200 trees were also selected as poles for determination of retention and sapwood penetration (Plate 7). Five and three trees were extracted from plantations at Yenku and Pra-Anum forest reserves respectively. Various tests using standard protocols were conducted for all required properties.

The results of the study showed that the morphological and anatomical properties of the *Eucalyptus* poles from MIRO (Ghana) Forestry Ltd. were comparable to other wood species such as Teak, Pines, and Kusia, which are already being used as utility pole materials in Ghana. The estimated basic density of the Eucalyptus hybrid (490.5 kg/m^3) falls within that of teak and the mean moisture content was 97.4%. The tangential, radial and longitudinal shrinkages were 0.96%, 5.79% and 8.50% respectively from green to oven dried and 4.85%, 2.70% and 0.53% from green to 12% moisture content in the same order. The degree of cross-sectional deformation and honeycombing were both low (1). Kiln drying schedule developed for the lumber up to 38 mm, according to Madison Kiln Schedule, was T10-D4. The average acetone, ethanol and hydrophobic extracts, as well as the lignin, lignocellulose and holocellulose contents determined give a good indication of the strength of the wood species. The sapwood penetration and sapwood retention ranged from 40mm to 50mm and 43.35kg/m^3 to 43.57kg/m^3 respectively.

A report of the results on the samples from MIRO (Ghana) Forestry has been submitted to Asuboa Wood Treatment Ltd and MIRO (Ghana) Forestry. Based on the study results, the Eucalyptus hybrid species, which was recommended for use as electric power transmission pole in Ghana, has been accepted by the Ghana Energy Commission. Work is on-going for phase 2 of the study and will be completed by the end of the year 2019.

A

B

C

Plate 6: Eucalyptus Plantation

Plate 7: Eucalyptus samples for retention and sapwood penetration

Activity 2.6: Establishing A Land Restoration Research and Demonstration Area Within Degraded Mining Sites in the Bibiani Areas, Ghana

Research Team: *B. Darko Obiri, M. Appiah, G. Djagbletey, R.T. Guuroh, E. Obeng, and K. A. Oduro.*

Donor: *CSIR-FORIG*

Small scale or artisanal unlicensed mining often referred to as "galamsey" has emerged as a major environmental concern in Ghana over the last decade. Although galamsey has been practiced by locals for several decades, the entry of the Chinese into the scene, with their more advanced machinery and technology, has led to large scale destruction of lands and water bodies including, in some cases, forest reserves and cocoa farms. Small-scale mining not only degrades the forest, but also contaminates the soil with heavy metals, which could be poisonous. Among the methods used to decontaminate and restore degraded mine soils to useful status, is the use of plants which have received increasing attention due to their sustainability and cost effectiveness. The strategy employs plants to remove contaminants from degraded soils and thus help restore lands for productive use. Unfortunately, the potential of most species to remediate and help restore degraded mine soils has not been adequately researched thus leaving gaps in our scientific understanding of how best to restore degraded mine sites. In contributing to this national agenda – aimed at ending illegal mining, CSIR-Forestry Research Institute of Ghana (CSIR-FORIG) has provided research funds to test the potential of some selected tree species for use in land restoration after mining.

A 0.25-ha experimental plot, laid in a simple random design was established with 4 fast growing economic tree species to test the initial survival in degraded mining sites. Two parallel experiments were simultaneously established to provide a basis for comparison of seedling growth increments. In one experiment (taken as control), seedlings of the selected species were planted on an unmined site in the same locality while in the second experiment, seedlings of the same species were planted on the selected mined site. Seedlings of two indigenous trees species (*Nuclea diderrichii, Terminalia superba*) and two exotic species (*Gmelina arborea, Senna siamea*) were acquired from FORIG nursery and planted. The species have been selected taking their economic importance into consideration since landowners usually consider such factors to decide on land use options. This will help to document how well different potential species for phytoremediation and land reclamation perform on degraded mined sites at the seedling and early growth stages.

Soil samples were collected and analysed at the start of the experiment to establish the baseline chemical and physical properties of mined-site soil. Samples were collected up to a depth of 40 cm so as to inform chemical depositions at various levels of the soil stratum. At the end of the ninth month, soil samples will again be collected to analyse chemical and physical properties relative to baseline values. These will give an indication of how well different species perform in phytoremediation and land reclamation. To discount any confounding influences, soil samples in adjacent areas (unplanted with trees) will also be tested before the mined site is planted and retested nine months after planting.

Currently, about 80% of work has been completed on the project and all field measurements are expected to end in March 2019. Due to the dependence of the ecological study on natural rains to monitor seedling growth over time, the study would require an extended period to yield better results.

Under the broad goal of seeking to establish a land restoration research and demonstration area within degraded mining sites in the Bibiani areas, Ghana, the socioeconomic component focuses on two key developmental objectives (i) establish the socioeconomic and ecological benchmarks for measuring the restoration success after project interventions; (ii) determine the motivational factors for tree planting as a restoration measure of degraded mining sites. Within the context of these objectives, we sought to understand stakeholder's perception and attitudes towards the impact of illegal mining activities on forest ecosystem and their willingness to pay for restoration initiatives that seek to enhance ecosystem services for improved livelihood.

Analysis of the socio-economic data is on-going. Based on the outcome of the results, recommendations on relevant information would be made to guide interventions for joint management of degraded mined lands with local communities. As part of the project activities, a technical report and a publication are expected to be produced.

Activity 2.7: Evaluation of the Phytoremediation Potential of Selected Indigenous and Exotic Tree Species in Ghana

Research Team: *A. Duah-Gyamfi, L. Amissah J. K. Korang, R. T. Guuroh, and S. A. Owusu*

Donor: *CSIR-FORIG*

Over the past two decades there has been increasing concern over the loss of forest cover in Ghana. Among the underlying causes for the rapid decline in forest resources, small scale mining operations has been flagged as a major contributory factor. Small-scale mining not only degrades the forest, but also contaminates the soil with heavy metals, which could be poisonous. Among the methods used to decontaminate degraded mine soils is, phytoremediation which has received increasing attention owing to its sustainability, low cost and easy large-scale applicability. The strategy employs plants to remove contaminants from degraded soils.

In Ghana, both indigenous and exotic species have been planted as part of several plantation development strategies introduced by successive governments in the past three decades. The goal of these plantation projects is to rehabilitate the country's degraded forests decimated by anthropogenic activities such as agriculture and mining activities. With an increase in small-scale mining activities and the concomitant increase in heavy metal contaminated soils, there is a pressing need to identify the most effective plant species with high efficiency and vitality for phytoremediation. However, the potential of tree species in Ghana to remediate degraded mine soils has received little attention. Information about the abilities or capacities of various species to absorb heavy metals can give insight into selecting suitable species for the government's drive of rehabilitating mined sites.

The overarching objective of this research is to determine the phytoremediation potential of both indigenous and exotic tree species. It is envisaged that the study would provide baseline information on appropriate species to be selected for the restoration of degraded forests resulting from mining activities.

Soil samples were randomly collected from a depth of 0-20cm from degraded mined portions of Atewa Range Forest Reserve (Plate 8A & B). Additional soil samples were collected from mine sites at Bibiani. Samples of the soils were analysed to determine the initial concentrations of heavy metals. Seeds of selected species including *Tighemella heckelii, Terminalia superba, Milicia excelsa, Nauclea diderrichii, Cassia sp, Tectona grandis, Cedrela odorata,* among others, were sown in bowls with soils collected from Atewa (Plate 8C). Germinated seedlings were transplanted into Polyvinyl chloride (PVC) pipes filled with soils collected from the study sites(Plate 8D). To assess growth performance of the species in both mined site and forest soils, five replicates of each species were selected and monitored for growth performance in a completely randomized design manner.

A

B

C

D

Plate 8: Collection of soil samples from degraded areas of the Atewa Forest Range (A) and (B); Germination of seedlings in bowls (C); Filling of PVC pipes with soils prior to transplanting of germinated seedlings (D).

So far, the preliminary results indicate the presence of different heavy metals in areas sampled. While the soil samples from Segyemase (SE) and Esikam (ES) portions of Atewa consisted of cadmium (Cd), mercury (Hg) and lead (Pb), Asiakwa (AS) and minor portions of Esikam were polluted with arsenic (As) and nickel (Ni). The results suggest the presence of different heavy metals within the same site, therefore, the need to identify appropriate species for each metal to rehabilitate the site.

After approximately six months of monitoring species for growth performance, relative height growth rates of *Cassia* spp (Casse), *Cedrela. odorata* (Cedod), *Tectona grandis* (Teagr), *Terminalia superba* (Tersu) were higher in the control sites (forest soil) compared to the mined site soil (treatment). In contrast, *Nauclea diderrichii* (Naudi) grew faster in the mined site soil than forest soil (Figure 1). The result is in line with the widely held view that species grow slowly in polluted heavy metal soils. However, differences in growth rates exhibited by the species seem to suggest different potential to grow in contaminated soils. This information is useful for the selection of species to rehabilitate degraded mine sites.

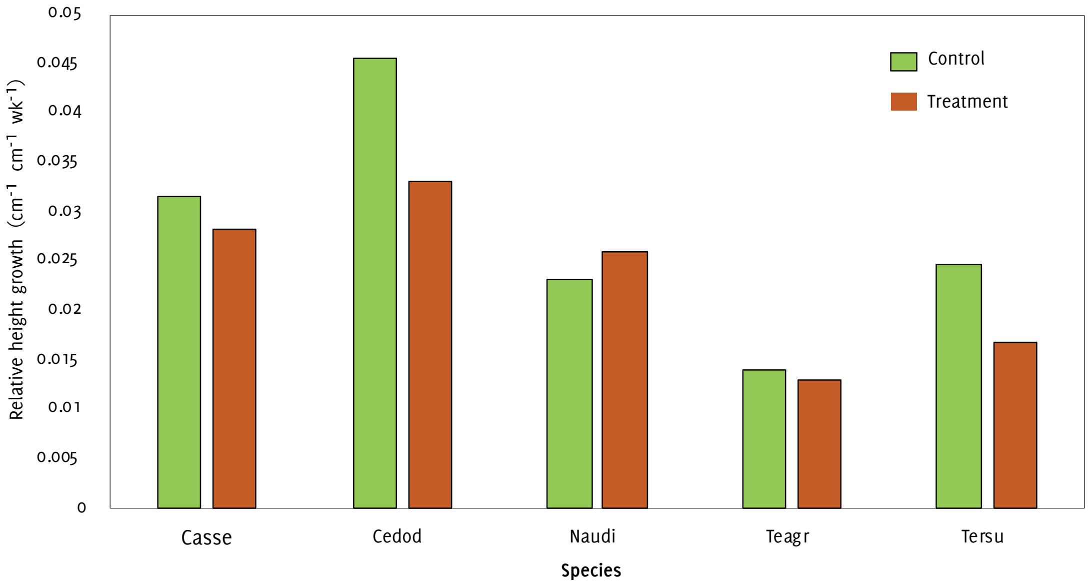


Figure 1: Relative growth rate of species in Control (forest soil) and Treatment (mined site soil). Species codes are: Casse - *Cassia* spp, Cedod - *Cedrela. odorata*, Teagr - *Tectona grandis*, Tersu - *Terminalia superba*, Naudi - *Nauclea didderichii.*

Activity 2.8: Develop Protocols for Mass Production of Selected Genetically Superior Planting Material of Selected Tree Species

Research Team: *J. Mireku Asomaning, L. Amissah, S. A. Owusu, E. Foli, T. Peprah, S.A. Owusu.*

Donor: *World Bank*

There are inadequate seed sources to produce planting material to meet the increasing demand to rehabilitate large tracts of degraded forest areas. This is because of irregular fruiting of some species as well as reduction in stocking levels of other species within the natural forest. Though vegetative propagation has been found to be a viable solution to this challenge there are no protocols for vegetative propagation of many preferred species. The project therefore focused on developing protocols for vegetative propagation of selected indigenous species. The specific objectives are 1) to determine the best grafting method for selected species and 2) determine the success in rooting, shoot formation and survival of stem cuttings of selected species,

A total of 324 stock plants of *Pericopsis elata* were grafted using scion materials collected from nine trees from three locations namely Abofour, Bobiri and Mesewam. Grafting was done by budding, top cleft and side (wedge) cleft methods. The grafts were assessed for the length of time taken for stock plant and the scion to fuse, survival and growth of successful grafts. The rooting success of four indigenous species: *Nauclea diderrichii, Tieghemella heckelii, Pericopsis elata and Guibourtia ehie* was tested using stem cuttings of stock plants that were about 6-7 months old. Cuttings of 10 cm long were used. The cuttings were treated with hormone (Hormodin) of three different concentrations (0.1%, 0.2%, and 0.3%) hereafter referred to as treatments. For each treatment there were three replicates with 10 cuttings per replicate. The control (i.e. cuttings with no hormone added) had similar replicates with 10 individuals per replicate. The cuttings were planted on 11th August, 2017 and were monitored weekly for seven(7) weeks.

Assessment of farmer plots with successful planted grafts was carried out successfully throughout the year.

Activity 2.9 : Production of Genetically Superior Planting Stocks of Selected Tree Species through Establishment of Seed Orchards

Research Team: *L. Amissah, J. Mireku Asomaning, S.A. Owusu, E. Foli, T. Peprah, S. Owusu. E. Manu.*

Donor: *World Bank*

There are inadequate seed sources for the production of high quality seedlings to facilitate forest rehabilitation due to irregular fruiting, overexploitation for production of wood for export and the local timber market as well as rampant wildfires. The objective of the project was to establish seed orchards with seedlings or clones produced from seeds or scion materials collected from superior trees.

In 2017, a total area of 11 ha of land was selected at Subri and Asenayo Forest Reserves for the establishment of seed orchards. Six hectares were demarcated at Subri Forest Reserve and 5-ha at Asenayo Forest Reserve. Land preparation began in March for the site at Subri Forest Reserve and in April for the site at Asenayo Forest Reserve. In the Subri Forest Reserve seedlings of two species; *Tieghemella heckelii* and *Nauclea diderrichii* were planted at a planting distance of 8m by 8m.; two hectares of *Tieghemella heckelii* and four hectares of *Nauclea diderrichii*. In Asenayo Forest Reserve clones of *Khaya ivorensis* (3-ha) and *Pericopsis elata* (2-ha) were planted in a completely randomised design with planting distance of 10 m. In 2018, additional orchards were established at Pra Anum Forest Reserve and Afram Headwaters forest reserves using a spacing of 3m by 3m for *Tectona grandis* and 6m by 6m for *Gmelina arborea*.

Maintenance and monitoring was carried for 11 ha seedling seed orchard established in 2017. In addition, in 2018 a total of 33 ha new seedling seed orchards were established at Asenanyo, Afram Headwaters and Pra Anum forest reserves. The orchards comprised one hectare of grafted *Khaya ivorensis* and one hectare *Tieghemella* heckelii planted at Asenanyo Forest reserve, 12 ha of *Gmelina arborea* and 4 ha of *Tectona grandis* planted at Afram Headwaters Forest Reserve and 15 ha of *Gmelina arborea* planted at Pra Anum forest reserve.

The design used for planting 1-ha *K. ivorensis* orchard was based on twelve accessions from five localities namely; Kubease, Amantia, Kasapen, Nkroful and Abofour. The seedlings were planted at a distance of 10m x10m. The 1-ha *Tieghemella heckelii* orchard was established using seedlings that remained after beating up was done for the 2-ha *Tieghemella heckelii* orchard established in 2017 at Benso. The design was based on two accessions from Amantia and 1 accession from Abi Shelterbelt. The planting distance was 8m x 8m. The last line of the 1-ha plot could not be planted due to inadequate seedlings.

The design of the 27- ha *Gmelina arborea* seedling seed orchards established using seedlings raised from seeds imported from Costa Rica under the FIP programme was based on five provenances per hectare planted at a planting distance of 6m x 6m. The same design was replicated in each 1-ha plot for the 27 ha area established. In the year under review, a 4-hectare *Tectona grandis* seedling seed orchard was established at Afram Headwaters Forest Reserve using seedlings produced from seeds imported from Tanzania.

Additional seedling seed orchards would be established in 2019 using seedlings produced from seeds of Eucalyptus provenances imported from Tanzania and *Tectona grandis* provenances. Maintenance of the orchards established in 2016, 2017 and 2018 will be continued. Labels and signposts would be procured for proper labelling and signage of the established orchards under the FIP programme.

Activity 2.10: Ex-Situ Conservation of *Talbotiella gentii* in Tain II Forest Reserve

Research Team: *L. Amissah , D. Ofori, D. Dompreh, S.A. Owusu*

Donor: *FORM International*

*Talbotiella gentii*is one of the few endemic tree species in Ghana and is a priority for conservation (Hawthorne & Abu-Juam, 1995). The species is classified as Critically Endangered on the IUCN red list. In some communities the species is used as firewood and for the production of charcoal because it produces charcoal of high calorific value. Irvine (1961) indicated that the tree is a decorative plant. Additionally, the leaves are used to treat convulsion and fever (Moss and Gyakari, 1992).

Threats to the species include wildfires, exploitation for charcoal, firewood and farming activities (Amissah, 2005). Due to these threats 10 out of 17 populations that were recorded in 1982 have been completely wiped out, while other populations have been severely damaged by recent wildfires (Dompreh *et al.*2015). In addition to these anthropogenic factors *Talbotiella gentii* has been found to experience high rates of fruit abortion, low fruit and seed set, low germination capacity and low seedling survival. These problems could reduce gene flow between populations leading to inbreeding and loss of diversity rendering the species less capable of surviving changing environmental conditions. To prevent loss of genetically distinct population there is the need to implement both in situ and ex situ conservation measures.

This project is aimed at conserving *Talbotiella gentii* populations by *ex situ* method at Tain II and Asubima Forest Reserves.

Seeds for seedling production were collected from two existing populations of *Talbotiella gentii* located at Sapawsu and Extension Forest Reserve and Bandai Hills Forest Reserve. Seeds were collected from target tree species based on the DNA results by Dompreh et al. (2011). In addition, seeds from other trees fruiting at the time of seed collection were collected. Seed collection was from 8 accessions (trees) in Sapawsu, Extension Forest Reserve and 6 accessions from Bandai Hills Forest reserve. Global Positioning System (GPS) locations of the selected trees as well as the diameter and the general health of the trees were measured and assessed. Seeds were processed at CSIR-Forestry Research Institute of Ghana Nursery. Germination tests were conducted for seeds collected from each accession (tree) using five replicates per accession. Each replicate contained 20 seeds. The seeds were further germinated in germination bowls for the mass productions of seedlings. Germinated seeds were transplanted into polythene pots. In addition to seeds collected from the two forest reserves, wildlings were also collected from Yongwa Forest Reserve and transplanted into polythene pots.

Results of the germination test indicated high germination success of the species at a high moisture content. So far, a total of 16,341 seedlings have been produced, out of which 15,230 seedlings have been supplied to FORM Ghana. Form Ghana has planted an initial 4 ha using a planting distance of 3m x 3m. A 1 -ha ex situ conservation plot has been established at Asenanyo Forest Reserve. Seedlings were planted at a spacing of 3m by 3m using seedlings from three provenances (Bandai Hill, Yongwa and Sapawsu Forest Reserve). The planted seedlings are being monitored at an interval of six (6) months for their performance (survival and growth).

Additional seeds will be collected from identified seed sources from which seedlings will be produced and planted at two (2) additional sites. Project completion report will be submitted after the remaining seedlings from the 2018 stock are supplied to FORM Ghana.

Activity 2.11: Conduct Field Investigation of Superior Varieties of Indigenous Tree Species for Enrichment, Nurseries, Trees on Farm and Plantations

Research Team: *L. Anglaaere, M. Appiah, B. Darko Obiri and E. Foli*

Donors: *World Bank/GoG*

Enrichment planting is commonly used for enhancing the density of desired tree species in secondary forests. There is interest in increasing tree density in Mpameso and Tano Suhyen forest reserves, which have lost significant tree species and diversity. Past experiences with enrichment planting have been varied depending on spacing, width of planting grids etc. The responses have been promising in situations where care has been taken to use good planting stock and where weeds and over-storey cover have been controlled. In other situations, particularly where the canopy cover is too great, many of the planted seedlings stagnate or are overcome by weed competition and the approach has failed.

It is therefore important to develop methodologies for the specific conditions present at each site and test various models/techniques for undertaking successful enrichment planting with superior varieties of indigenous tree species. The specific objectives of this study are (i) to develop/test various models/techniques for undertaking successful enrichment planting with superior varieties of indigenous tree species; (ii) to develop/test various models/techniques for integrating trees into already established cocoa farms and other farm landscapes; and (iii) to evaluate the effect of line planting on the survival, height growth and crown traits of the tree species growing in a secondary / degraded forest.

Planting strips were created and laid parallel to each other at 20 m apart in an area of forest covering 4.3 ha at Mpameso Forest Reserve, and 4.0 ha at Tano Suhyen Forest Reserve. The lines were opened at 2m and 4m widths in the plots, with planting points at 5 m apart in the cutting lines of 2, 4, and in untouched vegetation. The planting was done using a mixed-species planting configuration with seedlings of five tree species (Ofram, Emire, Mansonia, Wawa, Mahogany). A total of 399 seedlings were planted in the Brong Ahafo Region and 420 tree seedlings at Tano Suhyen in the Western Region. Growth and ecological data were collected from these plots.

Enrichment planting

Work planned for the period included:

- Monitoring and assessment of established enrichment planting trial plots in bothrRegions.
- Monitoring and assessment of growth performance of trees planted on already established cocoa farms in the Western Region.
- Field data collection on cocoa farm characteristics such as farm size, planting strategies, age of farm, seedling source, etc.
- Collection of data on farmers, including information on ownership status of land, age of farmer, gender of farmer, opportunities and challenges for integrating trees on farms, etc.

The activities above were carried out as planned. Monitoring of the enrichment planting plots continued during the third quarter. The team evaluated the survival of the species in all plots. Height and diameter at breast height (dbh) were also assessed. The number of leaves on each seedling were also counted and recorded. Seedling collar diameter was measured using digital callipers and their corresponding heights were measured using tape measure. The plots were maintained by weeding prior to each time of assessment.

Preliminary results show that there were significant differences in the growth rates among the different tree species as expected and the growth of species varied across the two trial sites. Height growth was at an average of 0.89 m across the two sites for species like Wawa, Emire and Ofram.

Generally, tree seedlings at Tano-Suhyen forest reserve did better in terms of height and diameter than those in Mpaemeso forest reserve. At Sefwi Wiawso, trees of dominant height and diameter happened to be found in the open (no shade). Even though, tree seedlings at Dormaa received almost equal amount of sunlight, their growth rates were not as good as those planted in the Tano Suhyen FR. In terms of mortality, the team recorded more at Dormaa than at Sefwi Wiawso with at most 35% mortality across the two sites.

The growth rates of seedlings that were recorded were as expected and appear to be in agreement with growth rates recorded for the same species planted in agricultural landscapes where there are more cultural practices and maintenance of planted trees. The results suggest that forest gaps and strip cleaning contribute to faster growth and enhance survival of trees. Based on these preliminary results, it is obvious that good maintenance of enrichment planting plots is required for good growth rates.

Trees on farm

One of the major thrusts of the FIP is to increase tree populations on cocoa farms in the Brong Ahafo and Western Regions. This especially involves improving shade cover on cocoa farms – both new and already established or matured farms. For integrating shade tree species into already established cocoa farms, 3 models were selected for trial. This involved planting the tree species at 3 different spacing – 7.5 x 7.5m, 12 x 12m and 15 x 15m. Plots were laid for each of these spacings on various farms and the indigenous shade tree species planted. The species used were mainly *Terminalia ivorensis, Terminalia superba, Khaya ivorensis, Entandrophragma angolense, Tieghemella heckelii* and *Mansonia altissima*.

Three (3) spacings are being tried on farm plots. These are (i) 7.5m x 7.5m; (ii) 12m x 12m; and (iii) 15m x 15m.

For the 7.5 x 7.5m spacing, a total of 16 plots (farms or replicates) were established with a total area of 18.2 ha. The 12 x 12m spacing was established on 17 plots, with an area of 18. 6 ha, while the 15 x 15m spacing comprised 10 plots covering 10.8 ha. Hence, a total of 47.6 ha of trial plots were established on admitted farms in the Western Region.

Table 1: *Different spacing being tried out for integration of shade trees into already established (mature) cocoa farms in Sefwi Bodi, Western Region.*

Spacing for shade trees (m)	Tot farm size (Ha)	Av. plot size (Ha)	Trial plot size (Ha)	Av. no. of tree seedlings planted/ plot	Tot. no. of tree seedlings planted	No. of farms (No. of Reps)
7.5 x 7.5	69.60	1.14	18.2	202	3,230	16
12.0 x 12.0	61.44	1.09	18.6	76	1,290	17
15.0 x 15.0	41.84	1.08	10.8	48	480	10
Total	**172.88**		**47.6**		**5,000**	**43**

Assessment of farmer plots will be carried out in the first quarter of next year **(January – March 2019).**

Activity 2.12: Climate and Land Use Effects on Plant Diversity in Ghana

Research team: *R.T. Guuroh, G. K. Adeyiga, and A. Duah-Gyamfi*

Donor: *British Ecological Society*

In contemporary ecological research, understanding ecosystem responses to global environmental change is a pressing theme (Reed et al., 2012, De Bello et al., 2006). Vegetation composition and diversity play a defining role in ecosystem health and functioning in response to changing environmental conditions (Ruppert et al., 2015). They also underpin the provisioning of ecosystem services that are of ultimate benefit for human wellbeing (Kohler et al., 2017, Allan et al., 2015). Ecosystems of all kinds, including forests and savannahs, supply various services to society including provisioning services such as food, water, timber and fibre; regulating services such as regulation of climate, floods, diseases, wastes and water quality; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfilment; and supporting services such as soil formation, photosynthesis, and nutrient cycling (MEA, 2005). In developing parts of the world such as Ghana, people tend to depend heavily on natural ecosystems for their survival thus making them highly vulnerable to environmental changes that have negative consequences on ecosystems (Naah et al., 2017).

The objective of this study was to contribute to an improved understanding on how land use and climate interactively affect vegetation composition, aboveground biomass production, as well as the taxonomic and functional diversity of woody and herbaceous vegetation in Ghana. The approach used was to compare three land use types – protected areas with and without controlled fires, and surrounding non-protected areas under communal use – along a climatic gradient of increasing aridity. This should ultimately help in development of sound management strategies to ensure conservation of plant resources in the face of increasing land use pressure and changing climate.

The study was conducted in Ghana with focus on three ecological zones; the semi-deciduous forest zone, the Guinea savannah zone and the Sudan savannah zone. In each zone, three land use types – protected areas with and without controlled fires and surrounding non-protected areas under communal use were selected to study the differentiation in vegetation. A nested plot design was used for sampling data on the woody and herbaceous vegetation. One protected area (PA) and one non-protected area (nPA) will be selected per ecological zone. In each PA, an unburnt area (PAU) and a burnt area subject to regular controlled fires (PAF) will be identified with the help of PA management.

The GPS coordinates of the 0.1 ha sample plots was recorded and satellite images obtained. Adult trees and shrubs with a stem diameter . 5cm at 1.3m (diameter at breast height, dbh) will be recorded on the 0.1 ha plots. Their species identity will be recorded; their dbh will be measured to the nearest centimetre and their canopy height to the nearest decimeter (see Ouédraogo et al., 2015). Juvenile woody plants (dbh < 5cm) will be recorded on the 180 subplots (25 m^2). Their species identity will be recorded, and their canopy height will be measured to the nearest decimeter. The identity, ground cover, phenological stage and height of all herbaceous species will be recorded on the 180 sampling quadrats (1m^2). On 90 of the 1m^2 plots – where species identities, vegetative heights, ground cover and phenological stages have been recorded – the plant biomass will be harvested at stubble height (ca. 3cm) and separated into species, discarding moribund material (Guuroh 2016). The samples will be oven-dried (60°C, 48 hours) and weighed. We will measure plant functional traits for two individuals of all woody species occurring on our plots. Besides height (see above), we will assess leaf area (LA) and specific leaf area (SLA), using standard protocols (Pérez-Harguindeguy et al., 2013). We will additionally assemble plant functional traits from taxonomic literature for both woody and herbaceous vegetation. This will be life history, life form, photosynthetic pathway, and growth habit. For woody species, we will also compile data on specific wood density. Historical climate data (over 30 years) will be downloaded from WorldClim database online.

Data collection has been successfully completed in all the three ecological zones. Data cleaning is on-going to be followed by analyses, writing of final project reports and journal publications.

3.0 MATERIAL SCIENCE AND MANUFACTURING (MSM)

Background and Highlights of Research Achievements MSM

CSIR-FORIG's research under this theme helps to improve competitiveness of industry by developing materials, which are preferred by Ghanaian industries. This year, the focus of the research was centred on two main programmes, namely;

- Material Science (Wood, Integrated Materials)
- Industrial Products (Bio-Resource)

Activity 3.1: Some Basic and Technological Properties of *Tetrapleura tetraptera* (Prekese) Wood

Research Team: *B. Brentuo, M. Mensah, and F. W. Owusu*

Donor: *CSIR-FORIG*

Expansion of the timber resource has become necessary due to the extinction of the timber resource base in Ghana. This will help to reduce the pressure on the available timber species, especially the primary and commercial timber species. Prekese (*Tetrapleura tetraptera*), which is an indigenous wood species, is classified as a lesser-known species because its stem as timber product has never been exported. It is also not familiar to the public and or to the timber industry. Prekese has a wide natural distribution over a large part of tropical Africa, especially in the rain forest belt of West, Central and East Africa (Ojewole, 2004, Enwere, 1998). The fruit is used as a spice and thickener, syrup and condiments among others (Derkyi et al, 2014). It is widely used in the alcoholic and non-alcoholic beverage industries in Ghana (Derkyi et al, 2014). Derkyi et al. (2014), used the woody part of the Prekese fruit to produce charcoal, while Abugri et al. (2013), extracted oil from the seeds of the fruit as a by-product. According to the report, the fruit extract contains important phytochemicals and the seed oil also contains very beneficial fatty acids.

In Ghana, the species grows in the wild where the public collects the fruits and bark. Therefore, its sustainability is not promising so plantations are being been set up in order to continuously benefit from it. After maturity/ unproductive period (when the yield drops to the minimum level) the stem of the tree species is underutilized because there is no scientific information about the species. There is therefore the need to determine the basic and technological properties of the Prekese stem for its effective promotion and utilization. Hence the objective of the study is to determine the physical properties and develop the kiln-drying schedule for Prekese (*Tetrapleura tetraptera*) stem.

Three trees of Prekese (*Tetrapleura tetraptera*) were extracted at Daban a suburb of Kumasi using a chainsaw. The logs were cross-cut into billets of 2.5m lengths and were conveyed to CSIR- FORIG workshop. Discs of 30cm from the butt, middle and top were obtained from each tree. These were further processed into 2cm X 2cm square sections with rip, planer and band saw machines for the determination of green moisture content and basic density while and 2cm X 2cm X 10cm and 2cm X 10cm X 20cm samples were prepared for shrinkage characteristics and kiln drying schedule development respectively.

The green mass (W) of the sample cubes was determined and then oven dried at 101-105 °C until constant mass (D) was attained. The moisture content (MC) was then calculated according to the formula - BS 373 (1957) & ISO 3130 (1975): MC, %= ((W-D)/D) x 100%. For the basic density, the 2 cm cubes were soaked in water overnight. The basic density on swollen volume and oven-dried mass basis was determined by the hydrostatic or immersion method. The wood specimen was submerged in the water, and the mass of the container plus water plus specimen was determined. The wood blocks were then oven dried at 101-105 °C to constant mass and the oven-dried mass determined. The basic density was estimated as:

Basic density (kg/m^3) = Oven-dried mass (kg) / Volume of water displaced by swollen specimen (m^3) - ISO 3129 (1975) & DIN 52180 (1976).

The samples were dried from green to 12% moisture content (partial shrinkage) and from green to oven-dried state (total shrinkage) for the longitudinal (L), radial (R) and tangential (T) directional shrinkages. These were expressed as a percentage using the formula: Shrinkage = ((Change in dimension)/(green dimension)) X 100%

Each of the specimens was placed and taken from the oven every hour for the first four hours and then every two hours for the next four hours on the first day. Weighing was done after each removal from the oven and end and surface checks that had developed during the drying were observed and noted down. This procedure was repeated until all the specimens were completely oven-dried. The condition of maximum check defect was compared with the checking criteria according to Terazawa (1965) and the specimen was then awarded a corresponding checking, honeycombing and deformation classification.

The results showed that the mean basic density for the three wood sections, butt, middle and top, were estimated to be 553.7 kg/m3 (27.1% moisture content), 501.4 (23.4% moisture content) and 495.1 (32.9% moisture content) respectively while the overall for the three trees was 513.5 (28.1% moisture content). With the mean basic densities, there were significant differences between the sections at p,0.05. Based on the mean density Prekese (*Tetrapleura tetraptera*) is classified as a medium density wood, which is equivalent to some wood species like African mahogany (Khaya spp.), *Gmelina arborea*, Bediwonua (*Canarium schweinfurthii*), African Walnut (*Lovoa trichiliodes*) and *Pycnanthus angolensis*. The mean total tangential, radial and longitudinal shrinkages were computed as 5.08% 3.34% and 0.86% respectively. Since the mean total longitudinal shrinkage exceeded the standard value figure of 0.2%, attention needs to be paid to structural design details in areas where longitudinal stability is important. The ratio of tangential shrinkage to radial shrinkage (T/R) was low (1.52). Based on the defects and drying conditions for Prekese (*Tetrapleura tetraptera*), the drying kiln schedules of T11-A5 have been proposed. This drying schedule indicates that the wood can withstand high temperatures during kiln drying. The degree of cross-sectional deformation and honeycombing were both low, indicating that the wood does not tend to collapse.

The study therefore recommends that Prekese plantations (*Tetrapleura tetraptera*) should be encouraged and expanded because the stems are potentially utilizable timber species when the trees become unproductive. Further research is also needed to determine other basic and technological properties of the species in at least two ecological zones and to develop prototypes for efficient promotion and utilization.

Activity 3.2: Evaluation of Timber Species on the Domestic Markets in Ashanti Region of Ghana

Research Team: *F. W. Owusu, E. Appiah-Kubi, L. Damnyag, J. Korang, B. Darko Obiri, E. Ebanyenle, K. A. Oduro, S. Pentsil, J. Govina, H. Seidu, E. Asiedu Opoku, and B. Brentuo*

Donors: *Forestry Commission/ CSIR-FORIG*

The timber market study consisted of a survey of wood merchants or suppliers at domestic timber markets across the Ashanti and Brong Ahafo regions. To ensure an effective survey, the selected study areas were divided into two zones based on the study by Owusu at al. (2014). Each of the survey team comprised a minimum of four enumerators, who collected data within the same period of 6 days simultaneously across the region. According to earlier studies by Hansen *et al* (2012) and Obiri et al. (2009), the peak period for the timber market is when large volumes of timber of different species are conveyed to the market centres, which is due to the ease of felling trees and conveyance of timber from forest areas while the lean season is the reverse. These periods are the dry and rainy seasons respectively. Due to limited resources, the study was undertaken during the peak period.

The seventeen (17) domestic timber markets and that of Techiman that were previously surveyed by Owusu et al. (2014), were used. A structured questionnaire amidst personal interviews was used to collect data on inflows and outflows of lumber, as well as the types of species supplied to the domestic timber markets, dimensions of the timber products, their prices and the types or sources of the products. The data has been analysed descriptively and summarized appropriately in the required reports. To facilitate cooperation of the timber merchants in collecting the requisite data, discussions between the research team and the leaders of the Domestic Lumber Traders Association (DOLTA) were held. The objectives of the survey were to identify and document the emerging lesser-known and technologically-unknown timber species on the domestic timber market in the Ashanti region of Ghana and to determine the wood qualities of the emerging lesser-known and technologically-unknown timber species in the domestic timber markets.

Monthly total volumes of timber stocked and sold with their values have been determined including those of beams, boards and lumber, which are the three major timber products in the domestic timber markets that were surveyed (Table 2).

Table 2: *Timber volumes stocked and sold per month at the domestic timber markets in Ashanti region and Techiman with their values*

Wood products	Volume stocked m^3	Value stocked Ghc	Volume sold m^3	Value after sales Ghc
Beam	5747.02	6014410	4045.08	4233250
Board	11218.35	7957820	7198.35	5100780
Lumber	22490.07	22643717	13991.95	14047112
Total	**39455.44**	**36615947**	**25235.38**	**23381142**

Individuals constituting 28% were identified to be the major customers of the timber merchants. A total of fifty-five (55) timber species were surveyed (Table 3), out of which thirteen (13), as asterisked (**) in Table 3, have been identified to have no working/utilization properties. The types of timber supplied to the markets were bush cut and sawmill with 83% and 17% of total volumes stocked per month respectively and corresponding values of 77% and 23% in the same order.

Different dimensions of beam, board and lumber totalling 142 were surveyed across Ashanti region and Techiman. The percentages recorded were 11, 35 and 54 for beam, board and lumber respectively indicating that there is still too much waste in the system, hence dimensions of boards and lumbers need to be standardized. This will contribute to the sustainable forest management of the country.

There was a challenge with the selection and or collection of wood samples to determine the wood qualities of the emerging lesser-known and technologically-unknown timber species in the domestic timber markets. During the study the timber merchants could not identify specifically where their products came from since they got them from different sources. So collecting some of the products from the species without the sources was a challenge.

This is because the utilization properties of wood species are determined from at least two ecological zones in the country in order to generalize the results for the country. Identification of the sections per lumber was challenging and the willingness of the timber merchants to give some pieces of the emerging species was also an issue. Therefore, the WIUD of the institute will have to look for funding in order to develop the utilization properties of some identified emerging timber species.

A policy brief to be delivered to the appropriate government ministries is being drafted in order to bring the project to completion.

Table 3: *Timber species surveyed at the Domestic Timber Markets in the Ashanti region and Techiman in the Brong/Ahafo region*

Local name	Scientific name	Local name	Scientific name
Onyina	*Ceiba pentandra*	Edinam	*Entandrophragma angolense*
Wawa	*Triplochiton scleroxylon*	Wawabima	*Sterculia rhinopetala*
Esa	*Celtis spp*	Wonton**	*Morus mesozygia*
Ofram	*Terminalia superba*	Okoro	*Albizia zygia*
Watapuo/Wobire	*Cola gigantea*	Aprokuma	*Antrocaryon micraster*
Nyamedua	*Alstonia boonei*	Apapaye	*Turraeanthus africanus*
Dahoma	*Piptadeniastrum africanum*	Ngo-ne-nkyene**	*Cleistopholis patens*
Senya**	*Daniellia oliveri*	Bediwonua	*Canarium schweinfurthii*
Otie	*Pycnanthus angolensis*	Akasa	*Chrysophyllum spp*
Kyenkyen	*Antiaris toxicaria*	**Nyankum**	***Heritiera utilis***
Essia	*Petersianthus macrocarpus*	Wama**	*Ricinodendron heudelotii*
Emire	*Terminalia ivorensis*	Kumanini	*Lannea welwitschii*
Akonkodie/ Onyina-koben	*Bombax buonopozense*	Bonsamdua	*Distemunanthus benthamianus*
Odum	*Milicia excelsa*	Abako / Baku	*Tieghemella heckelii*
Danta / Apro	*Nesogordonia papaverifera*	Konkroma**	*Morinda lucida*
Yaya	*Amphimas pterocarpoides*	Kwabohoro	*Guarea cedrata*
Nakwa / Nokwa**	*Holoptelea grandis*	Efobrodedwo	*Entandrophragma utile*
Asanfena	*Aningeria altissima*	Penkwa	*Entandrophragma candollei*
Kotreamfo	*Ficus sur*	African Mahogany	*Khaya spp.*
Cedrella / Dua-gyeene	*Cedrela odorata*	Opam**	*Macaranga spp*
Kusia	*Nauclea diderrichii*	**Etwere / Apotwere****	-
Koto	*Pterygota macrocarpa*	Dawadawa**	*Parkia bicolor*
Denya	*Cylicodiscus gabunensis*	Akuakuonesuo**	
Hyedua	*Guibourtia ehie*	Katawani**	
Awiemfosamina	*Albizia ferruginea*	Okuo**	*Zanthoxylum gilletii*
Mansonia	*Mansonia altissima*	Sapele	*Entandrophragma cylindricum*
Tweneboa	*Cordia millenii*	Sintia**	
Dubenebiri African Walnut	*Lovoa trichilioides*	**Redwoods**	

**** Emerging wood species surveyed in the Ashanti region and Techiman timber market in the Brong Ahafo region.**

Activity 3.3: Wood and Furniture Testing Laboratory at CSIR-FORIG

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

Donor: *SECO/UNIDO*

UNIDO through funding from the State Secretariat for Economic Cooperation (SECO), Switzerland, is supporting CSIR-FORIG to set up and obtain accreditation for the Wood and Furniture Testing Laboratory at CSIR-FORIG under ISO 17025. The laboratory will test and certify wood products for exports to meet standards and become competitive in the international market. The objective is to enhance the export performance of Ghana by creating conditions for strengthening supply capacity in the wood industry.

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. A re-design of the existing laboratory to accommodate the new equipment has been done and renovation is completed. New equipment and devices have been delivered and installed at the laboratory. Few additional fixtures and devices have been requested and waiting for delivery.

Draft documentation for accreditation is in the final stages of validation. Additionally, a blank audit has also been conducted by UNIDO experts. Comments have been received and corrective actions are being implemented. UNIDO will take a decision on the Accrediting body and provide the schedule for accreditation. The furnishing of the Administrative and Manager's offices is completed. Two other offices for technicians are yet to be furnished.

The centre is collaborating with the Ghana Standards Authority (GSA) to use the facility to test and certify furniture, for both domestic and imported ones, before they are allowed into the market. Discussions are underway on this and an MOU is being drafted. The laboratory will start receiving products from GSA for testing in January 2019. The Wood and Furniture Testing Laboratory is currently going through the process of getting accredited under ISO 17025. The consultants from BFH, switzerland have conducted a blank audit. Corrective actions are being taken to address findings of the blank audit. UNIDO experts in Accra have also conducted a follow up audit.

A Proposal was submitted to UNIDO for funding and sponsorship of industry (companies) to patronise the services of the laboratory. The proposal was approved and funding has been made available for the testing services to industry. Products are expected from the companies for testing in January 2019.

Plate 9: Testing facilities in operation – testing the stability of a chair

4.0 SCIENCE AND PEOPLE (SP)

Background and Highlights of Research Achievements SP

Research activities under this theme was aimed at aligning science with the development priorities of local communities, government and development partners by focusing on the socio-economic and sustainable resource management and utilization as well as highlighting the services that forests provide to society. In this regard, the research agenda is primarily focused on the following thematic areas:

- Policy and Governance
- Statistical, Social and Economic Research
- Culture, Indigenous Knowledge and Community Improvement
- Technology for Livelihood and Wealth Creation

Activity 4.1.Co-operation to Scale Up Private Sector Involvement in Support of Mitigation and Adaptation to Climate Change, including Addressing the Drivers Of Deforestation and Forest Degradation, and Enhancement of Low Carbon Sustainable Development in Panama, Ghana And PNG

Research Team: *E. Foli, S. Adu-Bredu, K. A. Oduro, W. Dumenu, S. Pentsil, E. Obeng, K. Adjei, Y. Kwakye, J. Amoako, R. Adjei.*

Donor: *Coalition for Rainforest Nations/ Italy*

The Coalition for Rainforest Nations (CfRN), through an MoU with Italy and Ghana, Panama and Papua New Guinea, secured funds from the government of Italy for a project aimed at enabling these countries to maximize their efforts towards a low carbon economic growth and development. By this, CfRN intended to offer cooperation to scale up private sector involvement in support of mitigation and adaptation to climate change, including addressing the drivers of deforestation and forest degradation, and enhancement of low carbon sustainable development.

To achieve this objective in Ghana, the CfRN signed a service agreement with CSIR-Forestry Research Institute of Ghana (CSIR-FORIG) on 20th March 2017, requiring the latter to execute specific activities. This includes a set of actions such as creating an enabling environment and enhanced engagement with the private sector, and developing a strategy for scaling up (Activity 1) and reviewing the National Forest Reference Level (Activity 2).

The primary goal of Activity 1 is to review the legislative, institutional and policy framework at the national level with a view to encourage and catalyse private sector participation in the full implementation of REDD+. Specifically, it is aimed at evaluating the legal and policy framework pertaining to or affecting various elements of climate compatible development, including carbon ownership and rights, and to assess their suitability to enabling more dynamic private sector involvement in related activities such as REDD+. It is based on the following sub actions:

- High level review, Policy framework, Gap analysis, Tool development and Recommendations.

Activity 2 is aimed at reviewing the national Forest Reference Level with the goal to (a) ensure consistency with relevant UNFCCC decisions and IPCC GPGs and guidelines, and (b) ensure it is developed in the context of national development objectives. It is based on the following sub actions:

- Independent review;
- Demonstration;
- Refinement;
- Submission.

In accordance with the requirements spelt out in the service contract, CSIR-FORIG engaged the services of local specialists, in collaboration with the National REDD+ Secretariat, to assist in the implementation of the activities.

High Level Review

This task has been completed, followed by a policy consultation workshop to discuss the gaps identified, with recommendations leading to the way forward and next steps to guide the policy framework review, and addressing the private sector challenges in undertaking REDD+ activities. The consultant has submitted his final report.

Policy Framework

This task has been completed, and the policy workshop to discuss the recommendations to inform the final report was held at the Eastern Premier Hotel in Koforidua, Ghana on 13 December 2017. The consultant has been furnished with the reports on the gap analysis and the stakeholder consultation workshop to guide him in finalizing his report, which will take into account the comments and feedback from national authorities and major stakeholders at the workshop. This will be forwarded to the relevant national authorities.

Gap Analysis

The Gap analysis team at CSIR-FORIG successfully organized the "**Consultative Workshop on Policy Gap Analysis and Private Sector Engagement and Participation in REDD+ in Ghana**" in collaboration with the National REDD+ Secretariat. The Chief Executive of the Forestry Commission endorsed invitations to the participants. The Policy Workshop took place on 12 – 13 December 2017 at Eastern Premier Hotel, Koforidua for approximately 40 participants.

Tool Development

The Gap Analysis report under Task 3 and the draft report on the Consultative workshop on policy gap analysis and private sector engagement and participation in REDD+, was shared with the Consultant to guide him in this activity. This task has now been completed.

Task has been completed and a report submitted to the CfRN for review.

Demonstration

As a sequel to the Training and Demonstration workshop on Ghana's forest Reference Level which was held at Goaso, in October 2017, a national workshop is being planned to bring together stakeholders from other landscapes within the High Forest Zone, as well as policy level actors, to discuss the outcomes of the demonstration workshop and the lessons learnt.

Refinement

No further activity has been undertaken on this task since the submission of the revised FRL to the UNFCCC.

Submission

No further activity has been undertaken since the submission of the revised FRL to the UNFCCC.

CSIR-FORIG has so far executed the project satisfactorily and the only remaining task is the national level demonstration workshop, which the Forestry Commission has decided to take over for implementation.

5.0 COMMERCIALIZATION

Actvity 5.1: Commercialization and alternative livelihood promotion

The Commercialization Division (CD) drives the business activities of CSIR-FORIG. The CD is responsible for spearheading, coordinating, developing long-term collaborative programmes with stakeholders; and strategically marketing all commercial entities of the institute. Promotion and marketing of wood thinnings, high quality species of forest tree seeds and seedlings, quality honey, prekese syrup, bamboo plantlets, consultancies, training in sustainable livelihood programmes such as snail farming, beekeeping and mushroom production were activities undertaken during the year under review.

The 2018 marketing objective, 'Customer acquisition and retention' was for clients to experience and or have a taste of CSIR-FORIG's commercial offers. To achieve set targets, marketing communication strategies were adopted. Key among them were market penetration, market development, increased awareness/visibility through the print and electronic media (flyers, posters, banners), partnering selected radio stations/FM stations (10 visited) to promote commercial entities through talk shows and live interviews. The Institute's website and other social media platforms such Whatsapp, Facebook and YouTube videos were extensively used to increase awareness of commercial entities.

In 2018, the Commercialization Division made frantic efforts to promote and market commercial products and services. Efficient marketing and communication strategies were explored to acquire and retain loyal customers for all products including the production of over 8,000 bottles of prekese syrup (125 & 250 mls) and nearly 12,000 bottles of high quality honey (500 mls).

The Institute collected and processed seeds of various species; while over 380,000 ornamental and exotic seedlings were raised, marketed and sold to governmental and non-governmental organizations, donor funded projects, private plantation developers, universities, second cycle institutions and the general public. CSIR-FORIG successfully won two contracts from the Ghana National Petroleum Company (GNPC) for the supply of wooden boxes and the Kunsu Catholic Church for the production and supply of church pews. There were also many requests from various categories of clients for the supply of wood products such as furniture, coffins, beds, high quality doors, and window and doorframes.

Regarding transferable livelihood programmes, 400 individuals from a broad spectrum of the country such as Accra, Ho, Takoradi, Kumasi, Obuasi, Sunyani and Yeji were trained in the following technologies; snail farming (240), beekeeping for honey production (125) and mushroom cultivation (35). Since the reactivation of the Institute's training sessions, more focus has been placed on enhanced training delivery, which has resulted in the interest and willingness of clients to adopt these technologies. For the period July 2017 to July 2018, the percentage of trained people who started using acquired skills in beekeeping and snail farming were 52.1% (beekeeping) and 66.8% (snail farming). A paper titled: 'Lessons learned from the transfer of snail farming and beekeeping technologies in four regions of Ghana' was presented at the 16th Globelics International Conference held from 24th to 26th October, 2018 in Accra. A key lesson learnt is that unlike the initial popular view of most

Ghanaians, that the unemployed youths would readily patronize such training activities; patrons are rather gainfully employed professionals (medical doctors, nurses, pharmacists, scientists, engineers, bankers, lawyers, judges, lecturers, marketers and teachers).

Plate 10: Snail training practical session in Accra.

Feedback gathered from training activities indicates the growing interest of Ghanaians in medium to long-term commercial production of honey, snails and mushrooms. The marketing and sale of beekeeping and snail related equipment / materials were piloted during the year under review. A cost-benefit-analysis of these commercial entities was forwarded to Management for possible inclusion into the Institute's mainstream commercial activities for 2019.

Plate 11: A section of snail farming trainees after a course at CSIR-STEPRI

Plate 12: Trained beekeepers in bee suits during a practical session in Accra.

A retrospective view of the CD's 2018 performance indicates significant improvement in inflows from the production of prekese syrup and honey as compared to 2017. The division's target is to expand key facilities/equipment at the prekese production centre so as to boost up production, invest in the establishment of more beehives for increased yield, have a well-planned monitoring and evaluation system, improve packaging of products and intensify visibility and marketing strategies in 2019.

Activity 5.2: Production of Seedlings by the National Tree Seed Centre (NTSC) for Reforestation

The NTSC was established among other things to ensure the conservation and production of superior quality seeds. During the year under review, seeds were collected and processed for storage in a cold room as a gene bank. Seedlings were also produced from seeds collected for planting purposes. The following quantities of seeds and seedlings were produced.

Table 4: List of seeds collected and issued during the period under in 2018

Species	Initial Quantity (Kg)	Quantity Supplied (Kg)	Quantity In Stock (Kg)
Ofram	300	174	126
Kusia	5.9	0.8	5.10
Albizia lebbeck	79	1	78
Militia	2	2	0

Species	Initial Quantity (Kg)	Quantity Supplied (Kg)	Quantity In Stock (Kg)
Cedrela	26	20	6
Emire	193	69	124
Prekese	44	2	42
Mansonia	17	3	14
Mahogany	24	24	0
Kokrodua	4	2.5	1.5
Acacia	1	1	0
S. siamea	2	2	0
Odum	0.84	0.41	0.43
Denya	1	0	1
Teak	764	764	0
Black hyedua	35	1	34
Edinam	6	6	0
TOTAL	**1,504.74**	**1,072.71**	**432.03**

Seedlings produced by NTSC

The total number of seedlings raised and released for planting in the year under review was 455,917 and 357,201, respectively. The estimated stock of seedlings at the nursery as at 31st December 2018 was 98,716. Table 5 shows the details

Table 5: Seedlings produced and supplied in 2018

Species	Quantity Produced	Quantity Lifted/Issued	Quantity in Stock	Seedling Distribution
Tectona grandis seedlings	40,000	38,230	1,770	Other customers
	100	100	0	KMA
Tectona grandis stumps	100,000	55,150	44,850	Raised for FC Industry plantation
Millettia thonningii	5,370	370	5,000	KMA
Milicia excelsa	200	200	0	KMA
Wawa	6,500	6,345	155	Other customers
	200	200	0	Other customers
Emire	35,000	34,125	875	Other customers
	120	120	0	Other customers
Mahogany	18,000	15,342	2,658	Other customers
Bako	250	250	0	Other customers
	1,707	940	767	FIP
	10	10	0	KMA

Species	Quantity Produced	Quantity Lifted/Issued	Quantity in Stock	Seedling Distribution
Ofram	42,000	41,940	60	Other customers
	800	800	0	KMA
Eucalyptus	1,000	600	400	Other customers
	230	230	0	KMA
Mansonia	10,000	9,875	125	Other customers
	10	10	0	KMA
Odum	5,000	4,485	515	Other customers
Kusia	17,000	16,050	950	Other customers
	4,500	2,696	1,804	FIP
	230	230	0	Other customers
Cassia	100	50	50	Other customers
Hyedua	1,500	1,500	0	Other customers
	20	20	0	KMA
	11,700	1,220	10,480	FIP
Edinam	3,000	2,600	400	Other customers
Cedrela odorata	114,000	111,150	2,850	Other customers
	330	330	0	KMA
Terminalia montalis	5,010	510	4,500	KMA
Ceiba	1,700	1,675	25	Other customers
Kokrodua	100	100	0	Other customers
	20	20	0	KMA
	6,500	2,260	4,240	FIP
Prekese	1,000	500	500	Other Customers
Dahoma	160	160	0	Other customers
Akyee	6730	3330	3400	Other customers
Allanblackia	660	200	460	NOVELLA Project
Acacia	2000	0	2000	Other customers
	100	100	0	Other customers
Subtotal	*442,857*	*354,023*	*88,834*	
ORNAMENTALS				
Montalis	300	125	175	
Millettia	400	290	110	
Royal palm	9292	1610	7682	KMA
	300	17	283	
Blighia	800	403	397	

Species	Quantity Produced	Quantity Lifted/Issued	Quantity in Stock	Seedling Distribution
Weeping willow	200	115	85	
	1768	618	1150	
Subtotal	***13,060***	***3,178***	***9,882***	
GRAND TOTAL	**455,917**	**357,201**	**98,716**	

A total of 24,407 seedlings were produced for the Forest Improvement Programme (FIP) project, out of which 7,116 was supplied. For the KMA Urban Forestry Project, a total of 30,540 seedlings were produced, out of which 8,808 were lifted. For the NOVELLA Project, *a* total number of seedlings potted were 660. Two hundered of this number has been sold. A total of 100,000 Teak stumps were raised for FC Industry, out of which only 44,850 (44.9%) were lifted, with the remaining 55,150 (55.1%) seedlings still sitting on beds.

Out of a total of 24,407 seedlings raised for FIP, only 7,116 were lifted with as many as 17,291 (70.8%) seedlings remaining in the nursery. Due to the inability of the projects to lift 50% of their orders, the nursery is saddled with the management and maintenance of the remaining 60% of the seedlings.

6.0 EDUCATION AND CAPACITY BUILDING

Activity 6.1: Promoting Educational Leadership in Climate Science and Integrated Natural Resources Management at Master of Philosophy and Master of Science Levels

CCST- Climate Change and Integrated Natural Resources Management Programme

CSIR-FORIG through CCST has underscored its resolve to create opportunities for many Ghanaians and nationals from other West African countries to be trained to acquire professional skills and expertise needed to manage the threat of climate change in their respective countries. The programme has, in the past year (2018), targeted natural resource managers who wish to enhance skills as well as those who wish to continue their studies after obtaining a Bachelor's degree. The Programme also targets people who are already working in different sectors of forestry and wish to build a new career pathway into Climate Change and Natural Resources Management. The above-mentioned programme being promoted by CSIR-FORIG at Fumesua, near Kumasi, is aimed at providing an elevated level of professional and technical expertise to address the challenges of climate change and natural resources management in West Africa. The programme has so far delivered some empirically grounded and conceptually rich courses to 14 students who are expected to exit the programme with the knowledge, skills and competencies highly desired in the public, private and not-for-profit sectors.

Scholars of CSIR-FORIG who are renowned for their research and education in the fields of climate science and natural resources management are delivering the programme. Among the courses taught are Climate Science, Climate Change Impact, Adaptation and Mitigation, Climate Change Modelling, Geographical Information Systems (GIS), Project Planning and Management, Scientific Communication, Innovative Processing and Sustainable Utilization of Biomaterials and other useful courses. Learning has been accomplished through problem-based group work activities, presentations, interactive students-led seminars, laboratory work, literature-based research and/or assignments and discussions online and offline on the distance learning platform (Moodle). This was done alongside face-to-face teaching (conventional lectures). The Moodle platform for teaching enables students to learn at their own convenience from a distance, while face-to-face classroom interactions are organized at a time that is convenient to both students and lecturers.

During the year under review, teaching of the first semester courses was concluded successfully and the end-of-semester examinations were also successfully conducted. The Institutional Affiliation Office of the University of Cape Coast conducted pre-and post-examination moderation exercises successfully. Procedures for admission of new students for the 2018/2019 academic year resulted in the admission of seven more students to the MPhil programme, bringing the total number of students enrolled on the programme so far to 41. The college's Climate Change and Integrated Natural Resources Management programme was reviewed by the National Accreditation Board (NAB) for re-accreditation and the revised programme document was submitted through the college registry to the NAB based on the reviewer's comments.

7.0 ADMINISTRATION DIVISION

7.1 Objectives:

The main objectives of the division include the following:

i) To ensure implementation of policies, procedures, rules and regulations of Corporate CSIR at the Institute level to facilitate effective and efficient performance of work by all Divisions.

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

7.2 Staff Strength

The total staff strength of the Institute, as of December 2018 was 216. The breakdown is as follows:

Staff Category	No.
Senior Members	49
Technologists	5
Senior Staff	73
Junior Staff	89
Total	**216**

7.3 Staff Training

Currently the total staff in training stands at seventeen (17). The detail with respect to level and type of training is summarized in the table below:

Level of Training	Type of Training		Total
	Local	*Foreign*	
Ph.D	3	7	10
MPhil./MSc./MA.	1	3	4
BSc./BA	2	-	2
Others	1		1
Total	**7**	**10**	**17**

7.4 Promotions and Upgrading

A total of fifteen (15) staff members were promoted during the period. The list comprises of eight (8) Senior Members seven (7) Senior Staff and eight (8) Junior Staff members. The details of the promotion is as follows:

Promotions

Senior Members

No.	Name	Former Grade	Present Grade	Effective Date
1.	Prof. Paul P. Bosu	Principal Research Scientist	Chief Research Scientist	1st January, 2018
2.	Mr. Francis W. Owusu	Senior Research Scientist	Principal Research Scientist	1st January, 2018
3.	Dr. Kwasi Dua-Gyamfi	Research Scientist	Senior Research Scientist	1st January, 2018
4.	Dr. (Mrs) Elizabeth A. Obeng	Research Scientist	Senior Research Scientist	1st January, 2018
5.	Mrs. Sarah Pentsil	Research Scientist	Senior Research Scientist	1st July, 2018
6.	Ms. Comfort Kontoh	Administrative Officer	Senior Administrative Officer	1st January, 2018
7.	Mrs. Georgia Marfo Coffie	Administrative Officer	Senior Administrative Officer	1st January, 2018
8.	Ms. Naomi Appiah	Marketing Officer	Senior Marketing Officer	1st January, 2018

Senior Staff

No	Name	Former Grade	Present Grade	Effective Date
1.	Mr. Osei Tutu Boateng	Principal Administrative Assistant	Chief Administrative Assistant	1st Jan, 2018
2.	Mrs. Anastasia Konadu Duah-Gyamfi	Principal Administrative Assistant.	Chief Administrative Assistant	1st Jan, 2018
3.	Mr. Kwaku Asumadu	Principal Marketing Assistant	Chief Marketing Assistant	1st Jan, 2018
4.	Mr. Ebenezer Ofori	Senior Technical Officer	Principal Technical Officer	1st Jan. 2018
5.	Mr. George Kwabla Kpodo	Security Officer	Senior Security Officer	1st Jan, 2018
6.	Mr. Michael Kwarteng	Security Officer	Senior Security Officer	1st Jan, 2018
7.	Mr. Maxwell Asante Boachie	Security Officer	Senior Security Officer	1st Jan, 2018

Junior Staff

No	Name	Former Grade	Present Grade	Effective Date
1	Mr. Stephen K. Appiah	Security Assistant Grade I	Snr. Sec Assistant	1st Jan, 2018
2	Daniel Awatey	Superintendent Grade II	Superintendent Grade I	1st Jan., 2018
3	John Mensah	Labourer	Snr. Labourer	1st Jan., 2018
4	Samuel Boateng	Superintendent Grade II	Superintendent Grade I	1st Jan., 2018
5.	Stephen E. K. Acheampong	Senior Security Assistant	Security Officer	1st Jan, 2018

No	Name	Former Grade	Present Grade	Effective Date
6.	Mrs. Eunice B. Boadi	Senior Technical Assistant	Technical Officer	1st Jan, 2018
7.	Mr. Ansah K. Joseph	Senior Security Assistant	Security Officer	1st Jan, 2018
8.	Mr. Richard Acquah	Traffic Supervisor	Assistant Transport Officer	1st Jan, 2018

Upgrading

No.	Name	Former Grade	Present Grade	Effective Date
1.	Osei Tutu Boateng	Chief Admin. Assistant	Administrative Officer	30th Oct., 2018
2.	Samuel Atusong	Chief Accounting Assistant	Accountant	30th Oct., 2018
3.	Gifty Wiafe-Mensah Tengkorang	Chief Accounting Assistant	Accountant	30th Oct., 2018
4.	Haruna Seidu	Principal Technical Officer	Principal Technologist	30th Oct., 2018
5.	Dorothy Asare Akoto	Principal Technical Officer	Principal Technologist	30th Oct.r, 2018
6.	Daniel K. Debrah	Principal Technical Officer	Principal Technologist	30th Oct., 2018
7.	James Oppong Amponsah	Chief Technical Officer	Principal Technologist	30th Oct., 2018
8.	Christian Opoku- Kwarteng	Principal Technical Officer	Principal Technologist	1st Nov., 2018

7.5 Compulsory Retirement

A total of ten (10) members of staff went on compulsory retirement from the service of the Council during the year 2018. The breakdown is as follows:

a)	Senior Member	2
b)	Senior Staff	6
c)	Junior Staff	2
	Total	**10**

7.6 Leave of Absence

CSIR granted approval for one year leave of absence to two Senior Members as follows:

1. Dr. Stephen L. Tekpetey - Wood Industry and Utilisation (WIUD) effective 1st January, 2018
2. Dr. Sandra Owusu Acheampong - Forest Improvement and Productivity Division (FIPD) effective 1st April, 2018

7.7 Resumption of Duty from Study Leave

Five (5) staff members, two each from Senior Members and Senior Staff categories, successfully completed during the year under review. The five (5) resumed duty as below :

No.	Name	Programme Offered	Date Resumed Duty
1	Dr. Shalom Addo-Danso	PhD, Forestry	27th June, 2018
2	Dr. Charles Essien	PhD, Forestry	12th December, 2018

No.	Name	Programme Offered	Date Resumed Duty
3	Ms. Dorothy Asare Akoto	MSc, Tropical Forestry	1st March, 2018
4	Ms. Safia Ibrahim	MPhil, Economics	5th September, 2018
5	Mrs Jemima Owusu	BSc Chemical Engineering	4th June 2018

7.8 Bereavement

During the first quarter of the year, precisely 4th February 2018, one Junior staff member, Mr. Emmanuel Siaw, attached to Bobiri Research Station passed on to glory. May he Rest In Peace.

7.9 Major Events

The following major events took place during the year as follows:

No	Event	Date
1.	Visit by the new CSIR Council Chairman, Prof Robert Kingsford Adaboh	17th January, 2018
2.	Inauguration of Wood and Furniture Testing Centre	6th February, 2018
3.	Hosting of Directors Management Committee (DMC) Meeting	13th – 15th February, 2018
4.	Internal Management Committee (IMC) Meeting	22nd March, 2018
5.	Inauguration of CSIR-FORIG Management Board	27th March, 2018
6.	Staff Durbar	27th April, 2018
7.	R-Statistics Workshop for Scientists & Technicians	9th April, 2018
8.	E-Capacities Platform Workshop	5th June, 2018
9.	FORIG Staff Fund 14th Annual General Meeting (AGM)	8th June, 2018
10.	43rd CSIR-FORIG Management Board Meeting	21st June, 2018
11.	Africa Scientific Renaissance Day Celebration	29th June, 2018
12.	CSIR Senior Members Forum	5th July, 2018
13.	74th Internal Management Committee (IMC) Meeting	10th July 2018
14.	CSIR Tripartite Lands Committee Meeting	4th July, 2018
15.	CSIR-FORIG: 2018 Mid-Year Review Meeting	17th July, 2018
16	CSIR-FORIG Open Day Celebration	14th August, 2018
17.	75th Internal Management Committee (IMC) Meeting	21st November, 2018
18.	Senior Staff Association (SSA) Conference	16th – 19th October, 2018
19.	Research Staff Association (RSA)	18th – 19th October, 2018
20.	Annual Planning (Review)	3rd – 5th December, 2018
21.	2nd Graduation Ceremony of the MSc/eMBA (ECORES) Programme	14th December, 2018
22.	Annual Staff Get-together and send off for retirees	20th December, 2018

7.10 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 I and II.

8.0 FINANCE DIVISION

8.1 objectives

Objectives of Finance Division are as follows:

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

8.2 Summary of Financial Results - 2018

Government of Ghana	Inflows (GHC)	Outflows (GHC)	Variance (GHC)
Personnel Emoluments (Note 1)	9,582,026	9,582,026	-
Administrative Expenditure (Note 2)	-	1,389,575	-1,389,575
Service Expenditure (Note 3)	-	316,287	-316,287
Internally Generated Funds	1,548,194	378,360	1,169,834
Guest Houses	228,205	63,767	164,438
Production Unit	189,940	119,457	70,483
Total	**11,548,365**	**11,849,472**	**-301,107**
Donor (Note 4)	6,222,976	6,889,120	-666,144
Grand total	**17,771,341**	**18,738,592**	**-967,251**

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 this expenditure.

Note 2: The Administrative expenditure was financed from IGF and administrative support from projects.

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

Note 4: Donor funds were received in Pounds and Ghana cedis. Average exchange rates were used (£/GHS=6.09) to convert them into Ghana cedis.

Note 5: The report is a draft one, as our account is yet to be audited.

9.0 STAFF PUBLICATIONS

9.1 Journal Papers

1. Acquah G, Essien C., Via, B. K. Billor, N. & Eckhardt L. G. (2018). Estimating the basic density and mechanical properties of elite loblolly pine families with near Infrared Spectroscopy *Forest Science* 64(2) 149 – 158 doi: 10.1093/forsci/fxx009

2. Acquah, S. B., Sraku-Lartey, M., Samar, S. B. & Djagbletey, G. D. (2018). Traditional knowledge and consumption of forest plant foods in Ghana. *Ghana Journal of Forestry,* 34 (1) 49-70.

3. Addo-Danso, S.D., Prescott, C.E., Adu-Bredu, A., Moore, S., Guy D.R., Forrester, D.I., Owusu-Afriyie, K., Marshall, P.L., & Malhi, Y. (2018). Fine-root exploitation strategies differ in tropical old growth and logged-over forests in Ghana. *Biotropica, 50* 606-615.

4. Adu-Bredu S., Ofori D.A., Ræbild A., Hansen J.K., Koffi A., Vigneron P., Erik, D. & Kjær, E.D. (2018). Trait variations in 28-year-old teak (*Tectona grandis*) provenance field trials in Ghana, West Africa. *Southern Forests: A Journal of Forest Science*, DOI: 10.2989/20702620.2018.1490993.

5. Aguilar, F.X, Obeng, E. A. & Cai, Z. (2018). Water quality improvements elicit consistent willingness-to-pay for the enhancement of forested watershed ecosystem services. *Ecosystem Services* 30, 158-171.

6. Amissah, L., Mohren, G. M. J., Kyereh, B., Agyeman, V. K. & Poorter, L. (2018). Rainfall seasonality and drought performance shape the distribution of tropical tree species in Ghana. *Ecology and Evolution*, 1-16. DOI: 10.1002/ece3.4384

7. Amponsah, J. O.; Maaleku, B. K., Djagbletey, G. D., Asomaning, J. M., Kumah, F. & Tandoh, P. K. (2018). Phenology and seed germination improvement of *Terminalia superba* and *Terminalia ivorensis* in a moist semi-deciduous forest in Ghana. *Ghana Journal of Forestry, 34* (1) 1-14.

8. Antwi-Wiredu, A., Amiteye, S., Diawuoh, R. G. & Klu, G.Y. P. (2018). *Ex vitro* propagation of rubber tree (*Hevea brasiliensis*) using stem cuttings. *International Journal of Environment, Agriculture and Biotechnology, 3*(3) 846-854 http://dx.doi.org/10.22161/ijeab/3.3.20

9. Antwi-Wiredu, A., Amiteye, S., Diawuoh, R. G. & Klu, G.Y. P. (2018). *In vitro* propagation of rubber tree (*Hevea brasiliensis*) using shoot-tip and nodal cutting explants. *International Journal of Advances in Scientific Research and Engineering, 4*(6) 17-29. DOI: http://dx.doi.org/10.7324/IJASRE.2018.32743

10. Armani M., van Langevelde F., Tomlinson K.W., Adu-Bredu S., Djagbletey, G.D. & Veenendaal, E.M. (2018). Compositional patterns of overstorey and understorey woody communities in a forest-savannah boundary in Ghana. *Plant Ecology and Diversity* DOI: 10.1080/17550874.2018.1539133

11. Banibéa Sanbena Bassan, B.S., Nuto, Y., Bosu, P. P., Komina Amevoin, K. & Kokou, K. (2018). Insectes associés à Nauclea diderrichii (Rubiaceae): diversité, caractéristiques et importance des dégâts Au Togo, Afrique De l'Ouest. *Afrique Science 14*(6) 103-115

12. Bosu, P. P., Frimpong-Anin, K., Adjaloo, M.K., Braimah, H., Oduro, W., Annoh, C. E. Aidoo, K. & Kwapong, P.K. (2018). Monitoring insect populations in cocoa agro-ecosystems within the catchment of the Bobiri Forest Reserve in Ghana. Ghana Journal of Horticulture (JHORT) 13(1) 121-136.

13. Darko Obiri, B., Obeng, E. A, Nunoo, I, Peprah, T. & Opuni Frimpong, E. (2018). Financial analysis of fuelwood production from woodlots in the savannah transition zone of Ghana. *Ghana Journal of Forestry*, *34* (1) 35-48

14. Djagbletey, G.D., Adu-Bredu, S., Duah-Gyamfi, A., Abeney, E.A., Asante, W.A., Akyeampong, E., Addo-Danso, S.D., Ametsitsi, G.K., Amponsah-Manu, E., Dabo, J., & Amponsah, J.O. (2018). Floristic composition and carbon stocks of tree species of different conservation status following selective logging in a moist semi-deciduous forest in Ghana. *Ghana Journal of Forestry*, *34*(1) 15-34.

15. Durán, J., DelgadoBaquerizo, M., Dougill, J. A., Guuroh, R.T., Linstädter, A., Thomas, A. D. & Maestre, F.T. (2018). Temperature and aridity regulate spatial variability of soil multifunctionality in drylands across the globe. *Journal of Ecology*, 99 (5) 1184 – 1193.

16. Essien, C., Via, B. K., Cheng, Q., Gallagher, T., McDonald, T., & Eckhardt, L. (2018). Determining the predictive accuracy of whole tree modulus of elasticity (MOE) of 14-year-old loblolly pine using density and dynamic MOEs estimated by three different acoustic tools. *European Journal of Wood and Wood Products*,1-12. https://doi.org/10.1007/s00107-018-1317-9

17. Essien C., Via, B. K., Gallagher, T. McDonald, T. and Eckhardt, L. G. (2018). Distance error for determining the acoustic velocity of standing tree using tree morphological, physical and anatomical properties doi.org/10.1007/s13196-018-0208-3

18. Ferner, J., Schmidtlein, S., Guuroh, R. T., Lopatin, J., & Linstaedter, A., (2018). Disentangling effects of climate and land-use change on West African drylands' forage supply. *Journal of Global Environmental Change, 53*: 24 – 38.

19. Guuroh R. T., Linstädter, A., Ferner, J., Canak, K., Ruppert, J. C., & Schmidtlein, S., (2018). Drivers of forage provision and erosion control in West African savannas – A macroecological perspective. *Journal of Agriculture, Ecosystems and Environment, 251*: 257 – 267.

20. Gvozdevaite A., Oliveras I., Domingues T.F., Peprah T., Boakye M., Afriyie L., da Silva K.P., de Farias J., de Oliveira E.A., Farias C.C.A., Prestes N.C.C.S., Neyret M., Moore S., Marimon B.S., Marimon Junior B.H., Adu-Bredu S. & Malhi Y. (2018). Leaf-level photosynthetic capacity dynamics in relation to soil and foliar nutrients along forest–savannah boundaries in Ghana and Brazil. *Tree Physiology*, 38(12): 1912–1925. doi:10.1093/treephys/tpy117

21. Janssen T.A.J., Ametsitsi G. K. D., Collins M., Adu-Bredu S., Oliveras I., Mitchard E.T.A. & Veenendaal E.M. (2018). Extending the baseline of tropical dry forest loss in Ghana

(1984–2015) reveals drivers of major deforestation inside a protected area. *Biological Conservation 218:* 163-172.

22. Julier A.C.M., Jardine P.E., Adu-Bredu S., Coe A.L., Duah-Gyamfi A., Fraser W.T., Lomax B.H., Malhi Y. Moore S., Owusu-Afriyie K. & Gosling W.D. (2018). The modern pollen–vegetation relationships of a tropical forest–savannah mosaic landscape, Ghana, West Africa. *Palynology 42***:** 324-338.

23. Julier A.C.M., Jardine P.E., Adu-Bredu S., Coe A.L., Fraser W.T., Lomax B.H., Malhi Y., Moore & Gosling W.D. (2018). Variability in modern pollen rain from moist and wet tropical forest plots in Ghana, West Africa. *Grana*, 58(1) 45-62, https://doi.org/10.1080/00173134.2018. 1510027.

24. Kemigisha, E., Owusu, E.O., Elusiyan, C. A., Omujal, F., Tweheyo, M. & Bosu, P. P. (2018). *Tetrapleura tetraptera* in Ghana, Nigeria and Uganda: households uses and local market. *Forests, Trees and Livelihoods*. DOI: 10.1080/14728028.2018.1498027

25. Mitchual S. J., Minkah M. A., Owusu, F. W. & Okai, R. (2018). Planning and turning characteristics of *Gmelinaarborea* grown in two ecological zones in Ghana. *Advances in Research*, *14*(2) 1-11. DOI: 10.9734/AIR/2018/39024

26. Moore, S., Adu-Bredu, S., Duah-Gyamfi, A., Addo-Danso, S.D., Ibrahim, F., Mbou, A.T., de Grandcourt, A., Valentini, R., Nicolini, G., Djagbletey, G., Owusu-Afriyie, K., Gvozdevaite, A., Oliveras, I., Ruiz-Jaen, M.C., & Malhi, Y. (2018). Forest biomass, productivity and carbon cycling along a rainfall gradient in West Africa. *Global Change Biology*, *24*(2) 496-510.

27. Obeng, E. A. & Aguilar FX. (2018). Value orientation and payment for ecosystem services: perceived detrimental consequences lead to willingness-to-pay for ecosystem services. *Journal of Environmental Managemen*t *206*, 458-471.

28. Obeng, E. A., Aguilar, F. X. & McCann, L. M. (2018). Payments for forest ecosystem services: a look at neglected existence values, the free-rider problem and beneficiaries' willingness to pay. *International Forestry Review*, *20*(2) 206-219

29. Oduro, K.A., Arts, B., Kyereh, B., & Mohren, G. (2018). Farmers' motivations to plant and manage on-farm trees in Ghana. *Small-scale Forestry 17*(3) 393-410.

30. Owusu, F. W., Damnyag, L., Marfo, E., & Oppong, J. A. (2018). The demand and supply patterns of timber at the domestic market in Ghana. *Agriculture and Natural Resources Special, 1: 63-79.*

31. Rifai, S.W., Girardin, C.A.J., Berenguer, R., del Aguila-Pasquel, J., Dahlsjö, C.A.L., Doughty C.E., Jeffery, KJ., Moore, S., Oliveras, I., Riutta, T., Rowland, L.M., Murakami, A.A., Addo-Danso, S.D., Brando, P., Burton, C., Ondo, F.E., Duah-Gyamfi, A., Amézquita, R.F. Freitag, R., Pacha, F.H., Huasco, W.H., Ibrahim F., Mbou, A.T., Mihindou, V.M., Peixoto, K.S., Rocha, W., Rossi, L.C., Seixas, M., Silva-Espejo, J.E., Abernethy, K.A., Adu-Bredu, **S.**, Barlow J., da Costa, A.C.L., Marimon, B.S., Marimon-Junior, B.H., Meri, P., Metcalfe, D.B., Phillips, O.L., White, L.J.T., & Malhi, Y. (2018). ENSO drives interannual variation of forest woody growth across the tropics. *Philosophical Transactions of the Royal Society B: Biological Science*, *373*: 20170410. doi: 10.1098/rstb.2017.0410.

32. Sraku-Lartey, M., Buor, D., Adjei, P. O. W., & Foli, E. G. (2018). Perceptions and knowledge on climate change in local communities in the Offinso Municipality, Ghana. *Information Development*, 1-20. DOI: 10.1177/0266666918811391

33. Thomson E.R., Malhi Y., Bartholomeus H., Oliveras I., Gvozdevaite A., Peprah T., Suomalainen J., Quansah J., Seidu J., Adonteng C., Abraham A.J., Herold M., Adu-Bredu, S. & Doughty C.D. (2018). Mapping the leaf economic spectrum across West African tropical forests using UAV-Acquired Hyperspectral Imagery. *Remote Sensing* (2018) 10: 1532; doi: 10.3390/rs10101532 www.mdpi.com/journal/remotesensing.

34. Tsobeng A., Asaah E., Leakey R., Tchoundjeu Z., Van Damme, P., Ofori D. & Jamnadass R. (2018). Effects of pre-severance irradiance on the growth of Allanblackia floribunda Oliv. stockplants and on the subsequent rooting capacity of leafy stem cuttings. *International Journal on the Biology, Biotechnology, and Management of Afforestation and Reforestation.* ISSN 0169-4286. New Forests DOI 10.1007/s11056-018-9673-1

35. Zhou, L., Lin S., Huang P., Lin, S., Addo-Danso, S.D., Ma Z., & Ding G. (2018). Effects of leaf age and exogenous hormones on callus initiation, rooting formation, bud germination, and plantlet formation in Chinese fir leaf cuttings. *Forests*, 9(8) 478. doi: 10.3390/f9080478.

9.2 Published Abstracts

1. Adutwum-Oppong, J. and Appiah-Kubi, E. (2018). Physical Properties of *Gmelina arborea* Roxb. Ex Sm. Timber Species Grown in the Dry Semi-Deciduous Forest Zone in Ghana. Paper presented at the first CSIR-RSA Scientific Conference held at GNAT village, Abankro-Ejisu on 17th October 2018. Theme "Catalysing economic development through scientific innovations", Book of Abstracts page 15.

2. Appiah-Kubi, E., Owusu, F.W., Ebanyenle, E., Korang, J., Damnyag, L. & Brentuo, B. (2018). Sustaining the furniture and wood industry in Ghana through Accredited Laboratory Testing Services. Paper presented at the first CSIR-RSA Scientific Conference held at GNAT village, Abankro-Ejisu on 17th October 2018.

3. Obiri, B.D., Obeng, E.A., Nunoo, I., Marfo, E., Owusu, F.W. & Adjei, R.K. (2018). Profits and constraints along the Ghanaian charcoal value chain. 4th Annual Flare Meeting, University of Copenhagen, Denmark, 17th - 20th October, 2018.

4. Owusu, F.W., Boakye, F., Oppong-Adutwum, J. & Mensah, M. (2018). Conversion of *Pterocarpus erinaceus* Poir (African Rosewood) into lumber using Wood-Mizer. Paper presented at the first CSIR-RSA Scientific Conference held at GNAT village, Abankro-Ejisu on 17th October 2018. Theme "Catalysing economic development through scientific innovations", Book of abstracts page 38.

5. Owusu, F.W., Parker, J.M., Sampene, S.M., Amonoo, J. & Agyenim-Boateng (2018). Developing alternative livelihood for Ghanaian illegal chainsaw operators: production of legal lumber through artisanal milling at three localities. Abstract accepted for presentation at the 2018 Joint convention of the Society of Wood Science and Technology (SWST) and the Japan Wood Research Society (JWRS) held on November 5-9,

2018 in the Noyori Conference Hall, Nagoya University and Nagoya Noh Theater, Nagoya, Japan. Theme: "Era of Sustainable World -Tradition and Innovation for Wood Science and Technology"

9.3 Books and Handbooks

1. Asomaning, J.M. (2018). A guidebook for tree seed testing. CSIR-FORIG Publication. 59 pages.

9.4 Conference Papers

1. Adu, G. and Appiah-Kubi, E. (2018). Bamboo as a business opportunity: The case of bamboo charcoal production. Paper presented at the Global Bamboo and Rattan Congress, BARC 2018, Beijing, China, 25th- 27th June, 2018.

2. Amissah, L. and Hagan Brown, W. (2018). Growth, wilting and physiological response of tree crops to simulated drought. 1st CSIR-RSA Scientific Conference, Book of Abstract. Page 8.

3. Appiah-Kubi, E., and Ofori, D.A. (2018). Harnessing the potential of Bamboo for socio-economic development in Ghana: The role of CSIR-FORIG. Paper presented at the 1st National Bamboo Stakeholders and Investment Forum. Organized by BARADEP and MLNR. Held at the La Palm Beach Hotel, Accra, 18th September 2018.

4. Appiah-Kubi, E., and Ofori, D.A. (2018). Harnessing the potential of Bamboo for socio-economic development in Ghana: The role of CSIR-FORIG. Paper presented at the 1st National Bamboo Stakeholders and Investment Forum. Organized by BARADEP and MLNR. Held at the La Palm Beach Hotel, Accra, 18th September, 2018.

5. Appiah-Kubi, E., Govina, J.K., Owusu, F.W. and Korang, J. (2018). Treatment of Bamboo culms for artisanal training in Ghana. Overseas training course on Bamboo and Rattan Product Development technology for Ghanaian Artisans. Organized by ICBR and INBAR, BARADEP and held at Forestry Commission Training Centre (FCTC), Ejisu from 15th October – 14th November 2018.

6. Appiah-Kubi, E., Osiakwan, J., Kwaku, M., Dovi, S. (2018). Bamboo for land scape restoration and poverty alleviation in Ghana through south-south cooperation and support. Paper presented at the Global Bamboo and Rattan Congress, BARC 2018, Beijing, China. 25th – 27th June, 2018.

7. Appiah-Kubi, E., Osiakwan, J., Kwaku, M., Dovi, S. (2018). Bamboo for landscape restoration and poverty alleviation in Ghana through South-South cooperation and support. Paper presented at the Global Bamboo and Rattan Congress, BARC 2018, Beijing, China. 25th – 27th June, 2018.

8. Appiah, Y.F.A., Damnyag, L. 2018. An evaluation of Ghana's cocoa rehabilitation policy—lessons on farmer participation in two districts. First CSIR-RSA Scientific Conference, Ejisu-Abankro, Kumasi, October 17, 2018.

9. Bosu, D.E., Pentsil, S. 2018. Participation of rural women in Ghana reforestation programme: consideration of education, incentives and socio-cultural issues. First CSIR-RSA Scientific Conference, Ejisu-Abankro, Kumasi, October 17, 2018.

10. Damnyag, L., Bampoh, A. A. 2018. Local knowledge on tree values and strategies for managing smallholder forest plantations in three forest reserves in Ghana. First CSIR-RSA Scientific Conference, Ejisu-Abankro, Kumasi, October 17, 2018.

11. Djagbletey, G. D., Adu-Bredu, S., Abeney, E. A., Asante, W. A., Dua-Gyamfi, A., Addo-Danso, S., Ametsitsi, G. K., Amponsah-Manu, E. and Dabo, J. (2018). Recovery of economic (Timber) species after selective logging of a moist semi deciduous forest in Ghana. First CSIR-RSA Scientific Conference, p25. 17th October 2018, GNAT Village, Ejisu-Abankro, Ghana.

12. Djagbletey, G. D., Adu-Bredu, S., Abeney, E. A., Asante, W. A., Dua-Gyamfi, A., Addo-Danso, S., Ametsitsi, G. K., Amponsah-Manu, E. and Dabo, J. (2018). Recovery of economic (Timber) species after selective logging of a moist semi deciduous forest in Ghana. First CSIR-RSA Scientific Conference, page 25. 17th October, 2018, GNAT Village, Ejisu-Abankro, Ghana.

13. Duah-Gyamfi, A., Adu-Bredu, S., Djagbletey, G. D., Addo-Danso, S., Moore, S., Malhi, Y. and Burton, A. J. (2018). Stand characteristics and species richness influence carbon storage differently among plant functional groups in pre- and post-logging stands of a moist tropical forest in Ghana. First CSIR-RSA Scientific Conference, Book of Abstracts, pp8-9. 17th October 2018, GNAT Village, Ejisu-Abankro, Ghana.

14. Govina, J. and Ebanyenle, E. (2018). Advanced Wood Identification: The new technology. Workshop on combating illegal timber trafficking. Organized by US Forest Service. 5th-9th Nov., Douala, Cameroon.

15. Govina, J. and Ebanyenle, E. (2018). Wood Identification. Workshop on combating illegal timber trafficking. Organized by US Forest Service. 5th-9th Nov., Douala, Cameroon.

16. Guuroh, R.T., Linstädter, A., and Schmidtlein, S. (2018). Are there consistent drivers of taxonomic and functional diversity in West Africa's Sudanian savannas? 61st Annual Symposium of the International Association of Vegetation Science: Natural Ecosystems as Benchmarks for Vegetation Science, 22nd – 27th July 2018, Bozeman-Montana, United States.

17. Guuroh, R.T., Linstädter, A., Schmidtlein, S. (2018). Drivers of forage provision and erosion control in West African Savannas – a macroecological perspective. WASCAL Science Symposium: Climate and Environmental Services to Reduce Vulnerability and Improve Livelihoods in West Africa-from theory to actions, 19th – 22st June 2018, Accra, Ghana.

18. Korang, J., Djagbletey G., Pentsil, S., Owusu, J., Pentsil, M. (2018). Evaluation of Agricultural residue for sustainable bioenergy. First CSIR-RSA Scientific Conference, p17. 17th October 2018, GNAT Village, Ejisu-Abankro, Ghana.

19. Obeng, E. A., Aguilar, F. X., Obiri, D.B. and Oduro, K. A. (2018). Valuing global forests: an application of the theory of planned behaviour to predict willingness to pay to

restore tropical rainforest watersheds. Paper presented at the 4th Flare annual meeting, October 2018. Copenhagen.

20. Obiri, B.D., Oduro, K. A., Acquah, S.B., Nutakor, E. and Obeng, E. A. (2018). Leveraging public private partnerships (PPPs) for enhancement of the Ghanaian forestry sector. Paper presented at the Scientific Conference at the 29th Annual General Meeting of the Research Staff Association of Ghana. 16-18th October 2018. Abankro,-Ejisu, Ghana.

21. Obiri, B.D., Oduro, K.A., Acquah, S.B., Nutakor, E., Obeng, E.A. 2018. Leveraging public private partnerships (PPPs) for enhancement of the Ghanaian forestry sector. First CSIR-RSA Scientific Conference, Ejisu-Abankro, Kumasi, October 17, 2018.

22. Obiri, D. B., Nunoo, I., Obeng, E. A., Marfo, E., Owusu, F.W., Opuni Frimpong, E., Oduro, K. A. and Adjei, R. K. (2018). Profits and constraints along the Ghanaian charcoal value chain. Paper presented at the 4th Flare annual meeting, October 2018. Copenhagen.

23. Owusu, F.W. (2018). Contribution of the Forest towards Energy generation in Ghana: Prospects and Challenges. Paper presented at an International conference on the Pyrolysis of Cocoa Husk held on 18th October 2018 at School of Engineering guesthouse KNUST – Kumasi. The theme was "Pyrolysis of Cocoa Husk and its potential for agriculture 2018".

24. Owusu, F.W. (2018). Contribution of the Forest towards energy generation in Ghana: Prospects and Challenges. Paper presented at an International Conference on the Pyrolysis of Cocoa Husks held on 18th October 2018 at School of Engineering Guest House KNUST – Kumasi. The theme was "Pyrolysis of Cocoa Husk and its potential for agriculture 2018".

25. Owusu, F.W. (2018). Promotion of new timber species for utilization in Ghana. Presentation made at the workshop at Sokoban timber market and organized by Forestry Commission Training Center (FCTC) on 17th September 2018. 9pp

26. Owusu, F.W. (2018). Promotion of new timber species for utilization in Ghana. Presentation made at the workshop at Sokoban timber market and organized by Forestry Commission Training Center (FCTC) on 17th September 2018. 9pp.

27. Owusu, F.W. (2018). The role of CSIR-FORIG in ensuring quality in the wood Industry. Paper presented at two workshops for the promotion of national standards on wood and wood products for the Wood Industry in Ghana. Held at CSIR-FORIG, Fumesua near Ejisu on Tuesday 15th May, 2018 and Best Western Hotel, Takoradi, on Tuesday 22 May 2018.

28. Owusu, F.W. (2018). The role of CSIR-FORIG in ensuring quality in the wood Industry. Paper presented at two workshops for the promotion of national standards on wood and wood products for the Wood Industry in Ghana. Held at CSIR-FORIG, Fumesua, 15th May, 2018 and Best Western Hotel, Takoradi, on Tuesday 22 May 2018.

29. Owusu, F.W., Appiah-Kubi, E. and Ofori, D.A. (2018). Wood and Wood-Based Materials for Construction in Ghana: The Challenges and Prospects. Paper presented at the first National construction fair Summit held at KNUST- KUMASI from 19th – 22nd September, 2018 and organized by Collage of Arts and Built Environment (CABE), KNUST. Theme "60 years of the Ghanaian construction industry: Uniting for industrialization"

30. Owusu, F.W., Appiah-Kubi, E. and Ofori, D.A. (2018). Wood and wood-based materials for construction in Ghana: The Challenges and Prospects. Paper presented at the first National construction fair summit held at KNUST- KUMASI from 19th – 22nd September, 2018 and organized by College of Art and Built Environment (CABE), KNUST. Theme "60 years of the Ghanaian construction industry: Uniting for industrialization"

31. Owusu, F.W., Boakye, F., Oppong-Adutwum, J. and Mensah, M. (2018). Characterization of sawing properties of *Peterocarpus erinaceus* Poir (African Rosewood) grown in Ghana. Paper presented at the first CSIR-RSA Scientific Conference held at GNAT village, Abankro-Ejisu on 17th October 2018. Theme "Catalysing economic development through scientific innovations". 20pp.

32. Owusu, F.W., Boakye, F., Oppong-Adutwum, J. and Mensah, M. (2018). Characterization of sawing properties of *Peterocarpus erinaceus* Poir (African Rosewood) grown in Ghana. Paper presented at the first CSIR-RSA Scientific Conference held at GNAT village, Abankro-Ejisu on 17th October 2018. Theme "Catalysing economic development through scientific innovations". 20pp.

33. Owusu, F.W., Parker, J.M., Sampene, S.M., Amonoo, J. and Agyenim-Boateng (2018). Developing alternative livelihood for Ghanaian illegal Chainsaw Operators: Production of Legal Lumber through Artisanal Milling at Three Localities. Paper submitted for presentation at the 2018 Joint convention of the Society of Wood Science and Technology (SWST) and the Japan Wood Research Society (JWRS) held from 5th – 9th November, 2018 in the Noyori Conference Hall, Nagoya University and Nagoya Noh Theater, Nagoya, Japan. The theme was "Era of Sustainable World -Tradition and Innovation for Wood Science and Technology".

34. Owusu, F.W., Parker, J.M., Sampene, S.M., Amonoo, J. and Agyenim-Boateng (2018). Developing alternative livelihood for Ghanaian illegal chainsaw operators: Production of Legal Lumber through Artisanal Milling at Three Localities. Paper submitted for presentation at the 2018 Joint convention of the Society of Wood Science and Technology (SWST) and the Japan Wood Research Society (JWRS) held from 5th – 9th November, 2018 in the Noyori Conference Hall, Nagoya University and Nagoya Noh Theater, Nagoya, Japan. The theme was "Era of Sustainable World -Tradition and Innovation for Wood Science and Technology".

35. Sraku-Lartey, M. (2018). Managing indigenous knowledge on climate change of local people in some selected communities in the Offinso Municipality, paper presented at the Third CARLIGH conference, 9th to 13th July 2018, AAU Conference Room, Accra, Ghana.

36. Sraku-Lartey, M. (2018). Promoting indigenous forest foods in Ghana–a librarian's perspective. Paper presented at the 2018 Annual General Meeting and Biennial Congress of the Ghana Library Association, 1st and 2nd November, 2018, University of Health and Allied Science (UHAS), Volta Region-Ho, Ghana.

37. Sraku-Lartey, M. (2018). Promoting indigenous forest foods in Ghana–a librarian's perspective. Paper presented at the 2018 Annual General Meeting and Biennial Congress of the Ghana Library Association, 1st and 2nd November, 2018, University of Health and Allied Science (UHAS), Volta Region-Ho, Ghana.

38. Sraku-Lartey, M., Buor, D., and Adjei, P. O. W. (2018). Assessing the vulnerability of livelihoods to climate change in the Offinso Municipality, Ghana. Paper presented at the First International Conference on Geography and Development, 25th-27th July 2018. KNUST, Kumasi, Ghana.

39. Sraku-Lartey, M., Buor, D., and Adjei, P. O. W. (2018). Assessing the vulnerability of livelihoods to climate change in the Offinso Municipality, Ghana. Paper presented at the First International Conference on Geography and Development, 25th -27th July 2018. KNUST, Kumasi, Ghana.

40. Swegle, T and Govina, J. (2018). Best Practice Guide for Forensic Timber Identification. Workshop on combating illegal timber trafficking. Organized by US Forest Service. 5th-9th Nov., Douala, Cameroon.

41. Twintoh, J.J., 2018. Financial analysis of Cedrela Odorata. First CSIR-RSA Scientific Conference, Ejisu-Abankro, Kumasi, October 17, 2018.

9.5 Posters

1. Appiah-Kubi, E., Owusu, F. W., Ebanyenle, E., Korang, J., Brentuo, B., Govina, J., Seidu, H., Mensah, M., Owusu, J., Apetorgbor, M & Boakye, F. (2018). Suitability of plantation-grown Eucalyptus species as utility pole material in Ghana. Poster presented at the annual planning for 2019, held from 3rd-5th December 2018 at CSIR-FORIG conference room. Theme "Bridging the Gap between Research and End Users".

2. Appiah-Kubi, E., Owusu, F.W., Ebanyenle, E., Damnyag, L., Korang, J., Seidu, H., Govina, J.,Brentuo, B., Mensah, M., Boakye, F., Safia, I., Owusu, J. (2018). Wood and Furniture Testing: Adding value towards sustainable forest management. Poster presented at the annual planning session, held from 3rd -5th December, 2018 at CSIR-FORIG conference room. Theme "Bridging the Gap between Research and End Users.

3. Appiah-Kubi, E., Owusu, F.W., Tekpetey, S.L., Ebanyenle, E., Jezler, U., Korang, J., Damnyag, L., Govina, J., Seidu, H. and Brentuo, B. (2018). The wood and furniture testing centre at CSIR-FORIG: Implication for the construction industry. A poster presented at the first National construction fair/Summit held at KNUST- KUMASI from 19th – 22nd September, 2018 and organized by CABE, KNUST. Theme "60 years of the Ghanaian construction industry: Uniting for industrialization".

9.6 Technical Reports

1. Amissah, L. and Hagan Brown, W. (2018). Growth, wilting and physiological response of tree crops to simulated drought. 1st CSIR-RSA Scientific Conference, Book of Abstract. Page 8.

2. Appiah Kubi, Wilson, E. Ebanyenle, Korang, Bridget Brentuo, Apetebor, Haruna and Govina (2018). Assessment of suitability of plantation-grown eucalyptus species as utility pole material in Ghana. Preliminary report submitted to the Management of Asuboa Wood Treatment and MIRO (Ghana). CSIR-Forestry Research Institute of Ghana, Kumasi.

3. Appiah Kubi, Wilson, E. Ebanyenle, Korang, Bridget Brentuo, Haruna and Govina (2018). Evaluation of timber species on the domestic markets in Ashanti region of Ghana. CSIR-Forestry Research Institute of Ghana, Kumasi.

4. Appiah Kubi, Wilson, E. Ebanyenle, Korang, Bridget Brentuo, Haruna and Govina (2018). Quality Management Handbook for Wood and Furniture Testing Centre. CSIR-Forestry Research Institute of Ghana, Kumasi.

5. Appiah Kubi, Wilson, E. Ebanyenle, Korang, Bridget Brentuo, Haruna and Govina (2018). Operational Procedures (Mgt. and Tech.) for Wood and Furniture Testing Centre. CSIR-Forestry Research Institute of Ghana, Kumasi.

6. Appiah, M., Akoto, D.A., Wumbeidow, H.M., Pentsil, S., Ofori, D.A. (2018). CSIR-Forig 2017 Annual Report, CSIR-Forestry Research Institute of Ghana, Kumasi, Ghana.

7. Duah-Gyamfi, A., Adu-Bredu, S., Djagbletey, G. D., Addo-Danso, S., Moore, S., Malhi, Y. and A. J. Burton. (2018). Stand characteristics and species richness influence carbon storage differently among plant functional groups in pre and post-logging stands of a moist tropical forest in Ghana. First CSIR-RSA Scientific Conference, pages 8-9. 17th October, 2018, GNAT Village, Ejisu-Abankro, Ghana.

8. Guuroh, R.T., Linstädter, A., Schmidtlein, S. (2018). Are there consistent drivers of taxonomic and functional diversity in West Africa's Sudanian savannas? 61st Annual Symposium of the International Association of Vegetation Science: Natural Ecosystems as Benchmarks for Vegetation Science, 22nd – 27th July 2018, Bozeman-Montana, United States.

9. Guuroh, R.T., Linstädter, A., Schmidtlein, S. (2018). Drivers of forage provision and erosion control in West African Savannas – a macroelogical perspective. WASCAL Science Symposium: Climate and Environmental Services to Reduce Vulnerability and Improve Livelihoods in West Africa-from theory to actions, 19th – 22nd June 2018, Accra, Ghana.

10. Korang, J., Djagbletey G., Pentsil, S., Owusu, J., Pentsil, S. (2018). Evaluation of Agricultural residue for sustainable bioenergy. First CSIR-RSA Scientific Conference, page 17. 17th October, 2018, GNAT Village, Ejisu-Abankro, Ghana.

11. Obeng, E. A.; Aguilar, F. X.; Obiri, D.B. and Oduro, K. A. (2018). Valuing global forests: an application of the theory of planned behaviour to predict willingness to pay to restore tropical rainforest watersheds. Paper presented at the 4th Flare annual meeting, October, 2018. Copenhagen.

12. Obeng, E., Oduro, K.A., Obiri, B. D., Duah Gyamfi, K., Paintsil, S., (2018). Assessment of socioeconomic baseline for Yawmatwa and Manzan CREMAs. Draft Report. Submitted to SNV.

13. Obiri, B.D., Oduro, K. A., Acquah, S.B., Nutakor, E. and Obeng, E. A. (2018). Leveraging public private partnerships (PPPs) for enhancement of the Ghanaian forestry sector. Paper presented at the Scientific Conference at the 29th Annual General Meeting of the Research Staff Association of Ghana. 16-18 October, 2018. Abankro,-Ejisu, Ghana.

14. Obiri, D. B., Obeng, E. A., Guuroh, R.T., Djagbletey, G., Oduro, K. A,, Appiah, M. (2018). Establishing a land restoration research and demonstration area within degraded mining sites in the Bibiani Areas, Ghana. CSIR-FORIG.

15. Obiri, D. B., Obeng, E., Oduro, K. A.,Damnyag, L. L. Pentsil, S., Adjei, R., Asumadu, K. Sarfo K. B, (2018). Socio-economic study. Progress report. Forest Investment Program-EFALP, MLNR/FC.

16. Obiri, D. B.; Nunoo, I.; Obeng, E. A.; Marfo, E.; Owusu, F.W.; Opuni Frimpong, E.; Oduro, K. A. and Adjei, R. K. (2018). Profits and constraints along the Ghanaian charcoal value chain. Paper presented at the 4th Flare annual meeting, October, 2018. Copenhagen.

17. Sraku-Lartey, M. (2018). Managing indigenous knowledge on climate change of local people in some selected communities in the Offinso Municipality, paper presented at the Third CARLIGH conference, 9th to 13th July 2018, AAU Conference Room, Accra, Ghana.

9.7 Policy Briefs

1. Damnyag, L., Owusu, F.W., Adutwum, O.J. (2018). Lumber value calculator at tree-level for small holder tree plantation farmers, Ghana. Policy Brief Number: CSIR-FORIG/PB/LD, FWO/2018/002. 4pp.

2. Obiri, B. D. and Oduro, K. A. (2018). Public Private Partnerships: Strategic investments for all-inclusive forestry sector development. Submitted to African Forest Forum Nairobi, Kenya.

3. Obiri, B.D., Oduro, K. A. (2018) Public Private Partnerships: strategic investments for all-inclusive forestry sector development. Submitted to African Forest Forum Nairobi, Kenya.

9.8 Facts sheet

1. Obiri, D. B., (2018). New forests: Leveraging Public Private Partnerships (PPPs) for enhancement of the Ghanaian forest products sector. Submitted to African Forest Forum Nairobi, Kenya.

9.9 Part-Time Teaching

1. Emmanuel Appiah-Kubi: Department of Construction and Wood Technology, University of Education, Winneba, Kumasi Campus.

2. Francis Wilson Owusu: Department of Forest Resources Technology, KNUST, Kumasi.

9.10 Supervision of Students

1. Francis Wilson Owusu: Seven (7) undergraduate students, Department of Forest Resources Technology, KNUST- Kumasi.

10.0 APPENDICES

10.1 APPENDIX I: List of Senior Members

ADMINISTRATION DIVISION	
Daniel A. Ofori	BSc. Agric., MPhil. Tree Improvement, PhD. Forest Genetics (Molecular Biology) *Chief Research Scientist*, **Director**
Lawrence K. Mensah	B.A. Social Science, MPA Public Administration, *Senior Adm. Officer*, **Head of Administration**
Comfort D. Kontoh (Ms.)	B.A. (Hons) Economics, Dip. Education, MBA Strat. & Consultancy Mgt. *Administrative Officer*
Georgia M. Coffie (Mrs.)	B. Ed. Secretarial & Mgt., MSc E-Comm. & Marketing, *Administrative Officer*
FOREST POLICY, GOVERNANCE AND LIVELIHOODS DIVISION	
Kwame Antwi Oduro	BSc. Nat. Res. Mgt., MSc. Forestry and Land Use, PhD. *Senior Research Scientist*, **Head of Division**
Eric E. Nutakor	B.A. Social Science, MPhil. Silv. & Forest Mgt., *Research Scientist*
Elizabeth A. Obeng (Mrs.)	BSc. Agric., MSc. Sustainable Res. Mgt., PhD Forest Resource Economics, *Senior Research Scientist*
William K. Dumenu▶▶	BSc. Nat. Res. Mgt., MSc. Forest Ecol. & Mgt., *Research Scientist*
Emmanuel Marfo*	BSc. Nat. Res. Mgt., MSc. Tropical Forestry, PhD. Environmental Science, *Principal Research Scientist,*
BIODIVERSITY CONSERVATION & ECOSYSTEM SERVICES DIVISION	
Bright O. Kankam	BSc. Nat. Res. Mgt., MPhil. Wildlife and Range Mgt. PhD. Primatology, *Senior 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*
Lucy Amissah (Mrs.)	BSc. Nat. Res. Mgt., MPhil. Silv. & For. Mgt., PhD. Forest. Ecology & Forest Mgt. (Functional Ecology), *Senior Research Scientist*
Akwasi Duah Gyamfi	BSc. Nat. Res. Mgt., MPhil. Ecology & Mgt., PhD. Forest Science, *Senior 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, Principal Research Scientist
James K. Korang	BSc. MSc. PhD. Chemistry, *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. and PhD. Civil Engineering, *Research Scientist*
Bridgette Brentuo	BSc. Physical Sci., MPhil. Wood Technology, *Research Scientist*
James Kudjo Govina	BSc. Nat. Res. Mgt., MSc. Forestry Science, *Principal Technologist*
Haruna Seidu	HND. Agric. Engineering, Dip Edu, MSc. Information Technology, *Principal 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*
Sparkler Samar Brefo	BA.(Econs. & Geog.), MA. Geog. & Rural Dev., *Research Scientist*
Jacqueline Joyce Twintoh (Ms.)	BA. Business Administration, MSc. Bio-Economy and Nat. Res. Mgt., *Principal Technologist*
FORESTS &CLIMATE CHANGE DIVISION	
Ernest G. Foli	BSc. Nat. Res. Mgt., MPhil Forest Men./Inventory PhD Silv. & Mgt., *Principal Research Scientist/* **Head of Division**
Gloria D. Djagbletey (Mrs.)	BSc. Nat. Res. Mgt., MPhil., PhD. Silv. & Forest Mgt., *Senior 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., *PhD Forestry, Research Scientist*

Gloria Kukurije Adeyiga	BSc. Nat. Res. Mgt., M.Sc. Sust. Env. Mgt., M.Sc. Agric Dev't., *Research Scientist*
Reginald Tang Guuroh	BSc. Nat Res. Mgt, MSc. Env. Forestry, PhD. Plant Ecology, *Research Scientist.*
Dorothy Asare Akoto (Ms.)	BSc. Nat. Res. Mgt., MSc. Tropical Forestry, *Principal Technologist*
James Oppong Amponsah	BSc. Environmental Science, MSc. Seed Science and Technology, *Principal Technologist*
Daniel Kwame Debrah	Dip. Nat. Res. Mgt., BSc For. Res. Tech., MSc. Forestry Science, *Principal Technologist*
Christian Opoku Kwarteng	BSc. Nat. Res. Mgt., MSc. Environmental Science, *Principal Technologist*
FOREST IMPROVEMENT & PRODUCTIVITY DIVISION	
Paul P. Bosu	BSc., MPhil. Biological Sci., PhD Forest Entomology, *Chief Research Scientist*, **Head of Division**
Joseph Mireku Asomaning	BSc. Agric., MSc. Seed Technology, PhD. Seed Science and Technology, *Senior Research Scientist*
Mark Appiah	BSc. MSc. PhD. Agroforestry, *Principal Research Scientist/* **Deputy Director**
Mary M. Apetorgbor (Mrs.) **	BSc. Botany, PhD. Plant Pathology/Mycology, *Chief 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, MPhil. Environmental Science, *Research Scientist*
Emmanuel Opuni-Frimpong*	BSc. Nat. Res. Mgt., MPhil. Silv. Mgt., PhD. Forest Entomology, *Principal Research Scientist*
Anthony Antwi-Wiredu	BSc. Agriculture, MPhil. Nuclear Agriculture, *Principal Technologist*
COMMERCIALIZATION DIVISION	
Naomi Owusu Appiah (Mrs)	B.A. Publishing, MBA Marketing, Senior *Marketing Officer,* **Head of Division**
Alexander Ansong Obeng	BSc. Nat. Res. Mgt., MSc Marketing, *Marketing Officer*
Osei-Tutu Boateng	B.A. Sociology and Social Work, M.A Public Administration, *Administrative Officer*
FINANCE DIVISION	
Yaw Adjei Osei	BSc. Accounting, MBA, ACCA, *Accountant* **Head of Division**
Kwasi Agyeman Prempeh	ICA, Accounting, *Accountant*
Evelyn Owusu Agyemang	BSc. Accounting, MBA Accounting, *Accountant*
Isaac Boahen	BEd. MBA Accounting, CA, CIPFA (AFIL), *Accountant*

Samuel Atusong	B.A. Business Administration, CEMBA, *Accountant*
Gifty Wiafe Mensah-Tenkorang (Mrs)	BBA. Accounting, CEMBA, *Accountant*
INFORMATION AND COMMUNICATION SECTION	
Margaret Sraku-Lartey (Mrs.)	BA. Social Science, Post. Grad. Dip. Lib. Studies, MA. Industrial Mgt. PhD Geography & Rural Dev. *Principal Librarian,* **Head of Section**
Stella Britwum Acquah (Mrs.) ⏵⏵	BSc. Computer Science, MBA. Mgt. Info. Systems, MSc. Biometrics, *Senior Research Scientist*
Hamdia M. Wumbeidow (Mrs.)	BSc. Agricultural Technology, MPhil Zoology. *Scientific Secretary*
Martina Elizabeth Nikoi (Ms.)	B.A. Information Studies, M.A. Information Studies, *Principal Technologist*

⏵⏵ Study leave
** Post retirement contract
* Sabbatical leave

10.2 APPENDIX II: List of Senior Staff

No	Name	Grade
1	Michael Mensah	Chief Technical Officer
2	John Agbozo	Chief Technical Officer
3	Mavis Serwaah Kwarteng	Chief Accounting Assistant
4	Paul Kankam	Chief Technical Officer
5	Kwabena Prempeh Bandoh	Chief Technical Officer
6	John Sackey	Chief Works Superintendent.
7	Magdalene Prempeh Agyeman	Chief Technical Officer
8	Samuel Kyei Yamoah	Chief Technical Officer
9	Elizabeth Appiah	Chief Auditing Assistant
10	Peter Loving Arthur	Chief Technical Officer
11	Eric K. Frimpong	Chief Technical Officer
12	Emmanuel Asiedu-Opoku	Chief Technical Officer
13	Markfred Mensah	Chief Technical Officer
14	Francis Asare Abetia	Chief Admin. Assistant
15	Ernest Osei Boakye	Chief Technical Officer
16	Frank Baffour Assuming	Chief Technical Officer
17	Osei Tutu Boateng	Administrative Officer
18	Sarfo Kwame Bonsu	Chief Technical Officer
19	Awurama Andoh	Chief Administrative Assistant
20	Kwasi Baah Acheamfour	Chief Technical Officer
21	Richard Kwadwo Adjei	Chief Technical Officer
22	Anastasia Duah-Gyamfi	Chief Administrative Asst.
23	Felix Boakye	Principal Technical Officer
24	Kwaku Asumadu	Chief Marketing Assistant
25	Jemima Owusu	Chief Technical Officer
26	Margaret Adubigire	Principal Administrative Assistant
27	Jonathan Dabo	Principal Technical Officer
28	Daniel Peprah	Principal Technical Officer
29	Sandra Owusu	Principal Technical Officer
30	Samuel Larbi	Principal Administrative Assistant
31	Georgina Boateng Yeboah	Principal Accounting Assistant
32	Elvis Nkrumah	Principal Technical Officer
33	Emmanuel Amponsah Manu	Principal Technical Officer
34	Wendy O. Amankwah	Principal Accounting Assistant
35	Hamdia Bijay Hudu	Principal Administrative Assistant

No	Name	Grade
36	Daniel Damte	Principal Draughtsman
37	Michael Ampah	Principal Administrative Assistant
38	Ebenezer Frans Mensah	Principal Technical Officer
39	Constant Ezuame	Principal Technical Officer
40	Eunice Okyere-Agyapong	Principal Technical Officer
41	John Bismark Amokwandoh	Senior Technical Officer
42	Samuel Apraku Yeboah	Principal Technical Assistant
43	Mark Debrah Marfo	Senior Technical Officer
44	Ebenezer Ofori	Principal Technical Officer
45	Jackson Nti	Senior Assistant Transport Officer
46	Sampson Adonteng	Senior Assistant Transport Officer
47	Peter Gamadey	Senior Assistant Transport Officer
48	Osei Boateng	Senior Security Officer
49	Gabriel Lumor	Senior Works Superintendent
50	Michael Atitsougbui	Senior Security Officer
51	Safia Ibrahim	Senior Technical Officer
52	William Hagan Brown	Senior Technical Officer
53	Mavis Agyekumwaah Bamfo	Senior Technical Officer
54	Adu-Gyamfi Asamoah	Senior Technical Officer
55	Isaac Donkor	Senior Administrative Assistant
56	Kwabena Achina Owusu	Senior Accounting Assistant
57	Emmanuel Sarpong	Senior Library Assistant
58	Sylvester Kuudaar	Technical Officer
59	Kester K. Mensah	Administrative Assistant
60	Joseph Sebuka	Administrative Assistant
61	Helena Akomaning	Administrative Assistant
62	Hilda Dokey	Administrative Assistant
63	Victoria Apaseku	Technical Officer/Catering
64	Patrick Baidoo-Ansah	Technical Officer/Catering
65	Maxwell Asante Boachie	Senior Security Officer
66	Michael Kwarteng	Senior Security Officer
67	George Kwabla Kpodo	Senior Security Officer
68	Benjamin S. Sarfo Maino	Senior Accounts Assistant
69	King Alhassan	Security Officer
70	Eunice Basanio Boadi	Technical Officer
71	Stephen E. K. Acheampong	Security Officer
72	Joseph K. Ansah	Security Officer

For more information, please contact

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