Technologies for Forest Management, Utilization and Development (1965-2012)

Compiled by: S.B. Acquah, S. Pentsil, N. Appiah, W.K. Dumenu and B. Daramani

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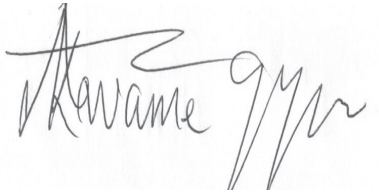
Foreword

This handbook is a compendium of practical technologies or knowhow developed by the Forestry Research Institute of Ghana of the Council for Scientific and Industrial Research (CSIR-FORIG) to assist forest and forest product managers, users and industrialists to improve on their line of work and business. The handbook is also aimed at combating environmental degradation and enhancing resource use and sustainability. A variety of technologies are presented in this book ranging from forest management, sustainable timber harvesting, bamboo and rattan utilization and non-timber forest products value-added production techniques.

The technologies presented in this handbook are a reflection of years of long-term research and dissemination of findings. Having been in forestry research for more than two decades, I appreciate the usefulness of such a handbook in guiding scientists, entrepreneurs, natural resources managers and policy makers in their bid to sustainably explore the nation's forest resources for economic development and improved livelihoods.

This handbook should be a welcome piece for all concerned about solving the problems of natural resources management and utilization with modern technologies or knowhow. I am confident that with adequate support from government and our stakeholders, we would continue to come up with technologies that would contribute to sustainable forest management in Ghana.



Victor Kwame Agyeman PhD., Esq, MGIF
(Director, CSIR-FORIG)

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List of Acronyms

CSIR	Council for Scientific and Industrial Research
ECG	Electricity Company of Ghana
ENGOs	Environmental Non-Governmental Organizations
FORIG	Forestry Research Institute of Ghana
FPRI	Forest Products Research Institute
HQCF	High Quality Cassava Flour
LUS	Lesser-Used Species
NGO	Non-Governmental Organization
NTFPs	Non Timber Forest Products
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WWCB	Wood Wool Cement Board

CSIR-FORIG in Perspective

Forestry Research Institute of Ghana (FORIG) is one of the 13 Institutes of the Council for Scientific and Industrial Research (CSIR). It is located at Fumesua, near Kumasi, in the Ashanti Region of Ghana. It started as a research unit within the Forestry Department in 1962. It was fully established as a Research Institute and named Forest Products Research Institute (FPRI) under the then Ghana Academy of Sciences in 1964. In 1968, the Institute was placed under the Council for Scientific and Industrial Research. By an Act of Parliament (Act 405) the Institute was transferred from the CSIR to the Forestry Commission in 1980. In 1991, the name of the Institute was changed to Forestry Research Institute of Ghana to reflect the widening scope of its research activities. In 1993, by another Act of Parliament (Act 453) the Institute was reverted to the CSIR.

The Institute is mandated to undertake forest, forest products and related research, disseminate and commercialise research outputs and services. Research is organized under three main programmes (Units) namely: (i) Forestry and Wildlife, (ii) Forest Products and Trade and (iii) Environment, Land-Use and Biodiversity. The Institute's permanent offices and laboratories are located at Fumesua, near Kumasi. It has research centres in five (5) research stations strategically located in one or more ecological zones of the country. These stations are: Benso in Wet/Moist Evergreen Forest Zone, Kubease in Moist Semi-Deciduous (North East subtype) Zone, Amantia in Moist Semi-Deciduous (South East subtype) Zone, Abofour in Dry Semi-Deciduous Fire Zone and Bolgatanga in Northern Savannah Zone.

The vision of CSIR-FORIG is to be a centre of excellence and networking hub for forest and forest products research in the humid tropics; and its mission is to conduct forest and forest products research for social, economic and environmental benefits of society. The principal objectives of the Institute are as follows:

- Develop technologies for sustainable management of natural forests and biodiversity conservation;
- Develop technologies for plantation forestry;

- Generate technological properties and appropriate processing techniques for efficient utilisation of forest resources;
- Enhance sustainable management and utilisation of wildlife and NTFPs;
- Mobilise, generate, process and disseminate information critical to the management of Ghana's forest resources;
- Strengthen capacity and use same for optimum research and commercialised services;
- Upgrade the infrastructure and facilities for Research and Development;
- Undertake contract/commissioned research, consultancies, training and related technical services in forestry;
- Foster strong linkages across disciplines with local and international bodies and organizations;
- Contribute through research to improve the social, economic and environmental well–being of Ghanaians.

The Institute is governed by a Management Board comprising seven members from forestry related sector organisations. The Director is the Chair of the Internal Management Committee and is assisted by Heads of Divisions. The Divisions are: Forest Products Trade and Marketing, Forest Industry Development, Ecosystem Services and Climate Change, Biodiversity and Land Use, Forests Livelihood and Governance, Forest and Wildlife Management, Commercialisation and Information, and Finance and Administration.

One of the major assets of CSIR-FORIG is the human resource capacity. As at December 2012, the Institute had a total staff strength of 252 made up of 57 Research Scientists and analogous grades, 62 Technical and Administrative staff and 133 supporting staff. Of the researchers, 90% have higher degrees (MPhil, MSc, MBA, MA and PhD).

Having earned recognition as a renowned tropical Forestry Research Institute, CSIR-FORIG has established linkages with several prestigious research institutes, universities and other organizations in more than ten

countries. The Institute has forged strategic partnerships and twinning agreements on forestry research projects and academic exchanges with renowned institutes and universities worldwide. These arrangements allow students, lecturers and researchers to undertake exchange programmes that give them the opportunity to interact and collaborate with other research institutes, universities, ministries, industry and NGO's.

Currently, the Institute is undertaking a number of research projects namely:

1. Capacity building for CDM forestry in the framework of SFM emphasizing community forests and poverty alleviation in Ghana.
2. Strengthening the capacity of ITTO producer countries in Africa in generating and disseminating scientific information on reducing deforestation and forest degradation and enhancing environmental services from forests.
3. Towards sustainable indigenous mahogany timber production in Ghana: Phase II, Refining the silvicultural "Tool Kit" and practical training for industrial-foresters and community FARMERS.
4. Sustainable soil & water conservation and sustainable agriculture in the Lake Bosomtwe Basin.
5. Reducing emissions from deforestation and forest degradation through collaborative management with local communities.
6. Savannah forest boundary transition in west Africa - Coupling the energy balance and hydrology and carbon cycles across the biome (captioned *GEOCARBON*).
7. Does shifting carbon use efficiency determine the growth rates of intact and disturbed tropical forests? Gathering new evidence from African forests.
8. Development of building blocks made of stabilized laterite and agricultural residues as an environmentally friendly alternative to cement blocks in Kumasi, Ghana.
9. Allanblackia standard setting and sustainable supply chain management.

10. Development and implementation of a species identification and timber tracking system in Africa with DNA fingerprints and stable isotopes. Collaborative project with participants from 7 African countries with Forest Genetic Research Institute of Germany as the lead Organization.
11. Advancing REDD+ in Ghana: Preparation of REDD+ pilot schemes in off-reserve forests and agroforests.
12. Set up and accreditation of test laboratory for the wood industry in Ghana.
13. Bamboo for housing in Ghana.

Introduction

Over the years, CSIR-FORIG has developed a number of technologies and interventions through research. Technology here refers to 'any specific information and know-how, tangible or intangible, required to solve a problem or for the development, production, management or use of resources (Wikipedia, 2012, UNESCO, 1985). The technologies generated at CSIR-FORIG are aimed at combating environmental degradation, safeguarding the sustainable use of the nation's forest resources and improving rural livelihood. All these technologies have the potential to contribute positively to the social, economic and environmental well-being of Ghanaians. However, many of the technologies have not been properly packaged, publicised and transferred to target stakeholders, users and the general public in comprehensible language.

CSIR-FORIG provides a variety of forestry-related products and services. The products include forest products (seeds, seedlings and wood thinnings), chemical products (gums, tannins, dyes, prekese syrup), prototype wood products (beds, chairs etc.) developed from Lesser Used Species and non-timber forest products (mushrooms, snails, honey). The services provided by CSIR-FORIG include contract research, consultancy, training workshops (on transferable technologies), ecotourism and information and communication services. The knowledge-based products of CSIR-FORIG are developed technologies packaged, presented and published in local and international Journals, technical reports, conference/workshop papers, theses, manuals/guides, brochures and flyers. Technical extension services are also provided.

This Handbook is a compendium of information on technologies developed in CSIR-FORIG over the years in the areas of environmental reclamation, forest plantation development, wood processing and utilization and non-timber forest products management, utilization and domestication. It only contains highlights of the technologies but not full descriptions. It is intended to bring technologies to the doorstep of users and bridge the gap between technology development and application. Additionally, it would also help scientists in identifying gaps where critical information is lacking so that further research could be conducted without

unwarranted duplication. The Handbook would also enable policy-makers to make informed decisions on issues relating to the environment which are critical to sustainable development. Ultimately, the adoption of forest management-related technologies could also facilitate proper management of forest resources in the country.

Several sources were utilized for the compilation of information on technologies, notably institutional repository, internet, Journals, posters and technical and annual reports. In addition, the technologies were identified by liaising with scientists and technicians to solicit their views. The information presented in this Handbook gives a brief background about the technology, users of the technology, technology outcomes and limitations (if any). It is presented through main headings, via, Forest Management and Plantation Development; Wood Processing and Utilization, and Non-Timber Forest Products.

FOREST MANAGEMENT AND PLANTATION DEVELOPMENT

1. Methods for Rehabilitating Degraded Forests and Mined Sites

Thirty-five percent (35%) of Ghana's land mass is categorized as forest. The forest landscape plays a very important role in supporting the economy of Ghana and the livelihood of the populace. However, the combined effect of over-exploitation of forest resources, unsustainable farming practices, wildfires and mining activities have significantly reduced the forest area and degraded nearly 32% of the reserved forests and over 70% of forests outside reserves. Continuous degradation of the forest cover has negative implications for agricultural productivity, water resources, land availability, biodiversity and wildlife, environment, livelihoods and socio-economic development. Nonetheless, as comprehensive solutions are being sought to address the factors of forest degradation, already degraded forest lands and mined sites have to be restored to ensure the flow of benefits to the society.

Plate 1(a) Forest land degraded by bush fire

Plate 1(b) Degraded forest reserve

Plate 1(c) Fire degraded forest restored with Terminalia ivorensis

Plate 1(d) Nine year old rehabilitated forest reserve


Plate 1(e) Degraded mined sites

Technology

CSIR-Forestry Research Institute of Ghana has established a suitable time-tested methodology for rehabilitating degraded forests and mined sites that cater for the diverse goals of forest management. The methodology provides guidance on land preparation and site-species matching and selection based on measured indicators; stand management as well as fire and tree health monitoring. The method has been designed to promote the use of both indigenous and exotic species for the rehabilitation and restoration of degraded forests and mined sites respectively.

Users of the technology

Forestry Commission, Minerals Commission, mining companies, private plantation developers and organizations in charge of watershed management.

Technology Outcome

Currently, CSIR-FORIG has rehabilitated the following three degraded forest reserves:

- Pamu-Berekum Forest Reserve – Dormaa Ahenkro
- Southern Scarp Forest Reserve – Begoro
- Opro Forest Reserve – Akomadan

Limitations

The methods for rehabilitating degraded forests and restoration of mined sites are concerned with the biophysical landscape. Governance issues and other social related issues are not considered. Users of the methodology

must satisfy the social and governance issues prior to the application of these methods.

2. Girth Limits and Sustainable Felling Intensity of Timber Species

The application of a felling diameter limit has been considered as one of the useful timber production control tools applicable to both reserved and off-reserve forests. Silviculturally, the effect of applying a felling limit is that it allows the residual stand to be composed mainly of productive trees (i.e. trees that are vigorously growing). For wood processing purposes, the major effect is the assurance of sustainable supply of good quality logs; i.e., trees occurring in the exploitable diameter will have good quality wood in contrast to the quality of immature timber.

Prior to the mid-1990s, Ghana experienced diminishing sizes of timber logs, especially the traditional timber species. This was a concern for the thriving timber industry, the Forestry Commission and the sector Ministry. The old and the then girth limit and felling intensity needed revision to reflect the realities of the demand for wood vis-a-vis the dwindling resource base.

Technology

The technology consists of a model developed for determining the minimum girth or diameter allowable for felling in a given forest and the level or intensity (i.e. number of trees per unit area). The model takes into account the various factors such as growth rate of trees, regeneration, availability/conservation status of species. These factors are context-specific to the Ghanaian forest situation.

Users of the technology

Ghana Timber Millers Association, Ghana Timber Association, Forestry Commission.

Technology Outcome

The current girth limit and felling intensity guide logging operations of timber companies in Ghana. It is used for monitoring by the Forest Services Division of the Forestry Commission.

Limitations

The minimum girth limit modality encourages removal of large-diameter trees hence has consequences for soil compaction resulting from use of heavy machinery for haulage and also high disproportionate felling damage. Felling is not controlled by total basal area but rather minimum diameter.

3. Techniques for the Production of Improved Seeds and Seedlings

The dwindling forest resource base needs augmentation through plantation development in order to satisfy the increasing demand for timber and wood products. Successful plantation establishment, *inter alia,* depends upon the selection of suitable high quality planting materials. The challenge is how to obtain adequate supply of genetically good quality seeds since existing seed trees are continually being depleted by indiscriminate felling and wild fire. Technologies are needed for high quality seedling production and improved vegetative propagation techniques for tree species that have poor and difficult seed production.

Technology

CSIR-FORIG has successfully developed technologies for the production of superior planting materials for major native species including *Khaya ivorensis* (Mahogany), *Entandrophragma utile* (Edinam), *Triplochiton scleroxylon (*Wawa) and *Milicia excelsa* (Odum). The technologies are a suite of appropriate techniques targeted at:

- Seed collection, processing, testing and storage;
- Seedling production; and

- Vegetative propagation for the production of true-to-type clones.

Plate 2(a) Special techniques for the collection of seeds and scion material from genetically superior trees

Plate 2(b) Seed processing and drying prior to sowing to increase viability

Plate 2(c) Nursery at CSIR-FORIG

Plate 2(d) Teak plantation at Pra Anum

The technologies are designed in a way to offer users easy and clear steps toward the production of viable high quality seedlings.

Users of the technology

Plantation establishers, commercial/recreational tree growers, Forestry Commission, mining companies and Environmental Non-Governmental Organisations (ENGO's)

Technology Outcome

Several clonal seed orchards have been established to supply genetically high quality planting materials using the technology. It has also been used to establish ten priority species (exotic and indigenous) for plantation development under the National Forest Plantation Development Programme. The exotic species are: *Cedrela odorata (*Cedrela), *Gmelina arborea* (Gmelina), *Eucalyptus spp*. (Eucalyptus), *Tectona grandis* (Teak), and *Pinus carribaea.* The indigenous species include: *Triplochiton scleroxylon (*Wawa), *Terminalia ivorensis* (Emire), *Terminalia superba (*Ofram), *Nauclea diderrichii (*Kusia) and *Ceiba pentandra* (Onyina). Furthermore, the need for importation of planting stock from other countries has been reduced considerably since many tree growers are using CSIR-FORIG's technology and superior planting materials to establish forest plantations.

4. Techniques for the Production of Odum Clones Tolerant/Resistant to the *Phytolyma lata* Pest

Milicia excelsa (Odum), also known as Iroko in global timber trade, is considered the most generally useful timber species in Africa. Its distribution stretches across the entire width of humid Africa from West through Central to East Africa. The demand for this valuable tree species has consistently been high locally and internationally. The species' susceptibility to the gall forming insect *Phytolyma lata* restricted its growth in plantations. The insect deforms the shoot apex and stunts the growth of the plant hence rendering it less useful for timber production.

Technology

CSIR-Forestry Research Institute of Ghana has developed techniques for production of Odum clones that are tolerant or resistant to *Phytolyma lata* using vegetative and tissue culture protocols to capture resistant lines.

Plate 3(a) Vegetative propagation of Odum

Plate 3(b) Odum trial plot at Abofour

Users of the technology

Tree Growers, Timber Industry, research and academia

Technology Outcome

The techniques and protocols developed have opened up opportunities for large scale planting of this important timber species. Odum is now being restored in the forest landscapes in Ghana and Cote d'Ivoire. The Odum research approach is being used as a template in addressing plantation failure of the African Mahoganies (*Khaya* and *Entandrophragma spp.*) and other indigenous species with endemic pest problems. A training course in vegetative propagation and nursery management was conducted for personnel in some timber industries in Ghana and Cote d'Ivoire. Additionally, vegetative propagation units were set up for some timber companies. The technology has been deployed extensively in Cote d'Ivoire for planting of the species.

5. Mixed Plantation Strategies to Reduce Pest Outbreak in Plantations

Since 2003, the area of forest plantations in Ghana has been increasing steadily. Almost all plantations have been established as monoculture systems. Monoculture plantations have high potential of pest outbreak.

Pest outbreaks have devastating consequences that may include losses running into millions of dollars and can erode huge capital investments and many years of hard work. It is very important to detect pests and diseases early before they attain the outbreak status or cause economic damage. One effective way of minimizing pest attack is the establishment of mixed-species plantations. Mixed species plantations provide both monetary and environmental benefits to the country. These include increased productivity, improvement of soil condition, promotion of biodiversity, protection against pests and diseases, improvement of wildlife habitats, and provision of multiple forest products. The lack of adequate silvicultural knowledge has prevented many investors from establishing plantations of mixed species.

Technology

CSIR-FORIG, having investigated various mixed species planting options to address the problem of insects and disease outbreak in plantations, has developed significant understanding of the principles underlying the establishment and management of mixed species plantations. The techniques developed encompass planting and management strategies of various mixed species well suited to the local conditions and practices.

Plate 4 Four year old mixed native species plantation in the South Formangsu Forest Reserve

Users of the technology

Forest Services Division of the Forestry Commission (FC), small and large scale private tree growers.

WOOD PROCESSING AND UTILIZATION

6. Customized Wood Identification System for Submerged Timber Trees

The building of the Akosombo dam on the Volta River some 50 years ago to supply hydroelectric power in Ghana resulted in the submergence of large tracts of forest. These submerged forests contain good and high quality timbers that are ready for large scale commercial harvesting necessary for economic development. The challenge was how to identify the timber species for processing for the local and international markets in situations where morphological identification was difficult. Failure to correctly identify species could result in huge financial burdens for the timber regulator agencies and industry.

Technology

The Customized Wood Identification System combines the use of macroscopic structure and physical features of wood with a dichotomous and computerized identification key to identify the names of all trees and wood stumps harvested from the lake. The technology is also used to identify timbers of commerce processed by local mills to avoid wrong identification which often results in payment of huge penalty by the exporter to the importer.

Users of the Technology

At present, the principal user is a Canadian company which is currently harvesting timber trees from the Volta Lake, Forest Services Division, Timber Industry Development Division, Timber companies and private individuals engaged in timber export.

Technology Outcome

To date about 40 commercial timber species have been identified from more than 1000 trees and wood stumps so far harvested from the lake. Some of the identified commercial timber species include *Milicia excelsa*

(odum), *Tieghemella heckelii* (makore), *Entandrophragma cylindricum* (sapele) and *Khaya ivorensis* (mahogany). The total value of the submerged wood is estimated to be over $300 million and estimated contribution (value) of the technology is over $30 million.

Plate 5 Samples of identified timber species harvested from the Lake

7. Techniques for Processing and Utilization of Lesser-Used Timber Species

Due to the premium prices for the so-called major species there has been over exploitation of these species over the years. Timber exploitation has been heavy on a relatively small range of species with high demand on the export and local markets. The result is the rapid dwindling of primary timber species even though a vast number of Lesser-Used Species (LUS), have physical and mechanical properties that make them suitable substitutes for many of the primary timber species. The timber and construction industries yearned for alternatives to meet the gaping

demand. However the industry was faced with technical problems such as field identification, end-use categorization, processing efficiencies, undesirable grain characteristics, high sapwood-heartwood ratio and non-durability of the LUS.

*Plate 6(a) Garden chairs from Alstonia boonei (**Nyamedua**)*

*Plate 6(b) Pallets from Antiaris toxicaria (**kyenkyen**), Bombax buenopozense (**Akata**) and Antrocaryon micraster (**Aprokuma**)*

Plate 6(c) Cabinet made from cocostem and peanut bowls made from rubber wood

Technology

Through intensive research, CSIR-FORIG studied and established the properties of over 35 LUS, which have proven to be good substitutes for the dwindling traditional species. All the relevant properties have been specified for industrial wood processing and use in the construction industry. Since technology is not a static process, some of the techniques developed continue to be revised to comply with current trends.

Users of the technology

Timber and construction industry.

Technology Outcome

Currently, the technology is in the public domain and being used by the timber industry for making a variety of products as recommended by CSIR-FORIG. The construction industry for example has substituted some traditional species such as Odum, Dahoma, Essia, etc. with LUS in various aspects of the construction process. Some of the LUS, example *Albizia ferruginea* (Awiemfosamina), *Distemonanthus benthamianus* (Bonsamdua) and *Albizia adianthifolia* (Pampena) have received considerable market acceptance and demand for these species has increased significantly. Additionally, the introduction of the technology has broadened the range of raw material to the timber industry, reduced the pressure on the dwindling primary timber species, provided more alternatives for local furniture producers to work with and increased government's net revenue. Within the last 5 years about 10% of LUS have come on the market contributing to about $24 million per annum to the wood industry (with a total export value of $200 million) and another estimated value of $15 million to the domestic market.

8. Sawing Techniques and Utilization of Small Diameter Logs

Dwindling timber resources makes it necessary to extend the range of indigenous timber species below the traditional prescribed girth limits (<40cm) and to efficiently utilise small diameter plantation species. Consequently, there is the need to develop techniques for processing small diameter logs.

Plate 7 Small diameter Logs

Technology

The Institute has developed techniques for processing small diameter logs using two sawing patterns (cant and plain) and narrow band saws (small kerf saws). The techniques enable the efficient processing of logs with small diameters based on the shape of the logs.

Users of the Technology

Wood processing industry

Technology Outcome

The sawing pattern technique (depending upon the shape of logs) has been well accepted by wood processors. The technology has broadened the timber raw material base, generated employment, enhanced skills in the industry and increased revenue due to increase in lumber yield. The widespread use of small kerf saws (narrow band saws) by wood processors is improving lumber recovery from small diameter logs.

Limitations

The technology is yet to be extended to rotary peeling of small diameter logs in order to increase the volume of rotary veneer products.

9. Techniques for Bamboo and Rattan Identification and Cultivation

Effective techniques to cultivate bamboo and rattan using seeds, culm cuttings, rhizomes and macro proliferation have been developed by CSIR-FORIG. The cultivation of bamboo involved several steps from site selection to the planting of the seedlings on the field. Site selection for bamboo cultivation is very critical since it is very difficult to remove bamboo from a site after establishment.

Misidentification of bamboo and rattan either in the wild or in processed form could lead to their improper utilization. Consequently, research has been conducted by combining both morphological and anatomical features of bamboo and rattans to develop a tentative identification key in Ghana.

Plate 8(a) Sprouted culm cutting

Plate 8(b) Seedlings for macro proliferation


Plate 9(a) Bamboo plantation in Bobiri Forest Reserve


Plate 9(b) Some finished products of bamboo and rattans

Users of the technologies

Forestry Commission, academia, bamboo and rattan collectors, artisans, merchants, NGOs and building and construction industry.

Technology Outcome

Bamboo and rattan are alternative sources of raw materials that may help to conserve our forests. Treated bamboo has become a substitute for wood in rural housing. This has minimized quantities of wood used in rural housing.

10. Solar Kiln Drying of Lumber

Many of the small and medium scale wood working industries in Ghana produce high quality wood products, though they do not have adequate drying facilities other than air-drying. Finished wood products that are not properly dried cannot compete on the world market. Improper drying and treatment of low and medium density wood for handicraft leave the handicraft particularly vulnerable to insect infestation.

Plate 10(a) Construction of solar kiln dryer

Plate 10(b) Solar kiln dryer

Technology

CSIR-FORIG has developed a cost effective technology known as the Greenhouse Solar Dryer for drying lumber and other wood products at lower moisture content (5-8%) which is of better quality than air dried wood with moisture content of approximately 16-18%.

Users of the Technology

Wood processing industries and wood carvers.

Technology Outcome

The technology is already in the public domain and a solar dryer has been built by CSIR-FORIG at the handicraft village in Aburi for the carvers. Many of the small, medium and large scale timber industries have been producing high quality wood at a faster rate using this technology and

are able to enter the competitive world market with high quality wood products. The handicraft industry is also able to export its products to earn higher income.

11. Pulp Production from Indigenous Species

With a population of about 25 million, Ghana uses her scarce resources to import all her paper requirements with the exception of certain brands of toilet tissue produced from waste paper. Yet Ghana abounds with the raw material needed for these products.

Plate 11 Wawa and bamboo species for the production of pulp and paper

Technology

CSIR-Forestry Research Institute of Ghana has developed a technology for the production of pulp using various indigenous and exotic tree species, namely, *Terminalia ivorensis* (Emire), *Triplochiton scleroxylon* (Wawa), *Morus mesozygia* (Wonton), *Sterculia rhinopetala* (Wawabima), *Musanga cecropioides* (Odwuma), *Broussonetia papyrifera* (Broussonetia), *Bambusa vulgaris* (Bamboo), plantain pseudostem, Gmelina and Eucalyptus species.

Technology Outcome

The technology is yet to be adopted for production of pulp and paper. This is largely due to the high capital investment required for setting up a pulp and paper facility.

12. Production of Woodwool Slabs

Wood Wool Cement Board (WWCB) is a versatile building material made from wood wool shavings and cement. It offers an effective, permanent and attractive solution for any kind of activity that produces undesirable noise levels within an enclosed space such as buildings. WWCB is fire resistant, wet and dry rot resistant, freeze-thaw resistant, termite and vermin resistant. Theses properties makes it versatile in its applications and durable over a wide range of climatic conditions. It provides thermal insulation and thus saves energy. It is also able to absorb sound and it accepts a wide range of finishes.

Plate 12(a) Cement bound wood wool slab

Plate 12(b) Constructing wood wool cement house

Technology

CSIR-FORIG has researched into some wood species suitable for the manufacture of woodwool slabs. Some of the species are *Chrysophyllum africanum* (Asanfena), *Chrysophyllum albidum* (Akasaa) and *Terminalia superba* (Ofram). Wood shavings from these species have been combined with cement under specialised conditions based on their unique properties.

Users of the technology

Building companies

Technology Outcome

Building companies have adopted the technology in the construction of low cost/affordable houses.

Limitation

Not all wood species are suitable for the manufacture of wood wool slabs due to chemical contents such as sugars and phenol, which may inhibit the setting of cement.

13. Techniques for Wood Waste Utilization for the Production of Briquettes, Charcoal, Slabs and Particle Board

In the production of sawn wood, large deposits of sawdust are generated as residue and this creates environmental problems. With the rising cost of fuel and also the growing interest in forest conservation, sawdust could be carbonated to yield good quality charcoal for household purposes.

Plate 13(a) Charcoal

Plate 13(b) Briquette

Technology

To effectively utilize these wood residues, CSIR-FORIG has developed techniques that convert wood waste into usable products such as briquette, slabs and particleboards.

Technology Outcome

The technology is yet to be applied. Its application is sure to generate employment for many people and improve cleanliness in wood processing industries.

14. Wood Shingles for Roofing

The rising cost of imported roofing materials calls for cheaper yet durable local alternatives. Shingles, which are rectangular pieces of wood used in covering roofs and exterior walls, is one such alternative. Wood shingles produced from abundant indigenous species even further reduces the cost. One major hurdle is the technology needed to produce wood shingles suited for different uses.

Plate 14(a) CSIR Basic School roofed with shingles

Plate 14(b) Offices of Mesewam Nursery roofed with shingles

Technology

CSIR-FORIG has developed a technique for manufacturing shingles from indigenous wood species for roofing. It is less expensive than conventional roofing sheets. Different designs have been developed which can be applied for different construction purposes.

Users of the technology

Building industry and private housing developers.

Technology Outcome

Few building companies in the country have adopted the technology. For the purposes of demonstration, CSIR-FORIG has roofed buildings using wood shingles. However, the technology has not been popular in its uptake due to the perception that wood is susceptible to fire and rot. Education is needed to get this technology adopted.

15. Techniques for Establishment of *Pinus caribaea* with Improved Physical Properties

Pinus caribaea is a hard pine, native to Central America, Cuba, and the Bahamas. Its establishment in Ghana was not possible initially because it was not well adapted to the soil conditions. In areas where it managed to grow, the wood quality was much affected. Pines can be used in general construction (floors, walls, doors, window frames), veneer, plywood, handicraft and furniture. *P. caribaea* is used as pulp for paper. Treated Pines are good for use as electric power transmission poles in Ghana.

Technology

CSIR-FORIG has developed techniques for effective establishment of *Pinus caribaea.* The technique treats the species with different mycorrhizal fungi grown in nurseries to correct certain deficiencies in the growth of *Pinus caribaea.* In nutrient-deficient soils, non-mycorrhiza grown pine seedlings produce only about half as much dry weight as mycorrhiza grown seedlings on soils deficient in phosphorus. Through determination of variations in diameter, clear bole height and clear bole volume, the best mycorrhizal fungi for *Pinus caribaea* trees have been identified. The mycorrhizal treatment of the Pine trees enhanced the physical properties of the wood.

Users of the technology

Forestry Commission, tree growers, wood industries, Ministry of Energy, Electricity Company of Ghana (ECG).

Technology Outcome

Pine plantations have been established in Ghana with improved wood quality.

16. Cassava Flour as Plywood Adhesive Mix Extender

Wheat flour is commonly used as an extender in the adhesive mix for plywood production, but wheat flour is expensive. Utilization of wheat flour as an extender increases greatly the cost of plywood production due to increasing cost of importation. A cheaper but effective alternative will largely reduce the cost of production and increase production volume.

Plate 15(a) Mixing of High Quality Cassava Flour (HQCF)

Plate 15(b) Plywood produced from HQCF

Technology

Research conducted at CSIR-FORIG indicated that High Quality Cassava Flour (HQCF) could be substituted for wheat flour. This led to the development of the technology that utilized HQCF as an extender for the manufacture of plywood conforming to various specifications. The technology has proved to be useful as it was found to minimize wear on cutting tools due to its low ash content. It also provides tack to the glue line and promotes faster and more complete cures.

Users of the technology

Plywood industry.

Technology Outcome

Plywood manufacturing industries in five regions in Ghana have observed the technical feasibility of using HQCF as a raw material and glue extender. In addition, two staff each from twelve plywood companies have been

trained to effectively use HQCF. The introduction of HQCF to plywood mills has resulted in a reduction in the cost of glue and many mills are eager to use the product. Currently, total adhesive mix is 20% cassava flour and 80% wheat flour. Contribution of cassava flour adhesive alone to the plywood industry amounts to about $900,000 per annum. This technology is also likely to expand markets for cassava and develop local entrepreneurship to meet industrial demands and save foreign exchange through import substitution. For instance, smallholder households will benefit by a minimum of US$190/household/year for a one-off investment in the value chain.

17. Rural-Based Non-Pressure Wood/ Bamboo Preservation Technology

The service life of forest products such as wood and bamboo can be extended by non-pressure application of chemical preservatives. Increasing the service life of forest products will lead to a decrease in wastage in the use of forest products, reduce deforestation and assist in conserving timber trees and bamboo culms. This will enhance effective use of forest products resulting in huge economic benefits to the rural poor in particular.

Technology

The non-pressure wood/bamboo preservation technology illustrates a step-by-step, simple but cost-effective method for extending the durability of forest products such as wood and bamboo in a rural setting. The do-it-yourself method of treatment can give a reasonable service life extension if the guidelines for ensuring effective treatment are adhered to. The eight different non-pressure treatment methods are well illustrated in a CSIR-FORIG publication titled "*Non-Pressure Wood Preservation for the Tropics*".

Users of the Technology

Non-Governmental Organizations, district assemblies, community groups and other individuals and organizations anxious to increase the

service life of wood, bamboo and other forest products, especially in rural areas.

Potential Impact

Use of rural preservation technology to extend durability of forest products such as wood and bamboo will help reduce wastage in the use of wood and bamboo by forest fringe communities, reduce forest destruction and thereby promote forest and tree conservation.

Plate 16 Non-pressure treatment of green bamboo culms by steeping, painting and sap displacement method

18. In-Situ Treatment of Utility Poles to Extend Service Life

Preservative-treated utility poles may develop incipient decay caused by biological hazards including fungi, termites and borers after 15 to 20 years in service. When a pole with incipient decay is left untreated for 30 to 40 years, it may eventually lead to advanced decay. More than 50% of the estimated one million poles in Ghana have been in service for more than 20 years and most of them urgently require in situ remediation treatment to arrest any possible incipient decay. Poles with advanced decay pose extreme danger to human life and have to be replaced to avoid unexpected falling, which may cause havoc to humans and property. The durability of a pole with incipient decay can be increased significantly beyond the expected service life of 30 to 40 years if the pole is given special *in situ* remedial treatment.

Technology

CSIR-FORIG has established a simple low-cost yet effective technology for increasing the service life of utility poles in the midst of scarcity and very high cost of replacing poles.

The technology involves the treatment of standing poles with a special bandage or chalk which contains diffusible preservative. The chalk is inserted in special drilled holes above ground line of the pole and thereafter plugged with special removable stoppers and the bandage is wrapped around the circumference of the pole at the ground line. The preservative in the chalk is released to stop internal decay in the pole and the preservative in the bandage is released to arrest external decay on the surface. The *in-situ* treatment, regularly applied in a 5-year cycle, can increase the durability of the pole from the estimated 30 to 40 years to about 50 years and beyond.

Users of the Technology

The major beneficiaries of the technology are institutions involved in treatment, installation and management of utility poles including the Electricity Company of Ghana, the Volta River Authority and the Ministry of Energy.

Potential Impact

The application of this technology on the 50% of the estimated one million poles in Ghana that have been in service for more than 20 years can arrest any possible incipient decay. Failure to administer remediation treatment may result in most of these poles reaching a state of advanced decay that would warrant their replacement at exorbitant cost or poles may fall down unexpectedly at the peril of human life and cause serious damage to property.

Plate 17 In-situ remediation treatment of external decay in poles using the preservative bandage.

NON-TIMBER FOREST PRODUCTS

19. Mushroom Cultivation

Protein deficiency is one of the major challenges of rural communities in most third world countries. To overcome the challenge, mushroom consumption is being promoted to provide the needed nutrients for good health. However, due to pronounced environmental degradation in most communities, the availability of wild mushrooms is diminishing at an alarming rate. There is therefore the need to domesticate mushroom for sustainable supply.

Technology

CSIR-FORIG has developed technologies for:

- Cultivation of mushroom (domo) using agricultural waste;
- Preparation of mushroom spawn (seeds) for mushroom growers.

Plate 18(a) Mushroom pin heads growing on plantain leaves

Plate 18(b) Mushroom spawn in an incubation chamber

Plate 18(c) Harvested mushrooms (domo)

Users of the technology

Individuals, local communities, Non-Governmental Organizations (NGOs).

Technology Outcome

A considerable number of people have been trained in mushroom farming technology at CSIR-FORIG. It has provided employment for many and improved the nutritional status of rural and urban households. It is an alternative source of livelihood for many households.

20. Snail Farming

Snail meat is high in protein and iron, and low in fat. It has medicinal value for the treatment of many diseases including anaemia, ulcer and asthma. In Ghana, the population of wild snail is declining as a result of deforestation, indiscriminate pesticides application, slash and burn agriculture, bushfires and collection of immature snails from the forest. There is considerable demand for snail meat locally and internationally and demand far outstrips supply. This has necessitated the need to domesticate snails to ensure sustainable supply.

Plate 19(a) Feeding snails with fresh watermelon and pawpaw.

Plate 19(b) Harvested snails

Technology

The technology developed by CSIR-FORIG demonstrates appropriate methods for the domestication of snails. It further stipulates the feeding

and breeding habits, site selection and housing of the species and effective methods for snail rearing.

Users of the technology

Individuals, local communities, District Assemblies, Non Governmental Organizations, Agriculture Science teachers.

Technology Outcome

A snail-farming demonstration farm/pilot, was established as a replicable model and by means of appropriate audio-visual materials the snail farming technology was extensively disseminated through training of extension officers, Agriculture Science teachers, farmers, church groups, rural forest communities and individuals. The technology has been integrated into many rural development programmes as an alternative livelihood scheme aimed at reducing the pervasive poverty in rural settings, not only in Ghana, but also in Nigeria, Benin and Cote d'Ivoire. It also provides employment as an alternative livelihood for farmers earning them much-needed income. Snail farming has been incorporated into the curricula of Secondary and some Tertiary institutions. Many are improving their livelihoods by raising snails for the local market, and the prospects for export overseas are high.

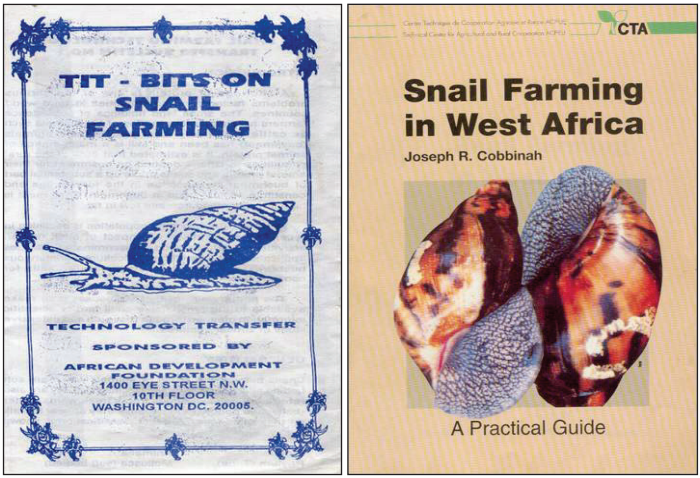

Plate 20 Training manuals on snail farming

21. Production of Prekese Syrup

In the current wave of concern about functional foods, considerable effort is being put into sources of "green" food, which includes syrup obtained from the fruit of *Tetrapleura tetraptera* (Prekese). Prekese fruit syrup qualifies as a green food source with no additives. It has inherent preservative and anti-hypertensive properties. Other therapeutic uses include management of convulsions and rheumatic pain. Prekese also has anti-ulcerogenic, molluscicidal, and antimicrobial activity.

Fruits and seeds of Prekese have low sodium content and are rich in potassium, iron, magnesium, phosphorus, and vitamin C. Traditionally, Prekese fruit has been used as preservative and flavour for soup and stew. Thus, Prekese is a household name in Ghana and its value is appreciated.

Plate 21(a) Prekese tree

Plate 21(b) Prekese fruit and syrup

Technology

CSIR-FORIG developed techniques for extracting and processing of syrup from Prekese fruits after years of scientific research.

Users of the technology

Confectionary industries, pharmaceutical industries, breweries and individuals.

Current status of the technology

The processing of the syrup is currently at the laboratory stage. Construction of a pilot syrup processing plant is in progress to improve quality and quantity of production. In addition, the Institute is in the process of acquiring certification from the Food and Drugs Board to enable it market the product widely. Currently, production is on a relatively low scale pending certification from the Food and Drugs Board. The Institute plans to market the product nationwide in pharmaceutical and all leading supermarkets to make it accessible to all. More research is needed to identify other food preparations from Prekese fruit.

Potential Impact

Due to its rich potassium, iron, magnesium and other vitamin content, users of the syrup are likely to be healthier. A healthy workforce is the backbone required to drive the economy. Prekese syrup production in the long run would provide employment opportunities for both rural and urban dwellers who may want to go into Prekese plantations or fruit syrup production.

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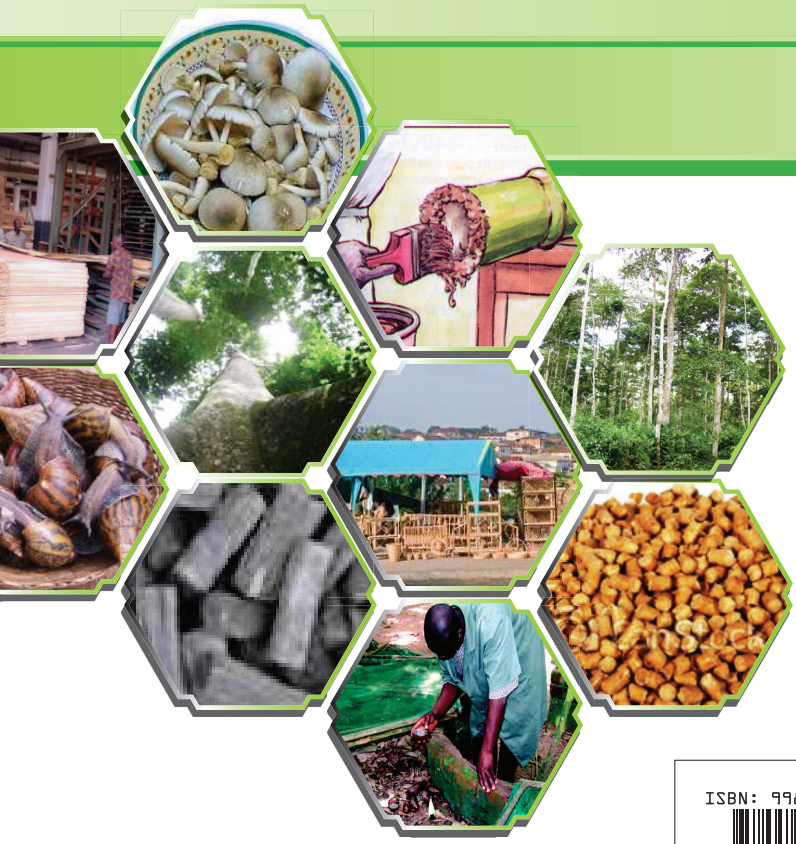

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