Project Proposal
For Submission to the International Cotton Advisory Committee for Funding from the Common Fund for Commodities

Economic Utilization of Cotton By-Products for Zambian Smallholders: Cotton Stalk-Based Chip in the Manufacture of Particle Board

Summary

Project title: Economic Utilization of Cotton Bye-products for Zambian Smallholders: Cotton Stalk-Based Chip in the Manufacture of Particle Board.

Project location: Zambia – Southern Province: Mazabuka District.

Project Implementing & Executing Agency: Cotton Development Trust (CDT)
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Collaborating institutions: Central Institute for Research on Cotton Technology (CIRCOT), Mumbai, India

Duration: Four years

Scope and Objectives:

i. Create opportunities for additional income for cotton farmers through value addition of cotton stalks for the hard pressed smallholder cotton farmers of Zambia; create business and employment opportunities through developing cotton stalks collection and supply chain for particle board manufacturing, in the process proving commercial viability of cotton chip-based particle board manufacturing technology developed by CIRCOT with CFC and ICAC support;

ii. Develop alternative fuel – briquettes from cotton stalk waste, thus in addition to wood substitution in forest-based industrial processes, reducing pressure on forest for charcoal-making which is depleting timber at an alarming rate and has major environmental sustainability consequences for Zambia;
iii. Analyze the potential impact of commercialization of cotton by products on cotton production potential and identify synergies between producers and processors especially for the industry based on stalk use in Zambia and other countries in the Region;
iv. Research and development of new particle board products as well as production and evaluation of boards of blended agro-residues with cotton stalk.
v. Social, economic and employment creation potential and impacts of stalk collection and processing within the project area;
vi. Analyze cash flow potential of agricultural biomass and the economic impact assessment of such innovation at national and regional level;
vii. Quantify the potential impact of cotton stalk use on particle board market, the potential of briquettes in reducing wood-based charcoal and their impacts on local/global environment, and other uses of stalk waste;
viii. Annual cash flow analysis of particle board manufacturing plant – economic analysis including expenses and income; and
ix. Organize a final workshop at the end of the project to share developmental experience and potential benefits of transfer of this technology within Zambia and Sub-Saharan Africa.

Main Expected Benefits:

i. Additional income for Zambian smallholder cotton producers to the tune of about twenty US dollars per hectare, which could be significant for Zambian smallholders. This will also demonstrate economic viability of particle board manufacturing process developed with earlier CFC support.

ii. About 36,000 tons of cotton stalk that are mostly burnt in the fields (about 12,000 Hectares) causing environmental damage will be stopped by converting these into about 18000 tons of chips for particle board manufacture. This will prevent — tons of carbon from being released into the atmosphere on account of cotton-stalk burning. Furthermore, about 7500 tons of waste from stalk cleaning will be used for making briquettes that will potentially substitute forest wood based charcoal, which is currently leading to deforestation at an alarming rate.

iii. Benefit environment through developing a commercial and/or industrial use for cotton stalks that are otherwise burned in the field adding to environmental pollution, and benefiting forest resource conservation by developing a new raw material for wood-chip based industry;

iv. Potential positive impact on forest resources – due to the ‘wood-substitution’ nature of this operation.
v. Social, economic and environmental impacts on target farming communities within stalk collection and processing area as well as for the environment in general.
vi. Creation of alternate employment opportunities in Zambian Cotton Farming System and rural communities.
vii. Demonstration, promotion and dissemination of economically viable and environmentally socially beneficial technologies with job-creation potential in non-farm rural space in Zambia and Sub Saharan Africa.

Projected Costs:

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<tr>
<th>Description</th>
<th>Cost</th>
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<tr>
<td>Estimated total cost</td>
<td>US$ 3,817,000</td>
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<tr>
<td>CFC Equity</td>
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<tr>
<td>CFC grant</td>
<td>US$ 1,693,000 (44.4%)</td>
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<tr>
<td>Counterpart contribution</td>
<td>US$ 1,742,000 (45.6%)</td>
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Project Proposal

For Submission to the International Cotton Advisory Committee for Funding
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Economic Potential of Cotton By-Products for Zambian Smallholders

Background

Zambia is a land-locked nation bordered by eight countries. It has a total land area of about 750,000 square kilometers and a population estimated at about 12 million people, with a low average population density compared to many African countries.

The Zambian economy has been historically dependent on copper mining. The gradual decline in world copper prices has led to economic decline and erosion of the relatively high standard of living enjoyed by the population in the 1970s, and per capita income declined from US$ 752 in 1965 (at Independence) to US$440 in 2004. Growth trends reversed, however, during 1999-2003 period, when real GDP grew at an average rate of 4.0 percent a year as following declines in copper earnings, agriculture has become a major driver of growth and a significant source of export earnings and diversification. Agriculture and agro-processing account for more than 40 percent of Zambia’s GDP and contribute about 12 percent of export earnings. The sector provides employment to some 67 percent of the labor force and supplies raw materials to agro-related industries, which account for some 84 percent of manufacturing value-added in the country.

Zambia has 42 million hectares of arable land (about 55 percent of total land area), of which only 1.5 million hectares is cultivated every year. The country’s 800,000 smallholders account for some four-fifths of this area. Government recognizes the importance of smallholder agriculture and is committed to supporting their development.

Past Government efforts to improve productivity of smallholders have not achieved expected results. Before introduction of policy reforms in the 1990s, the Government attempted to support smallholder commercialization through provision of subsidized inputs and credit, price interventions and operating agricultural parastatals. Following the economic reforms of the early 1990s, the Government reduced its role and budget for agriculture, leading to deterioration in public service delivery. With reduced Government role, the private sector has been spearheading the impressive growth in agricultural exports. Since the mid-1990s, production systems have emerged in Zambia that are based on partnerships between smallholders and commercial farmers or agro-entrepreneurs. Currently, almost a third of the 800,000 smallholder farmers in Zambia are organized in some form of out-grower scheme arrangements. The majority of those involved are contracted by cotton companies – in 2003-04, about 85 percent of farmers participating in formal out-grower schemes were contracted by cotton companies.

Cotton is undoubtedly one of the success stories in smallholder commercialization in Zambia. The sector currently employs some 220,000 smallholders, up from some 38,000 in 1990. Production volumes have increased from about 36,000 tons in 1990 to 170,000 tons of seed cotton in 2004.
Cotton is grown over about 250,000 hectares in Zambia. Most of this crop belongs to small holders who have joined ‘out-grower schemes’ under which gins provide farmers with a production package consisting of seed; micronutrients and some quantities of pesticides; with some extension services; and most importantly, an assured procurement price for the seed cotton produced. Cotton has been seen as a crop with major impact on poverty reduction in Zambia – leading to significant increase in the numbers of growers and the area (starting from a low of 25,000 ha in 1981-82 to well above 200,000 hectares since 2003-04) under this crop. Roughly one out of four smallholder farmers in Zambia rely on cotton for their livelihood.

Cotton is grown for its seed cotton – with lint and cotton seed as the only commercially useful products. But it has now been recognized that the plant has more valuable components than its seed cotton alone – stalks could be a remunerative source of income as well. Cotton stalk is rich in cellulose and of comparable composition and fiber structure to many hard wood species. While stalk can be used as a raw material for several industrial processes – paper, fuel and as wood substitute in many wood based industries, even the leftover waste can be used to make briquettes or substrate for mushroom growing. However, cotton stalk availability is seasonal and in order to ensure supplies as industrial raw material, the logistic supply chain – from harvest/collection/procurement at farmers field to preprocessing, bailing and storage and transportation to guarantee end users year round optimal quality raw material supply will assumes importance.

Using the most conservative estimates of cotton crop-based biomass, more than 200,000 Ha of rain-fed cotton in Zambia, potentially produces more than half a million tons of cotton stalks. This is a fair comparison with India, where a major share of cotton is rain-fed; the stalk yields average about three tons per hectare, with a range of 5 tons in irrigated areas and 2.24 tons in rain-fed areas. Zambian cotton stalk yields are higher because of the average rainfall (usually 800 mm and above per annum) and its spread during the cotton production cycle – which may lead to vegetative growth even when boll-formation is average and/or below average.

Cotton yields in Zambia are low in spite of the high production potential of Zambian cotton varieties and high ginning out-turn (40 percent and above). Average yields of seed cotton have lingered below 900 kg per hectare, and lint yields have seldom crossed 300 kg/Ha (1982-83, 1987-88 and 2002-03: ICAC Data), against the global average of 630 kg/Ha. While efforts are underway to increase the yields and improve profitability of cotton for Zambian farmers, significant yield increases are unlikely, at least in the near future due to increases in the prices of petroleum based inputs – chemical fertilizers and pesticides and dependence upon rains in the absence of irrigation for most small holders, as well as because of lack of appropriate agricultural extension support, leaving farmers highly dependent on ginners supplied inputs and less than optimum technical support.

In addition to being rain-fed cotton, yields are sub-optimal mostly due to: too little, too excessive, or untimely rains; lack of optimal fertilizer application and/or optimal pest control, mostly due to the lack of credit facilities for procurement of inputs and absence of appropriate technical support to enhance cotton production skills of small farmers. Cotton Development Trust (CDT) is already focused at increasing cotton productivity and to lower production costs for Zambian farmers. In addition to continued basic and applied research in developing appropriate germplasm for various cotton producing zones and appropriate agronomic techniques, it has re-initiated an integrated pest management (IPM) program to reduce reliance on pesticides and use all pest control tactics to achieve better yields with lower pesticide usage and these costs. However, research and technology development and adoption is
long term solution and its impact may take years to be felt at grass root levels. This has necessitated exploring any and all avenues of enhancing income for cotton growers in Zambia in the immediate future.

Zambia has potential to increase area and yields of the crop in the medium to long term depending upon the incentive regime and technical support to farmers. While developing farmer’s capacity to achieve optimal yields would take many years and much resources which are hard to come by with the current global economic downturn, utilizing cotton biomass which is burned presently, as a source of additional income proffers farmers an opportunity to increase their profits in more immediate terms while benefiting environment by overcoming the need to burn cotton stalk in field and by providing an alternative to wood chip based industry, which is impacting upon forest resources significantly at present. Additional incomes may further motivate the growers to increase their efforts for better crop management, thus enhancing yields in the long term.

Current low population pressure enables farmers to follow slash-and-burn agriculture and most of the biomass in cotton fields is ultimately burned in the field as Zambian Law dictates cotton stalk cleared from fields by September 1st. With the proper incentive of additional income, farmers would prefer to harvest cotton stalk – or sell the stalk to agents willing to harvest and process them for further use. Technologies have been developed with the assistance of international bodies – ICAC and CFC to explore and exploit the potential of cotton biomass as industrial input, relieving stress on forest resources at the same time, creating additional income stream for small farmers and creating employment opportunities in the rural areas, and subsequently, creating business opportunities in rural space for collection and pre-processing agents as well as for transport industry.

This project would provide additional incomes from cotton biomass (currently classified as waste) utilization by industry specific public private sector partnership institution in Zambia, the Cotton Development Trust. As such, the particle board manufacture facility and stalk collection and pre-cleaning operations will create hundreds of employment opportunities, both directly and indirectly. This will also demonstrate another avenue for further income generation for small holder cotton growers in other African countries that have cotton or are embarking on cotton production programs similar to the one in Zambia.

In addition to demonstrating market potential of the technology developed by CFC/ICAC20/CIRCOT with this project serving as an industrial scale trial to demonstrate economic viability in field conditions, this will improve livelihoods in rural Zambia and generate on- and off-farm economic activity with a potential for creating a non-farm economic activity stream for income enhancement in the rural space.

Cotton Development Trust is an initiative of the Government of Zambia, under the Ministry of Agriculture and Cooperatives (MACO) in partnership with the private sector as well as all the other stakeholders in cotton. The Trust aims at contributing towards agricultural development in Zambia through strengthening cotton industry by playing an important role in research and development, extension services, farmer training and seed technology and production. CDT strives to foster prosperity of the 200,000 to 250,000 cotton farmers through farmer participation in value adding in cotton production chain. CDT therefore occupies an important place in the economic development of Zambia and provides the technological base for development of cotton industry in the country. However, the principal beneficiaries are vulnerable small-scale farmers, many of whom are women and/or children headed households, an unpleasant consequence of the many premature HIV/AIDS related deaths.
The Cotton Development Trust is proposing to take advantage of a technology developed by CFC, ICAC through CIRCOT to establish commercial viability of value addition of cotton crop by products and provide additional incomes to hard pressed Zambian small holder cotton farmers, at the same time, benefiting environment by introducing an alternative to the practice of burning cotton stalk in the field and providing a viable substitute to wood chip for board manufacture, thereby reducing the pressure on deforestation. A successful run of this operation will also demonstrate the benefit of the technology adoption not only in other provinces of Zambia where cotton is grown but also in other Sub-Saharan countries that grow and are actively promoting cotton cultivation. CDT is uniquely positioned to introduce this technology and enhance income stream for small holder cotton farmers in Zambia in the immediate future and the Sub Saharan African countries subsequently.

**Commodity strategy:**

*To be contributed by ICAC on the world cotton situation and commodity strategy.*

**Project Rationale:**

Under the CFC/ICAC/20 Project, Central Institute for Research on Cotton Technology (CIRCOT) had obtained good technical results with the manufacture of particle and binderless boards based on chips made from cotton stalk. CIRCOT has also addressed the need of developing equipment for extraction, cleaning and chipping of cotton stalk from the field. Given its low density, unless cotton chip can be baled, the cost of transportation could be prohibitive. CDT will therefore emphasize the development of supply chain operators who would procure, extract, clean and chip the stalks close to farmer’s fields and transport and/or store chips only after baling for transportation to the board manufacturing facility on need basis. This would ensure the year-round supply of raw material for the use by board manufacture through out the year. Since this will be an introduction of a new economic activity, initially CDT will organize the supply-chain under its umbrella, but with the streamlining of operation, it will handover this function to private sector – initially providing them with necessary support until the operation becomes viable.

About 50 percent of cotton stalk may be lost during the pre-cleaning and chipping processes. However, this waste from the chipping processes can be used in the making of briquettes, which have the potential of meeting the fuel needs of many Zambian households who rely heavily on charcoal, mostly from illegally chopped down forest trees; or can lead to the creation of a cottage industry to cultivate mushrooms on this waste-based substrate or convert it into compost. Briquettes would further benefit the environment by reducing this unsustainable dependence on forests for fuel. These would be the spin-offs of cotton stalk based particle board industry.

Proposed operation by the CDT will take the CIRCOT Pilot effort to a degree of ‘up-scaling’ that will proximate commercialization that could benefit cotton producers on a wider scale as well as benefit environment in multiple ways. Thus this is essentially a ‘factory-scale’ demonstration trial of a technology developed with CFC funding. The CDT will initially focus manufacturing particle board using resins only due to the relative simplicity of the process as compared with binderless board that requires pulping and high priced equipment for pulping chip and processing the pulp into binderless board.

Cotton has been the mainstay of economies of many developing countries. Besides providing employment to farmers and labor in cotton value chain, in many countries of Africa, including Zambia where cotton is an engine the of poverty alleviation as it provides livelihood to increasing numbers of...
small holder cultivators. Due to a number of reasons – increase in production costs, lack of credit/finance facilities for procurement of optimum inputs – quality seed of approved varieties; chemical fertilizers and pest control chemicals; lack of adequate extension support; and the rain-fed nature of crop have constrained the producers from achieving optimum yields. There is a need to explore all available avenues to enhance returns of the crop for the growers. Utilization of cotton by products is one such option with multiple environmental benefits and the potential to decrease reliance on wood-chip based board manufacture, saving trees, and utilization of cotton stalk as an industrial raw materials rather than being burned in the field, in addition to additional financial benefits to the grower. This income enhancement might even motivate farmers to strive to adopt better production practices for obtaining higher yields of cotton and all other crops on their farms.

The Zambian cotton crop is estimated to produce around half a million tons of cotton stalk each year (about three tons of useable cotton stalk per hectare – yielding 1.5 tons or more useable cotton stalk based chip), and because there is no use for these either – as fuel (as stalk are used in many countries around the world), or as an industrial raw material, most of the stalk is either burned in the field or burnt after harvest partially because by law they have to be cleared from the field by September 1st to eliminate pest harboring sites. Thus demonstration of cotton stalk’s potential as an industrial raw materials would not only create an additional income stream for the producers, it will additionally provide a ‘wood-substitute’ raw material with significant environmental benefits for industries relying on wood chips, as has been shown successfully by CIRCOT. CDT intends to take this technology a step further by demonstrating commercial viability of cotton waste as a raw material for particle board, along with the impacts on employment creation in Sub-Saharan countries of Africa.

The historic average yield of cotton production in Zambia has mostly fluctuated between 133 (1988-89) and 337 (1982-83) Kg/ha of lint – around 800-900 Kg/ha of seed cotton. Yields have been consistently above 250 Kg/ha from 2000-01 onwards (286 kg/ha in 2005-06). Yet these are significantly below the world average of 730 kg lint/ha, and West African average of 391 kg/ha in 2005-06 (All data from ICAC publications), as well as the yield potential of local cotton varieties. In order to enable the cotton producer to increase his/her income from the field, efforts have been undertaken to add value to by-products which thus far were considered to be without economic value. Based upon initial laboratory and limited factory trials it appears that cotton stalks can be used, and has been used commercially, for hard board (binderless board), medium density fiber (MDF) board and particle board production creating additional incomes for hard pressed cotton farmers, and by creating employment opportunities in stalk harvest, collection, pre-cleaning, chipping, baling and chip transportation to particle board production unit. In addition, use of cotton stalks as base material for particle board production would have a positive environmental impact, as it would reduce the need for wood for this type of industrial purposes, thereby contributing to the slowing down of deforestation processes, as well as reduction in the current practice of burning of cotton stalks.

Cotton stalk yield depends upon climate, soil conditions and the species of cotton – Gossypium hirsutum in Zambia. Cotton stalk contains about 41 percent cellulose, compared with 42 and 45 percent for soft and hard woods, respectively. This is also comparable with other widely used agricultural biomass (cellulose 42 percent). At harvest, stalk contain about 10 percent moisture (bagasse usually contains 40 percent), and about 15 percent of it being trash and impurities. Another 25 percent may be lost in chipping, compacting and transportation. Thus stalk yields only 50 percent as useable chips for industrial uses. However, in addition to chip from cotton stalk having less than half of the moisture of bagasse – 1.75 tons of cotton chip yields a ton of board against four tons of bagasse for the same amount of board. However, while trade in baled bagasse has had become an acceptable norm for years for fuel for
power generation as well as for other industrial uses, logistic chain for cotton stalk would need to be developed and promoted for the first several years.

The proposed production unit will have an estimated production capacity of about 30 tons/day, which is expected to demonstrate the actual commercial production process. Preliminary assessments undertaken in a cotton stalks availability study in India indicated that on an average a cotton stalk production of around 3 tons/ha can be expected, which, allowing for losses during pre-cleaning, chopping and transportation would still yield to 1.0 – 1.5 tons of stalks-based chip/ha. Usually 1.75 tons of cotton stalk based chip is needed for the production of one ton of particle board. A production unit of 30 tons/day would thus require a “catchment” area of around 12,000 ha within some 20 km around the factory site.

With Zambian cotton production covering above 250,000 hectares, most of it in Eastern, Central and Southern Province – where this plant will be located; and with no known commercial, on-farm or domestic use of cotton stalk, the availability of cotton stalks as such is, or will not be a problem. However, since stalk availability is seasonal, developing a ‘supply-chain’ to collect, pre-clean, store (if it becomes necessary) and transport the chip to particle board factory all year round will take some time and effort to develop. The CDT therefore proposes to develop this supply chain as one component of this proposed operation initially, and will therefore procure necessary technology for chipping, pre-cleaning and baling. It will be possible to identify interested operators easily once a profitable supply chain model is demonstrated, at which stage collection and pre-processing will be out-sourced to collection agents. The CDT will actively encourage interested parties in developing the supply chain to create appropriate competition environment as developing an efficient supply chain mechanism will be critical for the success of this operation. While at some later stage, private sector may ensure year round supply of clean chip, at initially stages, it will be necessary to procure and store sufficient quantities for year long input supply, thus a proposed storage facility for baled chips at the particle board facility.

Currently Zambia has two board manufacturing operations based on wood chips – taxing forest resources. Potential plywood industry may seek vast tracts of forest/tree plantation for meeting raw material requirements. Various kinds of particle boards (medium density fiber boards, binderless boards and particle boards) are the next generation of wood product, and many can utilize various kinds of biomass. Zambia's potential biomass sources are bagasse from sugar cane, which is popular as fuel for power generation and in board production and cotton stalk, maize stalk and other agricultural waste.

The overall objective of the project is to demonstrate, economic viability of a scaled up version of the pilot operation developed and tested at CIRCOT with CFC support under supervision of ICAC and introduce newer technology with vast potential to create non-farm economic activity with employment opportunities in Zambia as well as Sub-Saharan Africa. This will be the scaling up of the technical and commercial feasibility of using cotton stalks as a base material for board production, addressing issues like collection of base material, (pre-) cleaning, processing and market survey of the boards. The logical framework of the project is given in Annex I. The technical concepts underlying the proposed design of the plant and envisaged process parameters are given in Annex II. The project implementation schedule is given in Annex IV.

**Project’s Relationship with CFC/ICAC/20**

CFC had approved “Utilization of Cotton Plant By- Produce for Value-Added Products” (CFC/ICAC/20) “for operational research and development for the establishment of optimum parameters for a commercially
feasible production process for preparation of particle boards using cotton stalk.” The project’s aim was “value addition for cotton faring by demonstrating the utility of cotton stalk residues in commercial particle board and fiber board production”. The overall objective was to demonstrate technical and commercial feasibility of using cotton stalk as a base material for board production. Additionally this would be developing cotton stalk as a wood substitution raw material for board industry, to arrest deforestation trends. Central Institute for Research on Cotton Technology (CIRCOT) of the Indian Council of Agricultural Research was the project executing agency.

CIRCOT was chosen because it was a premier research institution addressing the needs of the cotton sector in India, had several research institutions and out-reach facilities throughout India, and had been working on utilization of cotton residues for the benefit of Indian farmers with their own resources for several years before the inception of this project.

Project’s formal inception was on October 1st, 2004 and following one year’s extension, its completion is expected by the end of September 2009. Final workshop to share results with stakeholders and disseminate technology developed is scheduled for November 2009. However, in the final year of project implementation, CIRCOT abandoned their development effort for binderless fiber boards because of logistical reasons – it was difficult to supply large shipments of cotton stalk chip to a distant fiber board manufacturer in Southern India for testing.

The CDT intends to test on commercial basis the findings of this operation by installing a medium-sized particle board manufacturing unit and develop stalk/chip supply lines by identifying and building local entrepreneurship.

Under the CFC/ICAC/20, CIRCOT’s Pilot Particle board plant was designed to manufacture of 4’x3’ (1.22 x 0.92 meters) boards with 12-25 mm thickness. The overall objective of this project was to “demonstrate, at a pilot level, the technical and commercial feasibility of using cotton stalk as a base material for board production, addressing issues like collection of base material, (pre-) cleaning, processing and market survey of the boards.” Pilot board manufacturing unit had a production capacity of one ton/day, the minimum size/capacity to demonstrate (on reduced scale) the actual production process. CIRCOT had committed itself to design feasibility for a commercial unit with 30 tons/day production capacity. The CDT is using this as their guideline.

Unlike in India where the stalk may be used for domestic fuel, and because of high cropping intensity, the stalk has to be removed in the shortest possible time frame for planting of the next crop, in Zambia, farmers are under not much compulsion to remove stalk from their fields. We therefore expect longer availability of stalk – for about three months (even, more) after the completion of harvest (against two months), which would increase the time at our disposal to collect stalk and decrease overall chip storage requirements by at least ten percent.

**Project Duration:** Four years

**Expected Starting Date:** January 2010

**Collaborators:**
- Government of Zambia
- Cotton Development Trust
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Mr. Chitah, Director CDT acquired his master's degree in Agronomy from Tashkent, Uzbekistan and for the last 28 years is working on development of cotton production technology and spearheading a campaign for their adoption in Zambia and other countries in the region. He has developed and implemented cotton production plans and has conducted and participated in workshops in Zambia as well as in several countries of Africa and is in a position to be very effective in promoting cotton and cotton by product processing in many countries of Sub Saharan Africa.

Cotton Development Trust has the experience of collaborations with national and international research, extension and business interests in the agricultural/rural space since its inception as the CDT and prior to that as part of research establishment of the Ministry of Agriculture. Trust has collaborated extensively with the World Bank, USAID and CIRAD internationally and with GART, ZARI, ZCGA, CFU, ZNFU, ZCAZ, etc. CDT is also administering the Government of Zambia's Cotton Out-Growers Fund; and has recently completed Development, Adaptation and Dissemination of Cotton-Based Conservation Farming Technologies Program. The CDT is currently, implementing a research and infrastructure development program under the World Bank funded Agricultural Development Support Project. This is a US 1.4 million dollar infrastructure development and research capacity enhancement grant.

While initially, Cotton Development Trust will work on the entire process, from stalk collection to particle board manufacture, there is an expectation that once the profit potential becomes obvious, local ‘collection interests’ will emerge, and with the CDT support and guidance, in establishing efficient supply chain mechanism. The CDT had already identified interested parties interested in marketing this cotton stalk chip based particle board in Zambia and within the Sub Saharan African Region as long as quality parameters compare favorably with standard particle boards in the market and the prices are competitive.
CIRCOT established in 1924, is the premier cotton research institute of the Indian Council of Agricultural Research (ICAC). In collaboration with ICAC and CFC, CIRCOT had developed and tested cotton stalk based particle board and binderless board manufacture at pilot scale from stalk collection, pre-processing to industrial trials. CIRCOT had declared its intent to develop a viable model for stalk use for adoption by cotton growing countries in Afro-Asian region. The CDT is therefore looking forward to CIRCOT’s involvement with this “scaling-up” of this particle board manufacturing operation both as technical advisor and facilitator.

Common Fund Commodities
Stadhouderskade 55, 1072 AB Amsterdam,
The Netherlands

The focus of Common Fund of Commodities (CFC) is on commodities rather than on countries or geographical regions. Commodities are a backbone of economies of all developing and least developed countries and cotton is one of the more than 30 commodities covered by the fund. Fund had supported commodity-focused high impact projects with the potential of becoming self-sustainable, especially those addressing resource-poor small-holder farmers.

CIRCOT had developed and standardized the manufacturing process for particle board with the support of ICAC and CFC which owns the intellectual property rights. The CDT is therefore proposing that Common Fund for Commodities may consider an equity stake of up to 10% in this up scaled industrial and commercial run and share 10% of the net profit.

Project Description:

Cotton Development Trust proposes to site the particle board production unit and one of the three cotton stalk cleaning and pre-processing unit at the CDT Campus, and has earmarked three hectares – two for the plant and one for collection, pre-cleaning and storage of chip. In addition to pre-processing and chipping, this will be the premier demonstration resource as well. Other stalk collection and pre-processing sites will be located closer to farmer fields in Monze and Gwembe districts of the Southern Province. However, after successful demonstration and collection for the first two to three years, it is hoped that private entrepreneurs will be sufficiently interested in becoming collection and supply
agents and these two field operations (as well as any potential new entrants could also be supported by helping local fabrication facilities in manufacture of chipping/baling equipment) would be handed over to private collection and pre-processing agents with the CDT focusing primarily on particle board manufacture and dissemination of technology as widely as possible. The CDT will provide necessary technical support and guidance to facilitate the entrepreneurs and/or new entrants in promoting these technologies.

This Particle Board manufacturing facility will be a factory scale demonstration of a technology developed by CIRCOT with the support of ICAC and CFC. Particle board from cotton stalk will be produced by compressing small particles of cleaned chipped cotton stalk with synthetic adhesives (resins). Properties of various kinds of particle boards and consequently their uses differ due to difference in size and geometry of the particles/fibers, the amount of resins, and the density of the board. Addition of chemicals/additives can make particle board water proof, fire proof (with the addition of borax, boric acid and ammonium dihydrogen orthophosphate), termite resistant (by adding sodium pentachlorophenate) and if necessary, particle board can be customized for various uses, for instance for doors, furniture, false ceilings and panels, etc.

Since developing a supply chain will be very critical for the success of the operation, it is imperative to describe the key features of the supply chain in the earlier stage of this project. Main thrust of this supply chain process will be a demonstration of an emerging economic opportunity and to sensitize farming communities to the economic and employment creation potential of this activity, which will be highlighted during the CDT collection phase. The CDT will facilitate any prospective entrepreneur by providing training and assist with equipment procurement.

Key features of Supply Chain: Cotton Development Trust proposes a large scale chipping unit at the particle board manufacturing facility and two to three mobile chipping units.

The unit at manufacturing facility will be a large-scale chip making-cum-cleaning system capable of removing bark, pith and boll rinds and chipping the dried stalk to optimum chip sizes for various kinds of particle boards. This unit will also be used for re-chipping of the baled chips produced by the mobile units to feed optimum chips to the manufacturing facility. Subsequently this will serve as a demonstration site during the result dissemination/technology transfer phase.

Zambian cotton farmers are mostly small holders, and villages are not electrified. CDT will therefore procure two (or more) mobile chipping units for chipping and bailing the chips for transport to the particle board facility's chip storage site. Each mobile chipping unit will consist of:

1. Tractor
2. Mobile chipper
3. Mechanical drive
4. Boll rind remover/mechanical rind remover – removing boll rind preferably before harvesting stalk
5. Bark remover
6. Baling/compacting machine
7. Trolley
8. Briquetting machine
The CDT will select suitable locations (with thousand or more hectares of cotton) and lease one half to one hectare area as temporary collection, pre-cleaning and briquetting site. Once stalk in the area have been harvested, the collection site can be moved to another collection area.

The CDT has worked with cotton farmers throughout cotton growing areas of Zambia ever since its inception, and even before as the cotton research station. The CDT teams would use there goodwill and trust build over the years, thus ensuring farmer’s cooperation in selling the stalk rather than burning. If necessary, these teams will ensure farmers protect their stalk in field for harvesting as per CDT schedule, since after harvest, cotton is not followed by any other crop. This will extend the period of availability of stalk from less than two months to more than three.

The CDT will prepare lists of farmers willing to sell their cotton stalk standing in the field as well as those who would bring the harvest stalk to the collection site at a higher price (to compensate them for their labor). The team will ensure boll rind is removed before harvesting the stalk. After harvesting, the stalk will be allowed to dry in the field for one to two days to ensure moisture content was about 10 percent. Dried stalk will be chipped, cleaned and compacted before being shipped to the plant site. Baled chip can be stored at the site for shorter periods if necessary.

Converting cotton stalk into chip would lead to generation of significant quantities of waste at chipping sites (40 – 50 % of stalk harvested). Unless utilized in economically beneficial ways, this could become an environmental hazard of and by itself. Most of the waste generated therefore, will be converted into briquettes, while smaller quantities may be converted into substrate for mushroom cultivation and composting to explore their acceptability as cottage industry among the rural populations. Briquetting machines have therefore been added as part of chipping units.

While briquetting technology tested by CIRCOT will be acquired along the particle board plant, suitable technologies/best practice for converting waste into mushroom cultivation substrate and composting will have to be identified within the first year of operation, and initial tests run before the end of second year of the project. At this stage, it is assumed that once demonstrated, with appropriate awareness campaigns and information dissemination, their adoption will be fast. The CDT will collaborate with local NGOs for the widest possible reach.

Zambia retails a range of wood products including hard, medium and soft particle boards. The CDT will manufacture particle boards only. Usually these boards are three or more layered, but the CDT operation will generally produce the standard three layered board consisting of a coarser particle core and finer particles on the top and bottom layers, respectively. Standard board size in Zambia is 1.2 meters x 2.4 meters. Retail outlets carry particle boards ranging from 6 mm to 18 mm thickness. These fall within the range of board thickness researched by CIRCOT (9, 12, 18 mm).

Other quality parameters of interest for particle board are: average moisture content, water absorption (2 hours and 24 hours of soaking), swelling thickness, swelling due to surface absorption, modulus of rupture, screw withdrawal strength and nail withdrawal strength will be in compliance with the recognized product standards.

Cotton Development Trust, the premier cotton research, development and technology transfer institution in Zambia, is located 4 KM from the main Lusaka-Livingstone highway on an all weather road, and is about 28 KM from Mazabuka. This site is next to the Railway Systems of Zambia, a short distance from Magoye railway station; is connected to the national power grid and has ample water resources.
from Magoye River during and after rainy season as well as sub-soil water throughout the year. Completion of cogeneration unit of Zambia Sugar Mills at Mazabuka, will provide the grid with additional power, thus the occasional load shedding will further decrease substantially, if not eliminated all together. The CDT however intends to supplement power with its own in-house stand-by generator.

Flow Chart of Particle Board Production and Marketing Process for the projected 30 ton/day particle board plant can easily be divided into a three-step flow diagram:

I: **Stalk Collection Agent: Stalk Collection and Pre-Processing consisting the following:**

- Cotton plant stalk procurement, removing boll rinds and harvesting
- Field drying of stalk after harvesting
- Initial stalk cleaning (removing bark, pith, dried leaves and cotton fibers)
- Chipping
- Baling (or compacting)
- Transport to field collection site
- Transportation to particle board plant site for immediate use/storage
- Briquettes and mushroom substrate or compost from chipping/cleaning waste at collection points/site.

II: **Particle Board Plant**

- Re-chipping
- Drying
- Screening particle preparation
- Mixing with binder
- Mat formation
- Pressing
- Conditioning
- Cutting
- Sanding

While field collection, chipping and baling will be done close to farmer fields, using mobile chipping equipment, baled chips would be stored at the plant site and re-chipped to optimum particle size and dried to desired moisture level for final processing at the particle board plant.

III: **Particle Board Marketing**

- Domestic markets
- Regional markets
This operation will require the following Capital investments and production costs (annual production cycle):

A: CAPITAL INVESTMENT

I: LAND & BUILDING

<table>
<thead>
<tr>
<th>Description</th>
<th>US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Land (2 Ha for the Plant + 1 Ha for storage)*</td>
<td>60,000</td>
</tr>
<tr>
<td>2. Building – 40x30 M covered area</td>
<td>240,000</td>
</tr>
<tr>
<td>3. Perimeter fence</td>
<td>15,000</td>
</tr>
<tr>
<td>4. Site Development</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>TOTAL LAND and BUILDING</strong></td>
<td><strong>415,000</strong></td>
</tr>
</tbody>
</table>

II: PLANT & EQUIPMENT

<table>
<thead>
<tr>
<th>Description</th>
<th>US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plant and Machinery</td>
<td>1,500,000</td>
</tr>
<tr>
<td>2. Freight, Insurance, Taxes etc</td>
<td>225,000</td>
</tr>
<tr>
<td>3. Civil Works for Installation of Plant &amp; Machinery</td>
<td>200,000</td>
</tr>
<tr>
<td>4. Plant Erection and Commission</td>
<td>150,000</td>
</tr>
<tr>
<td><strong>TOTAL Erection and Commission</strong></td>
<td><strong>2,075,000</strong></td>
</tr>
</tbody>
</table>

III: MISCELLEANEOUS

<table>
<thead>
<tr>
<th>Description</th>
<th>US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Auxiliary &amp; Service Equipment including fire/hazard control</td>
<td>150,000</td>
</tr>
<tr>
<td>2. Auxiliary Electricity Generator</td>
<td>70,000</td>
</tr>
<tr>
<td>3. Preliminary &amp; Pre-Operating Expenses</td>
<td>150,000</td>
</tr>
<tr>
<td>4. Technology &amp; Engineering Fees</td>
<td>150,000</td>
</tr>
<tr>
<td>5. Publicity &amp; Workshops</td>
<td>165,000</td>
</tr>
<tr>
<td>6. Staff Management Fees</td>
<td>243,000</td>
</tr>
<tr>
<td>7. Contingencies (@10% of fixed capital)</td>
<td><strong>249,000</strong></td>
</tr>
<tr>
<td>8. Margin money for working capital (25% of working capital)</td>
<td>150,000</td>
</tr>
<tr>
<td><strong>TOTAL MISCELLEANEOUS</strong></td>
<td><strong>1,327,000</strong></td>
</tr>
</tbody>
</table>

**TOTAL PROJECT COST (I+II+III)**                                          **3,817,000**

*2 Hectare for the Particle Board Plant and 1 Hectare for the cotton stalk collection, pre-cleaning, chipping, baling and storage point at the Particle Board Plant Location at CDT, Magoye.
B: **COST OF PRODUCTION (Per Annum)**

<table>
<thead>
<tr>
<th>I: Raw Materials</th>
<th>US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Cotton stalk (15750 tons @ US $ 20/ton – earlier $20/Ha**)</td>
<td>315,000</td>
</tr>
<tr>
<td>b) Resin + chemicals (720 tons @ US $ 800/ton)</td>
<td>576,000</td>
</tr>
</tbody>
</table>

| II: Utilities (Electricity, Water & Fuel) | | US $ |
|-----------------------------------------|------|
|                                         | 250,000 |

| III: Labor & Supervision | | US $ |
|--------------------------|------|
|                          | 184,000 |

| IV: Repairs & Maintenance | | US $ |
|---------------------------|------|
|                          | 100,000 |

| V: Plant overheads @ 2% of plant and Machinery | | US $ |
|-----------------------------------------------|------|
|                                              | 41,500 |

| VI: Stores and Consumables | | US $ |
|---------------------------|------|
|                          | 100,000 |

| VII: Operating Supplies | | US $ |
|-------------------------|------|
|                         | 10,500 |

| VIII: Taxes & Insurance | | US $ |
|-------------------------|------|
|                         | 40,000 |

**TOTAL Manufacturing Costs** | **US $ 1,617,000**

| IX: GENERAL EXPENSES | | US $ |
|----------------------|------|
| a) Administrative overheads | 243,000 |
| b) Studies, publications, workshops | 115,000 |
| c) Selling cost | 160,000 |

**Total General Expenses** | **US $ 518,000**

| X: DEPRECIATION & INTEREST | | US $ |
|---------------------------|------|
| Depreciation: Plant @10% of plant & machinery cost | 207,500 |
| Building @5% of land & building cost | 20,000 |
| Interest: On long term loan @ 28% | 697,000 |
| On short term loan @ 31% | 220,000 |

**Total Depreciation and Interest** | **US $ 1,144,500**

**TOTAL COSTS: Manufacturing, General Expenses, Depreciation & Interest etc.** | **US $ 3,279,500**

| XI: Royalty on sales 2.5% on ex-factory sales | | US $ |
|----------------------------------------------|------|
|                                             | 87,000 |

**GRAND TOTAL of Cost of Production** | **US $ 3,366,500**

<table>
<thead>
<tr>
<th>Cost of Production/kg (US$)</th>
<th>0.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of production/sq meter (US$)</td>
<td>3.36</td>
</tr>
</tbody>
</table>

**Profitability (in US $)**

| a) Selling Price per unit (US$/12 mm thick 1.2 x 1.4 M board) | 10* |
| b) Gross annual income | 3,474,000 |
| c) Annual cost of production | 3,366,500 |
| d) Annual return (b-c) | 107,500 |

*This board is currently retail marketed at US$ 20 per board in Zambia.

** This is price of the chips – after harvesting, pre-cleaning, chipping, baling and transportation to the site!
The following substantive components (clusters of activities) have been identified for successful scaling-up/commercialization of CIRCOT developed design:

**COMPONENT 1: Stalk Collection and Preprocessing.**

Developing an optimized system for cotton stalk collection from farmer’s field and pre-cleaning, chipping, baling and transportation to Board manufacturing facility. This pre-processing would be done at farmer’s field and chip transported to collection operation’s storage site after baling at the field level would be to ensure availability of sufficient quantities of raw materials for year round operation of manufacturing facility.

Cotton is a seasonal crop wherein the cultivation starts from November and picking is carried out from May to July. Once the picking is complete, cotton stalks are available from July to September – when technically, no stalks should remain in the fields. Cotton stalk would therefore require harvest, processing and storage for guaranteed supplies to board manufacturers for whole year production.

Cotton stalks are bushy in nature, have low bulk density and may pose technical problems in collection, resulting in high cost of transportation. Further, on storage in stick form cotton stalks may get degraded due to attack of insect pests, especially termites, a major problem in Zambia. Therefore, ideally, the stalk must be processed at situ – and only cleaned and baled chip need to be stored in proper storage in field or after transportation to the processing facility may reduce the possibility of termite attack. Thus the proposal for having three chipping centers at two sites in the field and third at particle board manufacturing plant itself would be to ensure the success of sustainable cotton stalks supply around the year as an industrial raw material. These collection sites would have the ability to convert pith and other waste from stalk into briquettes or other useful by products – e.g. substrate for mushroom cultivation.

**Outcome:** An optimized system of stalk collection, preferably pre-processing at the field level, including recommended institutional arrangements for collection and transportation of baled cotton stalk chip to the production unit.

**Activities:** In the first year of the project, various activities under Component 1 will be carried out in and around CDT by setting up the following three cotton stalk collection operations under this project as well as initiate other activities for the development of efficient supply chain mechanism/arrangements for collection of cotton stalks within a radius of about 20-25 km.

Activity 1.1: Tender process for the Import/fabrication of portable/mobile chip cleaning and baling, and briquetting machines based on CIRCOT design.

Activity 1.2: Three cotton stalk collection, pre-processing (pre-cleaning, chipping and baling) operations: one at CDT and two in Monze/Gwembe, and transport to the board manufacturing facility at CDT for processing into particle board or storage for later use.

This will be the implementation of the Supply-Chain-Mechanism designed/developed by CIRCOT on commercial basis. Initially CDT will spearhead the collection and pre-processing process, but as local actors become aware of business potential, some of the responsibility will be transferred to private collection and supply agents. It is expected that within three years of the manufacturing of particle
board, CDT will have transferred all collection, pre-processing and transport of pre-processed and baled chip to private agents.

Activity 1.3: Developing efficient supply chain mechanism/players.

Creating awareness among rural entrepreneurs on the prospects of developing cotton stalk collection, pre-cleaning, chipping, baling and transportation to particle board plant at CDT. While CDT will retain at least one of three stalk collection operations for demonstration, it is expected that by the end of the project, private collection agents would have assumed responsibility for collection, pre-cleaning, chipping and baling and transportation of the baled chip and related functions on a commercial basis.

Activity 1.4: Utilization of waste from cotton stalk pre-cleaning process as raw material for briquettes making, and developing briquette making and marketing system in association with stalk collection chain.

Outcome: An optimized system would be that of stalk collection and pre-processing at the field level, and if necessary, storage at collection sites before transporting suitable/sufficient quantities of baled chips to board manufacturing facility – as well as recommended institutional arrangements. However, since CDT has sufficient land resources, to ensure steady chip supply to manufacturing operation, initially pre-processed and baled chips will be stored on site.

Transportation of baled, cleaned chips would be the most economical mode of transportation to board manufacturing site. It is therefore proposed that chipping equipment developed by CIRCOT under the CFC supported under the supervision of ICAC (CFC/ICAC/20) project shall be imported initially to proceed with the manufacture of particle board. Subsequently, Zambian equipment manufacturers would be encouraged to manufacture the Indian design – with any modification if required, either of the pre-processing/compacting technology, or of the complete particle board manufacturing operations.

Waste after pre-processing, processing, baling and transportation will be used gainfully for making briquettes and substrate for mushroom cultivation.

Under the guidance of Mr. West K. Chitah, Dr. Bruce M. Siamasonta and Mr. S. Selemani Farm and Station Manager will be responsible for collection, pre-processing, transportation of cotton stalk based chips to the storage facility at CDT. Mr. Slemani will be responsible for the overall Estate Management of the particle board plant and stores.

COMPONENT 2: Installation and Operationalization of Particle Board Manufacturing Facility at CDT and other associated infrastructure.

Installing and operationalizing cotton stalk-based particle board manufacturing facility as well as developing storage facilities, both for baled chip as well as finished product at CDT. Before the completion of physical plant and initiation of trial runs, a product marketing chain will be developed by co-opting or appointing an independent marketing agent for Zambia as well as for Sub-Saharan Africa. This Component will consist of the following activities:

Activity 2.1: Establishment of a 30-ton-per-day Particle board Manufacturing Unit based on up-scaled design of CIRCOT’s Experimental Demonstration Plant facility for particle board production. This will consist of:
1. Tendering for construction of a building for particle board production plant, associated workshop and raw material and product storage;
2. Simultaneous tendering for procurement and installation of the said plant; and
3. Construction of particle board plant under CIRCOT guidance/advice for at least one to two years/production cycles.

Activity 2.2: Installation and trial run of plant equipment for particle board production using CIRCOT specifications for: processing conditions (temperature, pressure, time and resin content) and synchronization of different parts of the system; establishment of quality parameters of cotton stalk particle boards; Identification of different processing conditions for different end-uses (paneling, table tops, false ceiling, partitioning etc.); Production and evaluation of boards with different thickness (12 and 18mm) and surface finishes (veneer, bamboo mat, pre-lamination etc.); Effect of different chemical additives (fire retardants, water repellent, termite protection) on process conditions and board quality; Production and evaluation of boards of blended agro residues (baggasse, wood chips, soya stalk, wild grasses, maize stalks, etc.) with cotton stalks.

The facility will need about 50 tons of chips per day [about 1.75 tons of chip from cotton stalk yields 1 ton Particle Board], which will be yielded by about 12,000 Ha for approximately 300 day operation to make this unit commercially viable.

Activity 2.3: Establishing a marketing chain for the cotton chip-based particle board in Zambia and Sub Saharan Africa.

Outcome: A fully operational ‘scaled-up’ production unit capable of producing 30 tons of particle board per day at CDT under technically identical conditions as commercially operated plants, and an efficient marketing organization for Zambia and Sub Saharan Africa.

Under the overall guidance of Mr. West K. Chitah, Mr. L. Silwimba will be responsible for developing the business plan. He will work closely with the Particle Board Plant Manager who will be responsible for production. An appropriately experienced Plant Manager will be hired with the consultation and advice of CIRCOT. It is expected that for the first two to three years, the Plant Manager may be a Contract Hire from CIRCOT India. Plant Manager’s proposed terms of reference are presented in Annex III.

COMPONENT 3: Studies and Analyses during the Project Implementation Period and Dissemination of Project Outcomes before Project Completion.

These will include studies on technology impact analysis; Cash-flow analysis, an assessment of agricultural biomass as industrial raw material and its cash-flow potential on ‘balance sheet’ of particle board enterprise; and dissemination of project outcomes through publications, demonstrations and national and regional workshops. Under this Component CDT will analyze:

• The impact of commercialization of cotton by products on cotton production potential and identify synergies between producers and processors especially industry based on stalk use in Zambia and other countries in the Region;
• Research and development of new particle board products as well as production and evaluation of boards of blended agro-residues with cotton stalk.
• Social, economic and employment creation impacts of stalk collection and processing within the project area.
• Quantify the impact of cotton stalk use on particle board market, and potential of briquettes in reducing wood-based charcoal and their impacts on local/global environment.
• Analyze cash flow potential of industrial use of agricultural biomass and economic impact assessment of such innovation at national and regional level as well as annual cash flow analysis of particle board manufacturing plant and economic analysis including expenses and income; and
• Organize a final workshop at the end of the project to share developmental experience and potential benefits of transfer of this technology within Zambia and Sub-Saharan Africa.

Following activities have been identified as relevant to this project.

Activity 3.1: Analyze cash flow potential of agricultural biomass and economic and environmental impact assessment of such innovation at national and regional level.

Activity 3.1.1: Cash flow potential of agricultural biomass as industrial raw material: particle board and briquettes.
Activity 3.1.2: Economic and environmental impact assessment of agricultural biomass.
Activity 3.1.3: Annual cash flow including expenses and income and economic analysis of the particle board plant.
Activity 3.1.4: Research and development: new particle board products; boards blended with other agricultural biomass.

Activity 3.2: Dissemination of Project Results at national and regional level.

In order to ensure the commercial adoption of the technologies introduced in Zambia under this program and to ensure market acceptability of the products prepared, we are proposing to establish strong and effective linkages with private industry on the one hand and cotton farming community on the other, and will be engaged through workshops and involvement of NGOs for promotional activities in rural areas. A well advertised ‘field-day’ to demonstrate the project and its potential outcomes will be held annually at the site. To establish the impact of such technology introductions, a socio-economic baseline will be established at the beginning of the project.

Promotional brochures, scientific papers and popular articles in the print media will be used to create awareness among relevant entrepreneurs and consumers. A techno-economic and socio-economic report will be published on the project findings. By conducting industrial scale trials, technology transfer to industries will be achieved. CDT will pursue an open-door policy to receive any interested party or parties from other cotton growing areas as well as countries in the region to see the application of this technology and provide support in adopting this technology as long as they will acknowledge the assistance provided by CDT as well as ICAC and CFC as the holders of intellectual property rights. As the first step in this direction, an international workshop of two days duration will be organized at Lusaka/CDT in which cotton growing member countries of SADC will be invited to participate. This will be followed by demonstration of stalk collection process, manufacture of particle board and marketing strategy to boost interest significantly in locally available agricultural raw materials with potential industrial use in general and cotton by-products in particular in the Sub-Saharan African countries creating opportunities for entrepreneurship, economic activity and employment creation.
Activity 3.2.1: Encouraging farmers and local NGOs for participation and cooperation in the development of primary production chain to supply cotton stalks/chip for particle board production.

Activity 3.2.2: Establishing a baseline of socio-economic indicators at the beginning of this project and evaluating impact of project interactions before mid-term review and after project completion.

Activity 3.2.3: Publication of Comprehensive Handbook in English and local language(s): Reporting of project findings in English and local language(s), highlighting the techno-economic feasibility and socio economic aspects of cotton stalk as raw material for board production.

Activity 3.3: Transfer of Technology: To disseminate and popularize the technologies adapted at national/regional levels by building an interactive website to disseminate results extensively.

Activity 3.4: Regional/international Workshops:
3.4.1: Production of an information brochure for the workshop in English.
3.4.2: Invitation to participants from CFC member countries growing cotton in Sub Saharan Africa, and national representatives.
3.4.3: Organization of a Regional/International Workshop for presentation of project achievements and demonstration of particle board manufacture and associated technologies to Workshop participants at CDT.
3.4.4: Demonstration of technologies to interested parties under CDT’s open-door policy for dissemination of this technology.

Outcome: Information on the data obtained and results achieved by the project documented and shared with relevant groups from the private sector, be it farmers (-groups), entrepreneurs, researchers, investors etc, in particular in African cotton producing countries.

Dr. Bruce M. Siamasonta and Dr. Malik S. M. Khokhar will coordinate the work under this Component. Under their guidance, Ms M. Chijikwa and Mr. Richard Ngoshe will create awareness amongst farmers, farmer groups and local NGO in the potential of extra income for farmers and local business communities in developing primary production chain for supplying cotton chips to the plant and substituting chip-waste based briquette for the forest timber-based charcoal, building upon the links developed by stalk collection teams. They will prepare Handbooks, brochures and other promotional literature for the dissemination of this technology. Mr. Chitah will organize regional and international workshop and Dr. Malik S. M. Khokhar will convene the Regional and Workshop with the help of Mr. N. Bbebe and International workshop with Ms. M. Chijikwa.

COMPONENT 4: Project management and monitoring and evaluation

This component will ensure effective utilization of project resources in establishing this facility for converting cotton stalks into particle boards, and waste from chipping into briquettes and dissemination of project results at national and international level.

The Project Executing Agency (PEA) will be the Cotton Development Trust (CDT), Magoye, Mazabuka District of the Southern Province. It will be the responsible Institution for the overall implementation of the scheme including its day to day management.

The CDT has the required organizational, managerial and the general technical capacity to take up the role of PEA. The Director of the CDT will be the person overall responsible for the project. He will set up adequate advisory and operational structures (within the CDT as well as incorporating the various
external parties/stakeholders of the project) as required for the adequate implementation of the project.

The CDT will coordinate the activities to be undertaken at various cotton stalk collection, cleaning, chipping and storage sites and will ensure that they are planned and implemented in a manner contributing effectively and efficiently to the achievements of the envisaged objectives of the scheme. The CDT will also maintain close liaison with the CIRCOT who will serve as technical support institution/project consultants. The PEA will prepare annual work program, budget, half yearly progress reports and annual progress reports and administer the finances of the project. An advisory committee specially constituted to assess the progress of the project would perform the job of monitoring by participation in an evaluation meeting once in six months during the execution of the program. A technical evaluation of the progress of the scheme is proposed at the completion of the second year of the project and will be organized in consultation with the funding and supervisory body and a final Report on completion of the project will be prepared and submitted to the funding agency in the fourth year. The final evaluation and assessment would be conducted by an expert team appointed by the funding agency at the successful completion of the whole program.

Outcome: An efficiently implemented and managed project, completed as planned within the set time frame and budget.

Activity 4.1: Project Management
4.1.1: Constitution of advisory board, consisting of 6 members, 3 external Scientists and 3 from private industry, under chairmanship of Director CDT.
4.1.2: Half yearly meeting of advisory board to evaluate the progress of work and planning.
4.1.3: Preparation of annual work programs, budget and progress reports
4.1.4: Capacity building and human resource development:
   • Consultancy and technical assistance for establishment of this operation
   • Training of Management/Technical staff
   • Project Monitoring and Evaluation
4.1.5: Midterm evaluation after second year by external experts assigned by CFC and ICAC officials.
4.1.6: Preparation of final project report
4.1.7: Final project evaluation at the end of the project by external experts assigned by CFC and ICAC officials.

Activity 4.2: Co-ordination of the Project Activities by the PEA
4.2.1: Preparation of management reports, financial statements duly audited, and coordination of project activities: Overall implementation of day-to-day activities.
4.2.2: Evaluation of progress of the project in regular Staff Research Council and Research Advisory Committee of CDT.

Mr. West K. Chitah will constitute the Advisory Board. Dr. Malik S. M. Khokhar will prepare detailed Annual Work Program and budget and regular progress reports with the help of Mr. L. Silwimba. After plant commissioning, Plant Manager (to be hired in consultation with CIRCOT) and Mr. Silwimba will report to Mr. Chitah who will ensure efficient and profitable management of this facility as a commercially viable operation and develop promotion of this technology in Zambia and Sub-Saharan Africa. Mr. Chitah would ensure timely reporting and coordination with ICAC, CFC and local stakeholders including Government of Zambia.
Collaborators’ Experience in Running Such Projects:

Cotton Development Trust: The CDT has the experience of collaborations with national and international research, extension and business interests in the agricultural/rural space since its inception as the CDT and prior to that as part of research establishment of the Ministry of Agriculture. Trust has collaborated extensively with USAID and CIRAD internationally and with GART, ZARI, ZCGA, CFU, ZNFU, CAZ, etc. The CDT is administering the Government of Zambia’s Cotton Out-Growers Fund; has recently completed Development, Adaptation and Dissemination of Cotton-Based Conservation Farming Technologies Program; and is currently, implementing a research and infrastructure development program under the World Bank funded Agricultural Development Support Project. This is a US 1.4 million dollar infrastructure development and research capacity enhancement grant.

The CDT has a dedicated team of Specialists, Technicians, field staff and an out-reach program serving cotton growers through out Zambia as well as sufficient human resources in business development and administration and skilled labor, which places it in a unique position to develop primary collection chain and develop a briquette marketing network. The CDT has already identified a local entrepreneur to market the Boards locally in Zambia as well as regionally in Sub Saharan African countries.

Mr. West K. Chitah, Director CDT is an acknowledged authority on cotton production systems in Sub Saharan Africa. His professional career has centered-around development of cotton production technology and spearheading a campaign for their adoption in Zambia and other countries in the region. He has developed cotton production plans and has led, conducted and participated in workshops in Zambia as well as in several countries of Africa and in most cotton growing regions of the world, and is in a position to be very effective in promoting cotton and cotton by product processing in many countries of Sub Saharan Africa.

Proposed Particle Board Plant and Stores Site is secured by an electric fence, is close to the Railway Systems of Zambia network (one kilometer from Magoye train station) is serviced by an all weather road, and connected to the national power grid. Water is available both from River Magoye through the irrigation system (in final stages of installation) and tube wells at the CDT Farms.

Central Institute for Research on Cotton Technology (CIRCOT) established in 1924, is the premier cotton research institute of the Indian Council of Agricultural Research. It includes a ginning training center at Nagpur and has six regional stations in major cotton growing areas of the country. CIRCOT has the mandate of increasing the productivity and quality of Indian cottons. Income from cotton farming is low for a large number of small holder cotton farmers faced with resource constraints. CIRCOT had been exploring economic potential of cotton plant by-products for many years. Cotton stalk was identified as one such by-product with the potential to generate additional income for the farming community.

Cotton stalk is rich in holocellulose (79%) and lignin (27%) and was therefore identified as a candidate by-product for value addition, thus generating additional income for small holder cotton producers. CIRCOT had conducted extensive research and has developed and tested cotton stalk based particle board and binderless board manufacture at laboratory scale. These technologies were further refined on an experimental plant and techno-economic feasibility was conducted to define parameters for commercialization of this technology with the help of ICAC and CFC funded “Utilization of cotton plant by-produce for Value-added Products (CFC/ICAC/20)” operation. This detailed project addressed all the relevant issues - from stalk collection, pre-processing to industrial trials.
A number of research and development objectives were defined for the project and the experimental plant, ranging from investigating best practices for pre-processing of stalk to refinement of board manufacturing technology for high quality board production. Finally, since ICAC, CFC and CIRCOT are committed to promote cotton stalk as industrial by-product, this plant would serve as a demonstration unit for propagating these technologies at national as well as international levels. Numerous ‘awareness’ meetings with stakeholders were conducted in different cotton growing regions of India, and an international workshop is scheduled by the end of 2009. CIRCOT was also committed to the scaling-up of this technology and will therefore be involved with CDT operation as technical advisor and facilitator.

Common Fund for Commodities (CFC): The focus of Common Fund of Commodities is on commodities rather than on countries or geographical regions. Commodities are a backbone of economies of all developing and least developed countries and cotton is one of the more than 30 commodities covered by the fund. Fund had supported commodity-focused high impact projects with the potential of becoming self-sustainable, especially those addressing resource-poor small-holder farmers. CIRCOT had developed and standardized the manufacturing process for particle board with the support of ICAC and CFC which owns the intellectual property rights. The CDT is therefore proposing that Common Fund for Commodities become an even more involved stakeholder and consider an equity stake of up to 10% in this up-scaled commercially run operation of its earlier intervention, and share 10% of the net profit. This might enhance the adoption of this technology in all cotton growing areas as well as areas of high biomass generation, globally.

Total Cost of the Project:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated total cost</td>
<td>US$ 3,597,000</td>
</tr>
<tr>
<td>CFC Equity</td>
<td>US$ 360,000 (10.0%)</td>
</tr>
<tr>
<td>CFC grant</td>
<td>US$ 1,615,000 (44.9%)</td>
</tr>
<tr>
<td>Counterpart contribution</td>
<td>US$ 1,622,000 (45.1%)</td>
</tr>
</tbody>
</table>

Benefits and Beneficiaries

Direct and indirect benefits to farmers: The main benefits of a successfully implemented project will be the additional income that cotton farmers will secure through the sale of their cotton stalks which are currently perceived to have no monetary value. Additional jobs will be created in the rural space when stalk collection and preprocessing is taken-up by the private sector. Stalk utilization in particle board manufacture will decrease quantities of stalk burnt in the field or in piles after harvesting as there is no perceived monetary value for them. Less-stalks burnt in the field would be a direct environmental benefit as well. The additional income could amount to US$ 20/ha (or more in case they harvest the stalk themselves), which in the case of small-holder farmers represents an increase of more than ten percent of their monetary income from cotton production alone. Marketability of stalk might motivate farmers to fertilize their crops, which would benefit both yields increase of seed cotton as well as of stalk.

Additional benefits can be found in the expected reduced use of wood as a basis for particle/hard board production, which would have strong environmental benefits; and in the possibility to create new rural based board manufacturing units which (with their raw material collection/supply systems) may require at least some 100 – 150 workers per unit producing 30 tons per day, with positive impact on reducing
rural unemployment, ideally in the Eastern and Central Provinces. Waste from stalk pre-processing and compacting can be used for making briquettes which will compete with wood based charcoal thus reducing pressure on under pressure forest resources in Zambia. Waste can also be used as substrate for mushroom cultivation, or as compost.

Development of supply chain players and cottage industry for making briquettes, mushroom substrate and compost, etc will be the indirect contribution in developing an off-farm rural economy, creating much needed employment opportunities in the rural space.

**Environmental benefits – local and global:** In addition to enhancing small farmer’s income, other benefits of this project can be summed as:

(i) Wood substitution nature of cotton stalk chip may relieve pressure on forest resources in a significant manner. Cotton stalk based chips and other agricultural waste might decrease the reliance of wood product industry on forest resources.

(ii) Briquettes as charcoal substitute can further reduce pressure on forest resources.

(iii) An additional environmental benefit (in addition to conservation of forests) will be stoppage of the burning of hundreds of thousand of tons of cotton stalk in the fields, as they are perceived to be without any monetary value at present, and in spite of best efforts, they cannot be incorporated into soil as organic matter. Thus preventing significant quantities of carbon dioxide from being released to atmosphere.

**Objectives and Rationale:**

**Objectives No. 1:** Cotton stalk collection, pre-processing (pre-cleaning, chipping and baling) at the CDT, Monze and Gwembe (up to three sites, initially), and storage and transport to the board manufacturing facility to be established at the CDT. Install a fully operational ‘up-scaled’ production unit capable of producing 30 tons of particle board per day at the CDT under technically identical conditions as commercially operated plants; marketing of the product and efficient utilization of the waste generated by the process cycle. This objective is essentially proving commercial viability of cotton chip-based particle board manufacturing technology developed by CIRCOT with CFC and ICAC support.

**Work to be done:** An optimized system for stalk collection and pre-processing at the field level, will be developed – one at the Plant site and the two to three with mobile chipping equipment within 10 – 15 KM from the Plant. Chips will be baled and transported to the CDT for storage. Civil works for particle board manufacturing plant at the CDT and acquisition and installation of physical plant; and developing a product marketing system/channel.

**Expected Outcome:** Additional income for cotton farmers from sale of cotton stalk and year round availability of cotton stalk based chip for the manufacture of particle board, manufacture and marketing of particle boards.

**Objective No. 2:** Develop alternative fuel – briquettes from cotton stalk waste, thus in addition to wood substitution in forest-based industrial processes, reducing pressure on forest for charcoal making which is depleting timber at an alarming rate and has major environmental sustainability consequences for Zambia. Besides briquetting, other options to use this waste, for
instance as substrate for mushroom cultivation; composting or any other beneficial use shall also be explored.

**Work to be done:** Installation of briquetting machines at the project site and at collection sites to utilize waste generated from cotton stalk processing by converting chipping waste into briquettes as alternative fuel.

**Expected Outcome:** Availability of an affordable alternative fuel to substitute wood-based charcoal used widely as fuel. This would reduce the need of wood-based charcoal with chip waste based briquettes

**Objective No. 3:** Analyze the impact of commercialization of cotton by products on cotton production potential and identify synergies between producers and processors especially industry based on stalk use in Zambia and other countries in the Region.

**Work to be done:** Data collection and analysis, and developing linkages between producers, collectors and processors

**Expected Outcome:** Small holder producers will start exploring potential not only of improved crop production but also or economically attractive crop biomass utilization potential as well.

**Objective No. 4:** Research and development of new particle board products as well as production and evaluation of boards of blended agro-residues with cotton stalk.

**Work to be done:** Making of particle boards with different specifications for different uses (paneling, table tops, false ceiling, partitioning, etc) and blending different agricultural residues – corn stalk, wild grasses, soya stalk etc. with cotton stalk for assessing particle board quality parameters.

**Expected Outcome:** This will extend the range of particle board products to meet niche requirements; at the same time identifying alternative biomass sources during cotton stalk shortages.

**Objective No. 5:** Social, economic and employment creation impacts of stalk collection and processing within the project area.

**Work to be done:** The CDT will actively pursue to demonstrate and motivate local entrepreneurs to get involved as supply chain actors.

**Expected Outcome:** This will likely lead to development of local businesses not only for collection of stalk but also for processing and marketing of briquettes, bringing potential economic activities to rural/local communities.

**Objective No. 6:** Analyze cash flow potential of agricultural biomass and economic impact assessment of such innovation at national and regional level.

**Work to be done:** Proper accounting procedures will ensure determining the profitability of this operation as a business at the CDT end.
**Expected Outcome:** The CDT will be able to demonstrate the profitability in terms of direct benefit as cash flow of the operation and indirect benefits as increased income for small holder cotton growers and global environmental benefits.

**Objective No. 7:** Quantify the impact of cotton stalk use on particle board market, and potential of briquettes in reducing wood-based charcoal and their impacts on local/global environment.

**Work to be done:** Cotton stalk will substitute wood chip in particle board manufacture. This will address two issues: acceptance of cotton stalked based particle board and utilization of stalk waste for briquette making. These will be a substitute to forest based charcoal.

**Expected Outcome:** Wood substitution and briquettes will relieve the intense pressure on forest resources in Zambia.

**Objective No. 8:** Annual cash flow analysis of particle board manufacturing plant – economic analysis including expenses and income.

**Work to be done:** Preparing audited balance sheet.

**Expected Outcome:** Cash flow analysis as well as economic analysis of the project

**Objective No. 9:** Organize a final workshop at the end of the project to share developmental experience and potential benefits of this technology; and demonstrate promote and disseminate this economically viable and environmentally and socially beneficial technology with its job-creation potential in non-farm rural space in Zambia and Sub Saharan Africa.

**Work to be done:** Regional and International Workshops will be conducted to disseminate the outcome of this intervention.

**Expected Outcome:** New income streams for small holder farmers, business opportunities at village/local level with the creation of supply chain and wood substitution raw materials for industry in addition to environmental benefit of prevention of stalk burning and conservation of forest resources.

An additional output of several of these objectives will be achieved through an efficient Project Management and Administration. The PEA will supervise the conduct of these studies and disseminate results and identified good practices not only within Zambia but also to other countries/players in the region willing to benefit from adopting such technologies.

**Application of Project Results and Beneficiaries:**

On approval of this proposal in the September-November of 2009, the CDT will simultaneously initiate the work on Component 1 and 2. While the supply chain is put in place during the cotton season of 2009–2010, order for the plant will be placed and civil works contracted before December 31st, 2009. The CDT will ensure civil works are complete by the time the plant reaches Magoye. Ideally the plant should be ready for manufacturing particle board by August 2010.
Initially the main beneficiaries of the successful implementation of this project will be the small holder farmers in Mazabuka, Monze and Gwembe districts of the Southern province. In addition to the farmers selling cotton stalk, this project will create hundreds of direct and indirect employment opportunities, both at the plant and in the development of supply chain actors. This will further stimulate rural economy by increasing economic activity. At a later stage, adoption of such production methods would benefit cotton farmers throughout Zambia and Sub Saharan Africa. These will be in addition to the environmental benefits of reduction of stalk burning in the field, a very unsustainable but common practice in Zambia.

**Limitations to Undertaking Such a Project/Research at National Level:**

CIRCOT has developed and tested a Model operation with the support of CFC and ICAC. The CDT is proposing to test CIRCOT design to proximate commercial operation, and will enter into an agreement with CIRCOT to act as Consultant during the installation, commissioning and operation for up to two years after the commencement of commercial production. Thus it is safe to assume there will be no technical constraints in developing this operation.

**Economic Impact of Project Findings:**

**Description of Project Components and Activities**

The project will be built on three main objectives and six equally important but supporting objectives including various socio-economic and environmental impact analysis, cash flow potential for supporting research and outreach programs of the CDT in dissemination of results and promotion of this technology in Zambia and Sub Saharan Africa towards the end of the project.

**Objective:** Create opportunities for additional income for cotton farmers through value addition of cotton stalks to the already hard pressed smallholder cotton farmers of Zambia; create business and employment opportunities through developing cotton stalks collection and supply chain for particle board manufacturing process.

This objective will be met by developing Cotton stalk collection, pre-processing (pre-cleaning, chipping and baling) at the CDT and Mazabuka/Monze/Gwembe (initially three sites), and storage and transport to the board manufacturing facility to be established at the CDT. Waste generated at collection sites will be utilized in briquette making – for which in absence of locally available technology, CIRCOT equipment will be procured; or preparation of substrate for mushroom cultivation or some other economically viable potential use.

**Outcome:** An optimized system would be that of stalk collection and pre-processing at the field level, and if necessary, storage at collection sites before transporting suitable/sufficient quantities of baled chips to board manufacturing facility – as well as recommended institutional arrangements. However, since the CDT has sufficient land resources, to ensure steady chip supply to manufacturing operation, initially pre-processed and baled chips will be stored at plant site.
Transportation of baled, cleaned chips would be the most economical mode of transportation to board manufacturing site. It is therefore proposed that chipping equipment developed by CIRCOT under the CFC supported under the supervision of ICAC (CFC/ICAC/20) project shall be imported initially to proceed with the manufacture of particle board. Subsequently, Zambian equipment manufacturers would be encouraged to manufacture the Indian design – with any modification if required, either of the pre-processing/compacting technology, or of the complete particle board manufacturing operations.

**Component 1: Stalk Collection and Preprocessing and waste utilization.**

Activity 1.1: Tender process for the Import/fabrication of portable/mobile chip cleaning and baling, and briquetting machines based on CIRCOT design.
Activity 1.2: Three cotton stalk collection, pre-processing (pre-cleaning, chipping and baling) operations: one at the plant site and two in Monze/Gwembe, and transport to the board manufacturing facility at the plant site for processing into particle board or storage for later use.
Activity 1.3: Developing efficient cotton stalk collection and supply chain mechanism/players.
Activity 1.4: Utilization of waste from cotton stalk pre-cleaning process as raw material for briquettes making, and developing briquette making and marketing system in association with stalk collection chain.

**Lead institution:** Cotton Development Trust.
Cost: US$ 335,200

**Objectives:**

- Benefit environment through developing a commercial and/or industrial use for cotton stalks that are otherwise burned in the field adding to environmental pollution, and benefiting forest resource conservation by developing a new raw material for wood-chip based industry.
- Developing alternative fuel – briquettes from cotton stalk waste, thus in addition to wood substitution in forest-based industrial processes, reducing pressure on forest for charcoal making which is depleting timber at an alarming rate and has major environmental sustainability consequences for Zambia;

This will be met with the installation of a fully operational ‘up-scaled’ production unit capable of producing 30 tons of particle board per day at the CDT under technically identical conditions as in commercially operated plants, marketing of the product and efficient utilization of the waste generated in this process cycle by converting it into briquettes or substrate for mushroom cultivation or other economically viable activities.

**Outcome:** A fully operational ‘scaled-up’ production unit capable of producing 30 tons of particle board per day at the CDT under technically identical conditions as commercially operated plants, and an efficient marketing organization for Zambia and Sub Saharan Africa. Waste generated from pre-cleaning, chipping and particle board manufacture converted into briquettes as alternative fuel and other uses.

**Component 2: Installation and Operationalization of Particle Board Manufacturing Facility at the CDT and other Associated Infrastructure.**
Activity 2.1: Establishment of a 30-ton-per-day Particle board Manufacturing Unit based on up-scaled design of CIRCOT’s Experimental Demonstration Plant facility for particle board production: tendering for construction/civil works and particle board plant
Activity 2.2: Installation and trial run of plant equipment for particle board production using CIRCOT specifications; Production and evaluation of boards with different thickness and surface finishes (veneer, bamboo mat, pre-lamination & lamination of particle boards, etc.); Effect of different chemical additives: fire retardants (borax, boric acid and ammonium dihydrogen orthophosphate); water repellent, termite protection (sodium pentachlorophenate) etc. on process conditions and board quality and end-user specifications for instance, false ceiling, paneling, doors, furniture, etc.
Activity 2.3: Establishing a marketing chain for the cotton chip-based particle board in Zambia and Sub-Saharan Africa.

Lead institution: Cotton Development Trust.
Cost: US$ 3,331,200

Objectives:
- Analyze the impact of commercialization of cotton by products on cotton production potential and identify synergies between producers and processors especially industry based on stalk use in Zambia and other countries in the Region;
- Research and development of new particle board products as well as production and evaluation of boards of blended agro-residues with cotton stalk.
- Social, economic and employment creation impacts of stalk collection and processing within the project area;
- Analyze cash flow potential of agricultural biomass and economic impact assessment of such innovation at national and regional level;
- Quantify the impact of cotton stalk use on particle board market, and potential of briquettes in reducing wood-based charcoal and their impacts on local/global environment; and
- Annual cash flow analysis of particle board manufacturing plant – economic analysis including expenses and income.

Outcome: Reports prepared by local consultant; Development of newer particle board types with combinations of various types of agricultural biomass; generation of non-farm economic activity and employment opportunities.

Lead institution: Cotton Development Trust.
Cost: US$ 135,000.

Objective: Organize a final workshop at the end of the project to share developmental experience and potential benefits of transfer of this technology within Zambia and Sub-Saharan Africa.

Outcome: Successful Workshop in Lusaka (Describe the output, its application and benefits)

Lead institution: ICAC/Cotton Development Trust.
Cost: US$ 92,000

COMPONENT 3: Studies and Analyses during the Project Implementation Period and Dissemination of Project Outcomes before Project Completion.
These will include studies on technology impact analysis; Cash-flow analysis, an assessment of agricultural biomass as industrial raw material and its cash-flow potential on ‘balance sheet’ of particle board enterprise; and dissemination of project outcomes through publications, demonstrations and national and regional workshops. This Component will conduct studies and analyze:

Activity 3.1: Analyze cash flow potential of agricultural biomass as industrial raw material for particle board and briquettes and socio-economic and environmental impact assessment of such innovation at national and regional level.
Activity 3.2: Dissemination of Project Results at national and regional levels.

Lead institution: Cotton Development Trust.
Cost: US$ 227,000

Component 4: Project management and monitoring and evaluation

Outcome: An efficiently implemented and managed project, completed as planned within the set time frame and budget. (Describe the output, its application and benefits)

Activity 4.1: Project Management
4.1.1: Constitution of advisory board, consisting of 6 members, 3 external Scientists and 3 from private industry, under chairmanship of Director CDT.
4.1.2: Half yearly meeting of advisory board to evaluate the progress of work and planning.
4.1.3: Preparation of annual work programs, budget and progress reports
4.1.4: Capacity building and human resource development:
   - Consultancy and technical assistance for establishment of this operation
   - Training of Management/Technical staff
   - Project Monitoring and Evaluation
4.1.5: Midterm evaluation after second year by external experts assigned by CFC and ICAC officials.
4.1.6: Preparation of final project report
4.1.7: Final project evaluation at the end of the project by external experts assigned by CFC and ICAC officials.

Activity 4.2: Co-ordination of the Project Activities by the PEA
4.2.1: Preparation of management reports, financial statements duly audited, and coordination of project activities: Overall implementation of day-to-day activities.
4.2.2: Evaluation of progress of the project in regular Staff Research Council and Research Advisory Committee of CDT.

Lead institution: Cotton Development Trust.
Cost: US ... [THIS SHOULD INCLUDE CFC COST. ADD CDT STAFF COSTS – BUSINESS MANAGER]
Cotton Development Trust will be the Project Executing Agency (PEA) and will constitute an advisory committee under the **chairmanship of Director CDT consisting of Eight/Six members**, four/three members will be scientists representing various research and development institutes and four/three members will be representing private industry, trade bodies, etc. for monitoring the progress of the project. This Project Coordination Committee (PCC) will meet twice per year or more frequently as deemed appropriate by its chairman. Meetings of the PCC can be attended by staff of the Fund and the ICAC as deemed relevant. The PEA through its Director remains, however, responsible for the implementation of the project. As project consultants, Director CIRCOT/Director’s nominee may also be invited to attend such meetings depending on the agenda.

As PEA, the CDT will prepare and submit to the Fund and the Supervisory Body an integrated annual work plan and budget *cum* implementation schedule, linking all the activities envisaged to be undertaken under each component in a logical timeframe. The work plan will include incorporation of measurable milestones which will enable adequate monitoring of the progress of the project. The first years work plan and budget will be prepared on the basis of the final version of the Appraisal Report. This work plan and budget will need to be endorsed by the International Cotton Advisory Committee and the Fund prior to the start of the project.

The PEA will submit to the Fund and Supervisory Body six-monthly progress statements and annual monitoring reports which will analyze progress made by the project against the targets set in the annual work programs and as reflected in the project’s final appraisal report. Variances will be accounted for and remedial action will be proposed if required. A substantive project progress report will be prepared annually by the PEA, which will be submitted to the Fund and the Supervisory Body (the ICAC) after reviewing draft by the Project Coordinating Committee, at its annual meeting. The PEA shall also prepare the standard financial reports as per the Fund’s pertinent rules and regulations.

In the monitoring of the project by CFC and the Supervisory Body two independent evaluations of technical achievements and the organization and management of the project are scheduled to be undertaken. The mid-term evaluation is scheduled at the end of the 2nd year of the project, at which time the plant will be in operation, while the final assessment is expected in the last year of the project, before or during the final workshop. The PEA shall organize and assist in the implementation of this evaluation. The PEA will be responsible for preparing and submitting the Project Completion Report before the final assessment. This report will highlight the project achievements, constraints and experiences gained in the design and implementation of the project. This report will include a summary assessment of the financial benefits resulting from the project achievements as well as guidelines to implement the recommendations of the project in other countries. The report, along with the final project accounts and audit, will be submitted to the Supervisory Body and the Fund.

PEA will prepare an annual supervision report with work plan for next year and submit the same to the ICAC with a copy to the Fund and perform its duties as required by the Project Agreement which will be drawn up between the Fund, the ICAC and the CDT, and signed before the start of the project.

PEA will hire a Plant Manager with sufficient experience to run a facility of this nature, to help with the installation and running of the plant. Plant Manager will be required to train staff in various operations. Since this is a new intervention, it is felt the Plant Manager would need to be hired in consultation with CIRCOT. A suitably skilled Plant Manager could therefore be an expatriate expert for the initial 2 – 3 years. Proposed terms of reference are presented in Annex III.
The CDT will pay all types of taxes, duties and insurance during transit and insurance premium every year after the installation of all machinery. Provision has been made at appropriate places in the budget.

Supervision of the Project

ICAC Secretariat, being and international commodity body on cotton and sponsor of the project to CFC, will supervise the project. CFC has to be kept informed on the progress of the work being done in the project. ICAC will focus on the technical side while CFC will resolve financial issues.

Given the nature of the project, ICAC will from time to time assign an expert(s) to physically review project implementation and the progress under the various components of this project.

Risks

This project is up-scaling of a technology tested under an earlier CFC funded project. The positive outcomes of the preceding intervention provide an adequate basis for the implementation of this project. Apart from unforeseen external event beyond the control of project parties such as change of government regulations allowing for import of cheap substitute products, or unexpected, new competitive uses of cotton stalk, it is safe to assume there are no direct risks affecting the implementation of the project.

Intellectual Property Right

After the project has been finally approved by the Executive Board of the CFC, the Project Executing Agency will sign the Project Agreement with the ICAC and CFC for implementation of the project as laid down in the project proposal. If applicable, the project must include information on the products to be developed that may have commercial value. General policy of the Fund is to provide free access to the project results to least developed and developing countries. But, potential patentable results where private companies may be interested could be commercialized better for the ultimate interest of developing countries. CFC will hold the intellectual property rights to project outputs and decide how to commercialize them better in consultation with the project partners and ICAC.

Project Costs and Financing

The total cost of the project is estimated at US$ 3,923,000 as summarized in Table 1. The project will be financed by a CFC grant US$ 2,250,000, CFC equity contribution of US $ 392,000 and counterpart contribution by CDT of US$ 1,235,000.

Table 1: Project Budget by Country (US$)

<table>
<thead>
<tr>
<th>Estimated total cost:</th>
<th>US$ 3,597,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFC Equity:</td>
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<td>CFC grant:</td>
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<tr>
<td>Counterpart contribution:</td>
<td>US$ 1,622,000 (45.1%)</td>
</tr>
</tbody>
</table>

Table 2: Project Budget by Objective (US$)
Co-funding and Counterpart Contribution

The project will be funded by CFC grant and CFC equity along with counterpart contribution from CDT.

Procurement, Disbursement, Accounts and Audit

**Procurement** will be in accordance with the Fund’s Rules a Regulations for the Procurement of Goods and Services of the Second Account for all items financed by the Fund and the applicable rules as described in the Fund’s Financial Procedures Manual. Project expenditures shall only be incurred for procurement of goods and services from Member States of the Common Fund. The list of Member States is given in Annex VIII. According to the Article 48 of the Agreement Establishing the Common Fund for Commodities, the Common Fund enjoys exemption from all direct taxes and from customs duties. Contracts for machines and equipment with a contract price of or exceeding US$ 100,000 shall be subject to International Competitive Bidding (ICB). Contracts for supply of goods and services with a price equal to or exceeding the equivalent of US$ 50,000, but less than the equivalent of US$ 100,000 shall be awarded following limited competitive bidding procedures. For procurement of items/contracts with a value of between US$ 5,000 and US$ 50,000 at least three quotations should be obtained of which at least two should be from reputable international suppliers. Consultants will be engaged following acceptable international procedures.

**Disbursement** against the purchase of items with a value of US$ 500 or more will be fully documented. Other expenditure will be disbursed against certified Statements of Expenditure (SOE). Documentation under SOE need not be forwarded to the Fund but will be retained in a central location by the PEA and the participating institutions for review during monitoring and supervision missions and for authentication by the auditors. Since the PEA and the collaborating institutions will not be in a position to pre-finance expenditures eligible for Fund financing, a project Account will be opened by the PEA in a bank satisfactory to the Fund, and in a convertible currency where CFC will remit the amount to CDT. All the financial statements regarding the project shall be submitted to the CFC directly by CDT. The Fund will make an initial deposit of US $ 150,000 after the conditions of disbursement have been met (such to be determined by the Fund’s Managing Director). The Project Account will be replenished in accordance

Notes: Add if there is a need to explain any costs/activities.

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<tr>
<th>Component</th>
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<th>CFC Loan</th>
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with the Fund’s procedures for operating a Project Account. Based on agreed work program and allocation of responsibilities, the PEA shall provide funds from the Project Account to service providing institutions for the implementation of that part of the program from the operational expenses allotted to PEA. The Supervisory Body will ensure, prior to the first disbursement from the Grant Account that the contributions from the counterparts are confirmed and quantified in the foreseen under the project.

**Accounts and Audit:** The PEA will maintain independent and appropriate financial records and statement, including those for the Project Account. These will be audited annually by independent auditors acceptable to the Fund. The audited accounts and the auditors report, including separate opinions on the Statements of Expenditure and on the utilization of the funds in the Project Account, will be submitted within three months after the end of the project’s fiscal year.
### Table 4: Project Budget by Objective

#### Objective 1:

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Appendix I

Project Logical Framework

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<th>Means of Verification</th>
<th>Results/Remarks</th>
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<td><strong>Objective 1</strong></td>
<td>Collection mechanism in place with the formation of dedicated teams for stalk procurement/collection, pre-cleaning, chipping and baling and transporting them to CDT storage site. Training collection teams to work effectively in ensuring collection of cotton chips for the annual requirement as this task will have to be completed within three months after cotton harvest. Tendering &amp; Procurement of equipment</td>
<td>Progress reports and Procurement/records store book/records and Physical verification. Increased farmer incomes and improved profitability for cotton farmers in stalk collection areas. Payments made to farmers.</td>
<td>This will be an activity to create maximum awareness in rural space highlighting potential of cotton bye products as industrial raw materials as well as potential non-farm economic activity for rural entrepreneurs as supply chain agents for particle board and briquette making. This will be critical as cotton stalk should not be left in the field beyond September 1st.</td>
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<tr>
<td><strong>Objective 2</strong></td>
<td>Installation of particle board plant to produce 30 tons/day particle board and all its associated structures.</td>
<td>Ad hoc activity reports; Technical reports and records; Physical establishment and operation of particle board plant; Supervision reports by the supervisory body; Monitoring and evaluation reports; and External evaluations.</td>
<td>Availability of counterpart funding and/or contribution to the project. Timely and efficient mobilization of required resources and inputs. Continued support from all stakeholders.</td>
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<td><strong>Objective 3</strong></td>
<td>Production of chip-waste based briquettes at chip collection sites/CDT.</td>
<td>Ad hoc activity reports; and production and sales reports</td>
<td>Chipping waste can also be used as substrate for mushroom cultivation. This is another potential cottage industry.</td>
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<td><strong>Objective 4</strong></td>
<td>Preparation of terms of references; Identification of a local consultancy or firm with suitable human resources to conduct this study.</td>
<td>Submission of terms of references for approval of Project’s sponsors. Consultancy report for comments; Final report addressing all observations/comments.</td>
<td>It is assumed that additional income from utilization of cotton by-products will motivate/prompt farmers to improve their management to enhance cotton yields as well as stalk</td>
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</table>

**Activity 1** Three cotton stalk collection, pre-processing operations at CDT, Monze and Gwembe.

**Activity 2**: Tender for the import/fabrication of portable/mobile chip cleaning and briquetting machines.

**Activity 3**: Developing briquette making and marketing system.

**Objective 2** Establishing and commissioning of stalk-based particle board facility and developing marketing chain in Zambia and SSA:

**Activity 1**: Installing 30-ton-per-day Particle board Manufacturing Unit.

**Activity 2**: Establish quality parameters – thickness, surface finishes; and effect of additives on quality.

**Activity 3**: Marketing of Particle Board in Zambia and Sub Saharan Africa.

**Objective 3** Briquettes from chipping waste as alternative domestic fuel.

**Objective 4** Analyze the impact of commercialization of cotton by products on cotton production in Zambia and Sub.
| **Objective 5** | Preparation of terms of references; Identification of a local consultancy or firm with suitable human resources to conduct this study. | Submission of terms of references for approval of Project’s sponsors. Consultancy report for comments; Final report addressing all observations/comments. | Development of non-farm economic sector and additional income opportunities. |
| **Objective 6** | Preparation of terms of references; Identification of a local consultancy or firm with suitable human resources to conduct this study. | Submission of terms of references for approval of Project’s sponsors. Consultancy report for comments; Final report addressing all observations/comments. | This is significant for developing a non-farm economic sector in rural space, providing additional income generation opportunities. |
| **Objective 7** | Preparation of terms of references; Identification of a local consultancy or firm with suitable human resources to conduct this study. | Submission of terms of references for approval of Project’s sponsors. Consultancy report for comments; Final report addressing all observations/comments. | These impacts assume significant global benefits by providing wood-substitution industrial raw materials and by preventing Carbon release from stalk burning. |
| **Objective 8** | Final Workshop. Promotional publications, brochures, and an internet site, frequently updated and ensured response to any queries within the shortest possible time. Maintaining a prudent open door policy to encourage visitation. | Queries received and responded to; website visits and visitor records. Final Workshop with participation of sponsors, partners, stakeholders and maximum numbers of countries and entrepreneurs participating. | If necessary CDT may appoint a full time Web Master to ensure frequent updates, and that all queries are responded properly and effectively in the shortest possible time for maximum dissemination of this income generation stream. |

**Project Management:**

| **Activity 1:** | Constitution and notification of the Advisory Board; Half yearly meeting of advisory board to evaluate the progress of work and planning; Preparation of annual work programs, budget and progress reports; Facilitation of the Mid-term review; Final project report and evaluation; and Dissemination of project results nationally and internationally. | Ad hoc activity reports; Progress reports and supervision reports as well as mid-term review report and final project completion reports. | Commitment of all stakeholders to the success of this industrial scale trial operation; Global downturn will be contained in the near future, causing demand for construction materials – particularly particle board to increase; Availability of funding in timely fashion; Timely and efficient mobilization of resources and inputs; Continued support from all key stakeholders; Continued demand for particle board; Buildings and plant sourced and mobilized in time and at foreseen costs; and Project management, other technical activities, studies and reports undertaken as scheduled. |
| **Activity 2:** | Preparation of management reports, financial statements duly audited, and coordination of project activities. Overall implementation of day-to-day activities. | | |
| **Activity 3:** | Dissemination of Project Results at national and regional level. | | |
Appendix II: Technical concepts underlying the proposed operation

Cotton Stalks

Cotton is grown the world over for its fiber. The main bye product of seed cotton is cotton seed which has several commercial uses in addition to its use as seed for the crop. Some of these are as animal feed, oil, seed cake and husks. However, the main bye product is considered a waste with no monetary value and is burned in the field in Zambia. This is the cotton plant itself – cotton stalk.

Cotton stalk yield will depend upon climate, soil conditions and the species of cotton. However, for each ton of cotton produced, anecdotal evidence suggests up to three tons or more, stalks are produced. Cotton stalk contains about 41 percent cellulose as compared with 42 and 45 percent for soft and hard woods, respectively. This is also comparable with the other widely used agricultural biomass – bagasse from sugar cane, which contains 42 percent cellulose. At harvest, stalk contain about 20 percent moisture (bagasse usually contains 40 percent), and about 15 percent of it is trash and impurities, including bark and the pith. Another 25 percent may be lost in chipping, compacting and transportation. Thus stalk would yields only 50 percent as useable chips for industrial uses.

Particle Board from Cotton Stalk

Particle board is produced by compressing small particles of wood by bonding them with adhesive (synthetic resins, usually urea formaldehyde) and wax, and compressed under high heat (hot pressed) for curing resin binder, before cutting and finishing it to a smooth surface. Usually a layer of coarser particles is sandwiched between two layers of finer particles. The properties and potential uses of particle boards differ with the size and geometry of particles, the amount of adhesive and the density of the board. Particles boards are usually produced using wood chips from different tress species, bamboo and agricultural residues like bagasse and rice husk. Tests have shown cotton chips can be used as effectively as any of these other chips. CDT plans to demonstrate the economic viability of this process with an industrial scale demonstration.

Chipping

After collecting cotton stalks from fields, it will be preferable to allow them to further dry for a day or two. Stalk is cleaned by passing through high pressure air nozzles that will loosen boll rinds, leaf bits, sticking cotton fibres and other light impurities before subjecting it to a “vacuum chamber” to suck all the loosened impurities. Stalk is chopped to uniform length in “chopper machine” before passing through “rotary roller cleaner” to clean and separate the heavy particles and other impurities.

After cutting and cleaning the stalk will pass through “chaff cutter”, the chips produced can either be stored for subsequent processing or can go directly for further processing at the production plant for preparation of particle board.
At particle board manufacturing stage, these chips will be pulverized and will pass through a final cleaning stage in which any bark fibres and fine powder is removed.

Cotton in Zambia is a small holder crop and most fields are small. Harvesting stalk and transporting them to CDT will be expensive due to the bushy nature of stalk. We are therefore proposing to procure mobile chipping equipment. Transport of baled chip will enhance efficiency and be more economical. CDT plans to use its tractors to power the chipping operations and baled chips will be transported to central storage site at CDT.

Particle board production process consists of the following steps/stages:

- **Cotton Plant Stalk**
  - [Procurement in the field, removing boll rinds, harvesting, field drying]
  - Chipping and Cleaning
  - [Chipping with mobile chipper, removing waste, baling and transport to Plant site]
  - Re-chipping
  - Drying
  - Screening particle preparation
  - Mixing with binder
  - Mat forming
  - Pressing
  - Conditioning
  - Cutting
  - Sanding
Appendix III: Terms of Reference for Plant Manager

Qualifications:

Graduate degree in paper/board technology, industrial chemistry with 10 years experience or Masters in relevant discipline with 7 years experience.

Experience:

1. Goal oriented with missionary zeal to ensure best effort in achieving targets on time;
2. Supervisory/administrative ability to run a medium sized particle board facility;
3. Experience with using agricultural biomass as industrial raw material, especially in particle board manufacture; and
4. Good knowledge on installations of particle board plant;

Duties and Responsibilities:

He/she will be overall in charge of the Particle Board Manufacturing Plant to be installed at CDT and working under the Director. The Plant Manager will be responsible for supervising the installation of plant machinery. He/she will be required to train 3 to 5 people (CDT staff) in operating and managing a plant of this type to take over the management functions at the end of his/her assignment and another team of technicians in operating the plant efficiently. More specifically, he/she will be required to:

1. Supervise construction of the site, especially the plant shed and storage area
2. Supervise the installation and commissioning of Particle Board Plant
3. Be responsible for day to day running of the Plant
4. Should train 3-5 assigned CDT staff in managing and several technicians in operation of various machines of the Plant to enable them to manage and operate the plant at the expiry of his/her assignment
5. Should maintain all the necessary records/data for working out costs, profitability and preparation of techno-feasibilities as and when required to do so
6. Should be able to demonstrate/train particle board manufacturing process to interested parties/entrepreneurs, NGOs and other stakeholders
7. Assist with any studies, trials, surveys to improve marketability of particle boards
8. Any other responsibility assigned to him/her by the Director CDT
## Appendix IV: Project Implementation Schedule

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