

# Model Fuelwood Plantations For Sustainable Energy Supply And Livelihood Development



Ministry of Power and  
Renewable Energy



Food and Agriculture  
Organization of the  
United Nations



SRI LANKA  
SUSTAINABLE ENERGY AUTHORITY



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## Contacts

**National Project Manager**

**Sustainable Biomass Energy Project**

**Sri Lanka Sustainable Energy Authority**

Block 05, 1st Floor, BMICH, Bauddhaloka Mawatha, Colombo 07.

Telephone: 011- 2 677 445, 011- 2 678 358

Facsimile: 011- 2 678 358

E-mail: [info@energy.gov.lk](mailto:info@energy.gov.lk)

Web: [www.biomassenergy.lk](http://www.biomassenergy.lk)

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**Sampath Ranasinghe**

National Project Manager

Sustainable Biomass Energy Project (Joint Project of FAO and UNDP)

Sri Lanka



## Promoting Sustainable Biomass Energy Production and Modern Bio-Energy Technologies (Biomass Project Phase 1)

The pilot project on “Promoting Sustainable Biomass Energy Production and Modern Bio-Energy Technologies” (Biomass Project Phase 1) was completed at the end of year 2018. This five-year project, implemented by the Sri Lanka Sustainable Energy Authority (SLSEA) along with the United Nations Development Programme (UNDP) and Food and Agriculture Organization of the United Nations (FAO) promoted the production and use of biomass across the nation. The Project worked with the Ministry of Power and Renewable Energy for guidance and technical input, while the Forest Department, Ministry of Plantation Industries, and the Ministry of Mahaweli Development and Environment provided resources and expertise towards establishing a sustainable biomass energy source.

Since 2013, the Project piloted technological applications with locally manufactured technologies among Small and Medium Enterprises (SME), and systematically promoted renewable energy through fuelwood production, growing models and collection systems across Sri Lanka.

### Pressure on Natural Forests

Wood is still Sri Lanka’s main source of energy and is used by households mainly for cooking and by industries for thermal applications. Most of this wood is sourced from home gardens, plantations, trees outside natural forested areas and by-products from wood processing. However, there is a threat posed to natural forests due to some unsustainable and illegal sourcing of wood.

While Sri Lanka’s forest cover stands at 29 percent to date, there is a national effort driven by the Forest Department to increase this cover to 32 percent by 2020. Contributing to this target and towards the promotion of sustainably grown fuelwood, the Sustainable Biomass Energy Project, together with the Forest Department, Rubber Research Institute of Sri Lanka (RRISL), Coconut Cultivation Board (CCB), Non-Governmental Organizations (NGO) and Community-Based Organizations (CBO), Regional Plantation Companies (RPC), and private land owners have established model fuelwood plantations.

Together, they are also involved in boosting the contribution of forestry for the welfare of the rural population and strengthening of the national economy with emphasis on equity, putting state forest resources under sustainable management, and allocating the natural forests for regulated multiple-use forestry after the needs for conservation have been given priority. Additionally, this helps with forming partnerships with rural people and their communities and other stakeholders, introducing appropriate tenurial arrangements, as well as rehabilitating degraded forest lands for conservation and multiple-use production, promoting tree growing by rural people - individually or collectively - and by NGOs. Furthermore, it places the responsibility for production and marketing of commercial forest products into the hands of rural people, organized groups, cooperatives, etc.

### Total Cultivated Land Extent

No.	Institute	Land Extent (ha)
01	FD	101.60
02	RPCs	123.67
03	RRISL	100.00
04	CCB	242.80
05	NGOs/CBOs	498.81
	<b>Total</b>	<b>1066.88</b>



### Barriers for Growing and Production of Fuelwood

- Limited land availability
- Unattractive fuelwood prices
- Lack of awareness on growing, production and benefits
- Lack of motivation and incentives
- Lack of proper collection mechanisms/centers
- No proper marketing systems
- Lack of proper coordination on available lands
- Lack of proper coordination among relevant agencies



### Benefits of Growing and Production of Fuelwood

- Energy security through long-term supply of sustainable fuelwood resources
- Generation of employment opportunities
- Foreign Exchange Savings
- Carbon sequestration
- Opportunities for carbon insetting/offsetting
- Contributing to upturn green/forest cover
- Improved micro-climatic conditions
- Improvements to soil fertility
- Animal fodder
- Soil erosion controls
- Live fencing



## Why Sustainable Fuelwood Plantations

Biomass remains the primary source of energy for more than half the world's population, accounting for over 14 percent of the total energy consumption (World Energy Council, 2017). Although generally regarded as a low status fuel, biomass is incredibly versatile and is predominantly sourced from wood.

In Sri Lanka, a major share (84.2 percent) of biomass energy is used by the domestic and commercial sectors while the industrial sector (including plantations) consume the balance (Perera & Sugathapala, 2000). It is estimated that about 78 percent of the country's population of 22 million use biomass for cooking. Out of the total biomass supply in the country, about seven percent of fuelwood is illegally sourced from natural forests, and as such, there is an urgent necessity to expand sustainable fuelwood resources to prevent deforestation and to meet the demand for fuelwood as a clean energy source.

Presently, about 55 percent or 90,000 ha of natural forest lands in this country falls under the purview of the Forest Department while the balance forest area is primarily managed by the Department of Wildlife Conservation with an exception of very small extents of isolated forest patches that come under other state agencies and private ownership.

Whilst the Forest Department manages and maintains these forests, they have joined hands with the Sustainable Biomass Energy Project to establish model fuelwood plantations in lands belonging to the Department. These plantations would prevent further damage to these natural forests.

The Project also collaborates with other government institutions such as the Coconut Cultivation Board (CCB) and the Rubber Research Institute of Sri Lanka (RRISL) (through their own lands and smallholder lands) to establish and promote these model fuelwood plantations. This Project supported provision to establish fuelwood plant nurseries, fuelwood plantations in buffer zones, and to enhance the capacity of fuelwood research through the establishment of a fuelwood arboretum.

Additionally, model fuelwood plantations with NGOs and CBOs (in various parts of the country) have been established with the support of the Project to protect forest buffer zones from illegal felling while providing a sustainable fuelwood supply for these communities. These model projects also support families through livelihood enhancement.

Perennial tree crops such as fruits and spices yield a significant volume of biomass during the application of improved crop management practices such as pruning and harvesting. This method is deemed sustainable as it utilizes by-products of forests or tree-crop management for energy generation while improving tree health. These tree crops also increase yields as they can be produced in large quantities and regrow rapidly after each harvest.

The sustainable fuelwood production models fall under five different categories and aid decision makers, investors and land owners develop necessary policies, take decisions on investments and land use sustainably, economically and efficiently.

These fuelwood plantations are managed under

5

categories

- 01 GOVERNMENT INSTITUTIONS
- 02 FUELWOOD RESEARCH & NURSERIES
- 03 COMMUNITY FUELWOOD PLANTATIONS
- 04 REGIONAL PLANTATION COMPANIES
- 05 NON-GOVERNMENTAL ORGANIZATIONS & COMMUNITY- BASED ORGANIZATIONS

GOVERNMENT INSTITUTIONS

The Biomass Energy Project collaborates with a few government institutions, including the Forest Department (FD), the Coconut Cultivation Board (CCB) and the Rubber Research Institute of Sri Lanka (RRISL) to establish and promote fuelwood plantations in lands available under their purview. These lands are also used to develop and improve plant nurseries and its facilities, to enhance fuelwood research capacity and other necessary programmes.

Forest Department

Model fuelwood plantations in Forest Department lands (which comes under the purview of the government of Sri Lanka) have been cultivated in six districts. These fuelwood plantations were once used as Pinus or teak plantations or illegally encroached by adjoining communities. They have now been reclaimed and replanted with Eucalyptus grandis, Gliricidia sepium, Acacia auriculiformis, Khaya senegalensis, Tamarindus indica, Eucalyptus camaldulensis, Acacia mangium, Alstonia macrophylla and other similar fuelwood species.

Generally, the rotation of these plants vary from eight to 12 years, except Gliricidia which can be harvested from 18 months to two years. However, the ideal age for harvesting of Gliricidia is four to six years.

With constant challenges and threats from wild elephants and encroaching cattle, wildfires and unhealthy growing conditions, etc., these fuelwood plantations are carefully maintained and overseen by vigilant Forest Department officers.

The long-term objectives for these model fuelwood plantations are:

1. Showcase successful fuelwood plantation models
2. Provide valuable data on yield, investment, etc.

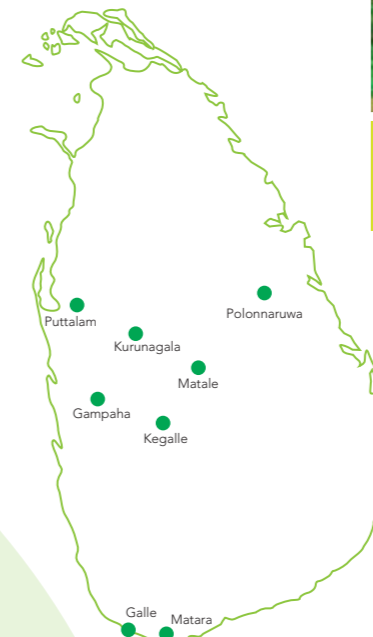
Cultivated Forest Department Land Extent

No	District	Land Extent (ha)
01	Anuradhapura	16.5
02	Puttalam	18.7
03	Badulla	10
04	Ratnapura	30
05	Matara	5
06	Nuwara Eliya	21.4
<b>Total</b>		<b>101.6</b>

Coconut Cultivation Board

Coconut is the most widely planted industrial tree crop in Sri Lanka. It covers about 25 percent of the total cultivated area on the island. A large number of perennial crops such as teak and mahogany, cashew, cinnamon and other fruit crops are grown together with coconuts as an intercropping model.

Under a project titled "Establishment of Fuelwood Plantations in Coconut Model Gardens of the Coconut Cultivation Board (CCB) and Selected Coconut Smallholder Lands for the Production of Fuelwood and Promoting Sustainable Supply", the CCB has cultivated 600 acres (242.8 ha) of fuelwood plantations, of which 118 acres are in their own coconut model gardens, and 482 acres are under coconut smallholder lands. These plantations comprise mainly of Gliricidia and Cinnamon, intercropped for fuelwood.



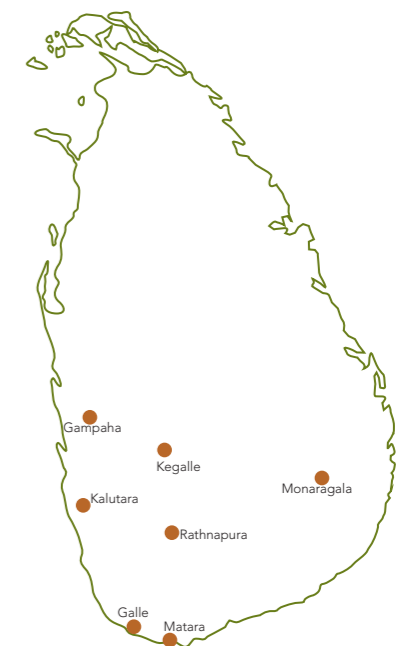
No	Area	Land Extent (ha)
01	CCB own model gardens	47.8
02	CCB smallholder lands	195.0
<b>Total</b>		<b>242.8</b>



Rubber Research Institute of Sri Lanka

Rubber is considered to be a labour intensive crop among the plantation crops in the country, second only to tea. It is common to intercrop diverse crop plants (medicinal, fruit crops and multipurpose crops) under rubber in non-traditional areas to ensure economically and environmentally sustainable land use practice for rubber cultivation.

The RRISL has cultivated 247 acres or 100 ha of fuelwood plantations in their own lands and rubber smallholder lands. These growing models incorporated fuelwood species; Gliricidia sepium, Acacia mangium, and Alstonia macrophylla.



No	Area	Land Extent (ha)
01	RRISL own model gardens	10
02	RRISL smallholder lands	90
<b>Total</b>		<b>100</b>





## FUELWOOD RESEARCH & NURSERIES

Research and development have an important role to play in solving the problems connected with conservation, and the utilization and promotion of forest and tree genetic resources. The Forest Department has established fuelwood research and nursery development programmes in ex-situ conservation cultivation models to help in the following:

- Collection of germplasm of endangered species from their natural range and planting in blocks as gene banks,
- Collection of seeds of native species and establishment of plantations,
- Establishment of seed orchards to conserve superior germplasms,
- Vegetative propagation of valuable local species for genetic improvement,
- Importation of genetic materials of plantation species from other countries and planting them in the field either to broaden the genetic base of existing species or to introduce new species.

### Fuelwood Arboretum

Set up with the aim of conserving native and exotic trees, the Forest Department's arboretum is located in Kumbalpola, Kurunegala. Covering a land extent of 0.6 ha, this arboretum is used as a tree seed bank and ex-situ genetic conservation facility. This arboretum has 17 species of exotic and indigenous fuelwood plants grown together to establish and ascertain the possibilities of the best use of these various species, collectively or individually.

The species under the research programme are *Acacia auriculiformis*, *Anacardium occidentale*, *Grewia damine*, *Mangifera zeylanica*, *Mitragyna parvifolia*, *Cassia spectabilis*, *Careya arborea*, *Pongamia pinnata*, *Khaya senegalensis*, *Schleichera oleosa*, *Adenanthera pavonina*, *Dimocarpus longan*, *Samanea saman*, *Hevea brasiliensis*, *Tamarindus indica*, *Pterospermum suberifolium*, and *Gliricidia sepium*.

### Fuelwood Nurseries

Improved planting material is one of the major requirements for high yielding and fast growing fuelwood plantations, and this can only be achieved through a proper seed/propagule development program and an associated proper nursery system.

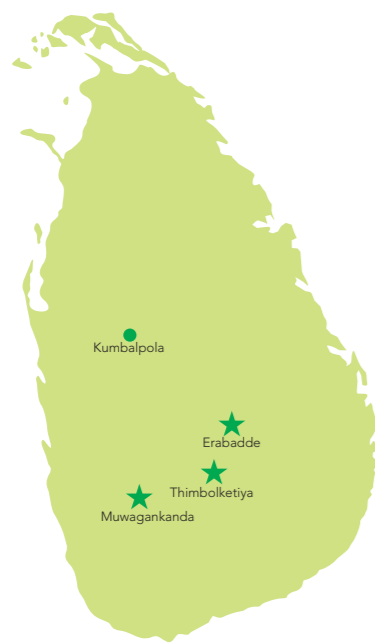
Eucalyptus species' experiments, *E. grandis* breeding trials (i.e. *E. progeny* trials), seed orchards and seed stands of Eucalyptus species have been established by the Department at Erabedda in the Badulla district. A propagation unit (nursery facility) for the tree breeding program has also been established at the Erabedda site, which includes the seed propagation facility, shade houses, hedge gardens, vegetative propagation units etc.

The Muwagankanda nursery which is situated in Ratnapura and the Thimbolketiya nursery that is located in Embilipitiya are working as main hubs for providing forest and fuelwood seedlings mainly to the Ratnapura district as well as adjoining districts.

With the support of the Biomass Project, these nurseries have been expanded after previously underutilized land has been flattened and levelled, irrigation improved after the construction of a 2000 liter overhead water storage tank with effective and efficient water distribution systems, proper drainage systems and the installation of a new electric water pump.

- Conditions of the Erabedda plant nursery have been improved to carry out Research and Training programmes related to fuelwood and timber production,
- Nursery planting capacity has been expanded by an additional 2.75 acres; Muwagankanda nursery has been expanded to produce an additional 125,000 seedlings and the Thimbolketiya nursery has been expanded to produce an additional 200,000 seedlings, annually,
- Two overhead water tanks constructed and nursery irrigation systems established,
- Two project hoarding boards designed and erected at Thimbolketiya and Muwagankanda nursery sites for project's visibility and public awareness.

The species under the research programme involves the possibility of successfully growing Cashew, Welan, Mee and Divul along with the popular fuelwood species *Gliricidia sepium*, which will be subsequently used for firewood and compost until there is an opportunity for selling it to a timber terminal.



● Fuelwood Arboretum  
★ Nurseries



### Forest Department & Community Model

The community fuelwood plantations model involves a collaboration between the Forest Department and the surrounding communities in selected areas.

In Harasbedda, Walapane, 180 community-based families have been allocated 5 ha of buffer zone land by the Forest Department. Through agricultural support and inputs by the Project, these families have cultivated this land with 12,500 Eucalyptus grandis and 1000 Gliricidia plants. These lands are also co-cultivated with various fruit and vegetable plants, i.e. nelli, lime, anodha, and curry leaves, which will support these families with an added income until the fuelwood has matured.

The fuelwood plantation in Pattipola, Nuwara Eliya, is a collaboration between the Forest Department and 117 families of the community-based organizations. The entire 3 ha of land is planted with Eucalyptus grandis and Acacia auriculiformis and co-cultivated with lime and anodha as an extra income generator. While the Project funds the purchase of seedlings, the Forest Department distributes plants from its nursery to these communities.

Based on the Community Fuelwood Agreement signed between the FD and the CBOs, 80 percent of the final harvest goes to the community and 20 percent goes to the FD. The entire thinning is shared amongst the community.

### Forest Department, Community & Private Sector Model

The Thalawakelle Tea Estate PLC has partnered with the FD and CBO to establish fuelwood plantations to preserve its biodiversity and to enhance the livelihood development of its workers. The Project disburses funds via the Forest Department to establish these fuelwood plantations in underutilized tea lands and buffer zones with the participation of the communities. This community participation and involvement has many benefits, including free sustainable fuelwood for the villagers, steady incomes through daily labor, and livelihood development. Other benefits of this collaboration include the protection of forest buffer zones from illegal felling, creating stronger bonds with estate management, and reducing the natural threat to forests.

After the final harvest, the CBO gets 50 percent, Thalawakelle Tea Estate PLC gets 30 percent and the FD gets 20 percent. The entire thinning is shared amongst the community.



Model	Area	Land Extent (ha)
Forest Department & Community	Pattipola + Harasbedda	8
Forest Department, Community & Private Sector	Great Western + Radella	13.4
<b>Total</b>		<b>21.4</b>





# CATEGORY

# 04

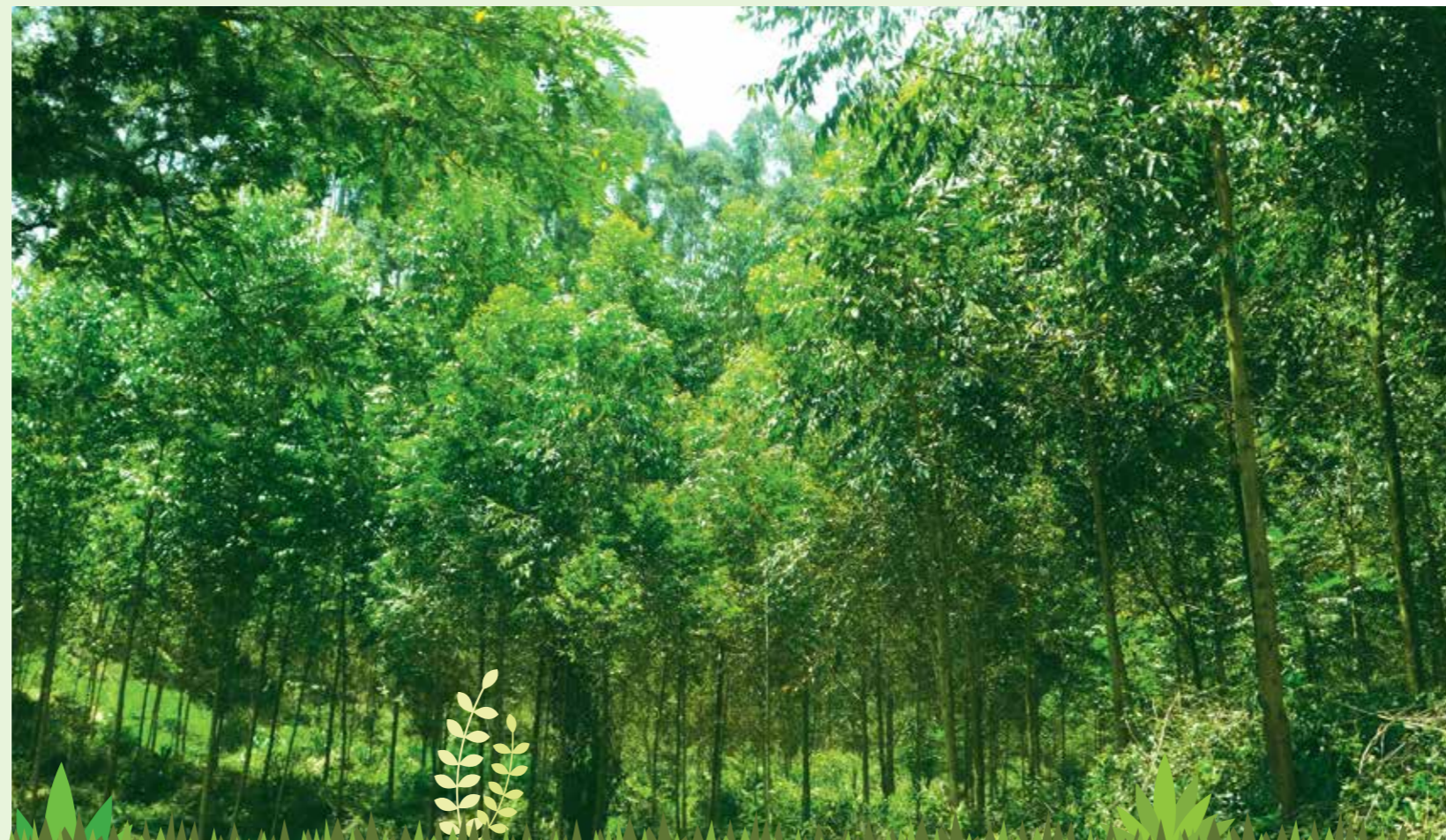
## REGIONAL PLANTATION COMPANIES

There are 24 Regional Plantation Companies (RPC) in the country of which, the project works closely with the Thalawakelle Tea Estate PLC for the promotion of sustainable fuelwood. With the objective of consistently increasing tree canopy cover, enriching the biodiversity value and achieving environmental and business sustainability, Thalawakelle Tea Estates PLC continues to plant a variety of plants annually. This has immediate benefits for the plantation as they have access to sustainably sourced fuelwood for their energy requirements. These plantations also help change the micro climate and in the conservation of water resources.

With the co-finance support of the Biomass Energy Project, the estate has allocated 123.67 ha for the cultivation of fuelwood. The plantations comprise of Eucalyptus grandis, Eucalyptus microcorys, Calliandra calothyrsus and Acacia decurrens as their main fuelwood species.



Model	District	Land Extent (ha)
Thalawakelle Tea Estate PLC	Nuwara Eliya	123.67
<b>Total</b>		<b>123.67</b>





CATEGORY

05

NON-GOVERNMENTAL ORGANIZATIONS & COMMUNITY- BASED ORGANIZATIONS

The Project has established fuelwood growing models with the support of NGOs and CBOs. So far, around 498.81 ha of various growing models were established by the CBOs/NGOs in Puttalam, Kurunegala, Matale, Monaragala, Galle, and other districts. These models will assist in increasing the production of biomass energy, which will deliver benefits to the society by supporting their household and industry requirements. These NGOs are supported by the Biomass Energy Project with funding for agricultural inputs and knowhow; fuelwood planting methods, training on soil conservation, intercropping, and other fuelwood cultivation practices, etc.

**Wanasarana**, a local NGO, works with 60 village communities and a school in Imaduwa, Galle. These communities were given fruit and vegetable seedlings, over 100,000 Gliricidia sticks and supported with agricultural knowhow to establish fuelwood plantations.

The **Mihimau Science Foundation**, located in Sevanagala in the Monaragala district, provides relief by way of seedlings and seeds to rural communities. This foundation works together with the Biomass Energy Project in providing best practices, capacity building and awareness programmes on crop cultivation. In total, Mihimau has planted 90,125 new Gliricidia plants covering an extent of 41 ha.

The **VOICE Area Federation** is a collaboration of Community-Based Organizations (CBOs) working in four Divisional Secretariats in the Puttalam district. These CBOs represent more than 3500 families. Apart from providing social relief and educative opportunities for children, VOICE also supports these families by uplifting livelihoods through the disbursement of plant materials and agricultural inputs. The total area under cultivation is 65.01 ha.

The **Arunalu Community Development Center** is a CBO comprising men, women and children from villages in Maningamuwa, Matale. This NGO helps uplift the livelihoods of these villagers through agricultural support. One of the key components is the growing of cash crops complemented by the growing of fuelwood as an additional income earner. Some of the main crops are pepper, betel, legumes, bananas and other vegetables, along with more than 403,540 Gliricidia plants that cover a total extent of 252.8 ha.

The **Sri Lanka Environment Exploration Society (SLEES)** has established up to 68.8 ha of model fuelwood plantations across 10 villages in the Kurunegala district. In total, over 115,022 Gliricidia plants have been planted to complement alternative income sources such as pepper, betel and vanilla cultivation for these rural communities. SLEES undertakes training and awareness programmes for farmers on agricultural inputs and supplies planting materials.

Name	District	Land Extent (ha)
Wanasarana	Galle	71.20
Mihimau Science Foundation	Monaragala	41.0
VOICE Area Federation	Puttalam	65.01
Arunalu Community Development Center	Matale	252.8
SLEES	Kurunegala	68.8
<b>Total</b>		<b>498.81</b>





## SUSTAINABLE SUPPLY CHAIN DEVELOPMENT

### Pilot Biomass Energy Terminals

One of the key criteria in the Project's success is the setting up of standardized and sustainable biomass collection and distribution terminals. Such terminals will cater to the requirements of industry and even settle supply and demand fluctuations and ensure longer term sustainability. Biomass that is certified sustainable, as well as biomass that is not sourced from sustainable sources will be tracked and labeled accordingly for the benefit of the end users.

The terminals also create job opportunities and improve alternative income sources to rural households. The Project has established pilot fuelwood growing models with the Forest Department, RRISL, CCB, RPC, NGOs and CBOs and private sector land owners in districts where the terminals are to be established. These models will assist in the ethical sourcing of fuelwood and increase the production of biomass energy, which will deliver benefits to the society.

The Project has, by the end of 2018, set up three terminals in Monaragala, Colombo and Kurunagala and three satellite supply chains within these three districts. These strategic locations are selected based on a study carried out by the SLSEA and a Biomass Resource Survey undertaken by the Biomass Energy Project on the consumption and supply of biomass.



### Sri Lanka Standard 1551: 2016

With the long-term objective of increasing the use of sustainably sourced fuelwood for bioenergy in Sri Lanka by 2020, stakeholders identified the need for standardization that would prevent mismanagement between sustainable and unsustainable sources of fuelwood. The objective is that large users of fuelwood (e.g. tea, rubber, textile industries and the energy sector) would require their fuelwood suppliers to demonstrate the sustainability of their sources by achieving this certification.

The Sustainable Biomass Energy Project, in collaboration with the Sri Lanka Sustainable Energy Authority, commissioned the Sri Lanka Standards Institute (SLSI) to come up with a proper standard with the help of a Technical Advisory Committee comprising the Central Environmental Authority, Forest Department, Ministry of Plantation Industries, Ministry of Mahaweli Development and Environment, universities, environmental NGOs, fuelwood users (industry), fuelwood producers (plantation owners), other key ministry representatives and research institutes.

On November 10, 2016, the Sectorial Committee on Materials, Mechanical Systems & Manufacturing Engineering, approved the standard and SLS 1551:2006 is now available for fuelwood producers to adopt and implement. Accredited certification bodies perform the audits and deliver sustainability certificates to producers who meet the standards and annual audits are conducted to ensure continued compliance. It is expected that these certified fuelwood producers will be the preferred fuelwood suppliers of medium to large scale industrials in Sri Lanka.

The concept of sustainability certification requires producers to demonstrate not only sustained yield, but also social and environmental leadership. The sustainable fuelwood standard is formulated so that it can be implemented by a very wide range of suppliers/producers, and specifically requires a) in compliance with Sri Lankan legislation; b) respect for the environment (protection of natural forests, soil and water, species at risk and control of invasive species); c) consultation with local communities and contribution to their social and economic development; d) for small landowners producing fuelwood, the standard suggests they should get together as a group to give themselves capacity and facilitate the implementation of the standard, and e) a basic chain of custody to provide assurance to buyers of fuelwood that the wood they are purchasing is indeed certified.





## Gender Equality, Social Inclusion, and Human Rights

Mainstreaming on gender, many entry points were identified and implemented for equitable benefit as the project recognized the differential needs and capacities of men vs women and provided an enabling environment to improve their engagement in project interventions. These included equitable accesses to technology, financing solutions, knowledge and information.

The Project also recognized that women play an important role in promoting biomass for energy generation and women in the SME sector specifically benefit from improved access to resources. Further, the enabling environment created by the Project provided opportunities for more women to enter into the SME sector to expand their income generation options. This applies for both- biomass growing and technology transfer. Ultimately these interventions will contribute to improving the quality of life of men and women in the long term in many ways.

## Phase II: Biomass Energy 2022: Fueling the Economy – Protecting Forests

Building on the experiences, best practices and lessons learned from **Biomass Project Phase I** (2013-2018), **Biomass Energy 2022: Fueling the Economy – Protecting Forests** (Biomass Project Phase II) will consolidate the results and up-scale promising models that support the local biomass industry, afforestation efforts and Sri Lanka’s goal of increasing the share of renewable energy in the energy mix in line with the energy policy. The Project will build on partnerships established with public institutions and private sector during the implementation of the GEF-funded Biomass Project Phase I and support the expansion of viable models and activities through new and existing partners and south-south cooperation.

The expected outcomes of the Biomass Project Phase II are strengthened rural economies, improved living standards for rural communities, sustainable Small and Medium Enterprises (SMEs) and large-scale industries in Sri Lanka, the growth of technology suppliers for clean and modern biomass technologies and helping to increase the forest cover. The project contributes to the achievement of the Sustainable Development Goals (SDGs) in Gender Equality (Goal 5), Affordable and Clean Energy (Goal 7), Industry Innovation and Infrastructure (Goal 9) and Climate Action (Goal 13). It indirectly contributes to targets under Life on Land (Goal 15) and No Poverty (Goal 1).



## Cost Effective Transportation of Biomass

One of the key supply chains of biomass distribution is transportation. However, when transporting biomass, it is vital that the cost to the end user remains competitive for biomass to be a preferred energy source. Therefore, transportation cost must be kept to its minimum.

After detailed analyses were conducted by the Project, it was confirmed that transporting biomass in large trucks is more cost effective on the per tonne and cost per MJ basis. In addition, larger trucks also maintain lower GHG emissions than medium-sized trucks and the same theory applies to small trucks.

Another cost factor is the lack of automation especially when it comes to loading and unloading of biomass for two reasons; Firstly, by reducing the time taken for this process, biomass distribution/transportation can be increased, which means the fixed daily cost to the driver can be halved. Secondly, this process will eliminate the need for a helper as the driver can handle this entire process alone.

But the industry has no automation at present and relies mainly on low skilled labour to unload/load and process the biomass. Therefore, it is worthwhile looking at automation as a cost savings across this supply chain.

Route analyses were also conducted by the Project. It was concluded that the use of higher grade roads is preferred as the average speed gives better fuel economy and therefore reduces cost and GHG emissions, even where the length of the journey is longer than a journey that uses minor roads.

Since the railway does not have the capacity or infrastructure to transport biomass at presently, this option is worth considering in the longer term.

Therefore, recommendations for subsequent actions are as follows:

- To encourage market participants to use large trucks and truck mounted cranes
- To investigate opportunities for automation
- To review flexibility on routing options



## Projected Yield Estimates of Fuelwood Plantations Established by the Sustainable Biomass Energy Project

							Tonnes of Fuelwood									
No	Implementing organization	Extent ha	Trees/ha	Fuelwood species	No of trees	Rotation	Year 01	Year 02	Year 03	Year 04	Year 05	Year 06	Year 07	Year 08	Year 30	
1	NGO/CBO fuelwood plantations	498.81	2000	Gliricidia sepium intercrop in home gardens	997,620	1 year	1,397	3,990	4,988	5,986	5,986	5,986	5,986	5,986		
2	CCB fuelwood plantations	242.8	1750	Gliricidia sepium intercrop with coconut	424,900	1 year	595	1,700	2,125	2,549	2,549	2,549	2,549	2,549		
3	RRISL fuelwood plantations	100	1928	Gliricidia sepium	192,812	1 year	270	771	964	1,157	1,157	1,157	1,157	1,157		
4	Thalawakelle fuelwood plantations	123.67	2500	Eucalyptus grandis	309,175	30 years									19,110	
5	Forest Department fuelwood plantations					8 years										
<b>Anuradhapura district</b>																
	Model 01	8	1600	Khaya monoculture	12,800	30 years									2,880	
	Model 02	4	938	Khaya	3,750	30 years									720	
			938	Gliricidia	3,750	1 year	5	15	18.75	22.5	22.5	22.5	22.5	22.5		
	Model 03	4.5	1111	Tamarind	5,000	8 years									80	
			1333	Gliricidia	6,000	1 year	8	24	30	36	36	36	36	36		
			56	Eucalyptus camaldulensis	250	8 years									10	
<b>Puttalam district</b>																
	Model 01	9	1600	Khaya	14,400	30 years									3,240	
	Model 02	1	2500	Khaya	2,500	30 years									562	
		3	2500	Gliricidia	7,500	1 year	11	30	37.5	45	45	45	45	45		
	Model 03	4.28	2500	Khaya	10,687	30 years									2,052	
		1.42	2500	Gliricidia	3,563	1 year	5	14	18	21	21	21	21	21		
<b>Nuwara Eliya district</b>																
	Model 01	3	2500	Eucalyptus grandis	7,500	8 years									561	
	Model 02	5	2500	Eucalyptus grandis	12,500	8 years									935	
			1000	Gliricidia	5,000	1 year	7	20	25	30	30	30	30	30		
	Model 03	13.4	2500	Eucalyptus grandis	34,000	8 years									2,507	
<b>Badulla district</b>																
	Model 01	2.5	1250	Eucalyptus grandis	3,125	8 years									467	
			1250	Acacia mangium	3,125	8 years									454	
	Model 02	2.5	1250	Gliricidia	3,125	1 year	4	13	16	19	19	19	19	19		
			1250	Acacia mangium	3,125	8 years									325	
	Model 03	5	1600	Eucalyptus grandis	8,000	8 years									935	
<b>Matara district</b>																
	Model 01	5	275	Eucalyptus grandis	1,375	8 years									234	
			275	Acacia mangium	1,375	8 years									71	
			275	Alstonia macrophylla	1,375	8 years									467	
			275	Gliricidia	1,375	1 year	2	6	7	8	8	8	8	8		
<b>Annual fuelwood harvest from pilot fuelwood plantations (tonnes)</b>							<b>2,304</b>	<b>6,583</b>	<b>8,228</b>	<b>9,874</b>	<b>9,874</b>	<b>9,874</b>	<b>9,874</b>	<b>36,707</b>	<b>28,564</b>	





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## Promoting Sustainable Biomass Energy Production and Modern Bio-Energy Technologies

**Sri Lanka Sustainable Energy Authority**  
Block 05, 1st Floor, BMICH , Baudhaloka Mawatha, Colombo 07.  
Telephone: 011- 2 677 445, 011- 2 678 358 Facsimile: 011- 2 678 358  
E-mail: [info@energy.gov.lk](mailto:info@energy.gov.lk)

