A SOCIO-ECONOMIC STUDY

ON THE DENDRO POWER PROJECT AT KUMBALGAMUWA, WALAPANE

CONDUCTED FOR THE ASIA PRO-ECO PROGRAMME

BY

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ABSTRACT

Development of renewable energy sources has become a national priority for energy security in Sri Lanka. The Energy Policy of the country clearly states that by 2015 at least 10% of the power generation should be achieved through renewable sources. Dendro thermal energy generation using biomass has been paid much attention lately. Two types of modern biomass energy interventions have already been established; The first being dendro plants providing rural electrification and also supplementing the energy budget of the industries, the second deals with providing electricity to the national grid. One major step in the second category is the 1 MW dendro power plant established in Kumalgamuwa, Walapane in Nuwara Eliya District.

The objective of the present study was to provide a full assessment of the socio-economic perspectives of growing short rotation fuelwood crops (*Gliricidia sepium*) for the supply of dendro power plants with special reference to the 1 MW dendro power plant in Kumbalgamuwa, Walapane. The study intended to synthesise the lessons learnt in the supply of short rotation crops to the plant, the issues to be considered both social and environmental in planning similar ventures in the future. The plant commenced its operations in December, 2004 and continued operations for almost one year till October, 2005. During this time the plant experienced many hurdles among which the irregular and sub-optimum supply of feedstock, the high moisture content of the feedstock, constant failures in the grid connection, the cost of production (Rs. 8.00/unit) being higher than the selling price (Rs. 6.50/unit) were significant. However, after much deliberations the Ceylon Electricity Board had agreed to purchase the electricity at Rs. 8.50/unit. Therefore, the plant is hoping to recommence operations from June, 2006.

The study was conducted in 3 selected villages ie Walapane, Nildandahinna in Nuwara Eliya District and Kandeketiya in Badulla District. Walapane was selected as the dendro plant was situated in the village, and the other two villages were selected at random from a host of other areas from where feedstock to the plant is supplied. A combination of methods was used in conducting the survey. Secondary information was gathered on the relevant areas followed by primary information gathering by field reconnaissance, rapid appraisal, focus group discussions and a household survey. Consultations were made with government, private sector, non governmental organisations and relevant personnel.

The results revealed that the only a very small percentage (about 1%) of the feedstock came from Walapane while the plant was greatly dependent on the stock coming from distant locations i.e. Nildandahinna, Kandeketiya (Badulla District), Polonnaruwa, Ududumbara etc. The situation largely contradicts with the assumption made in the feasibility study commissioned by the Ceylon Tobacco Company (CTC) in 2002, prior to the commencement of operations, which stated that feedstock would be available in amounts 3 times the required level from the surrounding area. Factors which contributed to this deviation were the difficult terrain which posed difficulties for the farmer to bring the feedstock to the road for collection, low price offered for the feedstock, the cumbersome procedure involved in the processing of the wood (including chopping and drying), farmers engaged in occupations with better prospects. Further, due to the noise, fly ash, problems with the disposal of storm water etc. the neighbourhood was disappointed with the Project, thus refrained from supplying feedstock.

Therefore, the supply chain had become quite long and since they have to be transported from far, cost of transport has been high. Despite the fact that the Dendro plant pays Rs. 2.70/kg plus

0.25/kg for transport, only a small fraction goes to the farmer (Rs. 1.00/kg on wet basis, Rs. 1.50/kg on dry basis).

There was expectation that energy plantations would be established (managed by communities) to supply wood for the project, presently the supply has been entirely from homegardens/private lands. No energy plantation has been established. However, as *Gliricidia* has already been planted as a support for pepper and was consequently in abundance in all the areas studied, there was no dearth of wood. The amount of wood produced depends on the extent of the garden and its condition. Large gardens recorded high yields thus high incomes while those with smaller land operated on a subsistence level. Assuming that the *Gliricidia* has been planted at 2.5 x 2.5m spacing and an average tree will record 6 kg of wood, the expected weight of wood if pruned once a year should be around 6,800 kg. This will record an income of Rs. 6,800/acre (Rs. 1 be paid to 1 kg of wet wood). However, in general gardens produced about little more than 2,500 – 3,500 kg thus registering an income of Rs. 2,500 – 3,500 /acre; which is much lower than expected.

The majority of the farmers who participated in the programme did so as an additional income. However, due to the difficult terrain and the labour days spent on processing (cutting, chopping and drying) there was less willingness to participate in the project. There was a general request to increase the price paid to feed stock at the rate Rs. 3.00 for a kg of dried wood (moisture content less than 35%) and Rs. 2.00 for a kg of wet wood. The principal participants were men in majority of instances although women and children participated in the chopping, drying etc. However, the young men/women did not consider this as a lucrative livelihood option. The collectors were benefiting well from the project, their average income being around Rs. 30,000

Among the challenges of the Project, irregularity of feedstock supply, high moisture content of the feedstock, insufficient storage space and poor quality of the grid line can be mentioned from the Dendro plant side. From the farmer's side, the lower price paid for the feedstock and the difficulties encountered in drying due to lack of space in their gardens were mentioned. The collectors too experienced difficulties during the rainy period and the festival months in procuring stable feedstock.

Lessons learnt for future investors

Selection of a suitable site is paramount for the success of such a project. Availability of ample feedstock, easy terrain for transporting and processing the material, location in the area where competitive employments are not widespread are all important factors. Further, it would be most appropriate if the plant is located on flat terrain in dry zone/dry intermediate zone so that the climatic factors will also aid in the fast drying of the feedstock.

While depending on the small holders for supply of feedstock, it is likely to be important to have a separate dedicated energy plantation to supply at least 1/3 of the feedstock on a regular basis. This will aid in the uninterrupted feed stock supply all year round. It is thus important for the plant to be located in a place where sufficient land is available to establish an energy plantation. The management of this area can be done by the dendro plant itself or contracted out. A full environmental assessment should be undertaken prior to the establishment of the dendro plant. The adverse impacts thus identified should be suitably mitigated prior to the establishment. The site should be located at least 500m away from a residential area.

It would be ideal to purchase the feedstock in raw and uncut conditions from the farmers and process it in the factory. The long sticks can be chopped using an industrial chipper or a chipper

could be a component of the collection truck so that more material can be taken in one trip. The chipped wood stock can then be dried on land belonging to the factory. The extent of this land should be such that at least one month's stock can be stored.

The supply chain should be kept as short as possible and the transportation distances should be also minimised. This will help to accrue more benefits to the farmer who are located at the end of the chain. If agents are also included in the chain, they should be monitored so that the feedstock is bought at standardised rates.

The price paid for the feedstock should be increased, at least Rs. 3.00 for dried stock and Rs. 2 for wet stock. This will enable the effective participation of the farmers in the project.

When selecting the type of feedstock, *Gliricidia sepium* or *Calliandra calothyrsus* can be used for all island and upcountry respectively. However, in the case of energy plantations, a species which has less moisture content ie *Leucaena leucocephala, Cassia siamea, Trema orientalis*, *Eucalyptus camaldulensis, Acacia auriculiformis,* can be used in the dry zone while *Calliandra calothyrsus, Grevilea robusa* can be used in the wet highlands. The widely available *Prosopis juliflora* (Kalapu andara) available in the Hambantota area can be used for a dendro project located at close proximity.

Finally, the dendro plant should be established in an area where the grid connection is optimal and functioning without any interruptions. It is important to recommend that the government should facilitate the creation of a demand for dendro energy to be used in the industrial sector so that there would be more demand for this type of clean energy in the country. Further, as this is an energy which is more sustainable in the long term, the purchase price should be further increased, thus on par with that of diesel.

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1. Introduction

In Sri Lanka biomass dominates the primary energy provision, and it is accounted for about 50% of primary energy requirements in 2002. Biomass fuel is the primary source of cooking energy in the rural households. It plays a vital role in catering for the energy needs and ensuring the livelihood security of over 15 million rural populations and supplementing the cooking energy needs of the urban poor. Nearly 10 million tons of biomass is consumed annually and the total value of this is about US $ 440 million in monetary terms. The consumers get woodfuel from natural forests as well as from the manipulated forest production systems. The mosaic of home gardens comprising of individual household gardens, live fences and hedges demarcating boundaries of individual plots of land including farms, ribbon belts of planted trees etc. are important sources of woodfuel. Petroleum is the second most significant source of primary energy and provided about 42.6% of primary energy in 2002. Hydropower is another major source of energy and contributed around 8% of primary energy as a dominant source for electricity generation. The potentials for expanding hydropower generation are limited due to resource constraints. The non reliability of fossil fuel and escalating costs has encouraged the power sector to search for renewable solutions.

1.1 Trends in the Energy sector

The development of renewable energy sources has become a national priority for energy security. This is facilitated by the decentralisation of power generation as about 1.8 million rural households and another 150,000 households in the estate sector do not have access to grid electricity. Further, there is also provision for renewable energy to be connected to the national grid. Major trends in this sector include;

- Private sector involvement in generating energy since 1996. As a result, in 2002, private sector stations provided nearly 32.6% of the annual energy requirements.

- Promoting off grid electricity generation for rural electrification. It is expected to achieve 80% of electrification by grid extension and the balance 20% by off grid electricity generation.

- Promoting locally available renewable sources such as hydro, biomass and wind for electricity generation securing external support as a way to enhance rural electrification. For instance, grid connected and off-grid mode micro hydro and dendro energy projects are promoted to cater for national and local electricity needs.

- Facilitation of dendro thermal energy generation using biomass for sustainability and decentralisation. As a result of this, a number of modern biomass energy interventions have been established. A community-based dendro plant has been established in Badalkumbura – Wadagahakiwula for electricity generation for the community. Many dendro plants using gasification technology has been established by the private sector to supplement their own energy needs.

The Government of Sri Lanka has taken the following steps to promote the growing and utilisation of fuelwood;

- An inter Ministerial Working Committee was established to identify the issues to be addressed to promote the growing and utilisation of biomass fuels.

- The Ministry of Plantation Industries has decided to support and promote fuelwood crop by including fuelwood as the fourth national major plantation crop under the Ministry.

- Coconut Cultivation Board has decided to give a subsidy of Rs. 7,500 per ha for inter-planting Gliricidia in coconut lands

- Coconut Development Authority has initiated action to support the use of branch coppice wood as the fuel for the desiccated coconut industry.

In the Energy Policy of Sri Lanka, special reference has been given to the non conventional renewable energy based electricity in the grid. The Government is hoping to reach a minimum level of 10% of electrical energy supplied to the grid to be from non-conventional renewable energy. This is facilitated by the access to green funding such as CDM (Clean Development Mechanism). The target year to reach this level is 2015. In order to make available the incentives for Non Renewable Energy (NRE) technologies, the Government had created an 'Energy Fund' which is managed by the Energy Conservation Fund. This fund is strengthened through an energy cess, grants received from donors and other donations as well as any funds received under the Clean Development Mechanism (CDM). It is hoped to use this fund to provide incentives for the promotion of NRE technologies and strengthen the transmission network to absorb the NRE technologies into the grid. NRE developments will not be charged any resource charge (royalty) for a period of 15 years from the commercial operation date. The resource charges shall be used to finance incentives for further NRE development through the Energy Fund. As a result from these incentives, a 35 KW model dendro plant in Sapugaskanda and 1 MW dendro plant in Kumbalgamuwa, Walapane have been commissioned by the private sector.

1.2 Bio Energy Initiatives

Two types of initiatives have been made to promote biomass energy technology, one model is to generate electricity for the national grid and the other is the community level off-grid energy supply to meet the electricity demand in rural areas. The potential for generating electricity from biomass has been investigated referring to three main aspects. The first is the past practical experience of the country in dendro power generation initiated by individuals and the private sector for their own use. The second is the potential for obtaining feedstock or the biomass on a sustainable basis as the raw material source for electricity generation. The third is the possibility of converting under-utilised, unutilised and degraded state lands for dendro plantations. The possibilities to motivate the private landowners to invest on dendro plantations are also considered to be promising.

The long-held practice of tree farming as an element of the land based livelihood in Sri Lanka is a mechanism for promoting energy enterprise – dendro energy. There are potentials for growing fast growing species for multiple benefits; targeting woodfuel production where only selected branches are removed for providing feedstock. Dendro energy development is seen as a strategy for the 'Re greening of Sri Lanka' and for addressing the energy crisis that the country has experienced. It is considered to be economically beneficial to make use of species grown in live

fences and also to inter crop coconut plantations for diversification. In this regard, pre-feasibility studies have been carried out by the Ministry of Science and Technology, Ministry of Environment and Natural Resources and non governmental organisations such as the Intermediate Technology Development Group (ITDG) and the Energy Forum.

The Bio Energy Association of Sri Lanka (BEASL) plays a leading role in promoting dendro-energy. It has been formed by several scientists with the intention of promoting the bio-energy industry. It has made a significant impact in this direction, particularly in promoting favourable policy initiatives, research, regulations, tax incentives and motivating and mobilising resources. Its aim is re-greening along with the production of biomass for the energy industry and to promote the concept that the growing and harvesting of wood fuel trees is sustainable and profitable. BEASL acts as a catalyst, and has built partnerships and interactions among the state agencies, NGOs, technical and research institutions, farmer organisations and the private sector.

1.3 Objective of the study

The main objective of this study was to provide a full assessment of the socio-economic evaluation of the growing of short rotation fuelwood crops (*Gliricidia*) for the supply to the dendro power plants using the 1MW dendro power plant in Kumbalgamuwa, Walapane as the model. The study intends to synthesise the lessons learnt in the supply of short rotation crops to the plant and the issues that have arisen - both social and environmental - in planning similar ventures in the future. It follows on from some of the concerns that were highlighted by Wickramasinghe (2006) in her study on the negative gender and social-environmental issues raised by the operation of the plant.

2. Methodology adopted

2.1 Site

Dendro power project in Kumbalgamuwa is a commercial energy enterprise established in 2004 for generating 7GWh electricity to the national grid. It is located in the Walapane Divisional Secretariat in the Nuwara Eliya District. **The energy plant requires about 40-50 metric tons of biomass daily** and it is expected to provide around 20 million rupees infusion to the rural economy. Technical investments are made by the Lanka Transformers Limited while the supply system including extension services is provided by the Ceylon Tobacco Company using the network links that it has had during last 5 decades in support of tobacco in this area. The dendro project has been justified focusing on multiple benefits. These include;

- Benefits to the energy sector – 7 GWh/year to the national grid
- Part time employment for many farmer families
- Establishment of energy plantations (3.2 million trees of *Gliricidia sepium*)
- Provide a market for woody biomass (40-50 tonnes of wood to be consumed in the power plant)

In addition to these direct benefits, supplementary benefits accrue by way of foliage as fodder, provision of nutrients to the soil etc. The project has been justified as a way to catalyse the economy and improve the quality of life.

The study was conducted in 3 selected villages ie Walapane, Nildandahinna in Nuwara Eliya District and Kandeketiya in Badulla District. The former was selected as the dendro plant was situated in the village, and the other two villages were selected at random from a host of other areas which supplies feedstock to the plant.

A combination of methods was used in conducting the survey. Secondary information was gathered on the relevant areas. In procuring the primary information, a rapid appraisal, field reconnaissance, a questionnaire survey, analysis of secondary information and focal group discussions were used. Consultations were made with government, private sector institutions, non governmental organisations and involved personnel attached to the industry i.e. Lanka Transformers Limited, Ceylon Tobacco Company, Ministry of Power and Energy, Ministry of Science and Technology, Bioenergy Association. In depth study was conducted in 50 households; each selected at random in Nildandahinna and Kandeketiya while 25 households were selected from Walapane. The selection of a reduced number of households from Walapane was due to the fact that a very limited supply of feedstock came from Walapane area.

3. Results

3.1 Sources of *Gliricidia*

According to the records maintained by the CTC the following are the information on the supply of feedstock to the dendro plant for a period of 6 months during 2005.

Table 1: Supply of feedstock (*Gliricidia*) to the Dendro plant for a period of 6 months

	Walapane	Nildandahinna	Kandeketiya	Polonnaruwa	Ududumbara
No. of suppliers	2	17	13	1	23
No. of farmers	200	1800	2200	1250	1200
Amount of feedstock (tons)	82	804	1592	1120	560

According to the table, the lowest participation of farmers and lowest supply of feedstock were from, very surprisingly, the Walapane area. Highest participation as well as greatest supply of feedstock was from Kandeketiya in the Badulla District. These figures especially the ones for the Walapane area are in contradiction with the projected ones by the CTC from the feasibility study conducted in March 2002. The selection of Walapane as the location for the dendro project was based on the abundance of *Gliricidia* in the area which covers an area of about approximately 1,200 ha. The survey had revealed that there were an estimated 2,523,850 established plants that would equate to around 500 ha of plantation (based on a standard spacing of 5,000 sph). Further, there was another 1,792,750 new plants that would equate to a further 358 ha of plantation grown by the farming community which will also be ready for supply in the near future. Therefore, considering the total extent of planting, in the close vicinity of the dendro plant there appeared to be adequate material for operating the plant at its assumed requirement of 50 tons/day.[1]

However, these assumptions did not materialise since the lowest participation in the project is from the Walapane area. The main reasons for the lack of enthusiasm have been the difficult

[1] The assumption being that the total plantings within the locality of the plant is already approaching the equivalent of 860 ha. Providing this will provide at least 20 tonnes per ha per annum, the annual production of wood should exceed 17,200 tonnes, equivalent to the annual demand of the plant.

terrain on which the *Gliricidia* is growing and the low price paid for the feedstock. Farmers did not consider that the total income was such to make this an effective livelihood option. Further, about 50% of the families were engaged in paddy as their main income whilst the rest were engaged in government and other employment. Another very significant reason for the lack of participation was the barrier between the plant personnel and the villagers on environmental grounds. This was prominent with those household in close proximity to the plant, since the noise, dust and effluents were regarded as a major infringement of day to day lives.

The organisation used for the collection and transportation of wood depends on the use of collecting agents: each agent or contractor dealing with about 150 farmers for the supply of wood. Almost all the entire supply is coming from home gardens/private land. *Gliricidia* is being harvested from shrubs which had been originally planted as support for pepper vines and sometimes as live fences. No new planting was established in the villages surveyed. Almost all the lands were noted to be steep and therefore, farmers were facing difficulty in transporting the harvested sticks to the road. The distance the farmer has to travel to the road was between 0.5 – 1.0 km in Nildandahinna and around 0.5 km in Kandeketiya.

3.2 The perceptions of the communities in growing this as a crop, whether it is considered as a viable livelihood option

In Nildahdahinna, about 50% of the gardens were around 2-4 acres while about 25% of the gardens were between 1-2 acres. Gardens more than 5 acres (=2 ha) accounted for another 25%. In Kandeketiya there was a marked diversity in the size of land holdings; more than 5 acres (5%), about 4-5 acres (26%), 2-4 acres (37%), less than 1 acre (16%). A smaller percentage (16%) did not own land at all.

In almost all the farm land, pepper had been planted using *Gliricidia* as the supporting poles. Usually the distance between two poles is 2m, amounting to about 2,500 plants per ha. However, this varies with the estate as the ones which are being well looked after always maintained this density whilst the others who were less well maintained had lower stockings. Usually, the assumption was that a mature *Gliricidia* tree having about 6 branches in general yielded about 6 kg. If this assumption was used, about 6,800 kg can be produced from 1 acre of land, (=16,830 kg/ha). If it takes in general 12 days to cut and process wood from 1 acre of land Rs. 568 can be earned per day by selling the *Gliricidia* sticks. This is much more than an average daily wage of a person.

However, during the survey, almost all the farmers expressed their dissatisfaction at the price paid for *Gliricidia* sticks which was Rs. 1 for wet sticks and Rs. 1.50 for dry ones. The amount of *Gliricidia* produced from each garden was also much less than the estimated sum. In Nildandahinna, the majority of farmers had land holdings equating to about 3-4 acres while in Kandeketiya, a good percentage had land which is less than 1 acre. In Nildandahinna, about 66% of the persons produced more than 10,000 kg, whilst 44% produced between 5,000-7,500 kg. In Kandeketiya, 11% recorded production between 2,500-5,000 while 44% recorded between 5,000-7,500 kg. Few (11%) recorded production between 7,500-10,000. The average production was about 2500 kg/acre (= 6,175 kg/ha) thus rendering an income of Rs.2500 - 3500/acre, (=Rs 6,175-8,650/ha). There was thus a marked deviation from the figures for well managed production to the real life situation in these areas.

Although, more farmers cut *Gliricidia* twice a year (40%) in Nildandahinna than in Kandeketiya (30%) there was a more regular supply of the feedstock from the latter.

In general, the majority who participated in the project were men. In Nildandahinna, 60% of the males and 40% of the females participated while in Kandeketiya 59% of the males and 41% of the females participated as the primary beneficiary. However, in general the participation of the entire family in the project was evident. In Nildandahinna about 75% of the people stated that they get the full assistance of the women and children in the families to the project. The participation of the women and sometimes children were mostly in chopping sticks to small pieces while the cutting of the sticks in the fields was carried out by men. The participation of women and children were even better in Kandeketiya (80%). Some agreed that this practice had helped the family to be bound together.

It should be noted that in an earlier study conducted by Wickramasinghe (2006) on the gender issues related to biomass energy programmes – including Walapane, she had also highlighted concerns that the community had over the operation of the plant with respect to the level of payment. In addition her study indicated that women in particular regarded the project negatively as their normal sources of domestic fuelwood were lost and at the same time men were taking over control of fuelwood collection and the resulting revenue that was associated with this activity was lost to them as a group.

A noteworthy fact was that the elderly personnel in the villages participated in this practice while the younger ones were less involved. They were either out of the village engaged in other occupations or not interested. In Nildandahinna, 60% of the participants were between 35-50 years of age while 40% were more than 50%. In Kandeketiya, 19% were less than 35 years while 75% were between 35-50 years. 6% were more than 50%.

No one did this practice as the sole income source. Almost all the people were involved in other occupations i.e. paddy, pepper cultivation, running shops and small businesses etc. In Nildandahinna, all were engaged in paddy and pepper while in Kandeketiya in addition to these they were growing “Other Field Crops” (60%) in Yala season, Corn (30%) and engaged in other occupations (25%). Therefore, the income from *Gliricidia* was about 25% of their total income. They were engaged in this practice primarily because they had to prune the *Gliricidia* sticks at least once a year before the rainy season in September to allow more light to the pepper lands. If they had not engaged in this practice, they have to remove the branches or pay about Rs. 4,000 to do so using paid labour. Further, they would have left at least 50% of the sticks on the ground and used about 50% as fuelwood. Therefore, this was a good opportunity for them to utilise a commodity which would otherwise have gone to waste.

Therefore, from the household survey, 95% of the farmers in Nildandahinna said that they participated in this project because it provided a good side-income while 5% said they do so because there is no other alternative. In Kandeketiya, 85% said they participated in the project because it was a good side-income. A further 8% of those interviewed considered the activity to be profitable and the remainder said they participated in the project because there was no other option. The major majority of farmers devoted only a few hours of their time to the activity.

The supply chain includes agents who collect the feedstock from the farmers and bring the material to the dendro power plant. The least number of agents were from Walapane area (2) whilst the highest was from Ududumbara (23). In Nildandahinna there were 17 agents while in Kandeketiya and Polonnaruwa there were 13 each.

In general, the agents were bringing feed stock ranging from 40,000 kg to 145,000 kg per month to the plant. They were being paid Rs. 1.25 per kg. In 2005, a transport incentive was also included as follows;

10,000 – 20,000 kg/day = 10 cents
20,000 – 30,000 kg/day = 20 cents
30,000 or more kg/day = 30 cents

However, this practice was discontinued and instead a sum of 25 cents was paid for each kg for goods transported from afar. Each agent is responsible for about 150 farmers and s/he gives bags in advance and collects the goods once they are ready. He/she travels about 7-8 miles to collect the goods. Most of them own the lorries that are used, otherwise they need to hire them at Rs. 3,000 for a trip to the dendro plant. Usually a truck employs about 2-3 personnel to aid in the collection of goods. Therefore, if an average person brings 40,000 kg of feedstock to the dendro plant

His/Her income @ Rs. 1.50 is Rs. 60,000	
Less	
Transport @ Rs. 3000 for 8 times	= Rs. 24,000.00
Collection of bags from 7-8 miles radius @ 3 days a week	= Rs. 2400.00
Payment for 2 labourers for collection for 12 days	= Rs. 3000.00
Total cost	= Rs. 29,400.00
Net income	= Rs. 30,600.00

Therefore, on average an agent is earning around Rs. 30,000 per month from the sale of the feedstock. Many of them had invested on their vehicles from this. This income is not their only activity as many are involved in other from of employment and other crops i.e. paddy, pepper, rice mills etc.

3.3 Benefit of the project in community development

The project produces energy at the rate of 7 GWh/year to the national grid when fully operatonal. However, there is no direct benefit from the project in power supply to the communities in the area. In addition to this, the project is purchasing at least 50 tons of feedstock per day @ Rs. 2.70 per kg amounting to about Rs. 135,000/day; or Rs. 4,050,000 per month; or Rs. 48,600,000 per year which is infused to the rural economy.

It provides part time employment to about 6,650 farmer families and if managed well at 2 x 1m spacing they can obtain about Rs. 6,800/acre (=Rs. 16,800/ha) annually if the crop is pruned once. This should be increased if the crop can be pruned twice a year. These figures were arrived at with the assumption that mature tree will yield 6 kg. Further, 68 agents are getting an income of around Rs. 30,000 per month after clearing their immediate costs. In the villages, the project has essentially created a market for wood which otherwise would have gone waste.

The majority of the households in both villages had grid connected electricity. However, the level of service was extremely poor. There are days in which there is no electricity. However, the people were not hopeful that the project will assist them in the power supply. This is in contrast to the situation where some dendro plants are providing electricity to the village. In the latter case there is more acceptance of the project by the villagers. In this present situation, the value of the project is only measured by the price given to the feedstock.

3.4 The Challenges of the Project

3.4.1 From the Dendro plant side

The following challenges have been experienced by the Dendro Plant

- **The irregularity of supply**

  The following are the extents of supply for the months in which the plant was in operation in 2005.

  - Jan – tons 1300
  - Feb – tons 1800
  - March – tons 1400
  - April – tons 380
  - May – tons 0
  - June – tons 1390
  - July – tons 1385
  - August – tons 1378
  - September – tons 1459
  - October – tons 1300
  - Nov – closed

  The above figures shows that there had been irregularity in the supply of feedstock. Except in the month of February, the stock had been less than the optimal requirement of 50 tons per day amounting to 1500 tons per month. In certain months like April, May the feed stock has been minimum due to festivals and other engagements.

- **The high moisture content of the feedstock**

The ideal condition for the optimum operation of the plant is to have feed stock which is dried to about 20% moisture. In this case about 1.5 kg of wood is consumed to make a unit of electricity. However, presently the moisture content of the wood brought to the plant is around 35% or a little less and in this condition about 3-4 kg of wood is required to make 1 unit of electricity.

- **The storage space in the plant is insufficient and transport distances too long.**.

Although the initial assumption was to get sufficient feed stock from the surrounding area, in practice it was almost non existent. Therefore, the wood had to be transported from distant locations, thus there has been a higher than expected expenditure on transport. The benefits to the farmers who is at the end of the supply chain are reduced with prices being squeezed. Therefore, there is a constant hue and cry to increase the prices of the feedstock which in turn affects the financial sustainability of the project.

- **No dedicated energy plantations established due.**

The feed stock is obtained from trees which had been already established as fencing or support for pepper. However, when the proposal for the plant was formulated, there was an expectation that farmers will be encouraged to grow the crop as energy plantations, solely to supply wood to the project.

3.4.2 From the farmers side

- **Low payment rates**

Almost all the respondents expressed their dissatisfaction at the rates given to their feedstock.

- **Difficulty in handling the material**

As the *Gliricidia* is grown in steep terrain it takes about 12 days or more for them to cut the sticks and bring them to the roadside and cut to pieces according to the requirements of the project. It takes another month to dry the sticks to the required moisture level and by this time the weight is lost by 30%. Further, they are also constrained with the lack of space for drying of the sticks. Therefore, people do not see this as a project which compensates their energy well. In Nildandahinna, about 80% of the farmers sold the sticks in dry condition (less than 35% moisture) whilst 20% sold them wet. In Kandeketiya about half of the people sold the sticks in dry condition while the rest sold them wet.

In Nildandahinna, most of the farmers in general said it would be better to sell the sticks unprocessed as they come from the field. Others agreed to dry the material for a shorter time (not more than 2 weeks). Only a minority were willing to dry it for a further 2 weeks in both locations studied.

- **Lack of consistency on payments**

Sometimes agents bought even the partially dried sticks at the wet rate. The farmers had not been advised of the supply contract conditions between the agents and the plant and felt that they had no direct avenue through which to complain. There is no organisation to represent the farmers in this context and therefore at times they are being exploited by the agents. According to the survey results, only 33% of the farmers were aware of the supply chain in Nildandahinna while the number in Kandeketiya was only 25%. However, everybody was of course aware of the dendro project itself and where the material was being taken.

- **Irregular operation of the dendro plant.**

For some months the plant had been non functional.

3.4.3 From the Agents/Collectors side

Most of the agents were happy about the project. However, the constraints they have to face are;

- Insufficient feed stock during the month of rains, during festival months (April – May) and also when farmers are busy with paddy cultivation

- Irregular functioning of the dendro plant.

3.4.4 Environmental constraints of the Project

There are about 10-15 families living in the immediate surroundings of the dendro plant. There had been insufficient transparency in the establishment of the plant and therefore those people in the area had learnt about the project after it has been already finalised and construction was underway. The major complaint from the residents of the neighbouring area is the noise. This is both the continuous noise emanated when the plant is in operation and the occasional one with a very high frequency when safety valves are being opened. Further, the fly ash and the ash which is being deposited are also problems. The poor maintenance of the discharge water pipes/storm

water pipes too reduced the quality of life of the neighbours. There had been many complaints and demonstrations against the functioning of the dendro plant from Walapane village.

4. Lessons learnt and recommendations for a new investor in establishment of a grid connected Dendro project

4.1 Site Selection:

- The plant should be established in an area where ample feedstock is available. The terrain in which it is growing should not be so steep to limit collection and transporations.
- Prior to the selection of the location of the plant, a feasibility study should be carried out on the following;
    - The availability of feedstock in the neighbourhood
    - The willingness of the farmers to participate in the project
    - The expected price for the feedstock
    - The other competing occupations of the farmers
    - Any other factors which could pose any constraints to the effective functioning of the Project

- An area which is on flat terrain in the Dry or Dry Intermediate Zone is preferable as the climatic factors will aid in the drying of the wood.

- The plant should ideally be located in close proximity to vacant land which could be used for an energy plantation. The extent of this land will depend on the capacity of the energy plant. This should provide at least 1/3 of the feedstock requirement. The management of the energy plantation can be done by the ownership of the dendro plant using mechanised operations, can be subcontracted to another party and come to an agreement for purchasing feedstock or by neighbouring community. The species that could be used apart from the already used *Gliricidia* are shown in the table under 'Alternative species'.

- It is also important that a suitable site which is at least 500 m away from a residential area should be selected to avoid the environmental problems i.e. noise, waste water discharges, fly ash discharges etc. causing problems to the neighbourhood. This can best be done by conducting an environmental assessment prior to the establishment of the Plant. This process should be very transparent so that the neighbourhood communities become aware of the project prior to its commencement. Otherwise, there could be many social and environmental complaints after the project commenced which would be difficult to handle.

4.2 Organisation and support for growers

- The dendro project can purchase wood directly from the farmers, chip and dry it in their factory yard and use it when they are ready (the moisture content then being less than 20%). For this, a yard should be made with covered chambers and the chipped wood should be stored according to the time it was brought to the factory. This yard should be

able to stock about a months supply. This would help the plant to operate smoothly even when the feedstock is not adequately available.

- A organisation of farmers supplying feedstock to the plant should be established. This will enable the farmers to be well conversant about the working of the factory, the supply chain etc. While helping them to understand the mode of operations in the factory it will also be a stage to express their grievances, concerns etc.

- The length of the supply chain should be as short as possible to accrue more benefit to the farmers. When it is long, the benefits are distributed among many thus the farmer gets a small benefit. This makes the farmers less enthusiastic to participate in the project.

- Most of the farmers would like to sell the feedstock straight from the field as many are having difficulties in chopping and especially drying due to lack of space in their yards.

4.3 Control and organisation of collectors

- For a plant to be sustainable it is vital that the feedstock should be received from the neighbourhood within 10-15 km from the dendro plant. There has to be a well organised collection system, either directly from the plant or through collectors. They should be given an incentive for bringing feedstock to the plant like the one which was operative in Walapane by the CTC. In this present study, it was apparent that the plant possibly over-paid for transport which would otherwise be of benefit to the farmers. The project benefited the agents/collectors more than it did to the farmers who actually provided the feedstock.

- There should be proper monitoring of the collectors so that a fixed price will be paid by them to the farmers. In the absence of such system, there is ample opportunity for the collectors to exploit the farmers by giving reduced prices than is promised. In the context of this study, there were occasions where both wet and dry wood was purchased at the same price of Rs. 1.00 per kg. Since the farmers did not know much beyond what the agents/collectors were telling them, they were helpless.

4.4 Levels of payment and margins

In the context of Kumbalgamuwa study, almost all the farmers who participated in the project did so with less enthusiasm due to the low price offered to the feedstock. This was especially so because the farmers were at the very end of the supply chain and although the management paid Rs. 2.70/kg plus transport allowance of Rs. 0.25/kg to the collectors, the farmers received only Rs. 1.00 for wet stock and Rs. 1.50 for dried stock which has been dried for almost a month in their yards. Therefore, In order to make the supply of feedstock a viable option the dried feedstock should be paid at least Rs. 2.50 -3.00 and the wet ones paid at least Rs. 2.00-2.50.

4.5 Opportunities for involvement and income generation for women and men

- In the context of the dendro plant in Kumbalgamuwa, those who participate in the supply chain i.e. farmers and agents/collectors were working on the project on part time basis

while engaged in other occupations. Therefore, the project had provided them an opportunity to have an additional income. However, the level of participation and the productivity on the basis of a unit area differed greatly. For the agents/collectors, this provided a good opportunity and the net income level was generally Rs. 30,000/month. There was little participation of women among the agents. This was due to the fact that the terrain was difficult for collection and the distance to the dendro plant was excessive. If the feedstock was supplied from the neighbourhood more women could participate as collectors. For farmers, the income from the participation of the project differed according to the extent of land, the density of the feedstock in the land, the frequency of pruning, the nature of the terrain etc. In general, at the optimum level of production, the income from 1 acre of land was Rs. 6,800/year (= Rs. 16,800/ha, on wet basis). However, in most of the instances the level of production was not optimum thus the income was much less. Therefore, proper management of the land, having a relatively large land area (about 4-5 acres), lack of other more lucrative employment opportunities in the village and outside will increase the involvement of both men and women. In the context of this present study, more participation to the project was shown from the village Kandeketiya in Badulla district compared to Nildandahinna. The reason for this was that the former village has had a very serious elephant conflict with paddy and home gardens being attacked by elephants. *Gliricidia i*s not attractive to elephant and therefore this crop has distinct benefits to farmers in such affected areas.

- It was also apparent that more elderly people participated in the project while younger ones pursued other avenues of more lucrative employment either in the village or outside. The participation of women in the practice was largely confined to chopping the wood to small pieces which they did late afternoon till dusk. This was due to the difficulty in cutting and bringing the sticks to the road. If the feedstock is established in easier terrain more women would participate in the entire operation. This also provides an opportunity for school children to participate in the project to earn an income to purchase the school items. However, this was not a very common practice in the villages studied.

- There was no discrimination by gender in procuring the benefit from the project in general. In many families this money was spent on family affairs. However, this depends largely on the relationships in the family and therefore cannot be generalised.

4.6 Alternative types of feed stock

- In a detailed study conducted by the Ministry of Science & Technology with many partner organisations including Coconut Research Institute, many tree species have been tested to be used in dendro power production. Among them, *Gliricidia sepium, Acacia auriculiformis, Calliandra calothrysus, Leucaena leucocephala* have proven to be successful. The assessment was primarily based on the wood yield, ease of establishment and the ability to withstand frequent coppicing. Further additional benefits such as rate of leaf decomposition which leads to the improved nutrient status of the soil were noted. Based on these results, *Gliricidia sepium* was selected as the best for a major proportion of the country.

- The main problem experienced by the Dendro power plant in Kumalgamuwa was the high moisture content of the feedstock. At the time of harvesting the moisture content is about 60%. After drying for about 4 weeks it is reduced to 35% thus the plant receives the feedstock which is having only 35% or less or else it is rejected. Since there is less

space for stocking, the chips having 35% moisture content are directly fed to the boiler and this gives less efficiency as the assumption was 1.65 kg of dried wood (20% moisture) would produce 1 unit of electricity. However, in reality about 3-4 kg of wood is consumed to produce 1 unit of electricity. Therefore, in the quest for selecting alternative types of feed stock the following should be considered;

- The availability of feed stock from the neighbourhood. This could be one variety or more depending on the type of machinery used (ideally the equipment should be able to handle a range of species).

- The feedstock should contain the following characteristics;
  - Low moisture level to maximise energy conversion values
  - Fast growth
  - Easy establishment
  - Production of high wood yield
  - Wood with high density
  - Ability to withstand frequent coppicing
  - Can be pruned easily by farmers or else machinery should be used for this purpose. Species with thorns give problems i.e. *Prosopis juliflora* (Kalapu andara)

The following table shows some alternative species that could be used especially as energy plantations;

Table 2: Alternative species that could be used for an energy plantation

Climatic zone	Species	Yield	Specific gravity/Density	Calorific value	Ability of coppice
Wet and intermediate dry zone	*Derris indica (Pongamia pinnata)*	Fast growing, reaches adult height in 4-5 years		4600 k cal/kg	Good
	Gmelina arborea	15-20m^3 /ha/yr	0.42 – 0.64	4800 k cal/kg	Good
	Leucaena leucocephala	30-40 m^3 /ha/yr	High	4200 -4600 k cal/kg	Good
	Trema orientalis	Fast growing		4500 k cal/kg	Good
Wet Highlands	*Grevillea robusta*	15-20m^3 /ha/yr	0.57		Rather poor but can be pollarded.
	Calliandra calothyrsus	30-50m^3 /ha/yr	0.51 – 0.78	4500 – 4750 kcal / kg	Good
Dry zone	*Adhatoda vasica* (has medicinal value too)	Fast growing	Moderately hard		Good

	Cassia siamea	15 m^3 /ha/yr	0.6 – 0.8		Good
	Eucalyptus camaldulensis	20-30 m^3 /ha/yr	0.6	4800 k cal/kg	Good
	Parkinsonia aculeata	Fast growing, will grow to 1m annually	0.6		Good
	Prosopis juliflora	30-50t/ha	0.70		Good

4.7 Technical considerations

From this study it was clear that some technical constraints have created problems with the smooth functioning of the project.

- The constant failures in the grid connection due to power interruptions lead to shutting down of the plant several times a month which causes considerable losses. Therefore, the power plant should be located in a place where the power lines are functioning optimally.

- It is advisable to invest on state of the art equipment since the overall efficiency of the plant is dependent on this and updating is expensive. It was known that the equipment was somewhat dated, but the overall intention was that the plant should provide a demonstration of what was possible.

- The dendro plant should be made sited and screened in order to minimise environmental concerns as much as possible.

- The fly ash and other wood ash should be disposed properly so that they will not be a environmental hazard.

- Recycling of resources i.e. water should be optimally done so that the quantity discharged is minimised.

4.8 Other

The dendro option is more feasible for the plantation or estate sectors since fuelwood is already established which can be utilised without further investment. This will reduce the cost of production thus make the plant more viable.

Finally, the dendro plant should be established in an area where the grid connection is optimal and functioning without any interruptions.

It is also important to recommend that the government should facilitate the creation of a demand for dendro energy to be used in the industrial sector so that there would be more demand for this type of clean energy in the country. Further, as this is an energy which is more sustainable in the long term, the purchase price should be further increased, to be on par with that of diesel.

5. Recommendations for the optimal functioning of the Dendro power plant in Kumalgamuwa

5.1 Feed stock supply

- The plant should purchase sufficient land to stock the wood at least for one month's requirement @ 50 tons/day. The feedstock should be stored under cover and organised in such a way that the period under storage for any particular consignment is known.

- CTC could promote the agents to purchase feed stock from the farmer as wet sticks (long ones or chopped) at the price of Rs. 1.50 and ask them to dry the wood until 35% moisture is reached. This will remove the burden from the farmers for drying. The agents who have sufficient land for drying should be given priority in the selection.

- Rather than the transport allowance, the agents could be given the transport incentive which was given prior to the factory closure since it encourages the personnel to bring more wood to the factory.

- When there is a price escalation, the feed supply from the Walapane area would also would be enhanced, thus reducing expenditure on transport. The factory should purchase as much feedstock directly from the Walapane area @ Rs. 2.50/kg.

5.2 Improvement of environmental conditions

- A tall wall/hedge should be erected around the factory so that any noise will be reduced.

- The ash residues should be disposed of properly, either taken out to a far place and buried or used for another purpose. However, it should not be stacked in the immediate environs as is presently the case.

- The water discharge route should be properly maintained, the drains repaired and corrected for proper slope to facilitate easy draining. The drains should be cleared from debris, plant material to facilitate the flow in the intended direction.

- Some positive interaction should be carried out so that the personnel in the plant and the neighbourhood communities could interact on a more friendly manner.

5.3 Poor quality of the grid line

- Discussions should be made with the personnel of the Ceylon Electricity Board (CEB) so that the power line could function without much interruption. This can be done by reducing the load taken for household power supply from the particular location, regular maintenance of the line which is travelling through the Victoria, Randenigala, Rantambe National Park.

5.4 General recommendations to the policy makers

Energy from renewable sources especially from wood biomass provides a long term sustainable energy source. However, except in the case of the estate sector where the feedstock is freely available in their plantations, others have to purchase the feedstock at competitive prices, thus the unit price of production is high. Therefore, energy from wood biomass is comparatively more expensive than that from small hydro power plants. However, while the latter is being tapped from natural resources the wood energy is being tapped from energy plantations which are grown for this purpose at a cost. Therefore, in line with the energy policy of the country which highlights that by 2015 at least 10% of the energy should come from renewable sources, a comparable tariff should be paid for energy derived from wood as that derived from diesel. This will be an encouragement for future investors to invest on wood energy in Sri Lanka.

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