

SOCIO - ECONOMIC AND ENVIRONMENTAL IMPACT OF ELECTRICITY GENERATION USING GLIRICIDIA SEPIUM: A CASE OF SILVER MILLS POWER PLANT IN MIRIGAMA

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Abstract

The study focused; to examine the socio economic impact to the cultivators and suppliers of the Gliricidia crop, to examine the environmental impacts of Gliricidia electricity generation process and to identify the problems faced by the cultivators, supplies and the management and to suggest the suitable solutions for the identified constrains and issues. Using the purposive sampling method, 25 farmers and 50 suppliers were selected considering the supply chains of the Gliricidia to the power plant located in Mirigama DSD. The data collection is based on the response of the questionnaire, which has been distributed among the farmers and suppliers and the case studies undertaken. The research ascertained that most of farmers who engaged in Gliricidia farming are traditional farmers. Out of total 48% farmers cultivate Gliricidia as an intercrop with

Keywords:

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coconut plantations, 24% cultivate as a mono crop and 18% gather Gliricidia woods from their home garden by maintaining live fences and setting as shades for garden crops. Approximately 78% of farmers were preferred to increase the crop in the same land while 56% of suppliers were preferred to cultivate the crop. Cultivation of Gliricidia gives socio economic effects by increasing the income, savings and covering expenditure of the both sample groups. The research has highlighted that the 88% farmers have increased their income after moving to sell the Gliricidia, as the crop is naturally growing and naturally protective from the pests and hazards than the other economic crops. Farmers have utilized the income received from selling of Gliricidia to cover the expenses of education (26%), food, medicine etc. Suppliers of the Gliricidia wood also received socio –economic benefits and the research indicated that 72% of suppliers of fuel wood engage as an extra income source while 28% practice it as a main source of income. Limited experience, lack of technical expertise locally, lack of access to financial resources and information on technical options were identified as the most common barriers in biomass utilization.

1. Introduction

The world is now gradually moving towards renewable energy sources which are less harmful to the nature and which naturally replenished as a circle. Most renewable energy directly or indirectly comes from the sun and the organic matter that makes up plants is known as biomass. First ever proposal in Sri Lanka to generate electricity by cultivating biomass came to a

discussion by Dr. Ray Wijewardene in July 1985. Harvesting and converting *Gliricidia* wood into electricity and supplying to the national grid can reduce the cost for fossil fuel. Assessment of socio environmental effects of renewable energies has done in many regions of the world. Now there's a growing trend for renewables with purpose of minimizing the carbon emissions. Assessing the socio economic and environmental impacts of a dam project was done relating to the case of Dams in Ghana by Divine *et al.* in 2017. It comes up with the general objective of investigate environmental and socio-economic impacts, as well as issues of public participation and community resettlements arising from the construction of the dams in Ghana. Sri Lanka also blessed with natural irrigation system where it managed effectively from the past. Most of the electricity requirements is fulfilled through hydraulic power. An article by Sustainable Energy Resources in Sri Lanka written by Moonasingha (N.D) provides basic knowledge of appliance of sustainable energy sources available in Sri Lanka. It focuses on energy utilization and development, sustainable development appropriate technology and environmental impacts too. So the article provides a good point of view to understand the basics of renewable sources available in the island while it emphasizes the effective applications too. The research on Biomass gasification in Sri Lanka: A low-cost option for the future written by Sugathapala (2007) and Regional Wood Energy Development Programme in Asia and Thailand is also presents the current status and future potential of biomass gasification technology in Sri Lanka. It highlights the importance of biomass, especially fuel wood, as a sustainable source of energy. It concludes that there will be a rapid increase in the demand for biomass gasifiers in Sri Lanka, mainly as a low cost option for thermal energy in industry and small scale off-grid electricity in rural areas. It emphasizes the potential application of biomass in rural electrification, industrial application and domestic and commercial sectors. Jayasinghe (N.D.) emphasizes the importance of bio mass as a resource for future energy generation in both thermal and electrical and the special attention is on use of biomass in Sri Lankan context. This article reviews the large potentials of short rotation crops in Sri Lanka. Thus, it is cleared that world has taken several attempts on energy planning for the better future. As a developing country which is lacking of fossil fuels have to focus more on sustainable outcomes of the energy sector with utilising the minimum and to gain the maximum. Accordingly, this study is to fill the unrevealed research side to the Sri Lankan context. Though it would not affect to food production, it can generate many rural jobs, and increase socio economic conditions of the farmers and also having

environmental impacts too. Therefore, the study focussed; to examine the socio economic impact to the cultivators and suppliers of the Gliricidia crop, to examine the environmental impacts of Gliricidia electricity generation process and to identify the problems faced by the cultivators, supplies and the management and to suggest the suitable solutions for the identified constrains and issues.

2. Research Method

Using the purposive sampling method, 25 farmers and 50 suppliers were selected considering the supply chains of the Gliricidia to the power plant located in Mirigama DSD. The data collection is based on the response of the questionnaire, which has been distributed among the agents of the production scheme. Sample population was selected in these two stages. First sample size of the supplier's category was selected considering the company data base which indicated the frequent suppliers of the wood. There were only 25 regular suppliers to the power plant so sample selection was carried out under judgement or purposive sampling method. Purposive sample is selected under the coordination of a responsible person of the supplier management of the power plant who was well known to the supply pattern of the woods.

Next the sample size of the cultivator category was selected according to the purposive method. Especially there were uncounted number of wood suppliers in small scale cultivators so they all were carries into one category of cultivators and selected 2 cultivators from each supplier from the chain. According to the purposive sampling method supplier named the best cultivator who carry the largest amount of wood share. Finally, total of 50 Gliricidia cultivators and 25 suppliers were selected as the sample of this study. Data collection for the research deals with two key methods such as primary and secondary data. Primary data are gathered from questionnaire, interviews, observation and discussions while books, journals, magazines and internet articles are used as secondary data sources. In order to analyze the data, quantitative (chi square test) and qualitative analysis were used.

3. Results and Analysis

3.1. Process of Electricity Generation Using Gliricidia Sepium

This research is based on the 5 MW Dendro Power Plant located in Loluwagoda Mirigama. The main objective of the power plant is to add Net 5 MW to the National Grid by using renewable source of energy. The objectives of the power plant were to

- Support the national grid to be energy independent
- Reduce Carbon signature and pollution
- Reduce outflow of foreign exchange.
- Consider the intangibles too when deciding rates.

Fuel source is the short rotation crop of Gliricidia Sepium, which is grown as Mono crop and intercrop in coconut plantations. It is harvested at 45-60% of moisture condition depending on zone. The company has implemented strategies to manipulate the source of Gliricidia supply according to their requirements. Their target is to transfer fuel to energy in rate of 1.4 Kg/ kWh.

Accordingly, this 5MW power plant requires steam of about 485 Celsius of temperature with 40 bars of pressure. Steam enthalpy is about kcal/kg 807.55. It requires plant materials with 20% of moisture content. It is estimated that power plant need 10 million plants in 12000 acres if intercropped or it requires 3500 acres if mono cropped. Power plant need 210 MT per day meaning 8.75 MT per hour at 40% and the moisture content is 1.75 Kg/ kWh. On the other hand, additional heat is required to evaporate the additional moisture content in fuel. Power plant has been working on contributing to establish energy crops in order to fulfill their requirements.

Specially the area is surrounded by industrial zones and highly populated area which generation huge impact on regional development mechanisms. Even though the raw materials are collected through the surrounded region, the final output of the green energy is directly added to the national grid. So the environmental and the human impact of the power plant is very crucial factor. The requirement for wood based steam turbine driven electricity generator of 1.0 MW power plant is about 40mt of Gliricidia wood per day (at 20% moisture level). Assuming the productivity of Gliricidia to be 30mt per ha per year, an average of 1.5 ha of Gliricidia plantation (monoculture stand) would be sufficient to meet this requirement on a per day basis.

There are number of suppliers of fuelwood into the power plant as well as the growers. So the power plant has the capacity of expanding or the reliability should take into consideration. As

well bio energy power plants in Sri Lanka were not gained success up to now in Sri Lanka so the decisive factors are to be discussed.

3.2 Supply Channel of Gliricidia Sepium to the Power Plant

The usage of the biomass seems the promising mode of energy for most of the industrial thermal energy generations. The above area is much more geographically significant in industrial location due to the huge density of economic activities surrounded by the main capital of the island. While the industrial sector moving more and more towards biomasses as the preferred fuel for energy requirements mainly due to fluctuating prices of fossil fuels in the local market. When the market of biomass is expanding there is a question of whether the market is strong enough for the growing demand. During these study key stakeholders in the supply chain is identified. Especially the discussion with suppliers assisted to identify the barriers that hinder the reliability of the supply chains while in depth analysis helped to identify the market behavior in the supply chain. Discussion with regulatory authorities also helped to identify the framework of the supply curve and to fill up the gaps generated through data supplied by the local suppliers.

Power plant requires both Gliricidia wood and fuelwood for their stocks. Major sources of fuelwood sources can be categorized as below,

- Intercrops or short rotation wood crops
- Plantations
- Commercial firewood in forestry
- Home garden
- Crop residue

Considering the sample populations about half of the cultivators were engaged in intercrop farming. Biomass supply channel to the power plant is done by individual suppliers who provide wood in regular manner. None of the suppliers were cultivating the crop in their own plots of land. They were only collecting the manure as a source of income. As number 18 out of 25 were engaging in wood supplying as extra source of income while only 7 out of were permanent wood suppliers as their main source of income. Most of them provide jungle wood combined with the Gliricidia woods. So the number of visits from each supplier can be identified.

Main stage is the cropping or collecting of wood. In this stage energy crop cultivation plays a vital role for the continuous supply chain. On the other hand, suppliers from different strata's are significant in considering the supply chain especially supplying wood also emanates through a channel from small collector to the vehicle owners.

3.3. Impact of Gliricidia Farming on Cultivators' Socio Economic Lifestyle

When considering the socio economic impact of Gliricidia as an energy crop there are many field reviewed in order to find the relationship between human societal and economic sectors. Most of the cultivators are centered along the district itself such as from Giriulla, Diwulapitiya, Warakapola, Kegalle, Loluwagoda and Mirigama. When considering the socio economic conditions of a particular population their age and the other demographic factors will be important in identifying the social disparities in most cases. Total amount of the sample is 50 and all of them were male headed families. According to the survey, majority of the cultivators (66%) belongs to age category of 30-50, because they were guided by the village organizations and engaged in the cultivation in order to increase their income. But age category of below 30 and above 50 shows less interest on crop cultivation. Level of education of cultivators is a good measure of basic socio economic status of the research. Among all number of cultivators those who entered to the higher education is very less and most of them and their family members were attended to primary education as minimum. But children of those families show good participation in education. Referring to the data 38% of cultivators have studied up to grade 10, while 28% attended only up to grade 05. Their lack of education seemed the turning factor of them to farming.

3.3.1. Using Gliricidia as their Main Source of Income

Power plant is located in the area which is very famous and suitable for coconut cultivation. Above that Sri Lanka has very less practices in energy crop cultivation as it is still not much popular even though we have the indigenous knowledge. This is due to the availability of hydroelectricity all around the island which could able to cover the most energy needs. Further, energy crop generation still in progress and the company itself provide guidelines through the rural associations to cover the demand of the power plant.

As many of the cultivators were engaged in other source of income generation activities particularly Gliricidia were cultivated in order to gain an extra income. Out of total (50), there were no one recorded as who depends on energy crop cultivation as their main source of income. This is due to the lack of knowledge on energy crops and due to their fear to move on for total cropping system. And especially the less payment for the crop also directly effect on cultivators as the income generated by energy crop only is not sufficient to full fill all the requirements of the family. The main sources of income of cultivators are depicted in Table 1.

Table 1. Types of main occupation of the cultivators

Type of occupation	Number	Percentage
Government	6	12%
Private sector	18	36%
Agriculture	19	38%
Other	7	14%
Total	50	100%

Source: Field Survey, 2017

According to the data gathered, most of who engaged in Gliricidia farming are traditional farmers. Where else very less number of government workers (12%) added their contribution on Gliricidia farming while (36%) private sector employers contributes much. When questioning the cultivators who mainly engage in private sector, most of them were used for additional farming activities due to the uncertainty of their occupations. Most of them were temporary workers of privately owned companies so they were less paid while they are not secured with pensions or ETF/EPF beneficiaries. So their ultimate purpose is to secure their future in a condition of good retirement plan.

3.3.2 Type of Cultivation of Gliricidia

From the sample population, 38% cultivators were depends on agricultural economy, animal husbandry or primary or secondary economic activities and others were depend on tertiary type of economic activities. Majority (48%) of them cultivate Gliricidia as an intercrop between their main crops such as coconut and pepper while 24% grow Gliricidia as a cultivation and these farmers have enough extent of land. Approximately, 18% of crop growers gather Gliricidia

from their home garden itself by maintaining live fences and setting as shades for garden crops. Ten percent (10%) of farmers who sells Gliricidia to the company gather from naturally grown trees in their lands (Figure 1). The reasons behind the cultivation of Gliricidia by these farmers are minimizing soil erosion and soil losses.

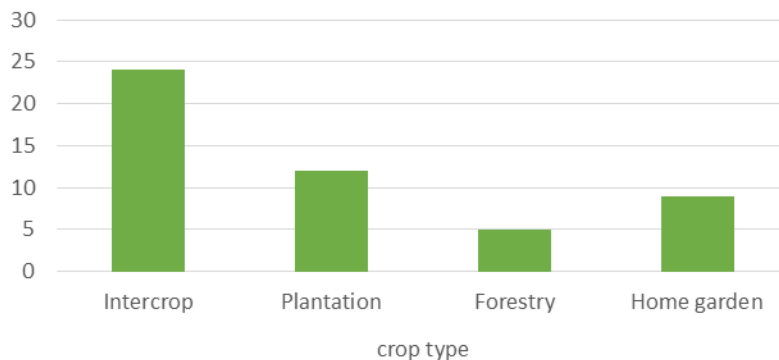


Figure 1. Type of Gliricidia Cultivation *Source: Field Survey, 2017*

3.3.3 Land Ownership

When measuring the socio economic impact of the crop it is very essential to check the land ownership of the particular crop. Land owners can get the ultimate benefits of this devastating crop such as increasing the soil nutrient level and increasing the productivity of the land without payment. Even though the income is divided into several portions if the land is not owned by farmer the total benefit could not gained. Approximately, 84% of cultivators who owns Gliricidia crops are the owners of the land itself. So they have clearly utilized their land for the crop production and the total income generated is beneficial for them. In the case of leasehold lands (14%), they were utilized not only for Gliricidia but also for the other types of economic crops such as coconut or pepper. Land tenancy (2%) also appeared in very les amount. So in this case land tenancy is not visible due to the less profits that could be occurred by allocating the land for tenure.

3.3.4 Other Uses of Gliricidia

Apart from using as a source of energy, farmers utilize this crop for many purposes. Farmers who engage in vegetable cultivation were using the wastage of Gliricidia cropping's such as leaves as a fertilizer for other crops. Gliricidia leaves are very rich source of nutrition which add nitrogen to the soil. Especially farmers were using Gliricidia leaves to cover top soil layer to

reduce soil degradation on heavy rains. Small branches are used are dried on the crop itself and produce a fertility as well and they reduce the soil infiltration and infiltration from plants. Especially this is used in plant nurseries as a shade for the crops in dry periods.

Flowers of the tree are used by local farmers as a pest controller. Tree is not flowering all the year along but it is a good source of pest control due to its fragrant. Also it was used as supporters for creepers such as pepper. Most importantly the leaves are used as cattle feed. This is very famous and cheaper fed for cattle. Especially for those who cultivate the crop use the waste of the trees as cattle feeds. There were few farmers who engage in cattle raring in small scale.

3.3.5 Maintenance and Type of Labour Use

In *Gliricidia* crop cultivation, majority (56%) use the family labour. As this crop is not much popular as an economic crop, cultivators still use to remove the *Gliricidia* crop as a waste material from tea or coconut plantations. Most cases they collect the substitutes by their own or they share their labor in order to gain more profit rather than hiring it from the outsiders. Even though the economic crops in Sri Lanka has built up a culture of hiring labour for the maintenance and harvesting as well there are machineries utilizing for the crops but relatively *Gliricidia* has no concern on hiring particular machineries or labour as it removes gradually as waste from home gardens or crops when they are widely grown disturbing the main crop. But in case of suppliers and collectors they prefer hiring labor with payments so they can hire labors in regular basis. When considering the sample population, main course for this situation is most of the crop owners of the sample population cultivate *Gliricidia* as an intercrop in between major cultivation. So green manure from *Gliricidia* tree is collected while maintaining the main crop once in a three month or half of a year. So no particular labour is needed to sacrifice on collecting the harvest.

Special feature of the crop is that no special care or maintenance is less regarded. And as well they are removed automatically in the season of main crop harvesting. While in form of energy crop cultivation as a major crop even the trees do not require labour to grow only fertilizing once in a six month. Most of the times this is done by farmer himself so the cost for additional labour can be minimized. The crop is much resistant to fires as well as good capacity of holding soil

moisture so the crop can survive even in the drought seasons so no water shedding is required. According to the survey, only 20% (10) of cultivators who are government workers and small business holders with lack of time in maintaining the crop rent labour. Fourteen percent (14%) were exchanging the labour from their friends and neighbors. So they take the maximum profit of the crop cultivation.

3.3.6 Preference for Increasing the Extent of Cultivation

According to the requirement of the future electricity generation, bio energy will be more sustainable and will become cheaper than using hydroelectricity and fossil fuels. It is less environmentally hazardous and as well now Sri Lanka reached to its maximum of hydro electricity generation. So the bio electricity is a way to develop and should have focus on developing a system to sustain for the future demand. In this base by the research it has focused to find the preference of the cultivators to extend their crops. Only the farmers who cultivate Gliricidia in the present have been questioned in order to effortlessly identify the problems and issues they faced.

As per the survey, the majority of farmers (78%) were highly preferred to increase the Gliricidia cultivation in the same land. Most of them were engaging in the cultivation as an intercrop in between the other economic crops. They were seeking for better income ratio and therefore most of them preferred to increase the crop with the purpose of income generation. The 16% of farmers expressed medium preference for increase of crop. Approximately 6% of farmers were less preferred in increasing the crop land due to lack of land. Especially they were utilizing the tenure hold lands or leasehold lands so they were reluctant to increase the extent of crop. However, this situation will completely be change if they were provided with sufficient land and other necessities.

So there is a different point of views from farmers belongs to different categories. Most of them have many more reasons except the income and the benefits generated through the crop. So here when considering the land size, the preference of increasing the crop can be proved by statistically. This is varying according to the rural and urban also.

Here first we built the hypothesis.

H_0 – There is no relationship between land size and the preference of increasing the crop land.

H_1 – There is a relationship between land size and the preference of increasing the crop land.

Table 2. Calculating the table value

Preference \ Land size	High	Medium	Low	Nc
Large size	10	5	5	20
Medium size	6	7	2	15
Small size	3	7	5	15
Nr	19	19	12	50

Source: Field Survey, 2017

The following formula was used to test Chi test here,

Formula
$$X^2 = \sum \frac{(fe - fo)^2}{fe}$$

Fe- Expected value Fo- calculated value N- Total population

Table 3. Calculating the Chi squared for the preference of increasing the crop

F_o	$F_e = \frac{(nc \times nr)}{N}$	$F_e - F_o$	$(F_e - F_o)^2$	$(F_e - F_o / F_e)^2$
10	7.6	-2.4	5.76	0.7578
5	7.6	2.6	6.76	0.8894
5	4.8	-0.2	0.04	0.0083
6	4.2	-4.2	3.24	0.7714
7	5.7	-1.3	1.69	0.2964
2	36	1.6	2.56	0.7111
3	1.9	-1.1	1.21	0.6368
7	1.9	-5.1	26.01	13.6894
5	1.2	-3.8	14.44	12.0333
			Total	29.7939

Source: Field Survey, 2017

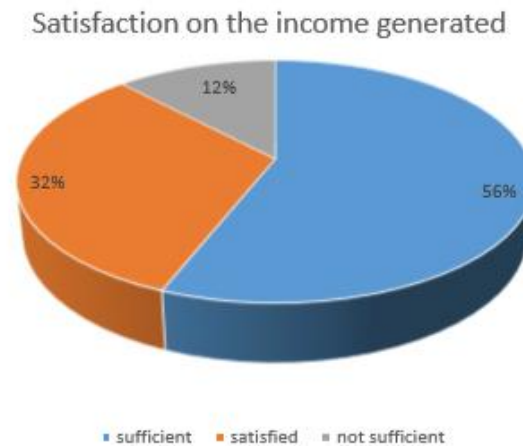
Calculating the degrees of freedom by using the formula of $(df) = (c - 1)(r - 1)$.

Accordingly, degrees of freedom considered as 4 and it is checked in the significant level of 0.05 in the table. The table calculated value is 29.7939, and the value in the table for 0.05 significant level is 9.488. Thus, the calculated value exceeds the table value so the null hypothesis is rejected while the alternative hypothesis is accepted. So finally it is assumed that there is a relationship between farmers' preference of increasing the crop and the size of land. To calculate the intensity of the preference, coefficient contingency was calculated as 0.611 using the

formula.
$$C = \sqrt{\frac{x^2}{n + X^2}}$$

3.3.7 Impact on Income and Expenditure of Cultivators

Income data are completely based on the opinions of the farmers. Accordingly, they were paid LKR 3.50 per one kilo of Gliricidia wood while kg of jungle wood was paid Rs.3.00. According



Source: Field Survey, 2017

to the farmers, they have increased their income after moving to sell the Gliricidia. As the crop is naturally growing and naturally protective from the pests and hazards than the other economic crops Gliricidia is popular among the farmers.

Figure 2. Satisfaction on the income generated through Gliricidia farming and collecting

Their satisfaction of the income generated was calculated and depicted in the Figure 2. Most of the farmers were satisfied of the income generated.

According to the sample tested farmers increased their income compared to the past situation. Most of the farmers were in critical situation due to lack of provision for qualitative goods such as healthcare and education.

When considering about the new income sources it is a very good measurement to check where society invest the money and what do they hope to do with it. It is a capable enough to predict the impact generated on poor.

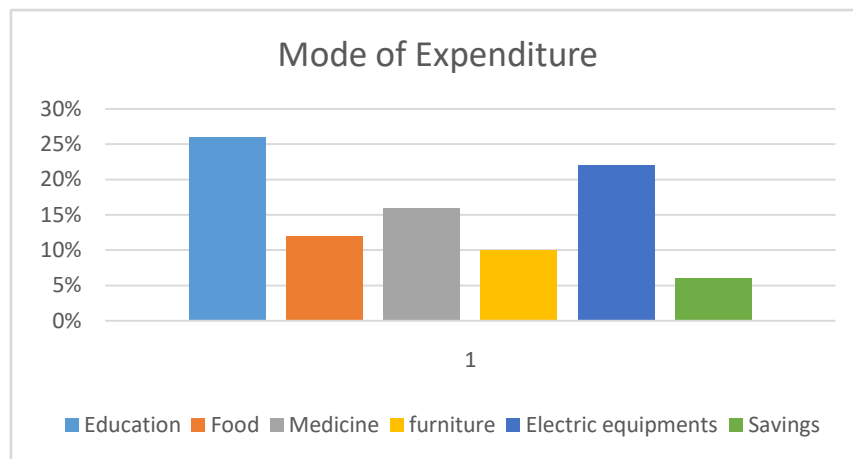


Figure 3. Areas of expending the income receiving from Gliricidia farming and collecting

According to the survey data there were 26% from the total who expense the extra income on educational purposes. They all were parents who were between 30- 50 and they were having 2 or more children in a family. Education also a major measurement of a development and the social welfare. So the invested educational level will incorporate in more social development. As well 16% of the group were supposed to expend them on their medicine. They were elder and except from that many of the farmers were expending their income on caring their elder parents. According to them the fee of selling Gliricidia provide economic stability for them to meet a doctor in the town hospital or to do their medical checkups. Apart from that some of the farmers used to expense them on electric equipment or furniture. As they were selling their crops twice a year and they directly buy equipment's from the money. According to the data only 6% used to invest their money in a bank. In the field discussions and interviews it was cleared that they save them in a bank for using in case of shortage in a future. Some of them were collecting them for building a new house and some were interested in buying jewelries for the family.

3.3.8 Institutional Support

This is measured to check the viability of institutional support from the Silvermills group. Cultivator's attitude on the company was measured so the amount of guidance and the support can be increased to the level of benefit to both parties. According to the opinion of the cultivators' institutional support is not totally enough as much of 46% of the total population are not fully satisfied with the institutional framework. As well 10% of the total population is totally not satisfied with the institutional support. This might be because of the less education of the rural cultivators of the crop. It seemed that the level of understanding and the cooperation between cultivators and the power plant is less and cultivators deals only with the suppliers of the wood. And also power plant also cooperating with the suppliers and less with the rural farmers.

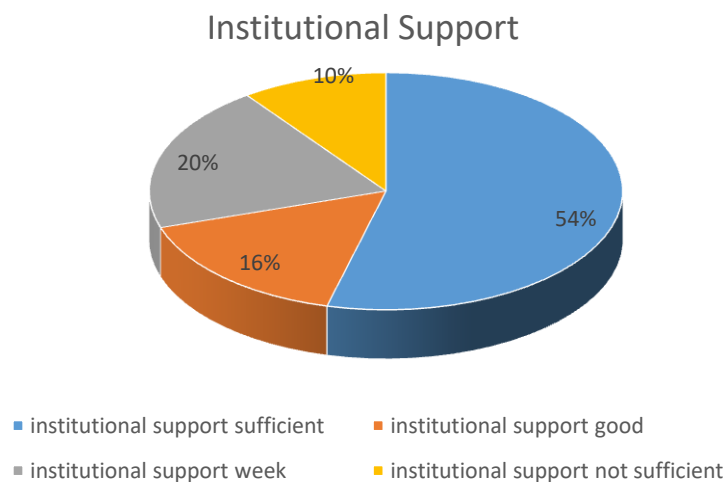


Figure 4. Institutional Support *Source: Field Survey, 2017*

3.4. Impact on Suppliers' Socio Economic Status

Impact of *Gliricidia Sepium* cannot be only measured based on cultivator's situation. It is also questionable in suppliers' aspect too as it can generate major influence on suppliers' lifestyles also. As well as the starting point of the energy its transportation to the industry generates waste number of impacts on human populations who are surrounded. In this case socio economic conditions of the suppliers also calculated in qualitatively and quantitatively through the data gathered from in-depth interviews, formal and informal discussions, questionnaires and observations. First of all, the company support its suppliers and they have clear list of regular

suppliers. These regular suppliers are used to collect raw materials from other regional suppliers as well. They provide both *Gliricidia* woods as well as jungle wood to the company.

Considering about the age, less number of suppliers are recorded from above 50 years as this has to go through many hardships such as collecting wood and transporting them, as well younger generation shows less interest on this. As majority of the younger population is educated and do not eager to engage in employment activities that have to go through hard daily routine. And as well they consider the income is less compared to the labour they spent. Figure 4.11 depicts the age distribution of the suppliers. Accordingly considering the percentage values 48% of large contribution can be seen among the age group of 40-50. While 32% of next contributes from age group of 30-40. Case studies shows that they were keen on supply chain due to the high income through firewood selling with minimum cost of expenditure to collect them. Most of them from the sample population are less educated and with huge families. Most commonly suppliers were aged between 20- 65 and they all were married. Only 2 families were recorded with minimum of 2 members in the family among the suppliers. Both families were composing of only the parents as their children were living apart due to marriages and their livelihoods. Majority of the families of about 14 out of 25 were composed of more than 5 members in a family. These families mother were recorded as less educated and they were very young. Those number represent 56% percent from the total. And only 9 families were recorded with 2 to 5 members in a family.

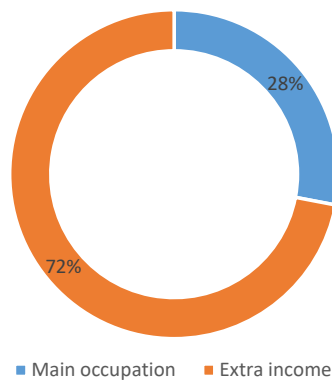
3.4.1 Impact on Increasing the Source of Income

Macroeconomic effects of these type of power projects are very significant in economic development referring to economy wide outcomes and also for the regional development. The implementation of this power plant produces effects in the rest of the economy because of the increase in demand of goods in the area and services created by the spending in the project. It is more difficult to measure the number of indirect jobs that may be created in associated supply and support industries.

Source of income is used in measuring the economic basis of the suppliers. Most of the suppliers of wood chips and logs to the power plant are engaging the activity as an extra source of income. They are engaging with some other major or minor economic activities and both balancing for the income generation. But comparatively there were much contribution to the power plant from

the families who engage in wood supplying as their main source of income. Comparatively their number of visits for wood supply is high than other suppliers.

Amount of suppliers engaged in wood supplying as their main source of income and as an extra income earners are depicted in the Figure 5. According to that only 28% from the total population engaged in wood supplying as their main source of income while 72% of them do this as supplementary income source.



Suppliers Engaged in Wood Supply as Main Source of Income

Figure 5: Suppliers engaged in wood supply as main source of income *Source: Field Survey, 2017*

When considering the population representing the extra income seekers are engaged in several occupations. 28% of them engaged in some activities in private sector. While there are about 16% of government workers too. This table emphasizes that how people seeks new methods of income generation.

Table 4. Type of income source of the extra income seekers

Type of occupation	Number	Percentage
Government	4	16%
Private sector	7	28%

Agriculture	5	20%
Other	2	8%
Total	25	100%

3.4.2. Suppliers Intention on Cultivating Gliricidia as a Crop

In this research cultivators and the suppliers are concerned in two aspects as none of the suppliers are engaged in crop cultivation. According to the discussions carried on, most of the suppliers are not interested in crop cultivation due to the lack of land. Most of them engaged in wood transportation for long term and so they are less cooperative in agricultural activities. As per the Figure 4. depicts, only 20% were interested in crop cultivation and 36% were interested slightly if they were given a land for cultivate. Anyway majority (44%) do not support the idea (Figure 6).

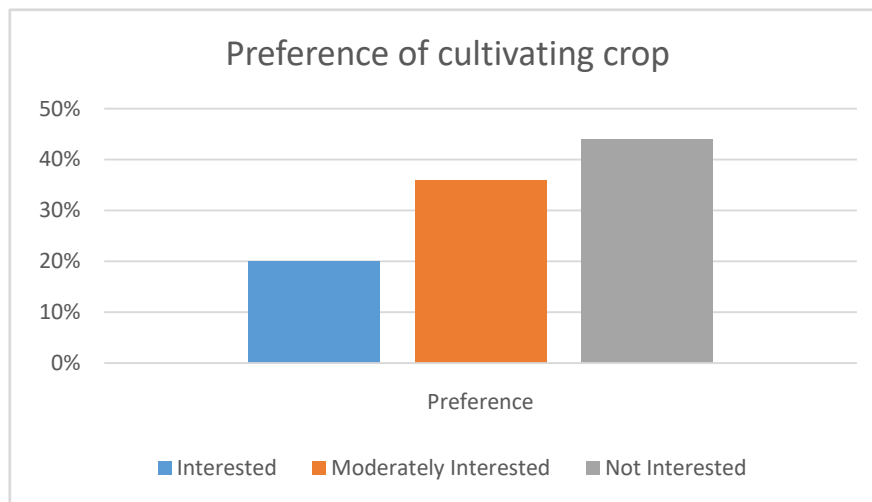


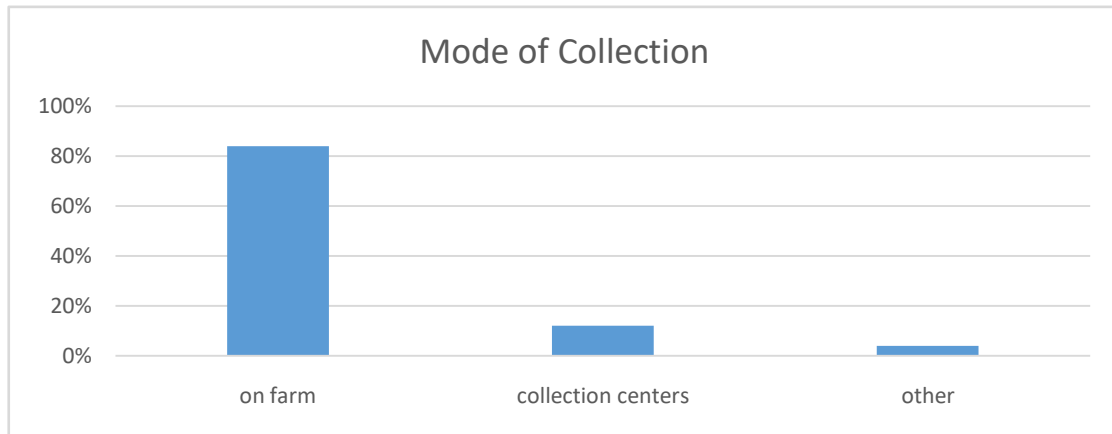
Figure 6. Preference of cultivating the crop *Source: Field Survey, 2017*

3.4.3 Cost of Transportation and Collection Methods

Suppliers of the fuel wood have to bear a cost for transporting the goods and for labors too. Most of the suppliers are from nearby areas of Giriulla and Kegalle. Most of them engaged in fuel wood supplying by their own vehicles but they do have to bear the cost for fuel and labor payments. According to the questionnaire survey minimum cost per time of visit was recorded as Rs: 1500 and minimum was recorded as Rs: 3500. As a whole from the total sample population

median transportation cost is Rs: 2500 per time. Most of the suppliers were recorded minimum 4 times to the power plant gaining minimum of Rs: 15000 of fuel wood.

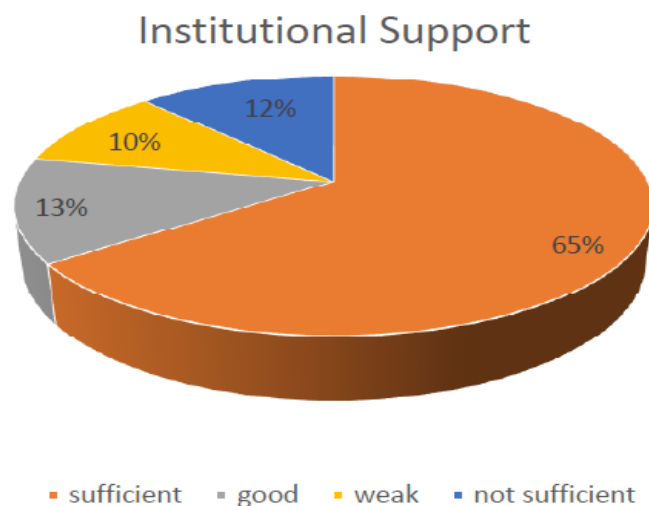
Fuel wood collection methods are different from place to place. Especially wood suppliers are going to the crop field so they can earn more extract from the crop. While very few number of



suppliers are used to gather them through collection centers. This is basically visible in rural associates.

Figure 7: Mode of wood collection *Source: Field Survey, 2017*

3.4.4. Institutional Support



Source: Field Survey,, 2017

Figure 8: Institutional support on suppliers *Source: Field Survey,, 2017*

When considering about the amount of institutional support much of the suppliers were satisfied with the institutional framework. About two third of the total population were totally satisfied with the institutional framework. They were satisfied with the on time payments and the reliability of payment schemes. But on the other hand 12% of the ample were not satisfied with the unit price of the fuel wood. They were seeking for an incensement of the payment as transportation cost is increasing. Most of the suppliers were regular suppliers of wood so they think that benefits should be added for the regular services. So the institution may concern on providing bonus for encouraging the suppliers.

3.5. Environmental Impact of Electricity Generation Using Gliricidia Sepium

Considering the secondary data and the cultivators, suppliers' data impact to the environment by cultivating Gliricidia has been identified. Human opinion is very considerable in identifying the environmental issues in non-theoretical way out of regarding the biological or chemical activities. People who grow Gliricidia in their home gardens are much aware of the good or bad properties of the crop rather than the impact analyzed through laboratory testing.

When considering the secondary data environmental impact if bio energy generation is somewhat wider than biomass converting to electricity. In many cases such as burning of bio fuels for heat or light generates huge amount of Carbon Dioxide but it is comparatively less in amount rather than the amount produced by fossil fuels. However, the growing biomass crops capture carbon dioxide out of the air, so that the net contribution to global atmospheric carbon dioxide levels is small. And on the other hand the energy residues of biomasses such as ash can be utilized into some other activity such as fertilizer. Gliricidia is a feasible fuel substitute for conventional energy sources.

Dendro power is almost carbon neutral as the carbon emissions released during combustion are recaptured during re-growth. It also allows to replaces fossil carbon with bio carbon. (Gunasekare, 2014)

Biomass is becoming recognized as a feasible fuel substitute for conventional energy sources with the rising opinion on addressing climate change and importance of reducing carbon emissions.

The leaves of the *Gliricidia Sepium* tree can also be used as cattle feed or as a substitute for urea as a soil nutrient. This increase the level of self-sustainability of farmers in order they can easily carry their energy crop while it ultimately supporting the animal husbandry. The foliage of the trees will provide good fodder to livestock, especially cattle and goats in the region, an industry currently being developed in the region for milk production.

As well *Gliricidia* incorporated with such other environmental benefits such as construction poles and crop supports especially for the creepers like pepper.

According to the Global Environment Facility Project Document in 1950s, the island had a 49% forest cover but by 2005 this had fallen by approximately 20%². Between 1990 and 2000, Sri Lanka lost an average of 26,800 has of forests per year. This amounts to 1.1% of average annual deforestation rate. Between 2000 and 2005 rate accelerated to 1.4% per annum.

Global Environmental Facility (GEF)/ United Nations Development project shows that impact of emissions from biomass combustion.

Carbon Dioxide (CO₂) this is the major combustion product of all biomass fuels which causing direct Green House Gas emissions but biomass as a neutral fuel.

Carbon monoxide (CO) occurs due to incomplete combustion of all biomass fuels. It has both health and climate impacts. Accordingly, indirect GHG emission as well as influences people with asthma, and embryos.

Methane (CH₄) occurs due to incomplete combustion of all type of biomass fuels. Direct and indirect greenhouse gas.

Non Methane Volatile Organic Components produces as a result of incomplete combustion of all type of biomass fuels causing negative effects on human respiratory system.

Soot char and other condensed heavy hydrocarbons from incomplete combustion of all biomass fuels may course into reserved greenhouse effect through aerosol formation. Indirect effects of heavy metals concentrations in deposited particles.

3.6. Issues and Constraints Faced by the Cultivators and Suppliers

Lack of awareness.

This is the main constrain affecting the energy crop. When considering about the context in Sri Lanka people only well known to coal electricity as well as hydroelectricity. But in this case bio electricity is not popular even though the government act has been already established naming Gliricidia as the fourth economic crop of the country.

Accordingly their awareness was measured under two sub categories of knowledge on the energy production process and knowledge on Benefits of the Gliricidia energy generation. Both environmental and Socio economic benefits were questioned. According to the views of the cultivators (9%) they were very poor in knowledge on process of energy generation. So that limits their capacity of thinking and do not motivate them to increase the crop. When coming into the suppliers of the wood they were better than the situation of cultivators, 50 % of the sample were known to describe the process and that may be due to their visits to the power plant. When moving on to the benefits of the wood less number of cultivators (23%) were known to the environmental benefits of energy generation through green energy. But most of the two parties were well known to other benefits of the plant.

Lack of knowledge on maintenance of the crop.

This seemed be the main reason for less amount of crop generation. Most of the farmers do not pay special attention on their crops and they were left to be grown naturally. Also intercrop farming and crops were done for helpers are very less maintained. So this cause in minimizing the productivity of the tree.

Most of the farmers continue to grow the crop according to their indigenous knowledge. And as well new technologies haven't been added to the crop further. New innovations such as new cropping systems or intensive methods should be carried out for the better crop productivity.

Low payments.

In case of increasing the demand of the crop amount payed for unit of Gliricidia wood should be increased. Or else new practices of encouragement should be introduced for the suppliers of the wood.

Less concern on natural environment

Major issues related with the suppliers are that most of them clear the natural forest in case of firewood. So that is beneficial to the suppliers but even though it is very dangerous for the natural vegetation's. Rules and regulations must be introduced to avoid illegal felling of Gliricidia trees in natural forests. Rather than using as a fire wood it compose of other environmental benefits such as fixing the nitrogen level and nutrition to the soil layer. So less degradation would provide more benefits to the environment.

Lack of wood

Power plant consume huge amount of wood per day as wood chips. So requirement of fuelwood is very high for the survival. Weekly bio mass supply is loaded and dried in the power plant premises. If the wood supply does not prevail in a constant range it is very hard to maintain the power plant. There are clear evidences of unsuccessful power plant projects even in Sri Lanka due to the lack of wood. 2 MW power plant which was in Walapane district and Thirappane power plants are closed and temporary closed due to this situation. Considering the Thirappane power plant it is said that selected site has not been suitable for successful operation of the plant as the plant is situated in an area where the terrain is hilly, difficult and not economically feasible to collect feed stock and transported to the site. The feedstock has been collected from distance palaces which has been costly as well as due to the mal functioning of the supply chain the collectors have been earning the major part of the payment made for the supply and the poor farmers have not been paid enough which also has discouraged the cultivation of the raw material. The plant owner has not been equipped with any plantation and it is revealed that it

would be beneficial for the plant owner to have his own plantation to supply at least one third of the requirement on a regular basis so that this will aid in uninterrupted power supply. When considering the Embilipitiya power plant also the supply has not been adequate for full operation of their plant. There are frequent break downs in the feeder connected to the grid as it feeds villages in distant locations and there are frequent break downs due to way leaves. So the situations of those experiences are not reliable and good so the power plant should go to more sustainable mode.

4. Conclusion

Green energy is one of the newest trend to the world with the main objective of to prevent global warming and to reduce pollution, sustain the future and to use as a solution to the energy crisis. In Sri Lankan situation agriculture is the mainstay of rural economy but it often records a low productivity. So the energy farming will added good value to strengthen their livelihoods. Rural areas include sparsely used croplands, scrub lands, and grass lands that can be utilized for energy plantations. These energy plantations also are a potential means of improving the agricultural practices with combination of intensive and sustainable farming practices. The economic, social, and environmental impacts expected from *Gliricidia* could give a tremendous boost to the community and the country as a whole according to the data gathered from the study area. Dendro power is almost carbon neutral as the carbon emissions released during combustion are recaptured during re-growth. It also allows to replaces fossil carbon with bio carbon. With the rising importance of reducing carbon emissions and addressing climate change, *Gliricidia* is a feasible fuel substitute for conventional energy sources. Every megawatt of Dendro power installed creates employment for people in rural communities. Coming to the supply and productivity it is more beneficial to both parties. Most of the suppliers of the fuel wood were not aware of *Gliricidia* energy generation. So they have no idea of focusing on their own crop cultivation. Considering the cost of fuelwood supply to the power plant suppliers are used to provide minimum load of wood cost of Rs: 15000 per time. If not they do not get sufficient amount of profit by selling their wood load. And they managed to provide minimum of 4 visits of wood loads per month. In this case Marginal lands, unused land and agricultural smallholdings are ideal locations for the establishment of bio-mass plantations, allowing people to enhance their earnings by selling fuel wood to dendro plants. The

decentralized generation of electricity reduces the transmission losses and will promote private sector investments in small power generation plants which will in turn boost economic activity in rural areas. The burden on the State for investments in the energy sector will be minimized. The process of fueling biomass energy plants involves three major steps, the biomass collection, its transportation and the energy conversion. There are nearly 150 workers providing labor on a daily basis to the power plant following the above 3 stages. Technical teams composed of technicians from several parts of the country so it provides respective professional opportunities to the national level too. Strategies need to be implemented to promote Gliricidia cultivation in rural areas. Cultivators should be made aware of the crop and its benefits, and marginal lands and to ensure additional income for the rural community or to offset the grid-connected electricity charges.

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