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LIFE CYCLE ASSESSMENT OF SEEDLINGS PRODUCED AT PRIVATE AND GOVERNMENT NURSERIES IN CHITTAGONG

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Abstract*: This study provides a comparative life cycle inventory analysis between government and private nurseries in Chittagong, Bangladesh. We developed a process-based life cycle inventory of GWP(Global Warming Potential) in terms of CO_2-equivalent emissions for three government and three private nursery operation in Chittagong City Corporation area by using questionnaire surveys, interviews, and life cycle inventory databases, The inventory demonstrated that 0.2523 and 0.0619 ton of CO_2-equivalent is emitted per 1000 seedling per year respectively from government and private nurseries. Electricity is responsible for highest CO_2-equivalent emissions in both categories of nursery. Electricity use is dominated by irrigation demands. Diesel and polybags are the next largest contributor of CO_2e emissions in govt. and pvt nurseries respectively. Identifying key sources of emissions in the nursery tree production system can help operators reduce emissions by targeting so-called hot-spots. This comparative life cycle assessment of nursery operations is a necessary step to assess the life cycle benefits or drawbacks of public and private sectors.*

Keywords: Nurseries, Seedlings, Life cycle inventory, Life cycle assessment, Global Warming Potential**.**

1. INTRODUCTION

Nursery production is one of the most authentic examples of intensive agriculture and forest. Trees mitigate climate impacts by assimilating carbon dioxide (CO_2) in their biomass as they grow and, through shading, cooling, and wind speed reduction, reducing building energy use and associated greenhouse gas (GHG) emissions from power plants (Akbari, 2002). Nursery plays pivotal role in any plantation program for the creation of tree cover. An area of 0.25 ha is sufficient to establish a small but viable nursery capable of raising 1,25,000 seedlings. The size of the nursery may be increased if needed to increase capacity and demand for planting material (Osman, 2013). Now-a-days, due to large use of non-renewable resources and the low efficiency in the management practices, this 'green industry' is often considered a diffused polluting industry. So, there is scope to reduce these emissions and lessen the impact of seedling production nurseries on future climate change. Calculating carbon footprint is the first step to reduce these emissions by identifying emission hotspots. The leading tool for achieving this and the only tool that can make a full evaluation of all sources and types of impact over the entire life cycle of a product or a process is life cycle assessment (LCA).

LCA is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product or process system throughout its life cycle. It is a "snapshot" of inputs to and outputs from a system. It is described as a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and materials used and released to the environment; and to identify and evaluate opportunities to affect environmental improvements. It can be used as a technical tool to identify and evaluate opportunities to reduce the environmental effects associated with a specific product, production process, package, material, or activity. LCA evaluates the environmental consequences of a product or activity completely, across its entire life (ISO, 2006). It is a technique for assessing the environmental aspects and potential impacts associated with a product- be it good or service. Iqbal and Rahim (2006) carried out the first comparative LCA in Bangladesh to evaluate the likely environmental impact by modification of the hull form of traditional wooden country boat to shape more suited to the speed range being encountered in Bangladesh.

Nursery products involve a diverse range of inputs and numerous on-site processes that contribute to emissions. The most important GHGs emitted directly from nurseries are carbon dioxide (CO_2) and nitrous oxide (N_2O). CO_2 is released by burning fuels in vehicles, farm machineries, pumps and various heating applications (greenhouses, propagation benches etc.). N_2O emissions result from the use of nitrogenous fertilizers. In addition to these two main gases, small amount of methane (CH_4)

may also be released from waste and waterlogged soils. This study is undertaken to find out the potential environmental impacts which is associated with the seedling production of nursery from cradle-to-gate. By using surveys, interviews, and life cycle inventory databases, we have developed a process-based life cycle inventory of GHG emissions for public and private nursery operation in Chittagong City Corporation, Bangladesh.
In this study GHGs are converted into CO_2-equivalents.

2. MATERIALS AND METHODS

We have used a process-based LCA approach, which directly measures and tracks material and energy flows through each of the phases in the life cycle of the product. This LCA study has a cradle-to-gate system boundary, beginning with the nursery establishment through seedling production to transportation of ready seedling to the plantation site.

The functional unit of this study was "1000 seedlings of different plant species" in public and private nurseries respectively. We also report results in equivalent units.

Nurseries located at Sholashahar and Chowdhuryhat in Chittagong are evaluated in this study (Figure-1). Chittagong has a tropical monsoon climate. Chittagong is located at 22°22′0″N and 91°48′0″E on the banks of the Karnaphuli River.

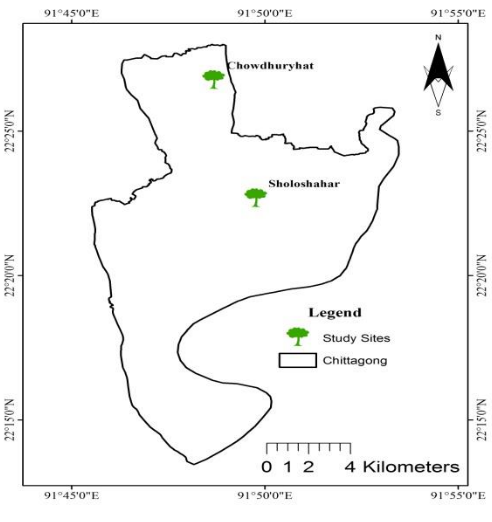

Fig.1: Study sites in Chittagong

The data are collected from 3 (three) govt. and 3 (three) private nurseries purposively. The field work was conducted over a period of twelve months from June, 2013 to May 2014. Weight machine, measuring tape and measuring scale are used in this field activity.

A semi-structured questionnaire is designed to get relevant information by keeping the objectives in views. The questionnaire have covered all of the materials and energy inputs to the establishment of nursery, use, and disposal of used products; and all of the outputs (air and water emissions, materials, and waste) from each phase of the nursery activities. Data collection is done by the questionnaire through field observation and interviews with the staffs of public nurseries and owners of the private nurseries. We assumed up all of the inputs and outputs of nursery industry and interpreted the results in terms of impacts on human health, ecosystems quality, and resource depletion. The input data for each unit process has been validated by on-site visits, telephone conversations, and on-site measurements.

Different categories of data are collected by several visits to the site. The categories are: Materials used, Energy required, Water required, Chemical used.

Data are analyzed with Microsoft Excel using reference values of Global Warming Potential (GWP) of commodities. The reference values are collected from previous LCA studies and from different directives.

3. RESULTS

The inventory data shows different kinds of commodities with their respective units and values i.e. agricultural implements (chopper, spade); woody materials (Tukri, Khuti, Shade); soil; cowdung; Polybag, energy (electricity, diesel, CNG); brick; water. However, seeds used in raising seedlings also have carbon footprint which is not considered in this study. To fulfill the Life Cycle Impact Assessment, data per species and per year are taken. The soil that is used in plantation activities, the labors that are employed have also some contribution but we have opted out those since we do not have any standard reference values for those.

3.1 LCA of Govt. Nurseries

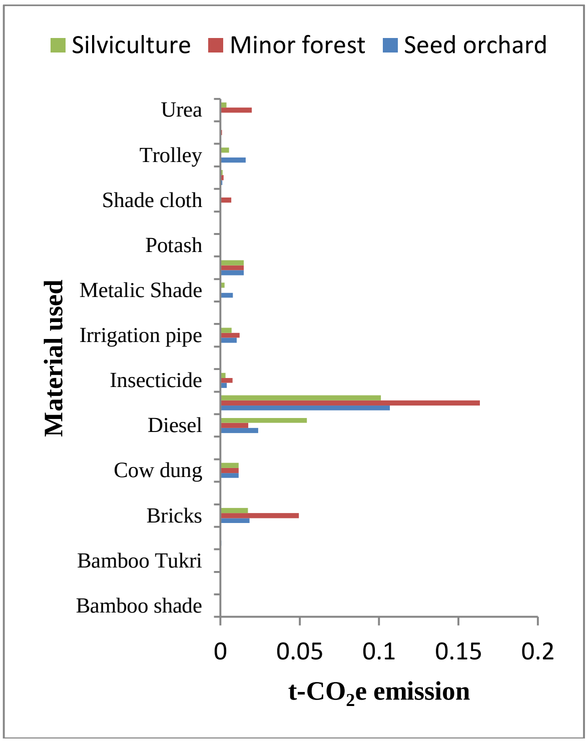

Fig.2: CO_2e emission of Govt. Nurseries

In minor forest nursery, carbon footprint of electricity energy (0.1635 ton-CO_2e) is much higher than other materials' footprint value per 1000 seedlings. This electricity energy is mainly used for irrigation pump in those nurseries. The second highest value is showed by bricks (0.0494 ton- CO_2e), those are mainly used around the nursery beds. Some materials (khuti, cutter) show much less responsible (are seen/observed to be less responsible) in GWP. The values of diesel, polybags, urea, and irrigation pipe are also (found?) in alarming rate (Figure-2). In Silviculture nursery, the used energy products provide much more value than all other values. The highest 0.1011 ton CO_2e is emitted by electricity energy per 1000 seedling, the second highest is diesel. This nursery collects different seeds from long distance which provides more GWP value of diesel (Figure-2).

The maximum GWP (0.1067 ton CO_2e) was for electricity in Seed Orchard nursery. Diesel is the second highest because the nursery seeds are mainly collected from Sylhet. In this nursery, metallic shade and trolley give the alarming rate of CO_2e.

3.2 LCA of Private nurseries

Shahjalal nursery at Chowdhuryhat shows different GWP values from govt. nurseries. In this nursery, polybags provide the highest GWP rate (0.119 ton-CO_2e) per 1000 seedling (Figure-3). On the other hand, cow dung is the second largest contributor of carbon footprint. Water source of this nursery is pond, so GWP of electricity goes down from top. The water source of Bhaibon nursery is sewage water. However, electricity is the top contributor (0.0277 ton CO_2e) for the emission of CO_2e per 1000 seedling. Foysal nursery gives the maximum GWP (0.029 ton CO_2e) in electricity used for 1000 seedling production (Figure-3).

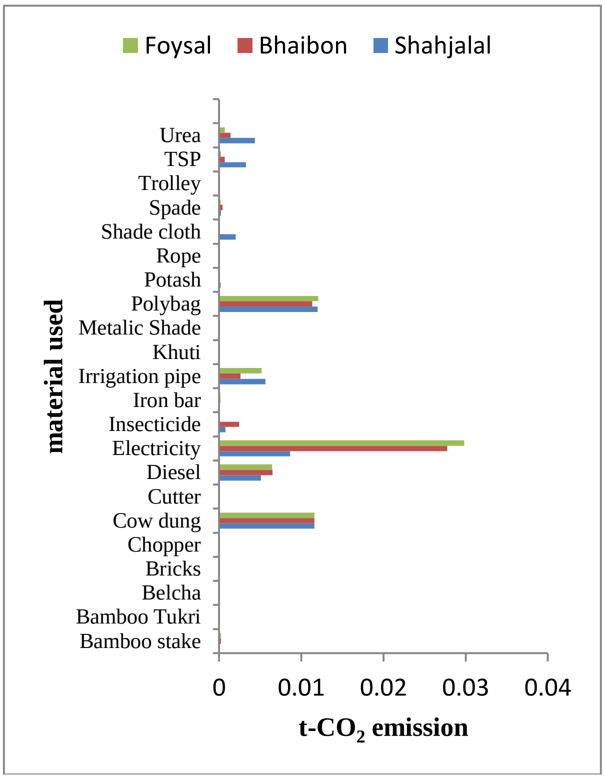

Fig.3: CO_2e emission of private nurseries

3.3 Government vs. Private nurseries

In producing 1000 seedlings, as we can see from Table-1, electricity showed maximum GWP carbon footprint from govt. nursery. In govt. nursery, carbon footprint of electricity energy (0.1238 ton-CO_2e) is much higher than other materials' footprint value per 1000 seedling. Diesel takes the second place by producing GWP of 0.031995681 ton CO_2e carbon footprint and bricks, polybags, cow dung follow gradually. In govt. nursery, metallic trolley, and metallic shades are also responsible in alarming rate in GWP. Tukri, khuti contribute much lower in GWP.

On the other hand, in producing 1000 seedlings, electricity has the highest carbon footprint from private nursery also (Table-1), its GWP is 0.02207557 ton CO_2e. Polybag, and cow dung show next place of electricity energy, then diesel takes place in GWP. Khuti,and bamboo stakes are much lower than others.

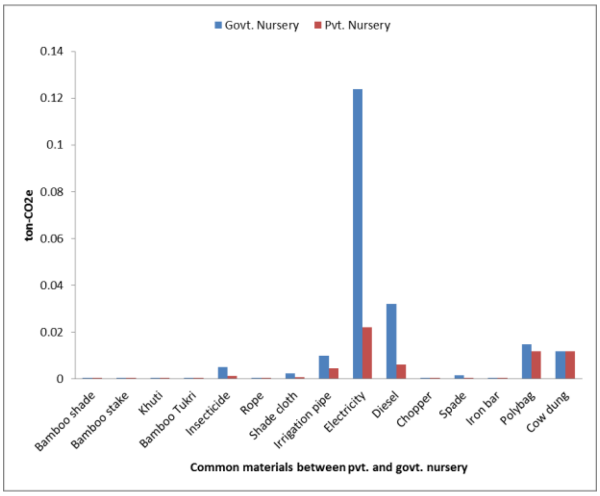

Fig.4: Comparison of CO_2e emission from materials used between pvt. and govt. nursery

There are many common materials used in govt. and private nurseries for 1000 seedling production. Depending on those used quantity, it is very difficult to calculate equivalent emission in CO_2. Figure 4 shows that all of the materials except cow dung, govt. nursery shows more GWP value than private nursery. Electricity is responsible for the highest CO_2-equivalent emissions in both categories of nursery. Diesel and poly-bags are the next largest contributors of CO_2e emissions in govt. and private nurseries respectively.

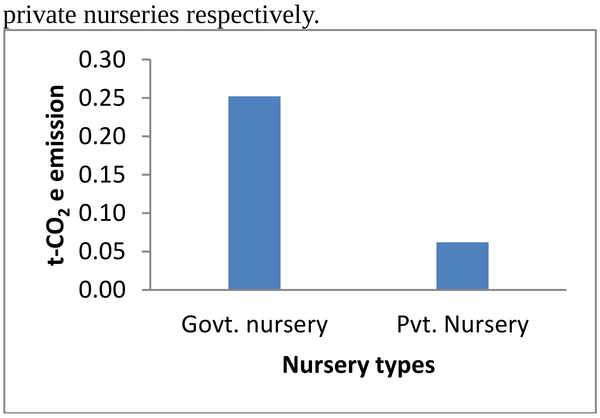

Fig.5: CO_2e emission from govt. and pvt. nursery per 1000 seedling

Table-1: t-CO_2e emission of studied Govt. and private nurseries

Materials used	t-CO_2e emission							
	Govt. Nursery				Pvt. Nursery			
	Seed orchard	Minor forest	Silviculture	Average emission (govt.)	Shahjalal	Bhaibon	Foysal	Average emission (pvt.)
Bamboo shade	-	3.52941E-05	-	1.17647E-05	-	-	-	-
Bamboo stake	-	3.52941E-06	-	1.17647E-06	-	0.000224579	0.000222844	0.000149141
Bamboo Tukri	-	-	4.09179E-06	1.36393E-06	1.74554E-06	2.24579E-06	2.22844E-06	2.07326E-06
Belcha	0.00064	-	-	0.000213333	-	-	-	-
Bricks	0.01848	0.049411765	0.017328741	0.028406835	-	-	-	-
Chopper	0.00024	0.000376471	0.000511474	0.000375982	2.48254E-05	7.98503E-05	7.92334E-05	6.1303E-05
Cow dung	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116
Cutter	0.000096	0.000141176	0.000136393	0.000124523	2.32739E-05	5.98877E-05	5.94251E-05	4.75289E-05
Diesel	0.02392	0.017588235	0.054478808	0.031995681	0.005088053	0.006487835	0.006437715	0.006004534
Electricity	0.1067904	0.163588235	0.101149112	0.123842582	0.008629946	0.027757954	0.02983881	0.02207557
Insecticide	0.00416	0.007647059	0.003324581	0.00504388	0.0007564	0.002432938	-	0.001063113
Iron bar	0.00024	0.000352941	0.000409179	0.00033404	9.30954E-05	0.000149719	0.000158467	0.000133761
Irrigation pipe	0.0104	0.012235294	0.00709244	0.009909245	0.005647789	0.002595134	0.005150172	0.004464365
Khuti	-	0.000352941	-	0.000117647	1.04732E-06	-	-	3.49108E-07
Metallic Shade	0.008	-	0.002727862	0.003575954	-	-	-	-
Polybag	0.014770288	0.014769835	0.014755	0.014765041	0.011969155	0.011304087	0.012043891	0.011772378
Potash	-	0.000252941	0.000146623	0.000133188	0.000166796	5.36494E-05	-	7.34818E-05
Rope	0.0000006	3.52941E-05	-	1.19647E-05	4.65477E-07	-	-	1.55159E-07
Shade cloth	--	0.006949647	-	0.002316549	0.002017067	-	-	0.000672356
Spade	0.00128	0.001976471	0.001363931	0.001540134	0.000217223	0.000399251	0.000198084	0.000271519
Trolley	0.016	-	0.005455723	0.007151908	-	-	-	-
TSP	-	0.001152941	0.000381901	0.000511614	0.00325834	0.00069869	0.000207988	0.001388339
Urea	-	0.019747059	0.003815597	0.007854218	0.004340574	0.001396132	0.000692673	0.002143127
Total	0.216617288	0.308217129	0.232342706	0.252392374	0.053835796	0.065241954	0.06669153	0.061923093

It has been shown in Figure-5 that the GWP (0.2523 ton $C0_2e$) of public nurseries is much higher than the GWP (0.0619 ton CO_2e) of private nurseries per 1000 seedling per year.

4. DISCUSSION

There is no comparative study of govt. and private nurseries based on LCA in the world. For that reason, there was less scope of discussion about the findings. However, we have discussed with LCA of nursery activities literature.

In 2011, Alissa kendall provides the first detailed, process-based life cycle greenhouse gas inventory of an ornamental tree production system, supported by field data from Monrovia Nursery in Woodside, CA, and its key suppliers (Kendall, 2011).

Other studies have considered greenhouse production systems that produce flowers and roses, but not trees (Russo and Zeller, 2008). In these greenhouse studies, diesel fuel and fertilizer-related emissions were the primary atmospheric burdens.

In our study, we found carbon footprint of electricity is 143 kg CO_2e for 1000 seedling is higher than other factors of production.

5. CONCLUSION

Nursery is the place where seedlings are raised and managed for a shorter period before it is planted to devoted site. The success of large-scale tree planting initiatives for climate protection depends on projects being net sinks for CO_2 over their entire life cycle. The objectives of this study are to produce detailed life cycle inventory (LCI) data for seedling production of nurseries and to analyze differences between government and private nurseries.

Electricity is found out to be the single largest contributor to nursery emissions. Electricity is used to power pumps for irrigation, lighting and air conditioning systems. In private nurseries, the second largest contributor is the poly-bag. On the other hand, in government nurseries, this place is taken by diesel.

Generating on-site renewable electricity, such as using photovoltaic panels, improving irrigation efficiencies, and reducing irrigation water demand, we can reduce energy-related CO_2e emissions.

This study can be used as a source of baseline information for improving the nursery activities to reduce CO_2e emission.

6. RFEERENCES

[1] ISO. (2006). ISO 14040 International Standard Environmental Management – Life Cycle Assessment–Principles and Framework International Organization for Standardization, Geneva, Switzerland.

[2] Iqbal, K. S., & Rahim, A. (2006). Mechanized Country Boats of Bangladesh: Assessing Environmental Impacts of Hull Form Modification. International Shipbuilding Progress, 53(2), 145-154.

[3] Akbari H (2002) Shade trees reduce building energy use and CO_2 emissions from power plants. Environmental Pollution 116(supplement 1): p. S119–S126.

[4] Osman, K. T. (2013). Forest Soils: Properties and Management. Switzerland. Springer.

[5] Kendall, A. E. G. (2011). A life cycle greenhouse gas inventory of a tree production system. International Journal of Life Cycle Assessment. DOI 10.1007/s11367-011-0339-x

[6] Russo G, Zeller BL (2008) Environmental evaluation by means of LCA regarding the ornamental nursery production in rose and sowbread greenhouse cultivation. ActaHort 801:1597–1604

6. NOMENCLATURE

Symbol	Meaning
t-CO_2e	Ton CO_2 equivalent emission
LCA	Life Cycle Assessment