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Carbon Footprint Mapping for Sustainable Development

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Abstract

An increase in Greenhouse Gases (GHG) due to the burning of fossil fuels, leads to drastic change in the climatic conditions also known as global warming. The carbon-di-oxide (CO_2) is one of the primary and most abundant GHG which is the main reason behind the climate change. The accounting of the GHG emissions is known as Carbon Footprint. The overall purpose of the study is to develop a tool useful for evaluating and assessing the Carbon Footprint generated by garment production units and various methods to reduce the emissions generated.

Key words*: Greenhouse Gases, Global warming, Climate change, Carbon footprint, Life Cycle assessment*

1. Introduction

An element found ubiquitous in the nature and in every creature is carbon. Another essential component is oxygen which we use for breathing. When both these components form a bond together they generate a gas called carbon-di-oxide (CO_2).

Carbon-di-oxide is a greenhouse gas which traps the heat from the atmosphere and makes the surface of the earth warm. The formation of carbon-di-oxide is mainly due to the burning of the fossil fuels such as coal, oil, natural gases, burning of wood, use of electricity etc. According to the Intergovernmental Panel on Climate Change (IPCC), there are a total of 18 greenhouse gases with different global warming potentials, but under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto protocol, only the following gases are considered for the purposes of carbon accounting, with others being regulated elsewhere (IPCC 1990; UNFCCC 1997); Methane (CH_4), Nitrous oxide (NO_2),

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Hydro chlorofluorocarbon (HFC), Per fluorocarbons (PFC), and Sulphur hexafluoride (SF_6). Of these gases Carbon-di-oxide gas is found in abundance. Carbon rotates from one segment of the earth to another through the carbon cycles. But nowadays the burning of fossil fuels has added up so much of burden to the atmosphere in comparison to the natural processes can sequester them [3]. In turn there is increasing amount of carbon-di-oxide in the atmosphere and is the main reason for global climate change. This has lead to global warming, water scarcity, air, water, soil pollution, melting of ice caps, ozone layer depletion, desertification, energy shortages, declining biodiversity [6].

This brings the urgency to figure out the sources of GHG emissions and how they can be effectively reduced. Nowadays most industries are taking measures to quantify and reduce their Environmental Footprints. One of the industries is textile and apparel industry which are also being challenged to quantify and reduce their GHG emissions or Carbon Footprint to the atmosphere which is considered during the study.

1.1 Textile and Apparel Industry

India's textile and apparel industry is also a major contributor in the generation of carbon footprint. This industry is the backbone of national economy. It contributes about 14% of industrial production, 4% of the GDP and employs 45 million people. The readymade apparel sector also has a huge share in the India's total textile exports which is nearly about 39% and apparel and cotton products has a share of about 74% of total textile exports. The contribution of this sector in terms of GHG emission is also quite high due to its huge size and scope. To manufacture 60 billion kg of fabric about 1 trillion kilowatt hours of electricity and 9 trillion litres of water is consumed. It is also estimated that this sector consumes nearly about 9-10% of total energy consumed in India and generates 3% of total GHG emissions [2].

1.2 Carbon Footprint and LCA

Carbon Footprint and life cycle concept addresses organised evaluation of product supply chain. It can be defined as the amount of carbon-di-oxide and other greenhouse gases generated from the manufacturing of a fibre, fabric production, garment production, transportation and distribution of the finished product, packaging, use (includes washing and care of the garment) and disposal of the garment. It also accounts all the inputs and outputs to understand all the impacts during the supply chain [9].

LCA is not a footprint but is a tool which provides insight on footprints with its 'cradle-to-grave" approach. This approach explains the full life cycle assessment from the extraction of material which is known as cradle till the disposal of the product known as grave.

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Other approaches are:

Cradle-to-gate: It is the life cycle assessment from extraction of material till the factory gate.

Gate-to-gate: This assessment approach takes in to consideration only one process from the entire life cycle.

Cradle-to-cradle: This is the assessment process from extraction of the material till the disposal of the product in the form of recycling [1].

Calculation of product carbon footprint using the LCA tool should be based on the existing standardised methodology by the organisations involved [5].

- International Organisation for Standardization (ISO) - Is an international organisation which frames standards. They have developed ISO 14040 (Lifecycle assessment principles and framework), ISO 14044 (Lifecycle assessment requirements and guidelines), ISO 14067 (Principles, requirements and guidelines for the quantification of carbon footprint of products) [12].
- British Standard Institution (BSI)- In association with Department of Environment, Food and Rural affairs (DEFRA) and the Carbon Trust formed Publicly Available Specification 2050 (PAS 2050) which provides specifications for the assessment of the life cycle greenhouse gas emissions of goods and services [8].
- The World Business Council for Sustainable Development and World Resource Institute in collaboration formed the greenhouse gas protocol tool which is widely used to quantify greenhouse gas emission for different industry [10].
- Intergovernmental Panel on climate change is the significant body for the assessment of climate change [11].

2. Methodology

The methodology has been designed keeping in mind the standard life cycle assessment process. The process highlights the key aspects in order to identify all the inputs that are involved in the manufacturing process i.e. energy, material, water, fuel and all the outputs released i.e. emissions, waste and waste water.

The study is a field study and the data collection through interview schedule, questionnaire and the observation of the garment manufacturing units near Delhi-NCR was done. A sample of 10 units was taken.

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The pilot study includes the assessment of unit with gate-to-gate approach (garment manufacturing). The process will be later on linked in their appropriate production chain to complete the life cycle from cradle to gate using the secondary databases.

2.1 **Steps of LCA Process**

- **Setting Organisational Boundaries:** The very first step in the LCA process is the mapping which includes identification of goal of the research, the functional unit and includes all the activities involved in the product life cycle. The typical life cycle of garment is cradle-to-cradle approach but in this research our main focus is on gate-to-gate evaluation [7].

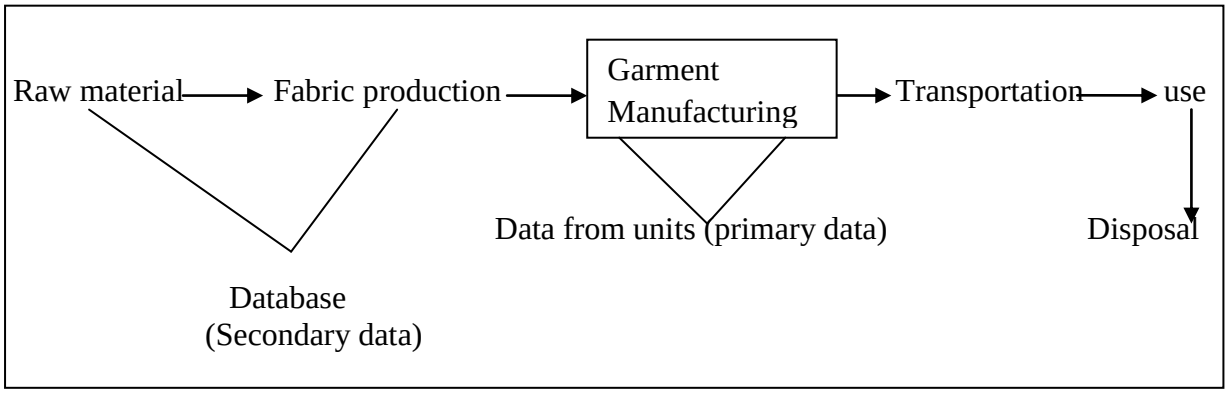

Figure 1: Identification of organisational boundaries

- **Defining Scope and Goals:** The scope of the analysis has been clearly stated. The methodology includes emissions from emissions from raw material, fabric production and garment manufacturing and excludes the reuse, disposal emissions. The study will consider the fuel usage from both direct and indirect sources, Transportation, energy use by the machinery and the purchased electricity. The scope 1 and scope 2 of GHG emissions will be collected. The study will include all the contributing factors of GHG emissions and ways to reduce the emissions will also be considered in the area of study.

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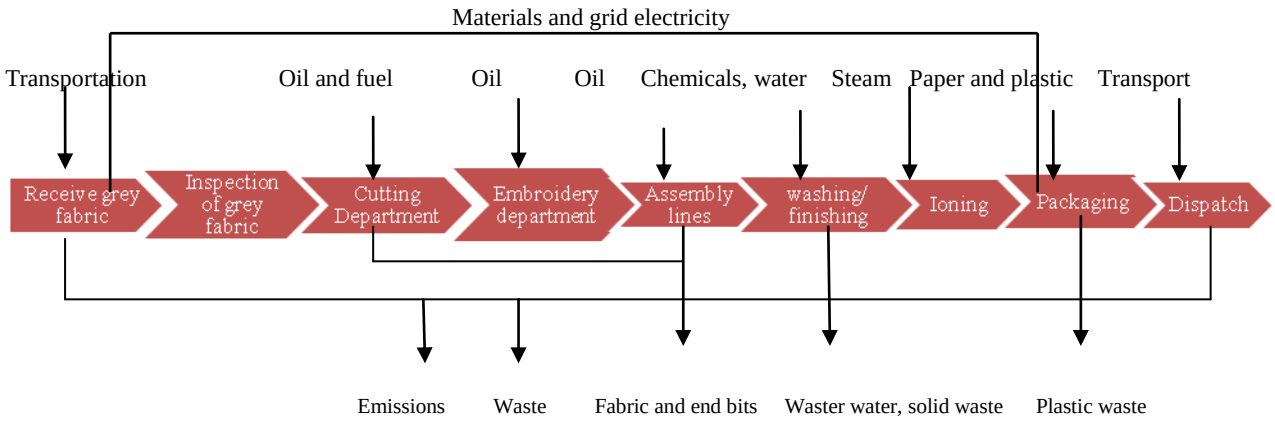

Figure 2: Setting of goal

- **Data Collection:** One of the compelling concerns in LCA is the collection of data. The data collected from the unit regarding the transportation of fabric whether vehicles not owned or controlled by the company, commutation of employees, business travel whether domestic or international, in self- owned vehicle or air, bus, train. The data was collected using questionnaire and interview schedule which was prepared keeping them simple and understandable. Questions related to the energy use, renewable source of energy, water consumption, waste generated, amount fabric used to make the final product, recycled content were included. The data was collected keeping in view the actual use of energy instead of industry standards.
- **Calculations:** The first step in the calculation is converting the primary and secondary data to the emissions by multiplying the data with the emission factors which is used as per IPCC guidelines. Then the emissions of a product are converted to CO_2 e value by multiplying the data with the global warming potential factor. Then the total product carbon footprint is the sum of emissions of all the activities of the life cycle. Carbon Footprint generated by vehicles emission require oxidation factor to know the carbon content of fuel which is oxidised in to CO_2. To calculate the CO_2 emissions from a gallon of fuel, the carbon emissions are multiplied by the ratio of the molecular weight of CO_2 (m.w. 44) to the molecular weight of carbon (m.w.12): 44/12.
- **Reporting and evaluation:** Carbon footprint report should include all the ways in which industry can reduce their emissions. Reporting should give a better understanding of all the specifications and it should provide the total carbon footprint with the functional units with the emission factors and global warming potential used. It should be relevant and complete with all the GHG emission sources and activities within the chosen scope and goal of research.

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3. Results and Discussions

The most important factor determining GHG emission of a garment is the fibre. Synthetic fibres as compared to natural fibres use less energy during the production process so the resultant emissions will be higher. An emission also depends on the sourcing of fibre; the transportation involved also puts an impact on the emissions. Dyeing of fibre and fabric requires higher energy consumption and water which leads to more emissions.

Garment cutting and sewing is the final stage of production before finishing of the garment. This stage results in a significant amount of wastage of fabric.

The sewing process is the largest contributor to the total energy consumed. This is closely followed by the cutting process and packaging. The main contribution of carbon footprint comes from electricity consumption by the sewing machines.

Garment requires washing, ironing, drying both at the manufacturing and in the consumer use phase. This entails a large energy input and it account for about 40-80% of total life cycle GHG emissions. Machine washing and drying has a larger affect as compared to hand washing and air drying.

Packaging also puts an impact on the GHG with the use of plastics and other non-biodegradable materials. Nowadays packaging material produced out of recycled material has found to have reduced this impact. The life cycle stages of fabric production have been found to have a higher contribution towards GHGs than the garment production, distribution and retail.

4. Conclusion

The purpose of the study was to gain an insight into the sources of the greenhouse gas emission in the selected manufacturing units. The garment industry is one of the most important sectors in India with a significant contribution to GDP and employment. The sector has an important place in the export market. Product carbon footprint has gained a lot of popularity during the recent year in the industry.

In the future, Carbon Footprint is likely to become mandatory as retailers seek to promote their environmental actions. Many commercial organisations are measuring their product Carbon Footprint and providing ways to reduce their GHG emissions.

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