Sustainable Clothing: Unveiling Carbon Footprint, Handprint, and Credits

Introduction:
The textile and apparel industry plays a pivotal role in our daily lives, influencing the way we express ourselves and interact with the world. However, the environmental impact of clothing production has become a pressing concern, prompting the need for comprehensive research to unravel the complexities of carbon emissions associated with the lifecycle of clothing items. In response to this global challenge, our group undertook a meticulous investigation into the carbon footprint and handprint of clothing, aiming to shed light on the environmental implications and potential solutions within the fashion industry. The research presents a detailed analysis of the carbon emissions across different stages of clothing production, explores innovative measures to reduce these emissions, and quantifies the resulting carbon credits. By delving into this research, we aim to contribute valuable insights to the ongoing discourse on sustainable fashion and inspire positive changes in industry practices.

Understanding Carbon Footprint in Clothing Production:
The first focal point of our research delves into the carbon footprint of clothing, meticulously examining the emissions associated with raw material production, manufacturing processes, treatment and processing, transportation and distribution, and the use and disposal of clothing items. Drawing on specific data collected from major clothing-producing countries—China, Bangladesh, India, and Vietnam—we deciphered the nuanced environmental impact at each stage of the clothing lifecycle. These insights provide a comprehensive understanding of the carbon-intensive processes inherent in the production of everyday garments, emphasizing the urgency to address and rectify these environmental challenges.

Crafting Solutions and Assessing Carbon Credits:
Moving beyond the elucidation of the problem, our research extends to propose actionable solutions aimed at mitigating the carbon footprint in clothing production. By drawing parallels with successful sustainability measures implemented in the denim industry, we offer tailored recommendations for each country, addressing key stages of the clothing lifecycle. Our analysis includes the adoption of sustainable farming practices, renewable energy integration, eco-friendly manufacturing techniques, and green logistics, among other strategies. To quantitatively measure the impact of these recommendations, we calculated carbon credits for each country, providing tangible evidence of the potential reductions in carbon emissions. This dual approach not only highlights the severity of the issue but also underscores the practical avenues for positive change, aligning with the broader movement towards sustainable and eco-conscious fashion.

Through this comprehensive exploration of carbon footprints, handprints, and credits in clothing production, our research endeavors to contribute to a more sustainable and environmentally conscious fashion industry. By bridging the gap between awareness and actionable solutions, we aspire to empower consumers, manufacturers, and policymakers alike to make informed choices that pave the way for a greener and more sustainable future.

Cotton T-Shirts:
Our scrutiny of the carbon footprint within the textile industry honed in on the ubiquitous cotton T-shirt, unraveling the environmental complexities woven into its production. By dissecting the lifecycle of a cotton T-shirt, we uncovered eye-opening insights into its carbon emissions at various stages. From the raw material production in countries like China, Bangladesh, India, and Vietnam, where sustainable cotton farming practices and eco-friendly agriculture methods were considered, to the manufacturing processes employing energy-efficient machinery and the adoption of renewable energy, our research yielded nuanced figures. For instance, the baseline emissions for a T-shirt in India stood at 1.3 kg CO_2, but through targeted interventions like solar power integration and the use of sustainable raw materials, this figure saw a potential reduction to 0.8 kg to 1.5 kg CO_2 per T-shirt. Moreover, sustainable washing practices brought the use and maintenance phase into focus, demonstrating a potential reduction of 5 kg to 10 kg of CO_2 per T-shirt. The culmination of our efforts resulted in the calculation of tangible carbon credits, underscoring the significance of our recommendations and the potential for a substantial positive impact on the carbon footprint of cotton T-shirts.

Denim Jeans:
Delving into the indigo-hued world of denim jeans, our research sought to unravel the intricate threads of carbon emissions embedded in their production. Analyzing the lifecycle of denim jeans, we pinpointed opportunities for sustainable practices to mitigate their environmental impact. From China's implementation of energy-efficient technologies in manufacturing to Bangladesh's adoption of eco-friendly dyeing techniques and water recycling systems, each country was scrutinized for its unique challenges and potential solutions. Calculations for denim jeans in China revealed a baseline emission of 4.3 kg CO_2 per pair, but with energy-efficient machinery and optimized logistics, the potential reduction ranged from 2 kg to 4 kg CO_2 per pair. Renewable energy adoption in Bangladesh could lead to a reduction of 1 kg to 2 kg CO_2 per pair. These targeted measures not only shed light on the carbon-intensive aspects of denim production but also provided actionable insights. Our comprehensive approach culminated in the quantification of carbon credits, showcasing the transformative potential of implementing sustainable practices in the denim industry.

Polyester Sports T-shirt:
The life cycle phases of a polyester sport shirt encompass raw material production, manufacturing, treatment and processing, use and maintenance, and end-of-life. According to life cycle assessment results, the shirt's entire life cycle consumes 109.9 MJ of energy, resulting in a global warming potential of 81.62 CO_2 equivalent and 2882.9 L water usage. Notably, the use and maintenance phase exhibit the highest resource utilization, contributing to 65.5% of energy use, 89% of water consumption, and 84% of global warming potential. Shirt production contributes 30.85% to energy consumption, 13% to total water use, and 13% to global warming potential, while shirt processing has the least impact across the three processes. Producing the PET for a single polyester T-shirt requires 7.6 kilowatt hours of energy, resulting in the emission of 5.95 kg of CO_2e, as reported by Australian researchers in a 2018 study at RM. Additionally, a polyester T-shirt manufactured in Vietnam emits 25% less CO_2e compared to one produced in India.

Sustainable Measures:

Producing clothing often involves consuming substantial amounts of water, even for a single t-shirt. Widespread production in large factories worldwide contributes significantly to air pollution. While the fashion industry is just one of many contributors, it is responsible for at least 10% of global carbon emissions. The excessive carbon emissions contribute to climate change and various health issues, including severe respiratory conditions.

Opting to shop at resale stores for second-hand clothing becomes a sustainable choice, curbing environmental harm by mitigating overproduction and slowing down the pace of "fast fashion," consequently conserving oceans and water resources.

A life-cycle assessment has validated the considerable carbon dioxide and water savings achieved through the reuse of second-hand textiles compared to new clothing production, as reported by the European Recycling Industries Confederation's (EuRIC) textiles branch. Their research indicates that reusing textiles results in an environmental impact 70 times lower, even when considering global exports for reuse, including transport emissions. EuRIC's findings highlight that for each high/medium-quality piece of reused clothing, 3kg of CO_2 is saved, and only a negligible 0.01% of the water required for new clothing production is needed for reuse.

Sustainable Measures for Polyester T-shirts:
The ecological footprint of a 100% polyester T-shirt (Grade C) is comparatively lower than that of the cream (100% cotton) and B grade (30/70 polycotton) counterparts. The overall impact is notably reduced for a reused polyester T-shirt, being 37 times smaller than that of a new one. The heightened environmental impact of the new T-shirt primarily stems from its production and, to a lesser extent, the manufacturing of polyester fibers. Transportation, even for long distances, has a minor role in the new T-shirt's impact.

Specifically, the carbon footprint of a new polyester T-shirt is approximately 40 times greater than that of a reused T-shirt. Similar to the polycotton T-shirt, the T-shirt's production is the primary contributor to climate change impact, with the production of polyester fibers constituting 27% of the carbon footprint.

Leggings:
Most of the leggings in the world are manufactured from three main materials such as nylon-lycra blends, cotton and spandex-polyester blends. For this research, the focus was primarily on cotton and leggings made of nylon-lycra blends. It was noted from the life cycle assessment of nylon-lycra leggings made in China, that the baseline carbon emission is 6.52kg CO_2eq per kg while in countries like Bangladesh, the total emission was 5.1 kgCO_2e kg.

In some regions of China, leggings and other textile waste might be incinerated for disposal. While incineration can reduce the volume of waste, it can also release harmful pollutants into the environment which contributes to the carbon footprint in the production process.

Various sustainability measures applied in these countries have served to reduce the impact of leggings production on climate change. One significant sustainability measure is use of recycled fabric in leggings production.

Through recycling, approximately 7 barrels of crude oil that would have been used in manufacture of leggings is saved and this leads to a reduction in the baseline carbon emission to 5.7 tonnes of CO_2 eq.emissions. This in turn has a significant contribution to the carbon credits when such emission reduction measures are applied.

In conclusion, this research sheds light on the impact that use of sustainable fabrics as well as recycling and purchasing of second hand clothing has on the environment. We hope that it will guide more intensive research and application of these sustainability measures to help revolutionize the fashion and textile industry thus creating a better and equal earth.