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GHG Emission Assessment For The Sri Lankan Industrial Park: Analysis Based On Case Study In Kandy Industrial Park, Sri Lanka.

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ABSTRACT

The Board of Investment (BOI) is a prime investment facilitation agency in Sri Lanka established in 1978, under the Greater Colombo Economics Commission to stimulate the Foreign Direct Investment (FDI). Countrywide, fifteen Export Processing Zones (EPZ) are dedicated to promoting FDI within the industrial zones while providing more than 1300 companies to operate outside the demarcated zones under the BOI purview. Out of the 15 EPZs operating, Kandy Industrial Park (KIP) plays a key role in the central region of Sri Lanka as it is the only regional industrial park functioning under the BOI by facilitating 24 industries to uplift the national economy. The area is located in a peak and forested interior and is demarcated as a sensitive area under the Soil Conservation Act in Sri Lanka. Kandy city and most of the region are shown as basin topography which is significant to the atmospheric emission and dispersion mechanisms.

Further, BOI was selected as the focal point to implement Nationally Determined Contributions (NDCs) under the framework of the United Nations Framework Convention on Climate Change (UNFCCC). Hence, Green House Gas (GHG) emission and Carbon Footprint (CFP) Calculation of this prime industrial park is essential to maintain a harmonized environment in terms of the economic, health, and social aspects and the view of global warming. This assessment spanned 195 acres covering a wide range of industrial activities including 24 industries of apparel manufacturing, food processing, pharmaceutical manufacturing, and telecommunication systems. According to the theoretical method to calculate CFP, scope 1, scope 2, and scope 3 were recommended. However, considering the deep analysis of park activity responses to the CFP, it has revealed that scope 1 and scope 2 are the most impactful emission types. The case study was selected the KIP as boundary. There in scope III were disregarded.

Accordingly, the GHG emission showed 1,617,341.13 metric tons of carbon dioxide equivalent (CO_2eq). Emission inventory for Scope 1 due to diesel and gasoline combustion contributed 42,775.63 CO_2eq (MT), while Scope 2 due to electricity usage accounted for 1,574,565.50 CO_2eq (MT). These values are committed to the environmental challenges and drive to initiate the mitigation measures.

In context, it has recommended encouraging investors and industrial management to align with renewable energy sources especially solar power compatible with the climate of the region. Further alternative fuel sources such as biofuels or electrical vehicle usage practices can be adhered. In addition, internal modifications, adaptation of cleaner production mechanisms, equipment optimizations, proper maintenance, and energy audits were recommended. Meantime, park managements and the users are adapted to increase the green cover in order to implement the natural carbon sink mechanisms forecasting the long term impact.

In conclusion, the CFP assessment emphasized the crucial requirements to implement the sustainable practices to minimize the environmental impact and global warming. By following the recommended approaches, the park can potentially address its CFP and enhance its climate change mitigation efforts align to the NDCs. This study provides a

model for other industrial zones in Sri Lanka and comprehensively underscores the significance of dynamic sustainability adaptations in industrial operations.

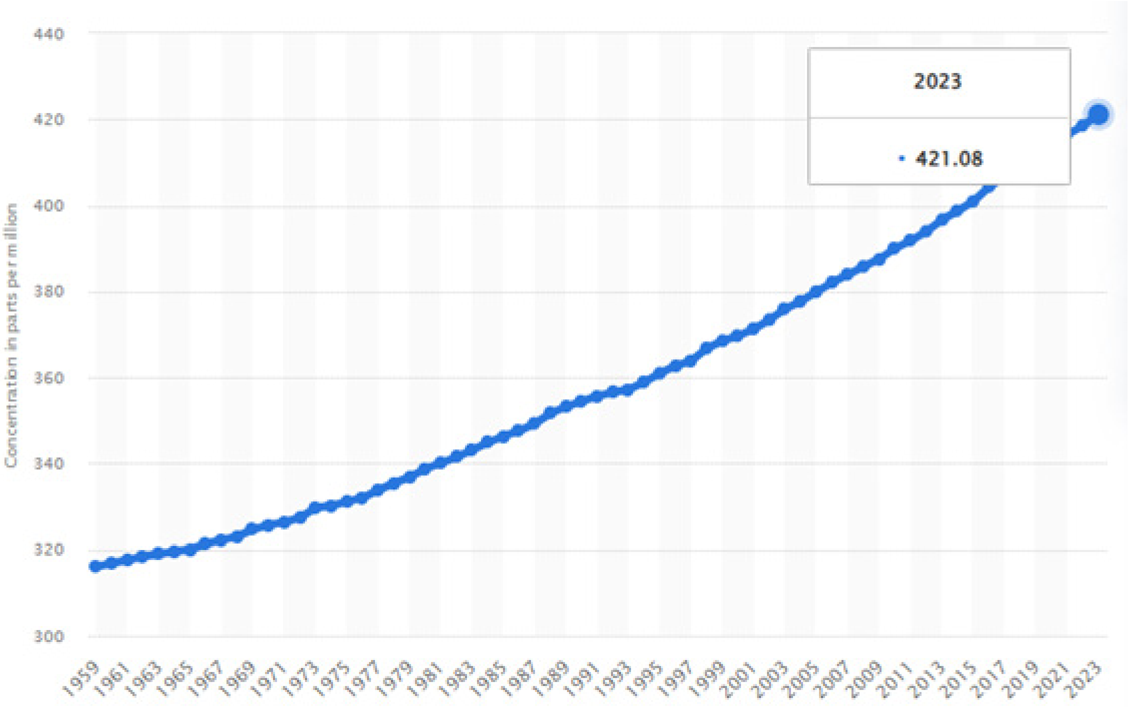
Keywords : *Carbon footprint, greenhouse gas emissions, Kandy Industrial Park, scope 1 emissions, scope 2 emissions, energy efficiency, renewable energy, sustainability, climate change..*

INTRODUCTION

Climate change, also referred to as global warming, is a phenomenon leading to large-scale irreversible changes globally. Climate change due to increased GHG in the atmosphere has been consistently observed since the mid-20th century (Bhatti *et al*., 2024). Anthropogenic activities cause the current climate change, which releases carbon dioxide (CO2) and other GHGs into the atmosphere. Climate change results in rising sea levels, a sharp deterioration in biodiversity, and ecological degradation, significantly affecting agriculture and forestry (Alhamid *et al.*, 2022). According to the Global Climate Risk Index, Sri Lanka has been identified among the worst affected nations by the acts of nature and climate change factors, especially in coastal areas related to sea level rise, increase of coastal erosion zone, and increased intensity of storm occurrences (Eckstein *et al*., 2021). If the world's current trends continue same, the Earth will warm by 2.5 °C to 2.9 °C during the twenty-first century, far exceeding the Paris Agreement goal of 1.5 °C (IPCC, 2024). To address these challenges, climate change adaptation (CCA) is recognized globally as a necessary solution to mitigate and prevent adverse impacts. Becoming carbon neutral is emphasized as a critical step in limiting global temperature increases to between 1.5 °C and 2 °C, aligning with the pre-industrial levels outlined in international frameworks like the Paris Agreement (IPCC, 2022).

Human activities enhance the GHG concentration in the atmosphere due to an increase in temperature in the Earth. The economic system trades in goods and services, land, labor, and capital, between industries and households, but more significantly, the system takes out energy and natural resources from the biosphere and dumps wastes and pollution into the biosphere which have adverse health impacts on people globally. The greatest emissions of greenhouse gases come from the use of goods and services by people (Bherwani *et al.*, 2022).

Figure 1: Direct measurement of atmospheric CO2 from 1959 to 2023 in ppm.



Within this context, understanding and managing carbon footprints at the organizational and industrial levels are critical components of achieving carbon neutrality. KIP serves as a vital industrial hub in Sri Lanka, including diverse industries. Despite its economic importance, the park's operations contribute significantly to GHG emissions, primarily through direct fuel combustion and electricity consumption. Quantifying and addressing the CFP of KIP not only supports climate change mitigation goals but also aligns with Sri Lanka's commitment to its NDCs.

Currently, in China, there are over 6800 industrial parks for the whole country which could be divided into several types, which are sector-integrated industrial parks (economic and technological development zones), sector-specific industrial parks (chemical parks or metallurgical parks, etc., which have sufficient types of sectors only), venous industrial parks (resource recovery parks where environmental technology companies and firms making green products together) (Geng and Hengxin, 2009). With the consultation of the Chinese Academy of Sciences (CAS) in China, this study aims to assess the CFP of KIP by analyzing Scope 1 and Scope 2 GHG emissions, providing actionable recommendations for emission reduction. By addressing these emissions, KIP can serve as a model for sustainable industrial practices in Sri Lanka and contribute to the nation's broader climate change mitigation efforts.

1.1 Background of the Study

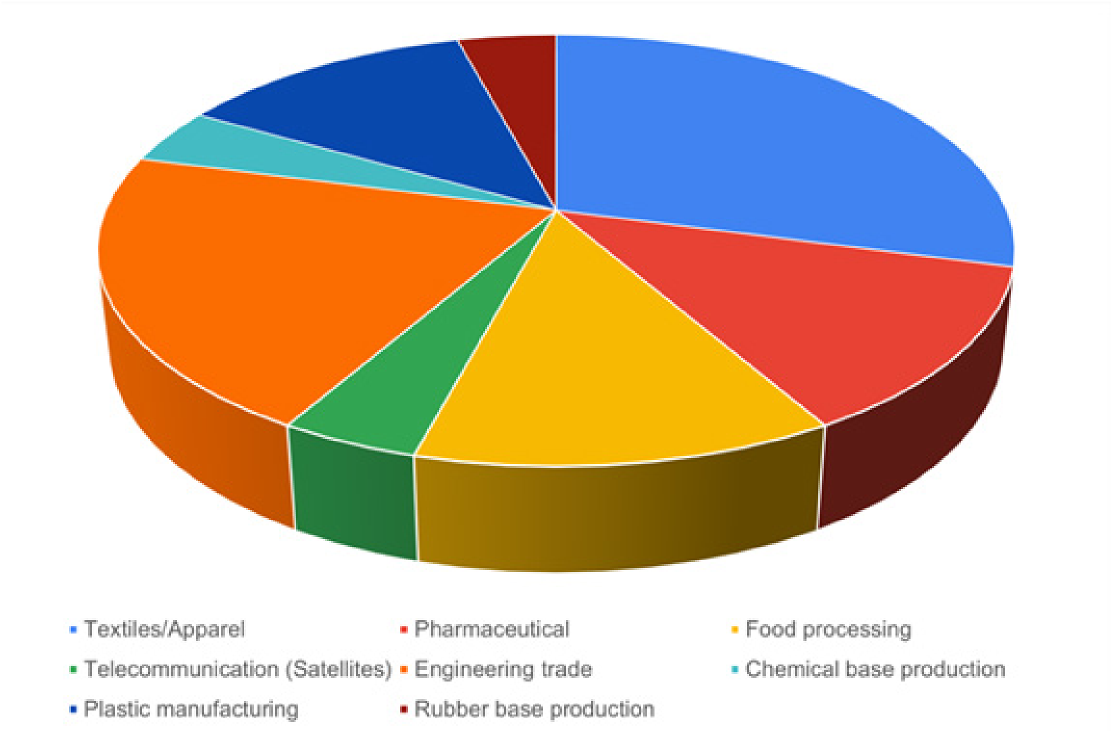
Climate change, driven by the increase in GHG emissions, is one of the most significant global challenges. The rise in GHGs, particularly Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O), has led to global warming, causing large-scale environmental changes. These include rising sea levels, extreme weather events, and ecological degradation, all of which threaten biodiversity, agriculture, and human livelihoods. The industrial sector is a significant contributor to GHG emissions, accounting for a considerable portion of global CO_2 emissions through energy-intensive activities and dependence on fossil fuels.

Sri Lanka, as a developing Asian country, is highly vulnerable to the impacts of climate change. The Global Climate Risk Index has identified Sri Lanka as one of the countries most affected by climate-related events. Rising sea levels, coastal erosion, and increasingly intense storm incidences are some of the climate change-induced phenomena that threaten the nation's coastal and inland regions. These impacts are combined with the country's economic reliance on sectors such as agriculture, forestry, and industrial development, which are sensitive to climatic variations.

1.1.1 Industrial Development and Environmental Impact

Industrial parks have become an effective strategy for government to promote sustainable economic development due to the following advantages: for example, they introduced the concept of shared infrastructure, and most industries and other activities are confined to the planned areas (Dong *et al.*, 2013). Industrial zones in Sri Lanka, including EPZs and specialized industrial parks, play an important role in the country's economic development. The KIP, located in the central region of Sri Lanka, is one of the country's key industrial hubs. Spanning 195 acres, the park hosts 24 diverse industries. These industries contribute significantly to local economic growth, job creation, and export earnings.

Figure 2: Industrial classification of KIP



However, industrial activities are inherently energy-intensive and frequently depend on non-renewable energy sources such as diesel, petrol, and electricity generated from fossil fuels. This reliance leads to significant GHG emissions, contributing to the country's overall carbon footprint.

The emissions can be categorized into three scopes: scope 1, which includes direct emissions from fuel combustion; scope 2, which covers indirect emissions from electricity consumption; and scope 3, which involves other indirect emissions throughout the value chain. However, considering the deep analysis of park activity responses to the CFP, it has revealed that Scope 1 and Scope 2 are the most impactful emission types.

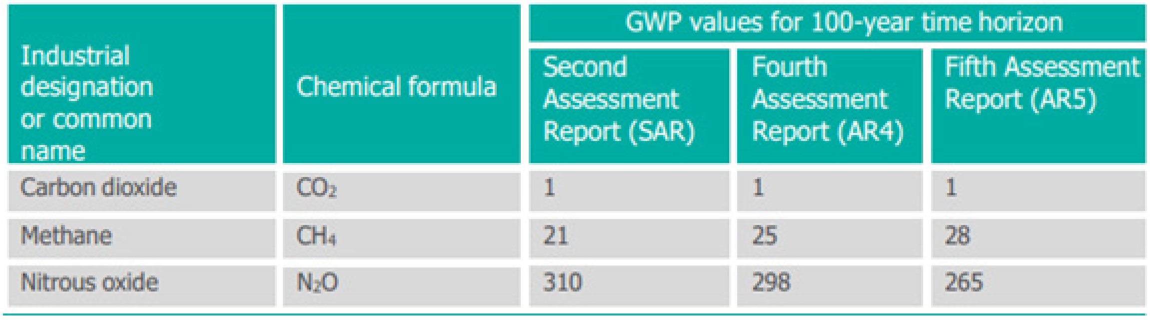
KIP's strategic location in a sensitive ecological zone adds to the urgency of addressing its environmental impact. The region's topography, characterized by basins and forested interiors, influences atmospheric emission dispersion mechanisms, potentially intensifying local air pollution and climate-related risks. Additionally, Sri Lanka's commitment to global climate action under the Paris Agreement and its NDCs emphasizes the need for industrial zones like KIP to adopt sustainable practices.

1.1.2 The Role of CFP Assessment

A CFP assessment provides a systematic approach to quantifying the GHG emissions associated with specific activities, products, or organizations. By identifying major sources of emissions, such assessments allow stakeholders to understand the environmental impact of their operations and prioritize areas for involvement.

The assessment involves calculating emissions using established formulas, emission factors, and global warming potentials. For scope 1 emissions, factors such as fuel type, consumption volume, and combustion efficiency are considered. For scope 2 emissions, the focus is on electricity usage and associated transmission and distribution losses. These calculations provide a clear picture of the GHG emissions in terms of CO_2 eq, a standardized unit that accounts for the varying global warming potentials of different gases (IPCC, 2014).

Figure 3: Global warming potential values relative to CO2



Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265

1.1.3 Global and National Context

Globally, the conversion to low-carbon industrial practices is in advance momentum as countries struggle to meet their climate commitments under the Paris Agreement. The agreement aims to limit global temperature rise to well below 2°C, with efforts to cap it at 1.5°C above pre-industrial levels. Achieving these targets requires substantial reductions in GHG emissions, particularly from high-emission sectors such as energy, transportation, and industry.

1.1.4 Challenges in Managing Carbon Emissions

Managing carbon emissions in industrial zones poses several challenges. First, the lack of reliable data on energy usage and emissions can delay the development of effective mitigation strategies. For KIP, the absence of a comprehensive CFP assessment restricts the ability to identify major emission sources and prioritize interventions. Second, transitioning to cleaner energy sources and improving energy efficiency require important investments in technology, infrastructure, and capacity building. Industries often face financial and technical limitations in adopting such measures.

Finally, develop a culture of sustainability within industrial zones requires strong stakeholder engagement, including collaboration among industries, government agencies, and local communities. Building awareness about the benefits of reducing carbon emissions and encouraging collective action are critical for long-term success (Finkbeiner *et al.*, 2009).

1.1.5 Importance of the Study

This study emphasizes the critical need for a CFP assessment of KIP, providing a foundation for sustainable industrial development in Sri Lanka. By quantifying scope 1 and scope 2 emissions, the study will highlight key areas for improvement and propose actionable strategies to reduce the park's CFP. The findings will also contribute to broader deliberations on how industrial zones can balance economic growth with environmental responsibility.

Furthermore, the study aligns with Sri Lanka's climate commitments and supports the global transition to a low-carbon economy. By adopting the recommendations from this study, KIP can serve as a model for other industrial parks in the country, representative the possibility and profits of integrating sustainability into industrial operations.

1.2 Problem Statement

According to an intensive literature review conducted on a global, regional and local scale, there are very few peer-reviewed publications related to sedge ecosystems available. The industrial sector is one of the largest contributors to global GHG emissions, playing a crucial role in driving climate change. Carbon emissions from industrial activities, including direct fuel combustion and electricity consumption, significantly contribute to global warming. Sri Lanka, a nation highly vulnerable to climate change faces increasing risks. These challenges are particularly acute given the country's reliance on industrial development for economic growth and employment. Despite global commitments to mitigate climate change under frameworks such as the Paris agreement, there is a growing gap between industrial growth and sustainability practices in developing nations. The park's operations generate substantial carbon emissions, primarily from scope 1 sources and scope 2 sources. These emissions not only contribute to Sri Lanka's GHG inventory but also pose challenges to local air quality, public health, and long-term environmental sustainability.

Furthermore, existing practices within the park depend on heavily on non-renewable energy sources and inefficient energy consumption, intensifying the environmental impact. Without targeted interventions, the continued growth of industrial activities in KIP is likely to result in intensifying emissions. Eventually, the lack of a CFP assessment and corresponding mitigation strategies for KIP underscores the need for this research. By addressing these gaps, the study will contribute to a broader understanding of how industrial zones in Sri Lanka can balance economic growth with environmental responsibility. It will also provide a model for other industrial parks in the country to adopt sustainable practices, ensuring that industrial development aligns with the global imperious to combat climate change.

1.3 Objectives

1. Calculate the impactful factor of carbon emissions within the KIP
2. Analyze of emission sources
3. Evaluation of Energy-related emissions
4. Development of mitigation strategies
5. Support for climate change Goals

2. METHODOLOGY

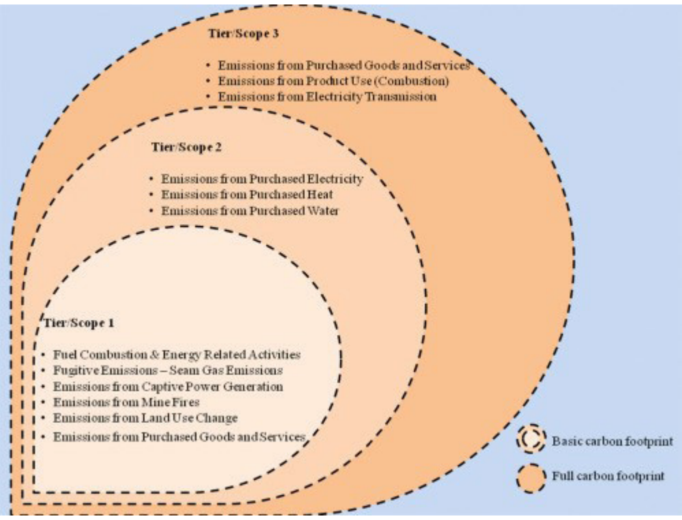
The study engages a quantitative approach to estimate GHG emissions within the operational boundaries of the KIP. It focuses on direct (scope 1) and indirect (scope 2) emissions, aligning with internationally recognized standards such as the GHG Protocol and IPCC Guidelines for National GHG Inventories.

2.1 Justification

According to the theoretical method to calculate CFP, scope 1, Scope 2, and Scope 3 were recommended. However, considering the deep analysis of park activity responses to the CFP, it has revealed that Scope 1 and Scope 2 are the most impactful emission types. The case study was selected the KIP as boundary. There in Scope III were disregarded.

Figure illustrates the three tiers in CFP estimation. The tiers II and III both include indirect emissions, but tier II refers to the emissions embodied in energy production or (and) purchase, transmission, and distribution caused by the entity under consideration, but end user emissions are out of scope of tier II (Dada et al., 2008). Tier III tends to cover all the embodied emissions within the specified boundary. But tier III has vaguely been defined and the most CFP studies limit up to tier II as it becomes too complex to estimate CFP beyond tier II with accuracy (Matthews et al., 2008). Also, it is important to be ascertained that to what extent responsibility and control over emissions can be made beyond tier II (Lenzen 2001). For this reason, most GHG accounting standards (PAS-2050, GHG protocol, and other registries and consultancies based on these) have kept tier III optional (Pandey *et al.*, 2011).

Figure 4: Three tiers in carbon footprint estimation



2.2 Data Collection

Primary data sources were fuel consumption data and electricity consumption records. Records of diesel and petrol usage by industrial facilities and vehicles within KIP. Data was gathered from monthly fuel logs provided by industries. Monthly electricity bills and consumption logs provided by industrial units. Secondary data sources were emission 2

2.3 GHG Emission Calculations

The intense increase in the world temperature is due to the enhanced greenhouse effect (besides the natural one) resulting from the emission of GHGs by human activities. Not all GHGs are capable of the same amount of warming but their ability is dependent on the radiation that it triggers and the time at which that gas molecule persists in the atmosphere. When taken together the average amount of warming that arises from it is known as its 'Global warming potential' (GWP) and this is computed mathematically and is normally relative to that of CO2. It follows that the unit of GWP is carbon-dioxide-equivalent or CO2-e for short (Pandey et al., 2011).

Based on the data collected within the KIP study boundaries, the results are as follows:

Scope 1 Calculations

Equation 1:

GHG emissions = Fuel consumption × Density × Net calorific Value × Emission Factor

Equation 2:

CO_2 eq = Emissions × Global Warming Potential

GHG emissions from Diesel = 38,144.89 CO_2eq (MT)

GHG emissions from Petrol = 4,630.74 CO_2eq (MT)

GHG emissions from Diesel/ Petrol= $CO_2 + CH_4 + N_2O$ emissions

GHG emissions = CO_2 eq (kg)

Scope 1 GHG emissions = Emissions from Diesel + Emissions from Petrol

= 42,775.63 CO_2eq (MT)

Scope 2 Calculations

Equation 3:

Emissions due to electricity= CO_2 emissions during generation+ Emissions due to T & D loss (T & D loss - Transmission and Distribution Loss = 8.72%)

Scope 2 GHG emissions = 1,574,565.50 CO_2eq (MT)

GHG Emissions (Scope 1 + Scope 2) = 42,775.63 + 1,574,565.50

= 1,617,341.13 CO_2eq (MT)

3. RESULTS AND DISCUSSION

The assessment of GHG emissions according to the S1 and S2 at the KIP revealed a carbon footprint of 1,617,341.13 CO_2 eq (MT). This figure reflects the substantial environmental impact of the park's industrial activities and highlights the critical need for sustainable practices within such zones.

Scope 1 emissions, totaling 42,775.63 CO_2 eq (MT), were primarily attributed to the combustion of diesel and petrol in vehicles and machinery operating within the park. These emissions represent direct GHG outputs from fuel usage in various industrial processes and transport systems. The reliance on fossil fuels for these activities is a significant contributor to localized air pollution and GHG emissions, underscoring the importance of transitioning to cleaner energy sources, such as biofuels or electric vehicles, to reduce the direct carbon footprint.

Scope 2 emissions accounted for the majority of the park's carbon footprint, amounting to 1,574,565.50 CO_2 eq (MT). These emissions result from electricity consumption by industries within the park, including losses incurred during transmission and distribution. The dominance of scope 2 emissions reflects the heavy dependence of industrial operations on grid-supplied electricity, which in Sri Lanka is predominantly generated from fossil fuels. This reliance not only amplifies the park's carbon footprint but also exposes it to vulnerabilities associated with fluctuating energy prices and potential grid instability.

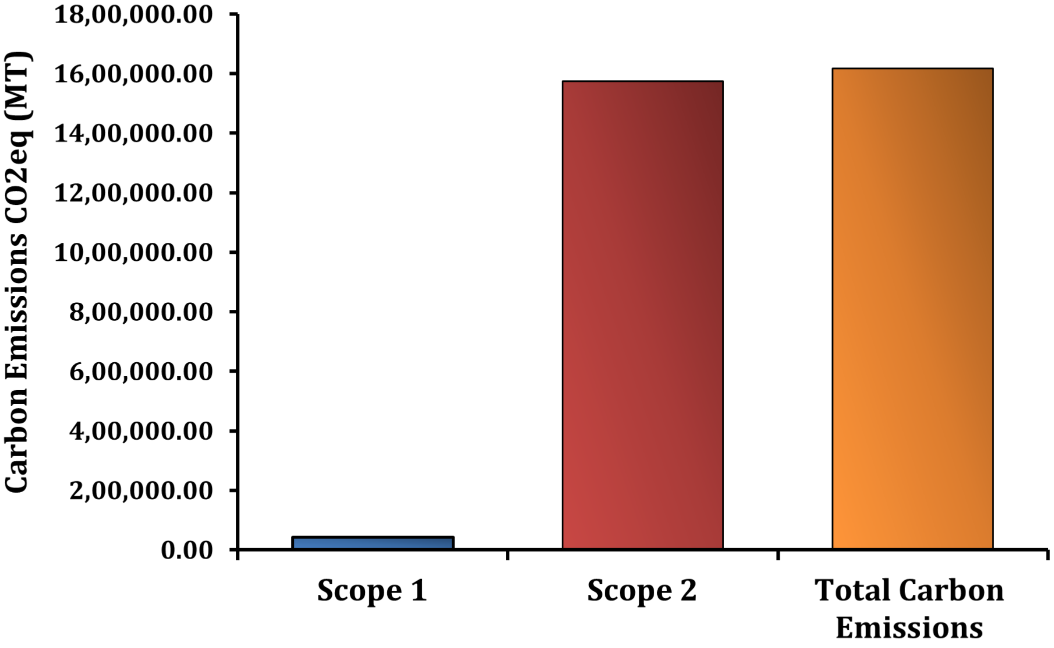
These findings emphasize the critical need for KIP to transition to renewable energy sources, such as solar or wind power, which are well-suited to the region's climatic conditions. Renewable energy systems can significantly reduce the park's scope 2 emissions by providing clean, sustainable alternatives to conventional grid electricity. Moreover, implementing on-site renewable energy solutions, such as solar photovoltaic systems or small-scale wind turbines, can enhance energy security and reduce transmission losses, further decreasing the park's overall emissions.

Improving energy efficiency within the park is another key strategy for mitigating Scope 2 emissions. Energy audits, optimization of industrial processes, and the adoption of energy-efficient technologies, such as LED lighting and high-efficiency machineries, can substantially reduce electricity consumption. Additionally, regular maintenance of machinery and equipment can prevent energy wastage and ensure optimal performance.

These findings also underscore the broader role of industrial parks like KIP in contributing to national GHG inventories. As significant emission sources, such zones must adopt targeted interventions to align with Sri Lanka's NDCs. Measures such as incentivizing renewable energy adoption, implementing carbon pricing mechanisms, and promoting collaborative efforts among industries are essential for achieving meaningful emission reductions.

The assessment not only highlights the urgent need for immediate action but also serves as a call to reimagine the operational models of industrial parks in the context of sustainability. By prioritizing renewable energy, enhancing energy efficiency, and adopting innovative carbon management practices, KIP can position itself as a leader in sustainable industrial development, setting a benchmark for other industrial zones in Sri Lanka and beyond (Stephen *et al.*, 2014).

Figure 5: Carbon Emission of KIP



3.1 Action to Minimize the Impact and Assess the Effectiveness of Natural Carbon Absorbance

3.1.1 Nature-Based Solutions

Addressing the impact of carbon emission of the KIP necessitates the adoption of integrated and innovative strategies. Among the various approaches considered, afforestation through the plantation of Mee trees (*Madhuca longifolia*) emerged as a central mitigation effort due to its proven ecological and carbon sequestration benefits. Mee trees, native to Sri Lanka, are well-suited for afforestation projects due to their resilience, adaptability to local climatic and soil conditions, and significant ecological benefits.

In 2023, a total of 300 Mee saplings were strategically planted across the Kandy Industrial Park as part of a broader green infrastructure initiative. The selection of plantation sites was guided by considerations of land availability, soil fertility, and proximity to emission sources, ensuring optimal growth conditions and maximum carbon sequestration potential. Then calculation has been carried out assuming all 300 Mee trees are matured after 5 years of period.

300 Mee Plants in the KIP

If a Mee plant grows to a height of 10m and has a tree trunk diameter of 12 inches by 5 years.

$10m = 10 \times 3.28084\, ft = 32.8084\, ft$

If Diameter > 11 *inches,* $W = 0.15 \times D^2 \times H$

Green Weight (Overground) $= 0.15 \times (\text{Diameter in inches})^2 \times (\text{Height in foot})$

$= 0.15 \times (12)^2 \times 32.8084$

$= 708.66\, lb$

The root weight is about 20% of the total weight

$\therefore$ *Total Green Weight =1.25 × (Green Weight Overground)*

According to research, a tree has about 27.5% water

$\therefore$ *Dry weight of a tree = 1.25 × (Green Weight Overground) × 72.5%*

$= 1.25 \times 708.66\, lb \times 72.5\%$

$= 642.22\, lb$

The weight of Carbon of a tree is about 50% of its dry weight

$\therefore$ *Carbon content in a tree is about* $= 642.22\, lb \times 50\%$

$= 321.11\, lb$

The Carbon in the tree is from the CO_2 *absorbed by the tree during its lifetime*

Carbon in 1 pound of CO_2 *= 12/44 lb*

The Sequestration of $CO_2 = 321.11\ lb \times \frac{44}{12}$

$= 1177.41\ lb$

1 lb=0.45 kg

$\therefore$ *Sequestration of* CO_2 *in 5 years* $= 1177.41 \times 0.453\ kg$

$= 533.37\ kg$

$\therefore$ *Average Annual Sequestration of* $CO_2 = \frac{533.37kg}{5}$

$= 106.67\ kg$

Average Annual Sequestration of CO_2 *for 300 such plants*

$= 106.67\ kg \times 300$

$= 32002.04\ kg$

For 300 Mee trees, these calculations revealed a substantial capacity to sequester atmospheric CO2, translating into an annual offset that partially mitigates the industrial park's carbon emissions. The estimated carbon sequestration by the fifth year highlights the potential of nature-based solutions in industrial decarbonization efforts.

3.1.2 Energy Conversion

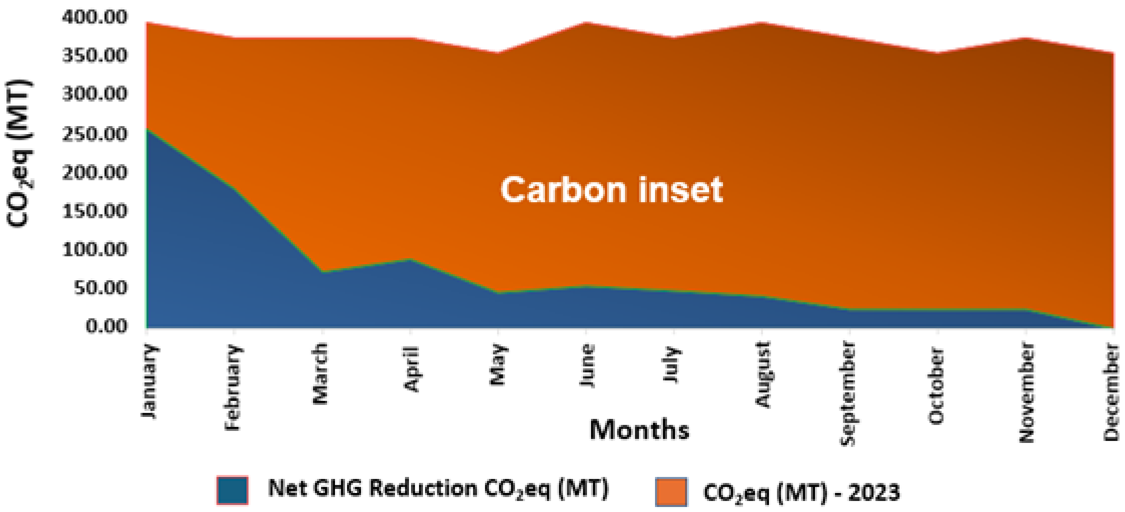
The KIP is home to numerous large-scale industries, primarily apparel manufacturing, which generates approximately 2400 kg/day of fabric waste. In early 2023, Sri Lanka's sole IV fluid manufacturing facility, Kelun Life Sciences (Pvt) Ltd, faced operational challenges due to its reliance on fossil fuel-dependent energy, consuming around 5000 liters of diesel daily.

In response, the BOI developed an efficient system to address these issues by implementing an industrial symbiotic Waste-to-Energy (WtE) boiler. This collaborative project between the BOI and Kelun Life Sciences (Pvt) Ltd utilizes industrial waste, such as fabric offcuts, as fuel for energy production, thereby reducing fossil fuel dependency and promoting sustainability ((Shashini *et al.*, 2019).

The WtE boiler system within KIP has significantly improved energy conversion practices. By leveraging waste derived biomass fuels, such as fabric waste, and integrating advanced combustion technologies, the system achieves high thermal efficiency while minimizing GHG emissions. This innovative approach not only balances carbon emissions but also aligns with circular economy principles by converting industrial waste into a sustainable energy source.

Based on the implemented mitigation measures for GHG emissions, the following reductions have been achieved.

Figure 6: GHG Emission Reduction



4. CONCLUSION AND RECOMMENDATIONS

The CFP assessment for KIP highlights the urgent requirement for adopting sustainable practices to mitigate GHG emissions and align with global environmental goals. The analysis revealed CFP of 1,617,341.13 CO_2eq (MT) with scope 1 emissions contributing 42,775.63 CO_2eq (MT) and scope 2 emissions accounting for 1,574,565.50 CO_2eq (MT). These findings underscore the significant impact of electricity consumption and fuel combustion within the park, emphasizing the need for immediate intervention and long-term sustainability measures. Industrial parks have emerged as a pivotal strategy for advancing economic development across countries. For example, they provide centralized infrastructure and services, reduce logistic costs, and promote industrial clustering, which enhances efficiency and innovation (Dong *et al.*, 2013). However, the energy-intensive nature of industrial operations poses several challenges, including resource depletion, and environmental degradation, and contributes to global climate change (Geng and Cote, 2004). At KIP, these challenges are particularly evident in the high levels of electricity consumption, which account for most of its CFP, and the reliance on fossil fuels for industrial processes and transportation. These practices not only deplete finite energy sources but also exacerbate local air pollution and strain the ecological balance of the sensitive surrounding area.

The KIP's dependency on traditional energy sources underscores the need for transformative measures. The following strategies are recommended to address these challenges:

1. Power the region's climatic conditions to adopt solar power, while properly evaluating the feasibility of such initiatives, including the initial costs, technological requirements, and potential barriers such as grid integration and regulatory constraints. These sources can significantly reduce Scope 2 emissions and enhance energy independence.
2. Conduct regular energy audits, optimize industrial processes, and adopt cleaner production technologies to minimize energy wastage and reduce operational costs.
3. Encourage the use of biofuels and electric vehicles to reduce Scope 1 emissions restricting direct fuel consumption.
4. Establish comprehensive monitoring frameworks to track GHG emissions and evaluate the effectiveness of implemented mitigation strategies.

By implementing these recommendations, KIP can substantially lower its carbon footprint, setting an example for other industrial zones in Sri Lanka. Expected outcomes include a measurable reduction in scope 1 and scope 2 emissions by 25% within the next five years, increased reliance on renewable energy sources, and enhanced energy efficiency across operations. These metrics will serve as benchmarks to evaluate the success of KIP's sustainability initiatives. Such actions not only contribute to the nation's climate change mitigation efforts but also enhance KIP's reputation as a leader in sustainable industrial development. Moreover, these measures align with global sustainability objectives, ensuring long-term economic and environmental benefits.

Acknowledgments

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