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LOW CARBON TRANSPORTATION GUIDELINES FOR THE FOOD SECTOR

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As globalization drives the expansion of supply chains, food products are often sourced from distant locations and transported across vast distances to meet consumer demand. This international movement of goods, coupled with the rise in fast, efficient food delivery, has resulted in a heavy dependence on high-carbon transportation methods. The food sector, with its complex global supply chains and frequent use of fossil fuel-powered vehicles, is a major contributor to greenhouse gas emissions. By adopting low-carbon transport solutions, the food sector can reduce its carbon footprint, mitigate the environmental impacts of global supply chains, and play a key role in combating climate change. This shift not only sets a new standard for sustainable business practices in the food sector but also helps businesses reduce costs and enhance long-term resilience in an increasingly interconnected world.

This **Low Carbon Transportation Guidelines for the Food Sector** is a part of the Series of Tools for Integrating Sustainable Consumption and Production into the Food Sector in Thailand, which consists of three guidelines:

1. Food Loss and Food Waste Reduction Guidelines for the Food Sector,
2. Single-Use Packaging and Tableware Reduction Guidelines for the Food Sector, and
3. Low Carbon Transportation Guidelines for the Food Sector.

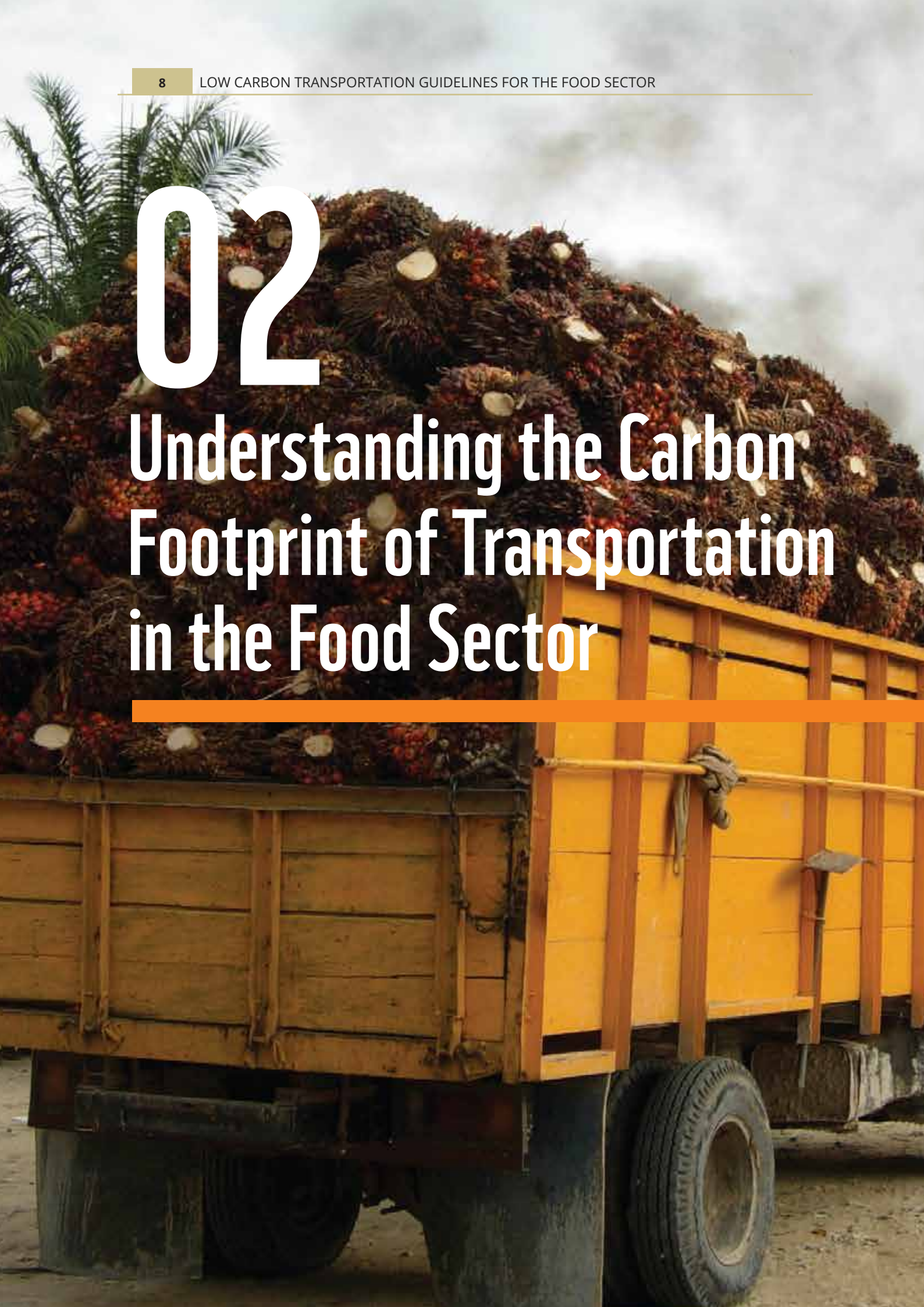
This series of SCP Tools was developed under the IKI SCP Phase II Project on Establishing SCP—initiated by WWF Thailand, with support from the International Climate Initiative (IKI) and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). The project is dedicated to fostering SCP practices within Thailand's food industry, focusing on chain restaurants, food retailers, and food delivery services.

TABLE OF CONTENTS

01 Executive Summary

The food sector in Thailand, including chain restaurants, food retailers, and food delivery services, is a critical part of the economy, but it also plays a significant role in contributing to carbon emissions, especially through transportation. With growing global awareness around climate change and the need for more efficient and sustainable practices, transitioning towards low-carbon transportation is an urgent priority. The food industry is a key sector to leverage in this shift due to its size and large contribution to carbon emissions. This tool is designed to assist businesses in Thailand's food sector to understand and implement solutions to reduce their carbon footprint while maintaining operational efficiency.

This guideline serves as an easy-to-follow resource for restaurants, food retailers, and food delivery services in Thailand by providing clear, actionable steps to transition toward low-carbon transportation. It simplifies the problem of carbon emissions in transportation by breaking down its impact on the environment and the economy, while also highlighting the benefits of adopting sustainable practices. This guideline offers practical solutions to help businesses reduce their reliance on fossil fuels while making the shift toward more sustainable transportation models. By providing a how-to format, the guide makes it easy for businesses to understand their role in reducing emissions and the steps they can take to improve sustainability in their logistics operations ensuring a brighter, greener future for Thailand's food industry.



02 Understanding the Carbon Footprint of Transportation in the Food Sector

Climate Change

Climate change is one of the most pressing issues of our time. ***Climate change*** *refers to the lasting changes in global temperature and weather patterns driven primarily by human activities since the Industrial Revolution.* One of the primary characteristics of this human-induced climate change is ***global warming,*** *the steady increase in Earth's average surface temperature largely due to increasing amounts of greenhouse gasses (GHGs) in the atmosphere.*

Greenhouse gasses *include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases (F-gases) and water vapor (H_2O). These gasses act like a blanket around the earth and trap heat from the sun, preventing it from escaping into space and thus warming the planet*. While water vapor is a naturally occurring greenhouse gas, its concentration increases as the atmosphere warms, thus further amplifying the greenhouse effect. While rising global temperatures are the most commonly known impact of global climate change, the implications of climate change on the planet and its ecosystems is drastic. Some impacts of climate change include melting polar ice caps, rising sea-levels, as well as more frequent and intense extreme weather events.

Climate change impacts have economic and social implications as well as environmental ones, affecting nearly every aspect of society. Economically, climate change leads to increased costs from damage to infrastructure caused by extreme weather events, such as floods, hurricanes, and wildfires. Rising sea levels threaten coastal cities, impacting real estate, tourism, and local economies. Agricultural productivity is also negatively affected, leading to higher food prices, loss of livelihoods for farmers, and food insecurity. Socially, climate change exacerbates existing inequality, as disadvantaged communities often bear the brunt of its impacts and they have limited resources to recover from these impacts. Health issues and associated costs also rise due to increased heat waves, the spread of diseases, and air pollution. In the long term, these effects are expected to increase as global temperatures rise and climate change impacts intensify.

Carbon Emissions and Carbon Footprint

One of the often-discussed impacts of human activities is the release of ***carbon emissions,*** *or the release of carbon dioxide and other greenhouse gasses,* into the atmosphere. Burning fossil fuels for transportation, electricity and industry are the largest source of carbon emissions. Methane and nitrous oxide also contribute significantly, particularly from agriculture and waste management. These emissions accelerate global warming by increasing the concentration of greenhouse gasses in the atmosphere, thereby further increasing global temperatures and exacerbating climate change.

One way to make carbon emissions more relatable is to express them in terms of the number of trees needed to absorb emissions generated by a particular activity. ***Trees*** *act as natural* ***carbon sinks,*** *meaning they absorb carbon dioxide from the atmosphere and store it in the tree as they grow larger and larger.*

On average, a mature tree can absorb about 10 kg of CO_2 per year.[1]

By comparing various sources of emissions to the equivalent number of trees required to absorb the carbon emissions released by those activities, it becomes easier to understand the environmental impact of everyday activities.

Carbon emissions of various human activities and products can be measured and expressed as a ***carbon footprint.*** *It is a measure of the total amount of greenhouse gasses, primarily carbon dioxide, that are emitted directly or indirectly* as a result of energy consumption, transportation, manufacturing, and food production when engaging in an activity or in the production of a product. *Carbon emissions are often expressed as in metric tons of carbon dioxide and can be estimated for different activities, products, or services using a* ***carbon footprint calculator.*** Reducing carbon footprints through energy efficiency, renewable energy, and sustainable practices is critical in addressing the issue of climate change and a primary concern for both the private and public sector.

[1] Bennet, Ross. (2023). *How Much CO_2 Does a Tree Absorb?* One Tree Planted. https://onetreeplanted.org/blogs/stories/how-much-co2-does-tree-absorb

One approach to addressing the environmental impact of greenhouse gas emissions is to use ***carbon offsets.*** *This involves supporting projects that remove or reduce an equivalent amount of carbon from the atmosphere,* such as renewable energy, reforestation, and carbon capture initiatives. **However, it is recommended to prioritize direct, in-value-chain emissions reductions as the most impactful approach.**

While offsets can complement these efforts by addressing residual emissions, this guideline primarily focuses on strategies to reduce emissions from transportation in the food sector, emphasizing on direct carbon footprint reductions within business operations.

Net Zero

Net zero *is the internationally agreed upon goal for mitigating global warming as the Intergovernmental Panel on Climate Change (IPCC) concluded the need for net zero by 2050 to keep global warming within 1.5 °C.* ***Net zero*** *refers to "a state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere."*[2] The target strives to prevent the worst climate damages due to human-caused emissions and is emphasized by the Paris Agreement signed by UN member states in 2016.

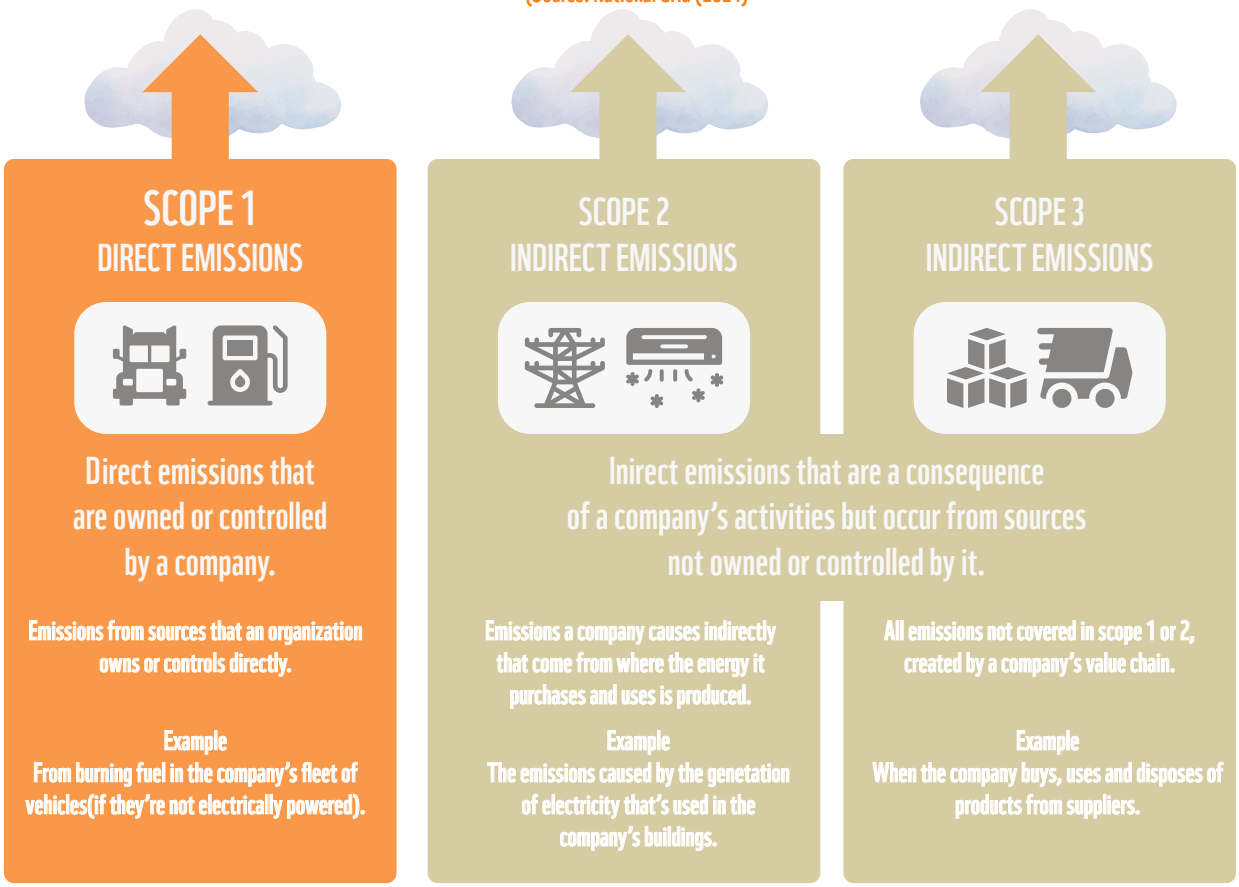
For the purposes of understanding and measuring emissions, there are three scopes of emissions that are discussed. These scopes are essentially the types or categories of carbon emissions.

Scope 1 emissions *from sources that an entity owns or controls directly.*
Scope 2 emissions *are emissions that an entity causes indirectly and are related to where the energy purchased and used is produced.*
Scope 3 emissions *are emissions that are not produced by the entity itself and are not the product of activities from assets owned or controlled by them, but up or down its value chain.* **Figure 1** summarizes these scopes and provides an example of each. These scopes can be used by businesses to understand their emissions and their value chain emissions and focus their efforts strategically to effect the greatest reduction in emissions.

[2] Oxford Net Zero. (n.d.) *What is Net Zero?* https://netzeroclimate.org/

Figure 1: Three Scopes of Carbon Emissions

(Source: National Grid (2024)



Although the Paris Agreement sets a global objective for reaching net zero by 2050, the actions needed to achieve that object is undertaken at the national level. **Countries party to the Paris Agreement are responsible for setting policies and taking appropriate action to achieve the common goal of achieving net zero.** As party to the agreement,

Thailand has set the goal for carbon neutrality by 2050 and net zero greenhouse gas emissions by 2065 in its nationally determined contribution (NDC) submitted in 2022.

In keeping with these targets, the food sector is poised to play a key role in moving Thailand towards its net zero goals.

Globalization in the Food Sector

Globalization and the increasing interconnectedness and interdependence of countries that characterizes it has resulted in a global supply chain across various industries. The food sector is no exception. As a result of globalization, the food industry has completely transformed how food is produced, distributed, and consumed. The global supply chain allows for the exchange of agricultural products, processed foods, and ingredients from every corner of the world, even allowing access to nonseasonal and exotic food products to consumers worldwide.

However, globalization's impact on the food industry also comes with a myriad of challenges. It has intensified the complexity of supply chains, making food transportation over long distances more common.

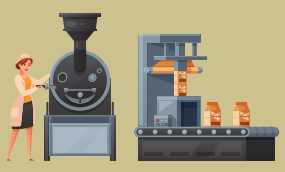
This results in higher carbon emissions due to the reliance on fuel-intensive transportation methods like air transport. Additionally, globalization has encouraged greater industrialization of agriculture to provide efficiencies of scale often at the detriment of sustainability.

Some of the negative impacts of the globalization of the food system include environmental degradation, deforestation, and biodiversity loss. Thus, **while globalization has broadened the food industry's reach and consumer choices, it has also raised questions about the sustainability of global food systems and the environmental costs associated with transporting food over vast distances.**

Coffee: an example of globalization in the food value chain

The process typically begins with coffee beansbeing grown in tropical countries like Brazil, Colombia, or Ethiopia.

Once harvested, the beans are processed and dried locally in the origin country before being exported to countries like the U.S., Germany, or Japan to be roasted and packaged.



From there, the roasted coffee is distributed to retailers, cafes, or directly to consumers worldwide.

The entire value chain involves various stages of transportation, energy use, and processing, making it an example of a highly globalized and interconnected food product.

Transportation in the Food Sector

Globally, the food sector accounts for roughly 26% of the 52.3 billion tons of carbon emissions released annually.[3] Transportation is a critical component of the food industry that connects producers, manufacturers, and consumers across local, regional, and global supply chains. From farm to table, food products must be efficiently moved to ensure freshness and meet consumer demand. The journey of food products from farm to fork involves numerous stakeholders, including farmers, manufacturers, logistics companies, and retailers, all contributing to the final product available in supermarkets or restaurants.

Greenhouse gas emissions from transportation primarily come from burning fossil fuel.

Over 94% of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel and results in direct emissions.[4]

The transportation sector is the largest source of direct greenhouse gas emissions.

Various modes of transportation, such as land, air, and sea, are utilized depending on the type of food, distance, and time sensitivity, with varying degrees of environmental impact. **As the food industry continues to grow and globalize, transportation plays an increasingly significant role in determining the accessibility, affordability and sustainability of food.** These issues raise important questions about how to balance the need for efficiency and accessibility with the need to reduce the food industry's carbon footprint.

Carbon emissions from the transportation in the food sector being a rather significant portion of the total carbon emissions from the sector. **A 2020 study suggested that transport accounts for about 19% of total carbon emissions from the food system.**[5] One way to lessen the amount of carbon

[3] Poore. J. and Nemecek, T. (2018). *Reducing Food's Environmental Impacts Through Producers and Consumers.* Science. 360 (6392) 987-992.
[4] Intergovernmental Panel on Climate Change. (2022). *Climate Change 2022: Mitigation of Climate Change.* Cambridge University Press.

emissions from the food sector is to emphasize sourcing and consuming food products that are grown, produced, and distributed within a specific region or country.

Additionally, the local food movement encourages consumers to be more conscious of the origins of their food and strengthens the connection between food origins and the community.

Local food systems minimize the distance between producers and consumers and are often associated with fresher produce, reduced carbon footprints due to shorter transportation distances, and stronger local economies.

The production, processing and consumption of Thai-grown coffee: an example of a locally produced product in Thailand

Coffee beans are cultivated, harvested and processed in the highlands of northern Thailand, particularly in regions such as Chiang Mai, Chiang Rai, and Mae Hong Son. These areas have the cool climate and rich soil that provides ideal conditions for coffee cultivation.

The coffee is sold to cafes, markets, and retailers throughout Thailand. These coffees are often marketed as a premium, locally sourced product.

This Thai-grown coffee value chain not only supports Thai farmers but also reduces the environmental impact associated with importing coffee from other countries and aligns with the local food movement. Thai consumers can enjoy a high-quality, locally grown product while contributing to the sustainability of their own agricultural sector.

[5] Li, Mengyu; Jia, Nanfei; Lenzen, Manfred; Malik, Arunima; Wei, Liyuan; Jin, Yutong; Raubenheimer, David (June 2022). *Global food-miles account for nearly 20% of total food-systems emissions.* Nature Food. 3 (6): 445–453.

Transportation Method

The food sector relies primarily on three modes of transportation: air, water, and land. Each of these modes of transport vary in terms of speed, costs, fuel consumption and carbon emissions. A ***ton-kilometer*** *is a unit of measurement for freight transportation of 1 ton of cargo over a distance of 1 kilometer.*

Air transport is the fastest option, commonly used for perishable or high-value food items such as seafood, fruits, and flowers. However, it is also the most expensive and has the highest carbon emissions, with air freight emitting about 500 grams of CO_2 per ton-kilometer, making it a significant contributor to climate change.

Water transport, such as shipping, is the most cost-effective way to move large quantities of food products, like grains and non-perishable goods, over long distances. It has relatively low carbon emissions compared to air, at around 10-40 grams of CO_2 per ton-kilometer, but it is slower and can delay the delivery of perishable items.

Land transport, which includes trucks and trains, is commonly used for both short and medium distances. Trucks emit around 100-150 grams of CO_2 per ton-kilometer, making them more efficient than air but less so than water transport. Trains offer a lower-emission alternative for land-based transport, emitting around 25 grams of CO_2 per ton-kilometer, but may not be as flexible in terms of direct routes.

Each mode of transportation plays an important role in the global and local food supply chain, but balancing cost, speed, and environmental impact is key to creating a more sustainable food logistics system.

While the majority of transportation vehicles have combustion engines and run on fossil fuels, there have been technological advancements in shifting towards electric and hybrid vehicles. ***Electric vehicles (EVs)*** *are powered entirely by electricity, producing zero emissions during operation.* EVs can be ***battery EVs*** or ***hydrogen fuel cell EVs,*** *although both are run on electricity, one has electricity stored in the battery while the other generates electricity onboard using hydrogen.* Hydrogen fuel cell is a clean and sustainable option but requires infrastructure development and improvements in technology. ***Hybrid vehicles*** *combine an internal combustion engine with an electric*

motor. This combination offers improved fuel efficiency and reduced emissions compared to conventional combustion engine vehicles.

When considering electric vehicles (EVs), the source of the electricity used to charge them plays a critical role in determining their overall carbon emissions.

Although EVs produce zero tailpipe emissions during operation, the carbon footprint of the electricity they consume varies significantly depending on how that electricity is generated.

If the electricity comes from renewable sources like wind, solar, or hydropower, the EV's overall emissions are minimal, contributing positively to reducing greenhouse gasses. However, if the electricity is derived from fossil fuels such as coal or natural gas, the EV's carbon footprint increases, as these energy sources release substantial amounts of carbon dioxide during power generation. In regions where the electricity grid relies heavily on fossil fuels, the environmental benefit of EVs can be reduced.

Therefore, to maximize the potential of EVs to reduce carbon emissions, transitioning to cleaner, renewable energy sources is essential for charging infrastructure.

Fuel Types

The majority of transportation vehicles are powered by fossil fuels. ***Fossil fuels*** *are a non-renewable energy source formed from the remains of ancient plants and animals that were buried and subjected to heat and pressure over millions of years.* These fuels, which include coal, oil, and natural gas, are composed primarily of carbon and hydrogen.

When burned, fossil fuels release energy, but they also emit significant amounts of carbon dioxide and other greenhouse gases.

The use of fossil fuels and the subsequent release of carbon emissions has resulted in global warming and climate change.

With increasing costs and the need to conserve fossil fuels, there has been the development of alternatives, such as biofuels. ***Biofuels*** *are fuels derived from biological sources like plants or waste, offering a lower carbon footprint than traditional fossil fuels.* Biofuels are a renewable energy source since they can be produced relatively quickly from living organisms or waste products. **While biofuels still release carbon dioxide when burned, the plants used to produce them absorb carbon dioxide during their growth. This can partially offset the emissions and results in a lower net carbon footprint compared to fossil fuels.** However, one issue with biofuels is that if they are not sustainably produced, they can lead to deforestation, water usage issues, and food insecurity due to competition with food production. **Table 1** compares different types of fuels based on their carbon emissions as well as the number of trees needed in one year to offset emissions from burning 1,000 liters of that fuel. Following the table, an example of the calculations is provided.

Example Calculation (for Diesel):

1. CO_2 Emissions per Liter: 2.68 kg.
2. Emissions for 1,000 Liters: 2.68 kg/L x 1,000 L = 2,680 kg.
3. Trees Needed to Offset: 2,680 kg ÷ 10 kg/tree/year ≈ 268 trees.

Table 1: Comparison of Fuel Types in Terms of Carbon Emissions and Number of Trees Needed to Offset 1,000 Liters of Emissions

Fuel Type	CO_2 Emissions (kg/L)	Emissions per 1000 Liters(kg)	Trees Needed to Offset (per year)
Diesel	2.68	2,680	~268
Gasoline (Benzene)	2.31	2,310	~230
Methane (Biofuel)	2.75	2,750	~275
Ethanol (Biofuel)	1.91	1,910	~191
Propane (Biofuel)	1.51	1,510	~151
Biodiesel (Biofuel)	2.50	2,500	~250
Gasohol (E10)	2.30	2,300	~230
Renewable Energy (EVs)	0 (during use)	0	0

(Source: U.S. Environmental Protection Agency, 2021 and Intergovernmental Panel on Climate Change, 2019)

Note: The calculations in this table are calculated based on the estimate that the average tree absorbs 10 kg of CO_2 per year for the first 20 years.[6]

Technological advances have been made in the areas of Renewable energy-powered transportation that are key to reducing the carbon footprint of transportation. ***Renewable energy-powered transportation*** *refers to the use of vehicles and transportation systems that are powered by energy generated from renewable sources such as solar, wind, hydro, or geothermal power.* These energy sources are naturally replenished and produce little to no greenhouse gas emissions during

Examples of renewable energy -powered transportation include EVs charged using renewable energy, electric trains, and public transit systems that rely on renewable power grids. While further development and investment in infrastructure is required, a shift towards renewable energy-powered transportation will play a major role in decreasing society's reliance on fossil fuels and lowering carbon emissions due to transportation.

[6] Bennet, Ross. (2023). *How Much CO_2 Does a Tree Absorb?* One Tree Planted. https://onetreeplanted.org/blogs/stories/how-much-co2-does-tree-absorb

Environmental, Economic and Societal Implications of the Carbon Footprint of Transportation in the Food Sector

Environmental Implications

The transportation of food products contributes significantly to the overall carbon footprint of the food sector. This is particularly relevant in cases where food is sourced from distant locations or when inefficient logistics systems are used. Nowadays it is common to have a global supply chain to meet consumer demands for food products. The environmental consequences of the carbon footprint of transportation includes greenhouse gas emissions and air pollution.

The burning of fossil fuels by vehicles releases carbon dioxide, methane, and nitrous oxides into the atmosphere, exacerbating climate change and its related impacts. The food sector is a major contributor to carbon emissions, especially through long-haul transportation of perishable goods in the global supply chain. In addition to carbon emissions, food transportation often leads to the release of pollutants such as nitrogen oxides and particulate matter, which degrade air quality and harm ecosystems. Addressing these environmental impacts is critical to ensuring the long-term sustainability of the food sector and mitigating climate change.

Shifting to vehicles that do not use or reduce use of fossil-fuels such as electric vehicles (EVs), hybrid vehicles, or biofuels can lower greenhouse gas emissions. This helps mitigate climate change and reduces the carbon footprint due to transportation, especially if the electricity source is based on renewable energy and not fossil fuels.

Another benefit to these vehicles is the lower emissions from vehicles, particularly in urban areas, resulting in better air quality by reducing pollutants such as nitrogen oxides and particulate matter.

Economic Implications

The carbon footprint of transportation in the food sector also translates into significant economic costs for businesses, consumers, and governments. These costs include fuel expenses, regulatory compliance, and supply chain inefficiencies. High carbon transportation methods, such as using traditional diesel or gasoline-powered vehicles, are associated with rising fuel costs as gasoline supplies dwindle.

Additionally, as governments impose stricter regulations on carbon emissions, businesses may face additional expenses in compliance. Inefficient transportation systems that generate high emissions are often associated with higher operational costs, including wasted fuel, poor route planning, and delays. These additional costs are often passed onto consumers in the form of higher prices for food products.

Transitioning to low-carbon transportation brings significant economic advantages for businesses, governments, and consumers including cost savings on fuel, lower maintenance costs, increased profit margins, compliance with regulations and increased brand reputation and brand loyalty.

These benefits provide a strong case for businesses in the food sector to transition towards low carbon transportation.

The shift away from fossil-fuel powered vehicles can result in several benefits. Firstly, electric and hybrid vehicles offer greater fuel efficiency, and the use of renewable energy can reduce operational costs over time. Secondly, as fossil fuel prices fluctuate, businesses benefit from the predictability and often lower costs of electricity and alternative fuels. Thirdly, since electric vehicles often have fewer moving parts than traditional combustion engines, leading to reduced maintenance costs over time. Lastly, by optimizing routes, using more energy-efficient vehicles, and reducing fuel costs, businesses can improve operational efficiency and increase profit margins, ultimately benefiting from reduced logistics costs.

Adopting these carbon emission reduction strategies can also be beneficial as governments are increasingly enforcing stricter emissions regulations and customers are becoming more environmentally concerned. Transitioning early to low-carbon transport helps businesses avoid potential fines or penalties while taking advantage of incentives such as tax breaks or subsidies for sustainable practices.

Furthermore, as more consumers become eco-conscious, companies that prioritize sustainability build their brand reputation and attract customer loyalty. This trend towards more eco-conscious consumers is expected to increase with increased environmental awareness and concern.

Social Implications

The social implications of carbon emissions in the food sector are equally important and should be considered in addition to environmental and economic implications.

The impacts of climate change and pollution are often disproportionately felt by marginalized communities, who may lack the resources to cope with climate change impacts or health problems related to air pollution.

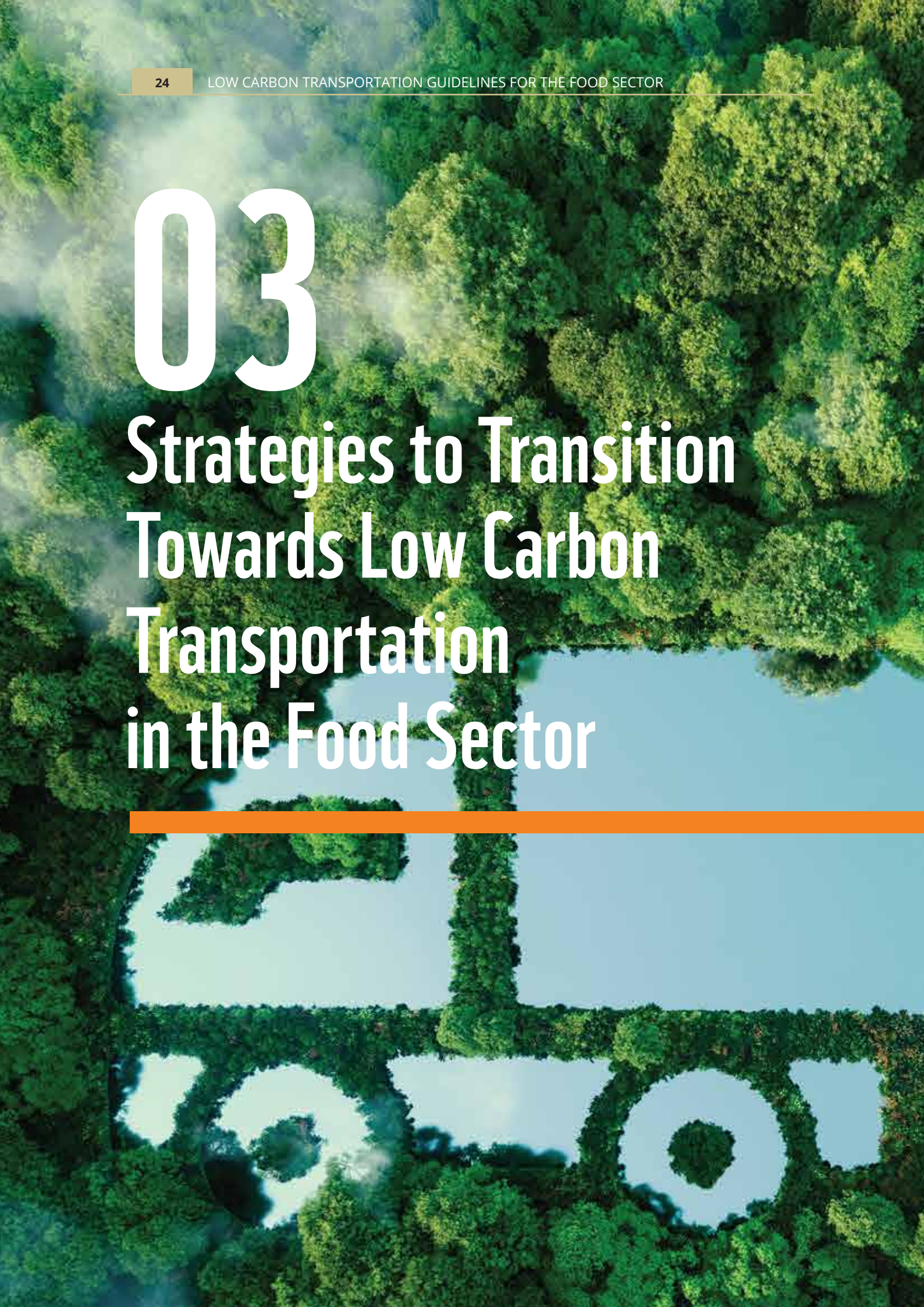
The air pollution generated by high-carbon transportation, such as particulate matter and nitrogen oxides, has serious health implications for communities, particularly those in urban areas where food deliveries are concentrated. Exposure to these pollutants is linked to respiratory issues, cardiovascular diseases, and other health problems, especially in vulnerable populations. These social impacts in terms of public health and social equity could be lessened by reducing the carbon footprint of transportation in the food sector.

Reducing vehicle emissions improves public health through improved air quality, which reduces the incidence of respiratory illnesses, cardiovascular diseases, and other health issues related to pollution, leading to healthier communities. This is particularly true in densely populated areas like urban centers. Moreover, the transition to low-carbon transportation drives job creation in sectors like electric vehicle manufacturing, renewable energy infrastructure, sustainable logistics, and maintenance services for new technologies. This can support the growth of a green economy and create new employment opportunities, further supporting the development of new technologies.

Transitioning towards low-carbon transportation is not just a business decision; it is a commitment to long-term sustainability and social responsibility. Since transportation in the food sector is such a large contributor to carbon emissions, businesses in this sector are in a prime position to take action and affect significant change.

Table 2: Issues Related to Transitioning Towards Low Carbon Transportation

Problem	Advantages	Disadvantages	Possible Solutions
Electric vehicles (EVs)	• Reduces overall carbon footprint • Improves air quality	• High upfront costs for EVs and hybrids • Limited charging infrastructure • Limited benefit if electricity is generated from fossil fuels	• Invest in electric and hybrid vehicles • Install EV charging stations powered by renewable energy
Global supply chain	• Supports customer demand for global goods • Access to diverse products	• Long distance transportation • Increases carbon emissions • Relies heavily on fossil fuels	• Source more locally • Establish partnerships with local suppliers • Focus on community-supported agriculture
Route optimization	• Reduces unnecessary trips • Saves fuel costs	• Complex logistics management • Needs investment in technology	• Use route optimization software • Consolidate deliverie by area • Efficient scheduling
Last-mile delivery to consumer	• Provides convenient door-to door service • Reduces waiting times for customers • Improves customer satisfaction	• Increases carbon emissions due to faster but less efficient delivery routes. • Expensive to implement sustainable last-mile solutions	• Offer eco-friendly delivery options • Educate consumers on slower but grouped deliveries to reduce emissions • Adopt bicycles, e-bikes, or electric scooters for local deliveries • Partner with local delivery services
Renewable energy in transportation	• Reduces reliance on fossil fuels • Lowers long-term operational costs	• High investment cost for renewable energy infrastructure • Maintenance cost for renewable energy infrastructure	• Install solar or wind-powered EV charging stations • Explore biofuel alternatives for larger vehicles
Tracking of carbon emissions in logistics	• Improves transparency • Identifies areas for carbon reduction	• Cost and time investment to track emissions accurately	• Use carbon tracking software • Collaborate with carbon-conscious logistics providers



03

Strategies to Transition Towards Low Carbon Transportation in the Food Sector

Building on the previous discussion of low carbon transportation in the food sector, this section will examine different ways to measure and evaluate the environmental impact of transportation focusing on carbon emissions. By quantifying the carbon emissions of various food items, actions can then be taken by businesses and consumers to reduce the carbon footprint of transportation in the food sector.

Three methods of measuring and assessing the environmental impact of transportation will be examined, including Life Cycle Assessment (LCA), food miles and carbon footprint. Varying in complexity and methodology, these metrics provide different perspectives and scope on the environmental impact of the food item. Since these guidelines focus primarily on transition towards low carbon transportation in the food sector, the emphasis will be on two measurements: food miles emissions and carbon footprint due to transportation.

Life Cycle Assessment

One method of analyzing the potential environmental impacts deriving from products, processes or activities along their life cycle is a ***Life Cycle Assessment (LCA).*** It takes a "cradle-to-grave" approach to product lifespan by evaluating the six stages of the food chain including production or raw materials acquisition, supplier, manufacturing, distribution, retail and wastes.

Figure 2: Phases of Life Cycle Assessment

(Source: Satpute, M.S. et al, 2013)

The four phases of the LCA are shown in **Figure 2,** namely goal and scope definition, inventory analysis, impact assessment and interpretation of results.

The first component of the LCA is **goal definition and scoping** which involves defining and describing the product, process or activity as well as the boundaries and environmental effects to be analyzed. The goal and scope must be revisited regularly to ensure consistency of the data collection with the desired end results.

The second component of the LCA is **inventory analysis,** which is the process of quantifying all the various data regarding inputs and outputs for the entire life cycle of the product, process, or activity. These data include energy and raw material requirements, carbon emissions, solid wastes, and other inputs or outputs.

The third component of the LCA is the actual **impact assessment** which involves data collection, calculation and data analysis.

The final component of the LCA is **interpretation and the provision of recommendations** based on the findings of the previous three phases of the LCA. As shown in **Figure 2,** the interpretation of results is informed by and informs all of the other three phases.

In the food sector, LCA is particularly useful for assessing the environmental footprint of food products from production to consumption. By considering factors like energy use, water consumption, carbon emissions, and waste generation, LCA helps identify which parts of the food supply chain have the highest environmental impact. This information is crucial for businesses in the food industry to make informed decisions on sourcing, production methods, and sustainability initiatives. By using LCA, the food sector can reduce its environmental impact, improve efficiency, and promote more sustainable practices. It is important to note that these guidelines will focus on the carbon footprint from transportation, although carbon emissions occur all along the value chain.

Conducting an LCA in the food sector presents several challenges, primarily due to the complexity and variability of the food supply chain. The most difficult issue is the lack of data and the reliability of the data, especially across different regions and agricultural practices. Due to the complexity of food systems, especially due to the global supply chain, it is difficult to capture all environmental impacts accurately.

In addition, the variability in farming methods, land-use changes, and differences in nutritional values across products further complicate the assessment. Finally, the time, resources, and expertise required for an accurate LCA can be barriers, particularly for smaller businesses, and interpretation of the result can be challenging as well as it involves a multitude of trade-offs.

Food Miles

Food miles *refers to the distance that food travels from its origin or point of production to the consumer.* While traditionally measured in miles, the concept is equally applicable in kilometers. Additionally, various modes of transportation like trucks, ships, and airplanes release different amounts of carbon emissions thus influencing the food miles emissions.

While food miles give insight into how far food has traveled and the carbon emissions due to transportation, it is not as complete of an evaluation of environmental impact as an LCA or carbon footprint. Therefore, even though reducing food miles can lower emissions, other factors like farming methods and food processing should also be considered for a holistic understanding of a product's environmental impact.

In the case of **local foods,** which are grown, processed, and sold within a relatively short distance, food miles and related carbon emissions are typically much lower. This reduces the overall environmental footprint of local foods, as shorter transportation distances mean less fuel consumption, less spoilage, and fewer emissions.

On the other hand, foods that rely on the **global supply chain,** such as imported fruits or seafood, often travel thousands of kilometers by air, sea, and land. These long distances contribute significantly to carbon emissions, particularly when air freight is involved, which is the most carbon-intensive mode of food transportation. These considerations make food miles and their associated emissions an important aspect of reducing the carbon footprint of transportation in the food sector.

In order to calculate food miles, the distance a food item travels from its origin to the final point of sale or consumption needs to be determined.

This calculation considers the distance traveled (kilometers or miles), mode of transport (truck, ship, plane or train), and quantity transported (volume or weight of food transported). The total food miles are usually calculated by multiplying the distance traveled by the carbon intensity of the transport mode, which is measured as the amount of CO_2 emitted per unit of distance (e.g., grams of CO_2 per ton-kilometer). See **appendix 2** for more details regarding food miles calculations.

Carbon Footprint

In the context of the food industry, the ***carbon footprint*** *comprises of emissions from various stages of food production, including farming, processing, transportation, storage and even disposal.* The food industry's carbon footprint also includes emissions from energy consumption in processing and packaging facilities, as well as waste generated when food is discarded. By measuring and reducing the carbon footprint, the food industry can minimize its environmental impact, helping to combat climate change and move towards more sustainable practices.

Conceptually, food miles emissions and the carbon footprint from transportation are closely related but they are not identical. Food miles emissions focuses solely on the distance that food travels from production to consumption and emphasizes the environmental impact of transporting food over long distances.

However, it only accounts for emissions generated by transportation via different modes of transportation without consideration of other factors like production, processing, or packaging.

In contrast, **carbon footprint is a broader term, even when only considering the carbon footprint from transportation. It not only considers distance traveled and mode of transportation, but also takes account the fuel efficiency of the vehicle and other factors influencing emissions.** Overall, the carbon footprint from transportation is a more comprehensive and informative measurement, if appropriate data are available.

04

Step-by-Step Framework to Transition Towards Low Carbon Transportation in Restaurants, Food Retailers, and Food Delivery Services

01 Setup and Planning

Obtain buy-in from management and form a dedicated project team of key personnel from various departments within the organization.

02 Plan and Conduct Transportation-Related Carbon Footprint Assessment

Assessing the current transportation-related carbon footprint will serve as a baseline and allows businesses to track and evaluate their progress over time.

03 Implementation of Carbon Footprint Reduction Measures

Reduction targets need to be set as well as the development and implementation of improvement measures to reach these targets.

04 Employee Engagement and Training

It is essential that employees receive proper and adequate information on the protocols for reducing transportation emissions. This includes understanding eco-friendly practices and knowing how to communicate these initiatives to customers.

05 Customer Engagement

Awareness raising campaigns for customers as well as various initiatives and incentives can be very effective in communicating the importance and benefits of various strategies to reduce carbon emissions due to transportation.

06 Continuous Monitoring and Feedback

Essential in the transition to low carbon transportation is continuous monitoring of data and responsive feedback mechanisms.

07 Summary and Outreach

Communicating progress towards reduction goals and showcasing successful initiatives serves to inspire other businesses and to further drive industry-wide improvements.

The following step-by-step framework outlines a practical approach to transitioning to low carbon transportation. These strategies are designed to be actionable and measurable, helping businesses reduce transportation-related carbon emissions and help mitigate climate change.

In order to facilitate the use of this framework by the different types of businesses in the food sector, all of the strategies in this step-by-step framework will be marked with a different icon to identify the types of businesses to which the strategy would be the most relevant.

The types of businesses in the food sector and their icons are associated as follows:

Obtain Management Buy-In

The initial task is to gain support from upper management. To do so, a detailed presentation that emphasizes the business advantages of reducing the carbon footprint in transportation should be presented. Include data on cost savings from fuel efficiency, optimized logistics, and the use of eco-friendly vehicles, along with the potential to strengthen brand reputation and loyalty.

The sustainability director can act as a change agent by reviewing and analyzing global emerging trends and standards. The materiality issue can then be embedded into the business plan and strategy.

Assemble a Dedicated Team

Once buy-in is obtained, form the carbon footprint reduction team for transportation and clearly define the roles and responsibilities of each member. The team should be key personnel from various departments of the organization relevant to transportation. Assigning specific tasks ensures accountability and promotes efficient collaboration across the team.

Appoint a project leader or coordinator to manage the team's activities. The project leader will also act as the main point of contact for upper management and stakeholders, ensuring that the team's efforts align with the broader business objectives.

Involve All Departments for Maximum Implementation

Influence collaboration among all departments to maximize the effectiveness of the transportation carbon emissions reduction strategy. By involving every department, the organization can ensure that carbon reduction is integrated into all aspects of the business, from logistics to marketing to customer service.

Establish regular meetings to facilitate communication among team members and ensure that everyone is aligned on the goals. These meetings should be used to discuss progress, share insights, identify challenges, and brainstorm solutions for reducing transportation-related emissions.

Ensure that each department has the resources it needs to contribute effectively to the project. This could include access to carbon emissions data, training programs on low carbon transportation practices, or budget allocations for implementing eco-friendly transportation solutions.

Plan the Assessment

Determine the scope of the assessment, including number of items to be assessed and duration. Set clear goals to guide the assessment process, such as identifying key sources of carbon emissions in transportation, calculating food miles, or evaluating the effectiveness of current carbon reduction strategies.

Ensure that the assessment targets critical areas like distance, fuel efficiency, route optimization, and the use of low-emission vehicles to measure and improve the overall transportation carbon footprint.

Data Preparation

Collect the data needed to perform the necessary evaluation of carbon emissions due to transportation including distance traveled, modes of transport, type of fuel, and electricity source for EVs (if applicable). Due to the nature of the data, cooperation with suppliers will be needed to obtain the variety of data needed to complete the evaluation.

Food delivery services may develop in-app tracking features to record and track delivery distances. In addition, restaurants and food retailers can utilize technology to track transportation distances.

Calculate Carbon Footprint and Food Miles as a Benchmark

Use the collected data to calculate the carbon emissions from the selected food items or food delivery service (as applicable).

Since it would be time consuming to do these calculations for all ingredients or food items available, it is suggested to select a few indicator food items to be evaluated for reduction measures, rather than the entire inventory. Overtime, a database of carbon footprint for selected food items and ingredients would be accumulated.

Alternatively, use an online calculator **(see Appendix 1 and 2).**

Analyze and Report Results

Analyze the collected data to identify areas to tackle in terms of carbon emissions reductions from transportation. This analysis will enable the setting of realistic reduction targets and help in developing specific strategies to prioritize areas for improvement.

By understanding and then reporting which activities contribute most to the carbon footprint, targeted measures can be implemented to effectively reduce emissions.

Set Reduction Targets

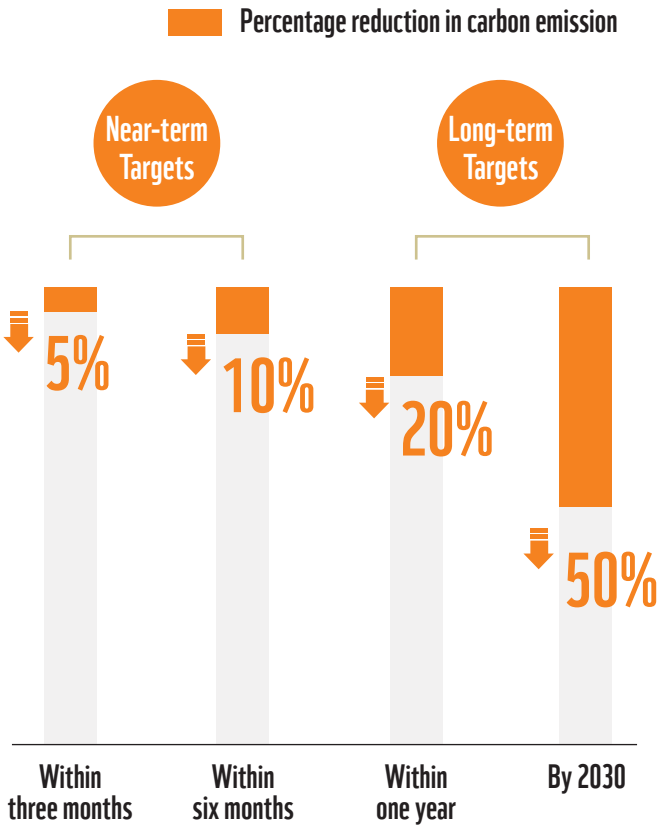
Based on the assessment, set achievable reduction targets:

Near-term Targets (3-6 months): Focus on quick and easy wins, such as sourcing local and seasonal foods with local farms or growing food on-site.

Long-term Targets (1 year or more): Aim for broader changes, such as improving fuel efficiency or shifting to sustainable fuels or EVs.

Figure 3: Near-term and Long-term Low Carbon Transportation Targets

(Source: adapted from Shenzhen One Planet Foundation, 2017)



Develop and Implement Improvement Measures

Regularly review and adjust transportation-related carbon emission reduction strategies to ensure continuous improvement. Various improvements measures that are applicable to businesses in the food industry are listed below:

Local Sourcing and Seasonal Ingredients

• Prioritize Local and Seasonal Ingredients

Sourcing locally and using seasonal ingredients reduces transportation distances and the need for long-distance shipping. Building relationships with local farmers and adjusting menus to reflect local and seasonal availability helps lower transportation emissions while supporting local economies.

Promotions and menus designed around local and seasonal food items could be used to encourage the use of local and seasonal foods by businesses in the food sector. Businesses should also promote these foods to their consumers and explain the benefits of local and seasonal foods.

Training and capacity development for supply chain to help them improve on sustainability practices. This can include the formation of farmer or restaurant groups and community enterprises to improve collaboration.

Collaborate with Local Suppliers

Partnering with local suppliers or engaging with Community-Supported Agriculture (CSA) programs further reduces food miles and carbon emissions.

Urban Farms and Growing Food On-Site

Businesses can consider growing their own food on-site or supporting urban farms to further reduce or eliminate the transportation component of their supply chain.

Minimize Processed Foods

Processed foods typically have a higher carbon footprint due to energy-intensive production and packaging as well as longer distances for transportation in different parts of the supply chain. By supporting and focusing on fresh and whole ingredients, businesses can reduce both the energy used in manufacturing and the associated transportation emissions.

Sustainable Transportation Initiatives

Set Speed and Emissions Limits

Restrict vehicle fleet to certain speed limits that drivers cannot exceed to reduce carbon emissions. Ensure properly maintained vehicles to limit emissions.

Adopt Electric or Hybrid Delivery Fleet

Transitioning to electric vehicles (EVs) or hybrid vehicles for delivery can drastically reduce transportation emissions. EVs eliminate direct emissions, especially when powered with renewable-energy sources, while hybrid vehicles offer a less carbon intensive option to conventional vehicles. For short-distance deliveries, using motorcycles, bicycles or e-bikes can further cut carbon emissions.

Route Optimization and Scheduling

Optimizing delivery routes and scheduling can significantly reduce transportation-related carbon emissions. Route optimization software helps group deliveries in similar areas to minimize the distance traveled, fuel consumption, and emissions.

Avoid Deadhead Miles

Optimize the use of truck and delivery vehicles capacity by coordinating loads, renting out extra space and empty return freight (deadhead miles) to avoid traveling with valuable empty spaces and maximize freight efficiency.

Decentralized Warehouse and Food Sourcing

Establish smaller, strategically located warehouses closer to market areas to cut down on long-haul trucking and improve last-mile delivery, reduce fuel consumption and emissions. Local sourcing further supports this by focusing on nearby suppliers, which reduces "food miles" and supports fresher, seasonal produce with fewer storage needs.

Encouraging Sustainable Transportation for Staff and Customers

Encouraging employees and customers to use sustainable transportation methods, such as biking, walking, or public transit, when coming to work or coming to support the business. Incentivizing the use of these alternatives helps promote a culture of sustainability throughout the organization and in society.

Energy-Efficient and Renewable Transportation

• Promote and Invest in Renewable Energy-Powered Transportation

Promoting and investing in renewable energy-powered transportation, such as offer incentives or installing solar or wind-powered EV charging stations, helps reduce the carbon footprint of transportation. Businesses can also explore the use of biofuels for larger vehicles that cannot transition to electric.

• Implement Energy-Efficient Delivery Systems

Energy-efficient delivery systems, such as electric vehicle fleets, motorbike-based, bicycle or e-bike delivery services, reduce the need for fossil fuels and cut transportation emissions. These delivery systems should be coupled with efficient delivery scheduling and route optimization to further reduce the business's carbon footprint.

Data-Driven Approaches and Industry Collaboration

Leverage Data for Carbon Tracking and Reduction

Using data to track transportation emissions is essential for identifying opportunities for improvement. Carbon footprint tracking tools can monitor the impact of different transportation methods, helping businesses optimize their sourcing and logistics decisions to minimize emissions.

Engage in Industry Collaboration

Collaborate with other businesses to create more efficient and sustainable transportation networks. Industry coalitions can promote bulk purchasing or shared delivery infrastructure to avoid deadhead miles or empty return trips by vehicles, reducing unnecessary journeys and emissions.

Prioritize in-value-chain actions to address transportation emissions and consider supporting nature-based climate solutions, such as forest restoration or renewable energy investments, to offset residual emissions that are hard to eliminate.

Educate Staff on the Importance of Carbon Emissions Reduction

Educate staff on the importance of reducing carbon emissions in transportation. This includes the environmental consequences, such as the contribution of transportation to greenhouse gas emissions and the depletion of fossil fuel resources, as well as the economic implications for the business, such as increased fuel costs and reduced operational efficiency.

Develop training sessions tailored to different roles within the organization. For example, logistics and delivery staff could focus on route optimization, vehicle maintenance for fuel efficiency, and the use of eco-friendly transport options, while staff who deal with customers could be trained to communicate the benefits of local foods, seasonal foods, and eco-friendly delivery options.

Develop and Provide Educational Materials

Develop and provide educational materials focused on carbon reduction in transportation, including instructions, descriptions, visual aids, and process flow diagrams. These guides should be clear, concise, and accessible, with step-by-step instructions for tasks such as route optimization, vehicle efficiency, and eco-friendly delivery practices. Incorporate visual aids such as infographics, posters, and process flow diagrams to illustrate key points, making it easy for employees to understand and implement carbon reduction strategies in transportation.

Service Expressions and Customer Engagement Scripts

Develop scripts and talking points for staff to use when interacting with customers about carbon reduction in transportation. For example, staff could ask customers if they would like to choose eco-friendly delivery options, suggest consolidating orders to reduce transportation frequency, or inform them about the use of electric vehicles or hybrid vehicles for deliveries and the benefits of reducing transportation emissions.

Promotional Messaging

Train staff to weave carbon emissions reduction messages into their everyday interactions with customers. This could include suggesting menu items that utilize local and seasonal ingredients, promoting local produce, and/or encouraging customers to try eco-friendly delivery options.

Feedback and Follow-Up

Encourage staff to seek feedback from customers on their experience with eco-friendly delivery options and carbon reduction efforts in transportation. This feedback can help the business refine its sustainable practices, improve delivery efficiency, and strengthen customer relationships by showing a commitment to environmental responsibility.

Employee Incentives and Recognition

Establish a reward program that offers incentives to employees who demonstrate exceptional commitment to reduce carbon emissions in transportation and consistently meet emission reduction goals.

Hold regular recognition events to acknowledge employees who have significantly contributed to reducing transportation emissions through eco-friendly practices.

Link carbon reduction efforts to performance reviews, where employees who excel in implementing low-emission strategies, such as optimizing delivery routes or promoting eco-friendly options, can receive higher performance ratings, potentially leading to promotions or raises.

Awareness Raising Campaigns

Signage and Displays

Use clear and visually appealing signage in prominent areas, such as near ordering stations, delivery points, and takeout counters, to educate customers about the importance of reducing carbon emissions from transportation. Signs can include statistics on transportation-related emissions, tips on how customers can contribute to emissions reduction, and information on the business's efforts to use eco-friendly transport options.

Display posters that guide customers on how to reduce transportation emissions, such as combining deliveries, selecting eco-friendly delivery options, or choosing local pickups instead of long-distance shipments.

Highlighting the Benefits of Carbon Emissions Reduction

Communicate the environmental benefits of reducing carbon emissions from transportation, such as lowering greenhouse gas emissions and conserving fuel. This can be shared through messages on vehicle signage, receipts, and digital platforms.

Highlight how transportation emissions reduction efforts contribute to supporting sustainability goals, such as by using eco-friendly vehicles or partnering with local green initiatives. Customers are more likely to engage when they see the positive environmental impact of their choices.

Customer Role in Carbon Emissions Reduction

Launch educational campaigns that inform customers about their role in reducing carbon emissions from food, such as buying local food, buying seasonal food, or buying in bulk.

Calculate carbon footprint of each food product and label each item so that consumers can become aware of these issues when selecting and purchasing food items.

Use digital platforms like social media, websites, and apps to educate customers about carbon emissions reduction. Share tips, infographics, and success stories that encourage customers to take part in the initiative.

Initiatives and Incentives

Discounts

Offer discounts or incentives to customers who choose to participate in carbon reduction initiatives. For instance, provide a discount for customers who buy local foods, buy seasonal foods, or select consolidated deliveries.

Offer reduced delivery fee for customers who opt for slower delivery times to allow for multiple orders per driver. This maximizes capacity of the driver while minimizing emissions, especially when coupled with route optimization.

Implement a loyalty program where customers receive rewards for consistently choosing more sustainable transportation options, such as using electric vehicle delivery services, bundling orders to reduce trips, or picking-up orders by walking or cycling.

Activities and Contests

Organize challenges where customers are encouraged to reduce their carbon emissions over a set period. Participants could track their use of eco-friendly delivery methods, such as opting for consolidated shipments or walking to pick up orders, and share their experiences on social media for a chance to win prizes or discounts.

Host contests that invite customers to submit creative ideas for minimizing transportation emissions, such as optimizing delivery schedules or choosing low-emission transportation options. Winning ideas could be highlighted on the company's website or social media, showcasing innovative ways customers can contribute to reducing the carbon footprint.

Customer Feedback

Implement customer surveys or feedback forms that specifically ask about their experience with the company's transportation-related carbon reduction practices. This could include questions about delivery options, their awareness of eco-friendly choices, and their willingness to participate in various carbon reduction efforts.

Solicit feedback on the delivery process, focusing on the efficiency of eco-friendly transport options and the effectiveness of reducing emissions.

Leverage digital channels such as email surveys, social media polls, or feedback sections on your website to gather insights from customers regarding their preferences and experiences with the company's transportation-related carbon reduction practices.

Regularly Monitor Transportation-Related Carbon Emissions

Establish a system for consistently collecting and tracking transportation data to monitor carbon emissions. Set up specific metrics to measure key aspects, such as fuel consumption, distance traveled, vehicle efficiency, and the types of transportation used (e.g., trucks, electric vehicles, or hybrids). Additionally, track the impact of route optimization, vehicle load efficiency, and alternative fuel usage on emissions reduction.

Schedule regular reviews of the collected data—monthly, quarterly, or annually—based on the size and nature of your operations. These reviews should involve key stakeholders, including management, logistics teams, and sustainability officers, to assess the current status of carbon reduction efforts. Use these reviews to identify trends, successes, and areas that need further optimization.

Maintain detailed records of all transportation data and monitoring activities to better understand the impact of carbon emissions reduction strategies over time. Regular reports summarizing progress should be shared with relevant stakeholders, including employees, management, and any external partners involved in the low carbon transportation initiative.

Compile the Results of Carbon Emissions Reduction Efforts

After implementing the carbon emissions reduction strategies, it is essential to compile and analyze the data collected during the process. This includes gathering quantitative metrics such as reduced fuel consumption, lower carbon emissions, increased use of electric or hybrid vehicles, and cost savings achieved from more efficient logistics.

Compare the results against the baseline data collected before the implementation of carbon emissions reduction strategies. This comparison will help measure progress, identify successes, and highlight areas that may require further improvement.

Establish a regular reporting schedule to track ongoing progress. Reports can be generated monthly, quarterly, or annually, such as Annual Reports or ESG and Sustainability Reports.

Promote Success Stories and Best Practices

Utilize internal communication channels to share the successes and best practices of the low carbon transportation program with employees.

Host workshops or seminars where successful teams or departments can present their strategies and share their experiences with others in the organization.

Share successes and best practices with other businesses, NGOs, and the public sector as well as customers and the local communities to increase knowledge sharing and demonstrate commitment.

Develop partnerships and collaborate with other businesses, NGOs, and the public sector to work cooperatively towards shared carbon reduction goals.

Disclaimer

The various strategies presented in this step-by-step framework provides a comprehensive, although not exhaustive, entry point for businesses in the food sector to begin to transition towards low carbon transportation. Keep in mind that there is no one way to approach the transition to low carbon transportation and that this framework can be adapted to suit a particular business.

In addition, taking action towards sustainable consumption and production based on the suggestion in the guidelines in this series may prove difficult to implement as some initiatives may conflict with each other and it is difficult to balance all of the goals presented. It is recommended that businesses set their targets for their top priorities and work towards those targets in a strategic manner.

05 A Call to Action

The issue of climate change has made the reduction of carbon emissions essential. Due to the large contribution of transportation-related carbon emissions from the food sector, there is a huge opportunity to make a significant impact in carbon emissions reductions. Both businesses and consumers, working in collaboration with governments and NGOs, have the ability to take action in reducing transportation-related carbon emissions in the transition to low carbon transportation in the food sector.

With a multitude of strategies available that can be adopted and implemented to reduce carbon emissions due to transportation, businesses need to take action to realize the environmental, economic and social benefits of these reductions. Taking these steps to shift to low carbon transportation means businesses can increase operational efficiency, decrease fuel and transportation costs, as well as stay ahead of emerging government regulations. Moreover, implementing these strategies enhances brand recognition and loyalty which can provide a competitive advantage over other businesses.

The transition towards low carbon transportation in the food sector is a positive step in taking action on climate change. The implementation of carbon emissions reduction measures by both businesses and individuals furthers this difficult but necessary transition towards the creation of a more sustainable world, especially in light of the climate crisis. This tool provides a starting point for businesses to take strong action in shifting towards low carbon transportation in the food industry.

Through practical and systematic transformations, the private sector holds a pivotal role in reducing transportation-related carbon emissions in the food industry. The collective impact of these efforts can lead to significant environmental, economic, and societal benefits. By adopting greener technologies, optimizing logistics, and encouraging sustainable commuting, businesses have the opportunity to drive meaningful change. Embracing this opportunity to impact drastic change is not only advantageous but essential to mitigating climate change and ensuring a sustainable future.

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Appendices

Appendix 1 Carbon Footprint Calculators

Carbon Footprint from Transportation Calculations:

The basic formula for calculating carbon emissions from transportation involves multiplying the quantity of fuel used by the emission factor specific to the fuel type. The amount of fuel consumed is determined by the vehicle type, the distance covered, and its fuel efficiency. To use this formula, you'll need information about the vehicle type, the distance traveled, and its fuel efficiency.

Transportation-related Carbon Emissions = D x W x EF

Where:

D = distance traveled,
W = weight or volume, and
EF = emissions factor of transportation.

(Source: Environmental Defense Fund, 2015)

Helpful Websites and Apps:

- Carbon Trust Footprint Calculator: www.carbontrust.com
- CERO: www.cero.org
- Cool Food Calculator : www.wri.org/initiatives/cool-food-pledge
- Eaternity: www.eaternity.org
- Foodsteps: www.foodsteps.earth
- Energy Star Portfolio Manager: www.energystar.gov/buildings/benchmark
- Net Zero Man App: https://apps.apple.com/th/app/thai-carbon-footprint-calculator/id938564037?l=th

Appendix 2 Food Miles Calculators and Calculations

Food Miles Calculations:

The **Weighted Average Source Distance (WASD) formula** takes into account the amount of food transported in weight and the distance that it travels from the place of production to the place of sale or consumption. **Items consisting of only one ingredient, such as fruits and vegetables, would generally use the WASD formula for calculating food miles.**

The **Weighted Total Source Distance (WTSD) formula** developed by the Leopold Center for Sustainable Agriculture helps to account for multiple-ingredient foods by taking into consideration the weight and distance traveled for each ingredient. **Processed foods would typically employ the WTSD formula for calculating food miles.**

$$WASD = \frac{\Sigma(m(k)*d(k))}{\Sigma m(k)}$$

Where:

k = different locations of the production origin,

m = amount consumed from each location of consumption origin, and

d = distances from the locations for production origin to point of consumption.

$$WTSD = \Sigma(W*D*T*R)ingredient$$

Where:

W = Weight of each ingredient (per container),

D = Shipping distance between ingredient origin and destination

T = Percent of total amount shipped from each origin per ingredient, and

R = Ratio of shipping weight to processed weight.

Both the WASD and WTSD provide an estimate of the distance food travels between the origin and the point of sale or consumer. However, neither formula addresses the carbon emissions associated with this distance. The Weighted Average Emissions Ratio (WAER) formula, developed by Life Cycles in 2004, takes into account both distance and the associated carbon emissions for different modes of transportation.

(Source: Hill, 2008 and Pirog and Benjamin, 2005)

Helpful Websites and Apps:

- Foodmiles.com:
  www.foodmiles.com

- Food Carbon Emissions Calculator (CleanMetrics):
  www.cleanmetrics.com

- EcoTransIT World:
  www.ecotransit.org

- BBC Food Carbon Footprint Calculator:
  www.bbc.co.uk/climate/food_calculator

- Food Footprint Calculator (Sustainable Food Trust):
  www.sustainablefoodtrust.org

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