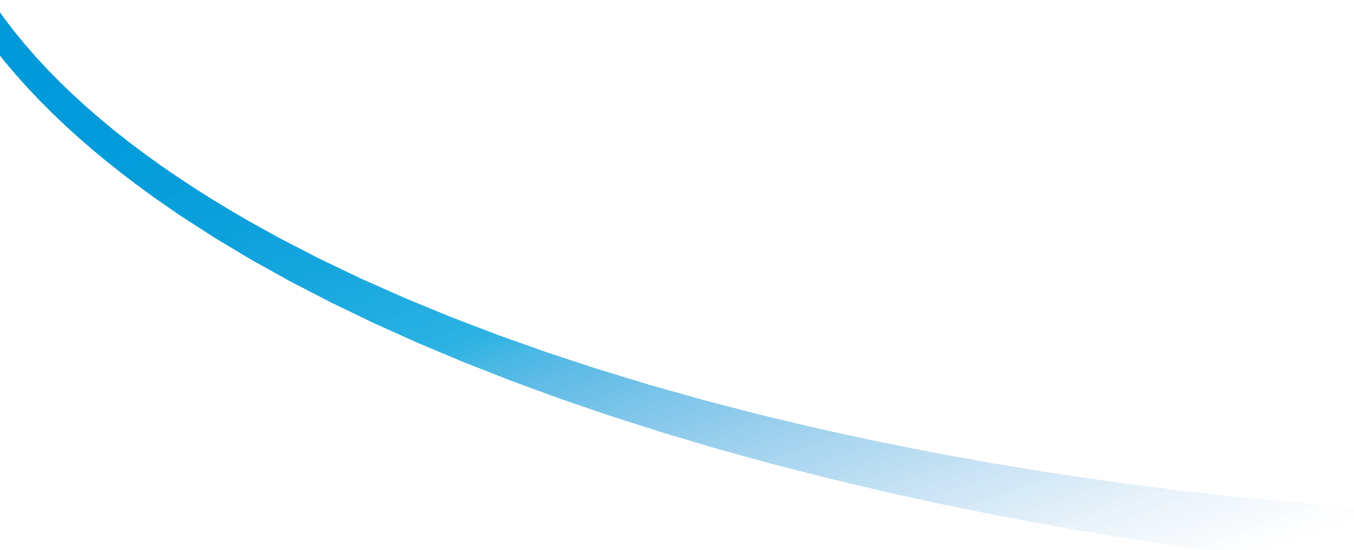




REIMAGINING THE COLD CHAIN IN A POST-PANDEMIC WORLD

June 2020



While the rapid transmission of COVID-19 has amplified conversations about the security and resiliency of the global food system, none of the underlying issues is new.

Prior to the latest pandemic, the Food and Agriculture Organization (FAO) of the United Nations estimated that more than 820 million people around the world suffered from hunger. In addition, some 2 billion people faced food insecurity, defined as the lack of reliable access to safe, nutritious and sufficient food. The FAO recently estimated that the pandemic and lockdowns could force another 420 million people into absolute poverty.¹

Food insecurity is also haunting some of the richest countries in the world, including 8% of the people of North America and Europe.² In some dense urban areas such as New York City, the number may be closer to one in four. "Before the coronavirus, we thought somewhere around a million people were food insecure," New York City Mayor Bill de Blasio says. "Now we think that number is 2 million or more."³



In [Food Foolish](#), the issues of hunger and food insecurity are examined in the context of a global food model that already produces more than 1½ times enough food to feed everyone on the planet.⁴ Despite this abundance, an astonishing one-third of all food produced for human consumption is lost or wasted.⁵

This appalling loss impacts not just hunger and food insecurity, but the well-being of the planet. The FAO estimates the total carbon footprint of lost and wasted food to be 4.4 gigatons (Gt) of greenhouse gas (GHG) equivalents.⁶ One target set under the United Nations Sustainable Development Goal 12, to cut waste in half by 2030, would reduce the global carbon footprint by 1.4 Gt annually, an amount equal to emissions from the entire Japanese economy.⁷

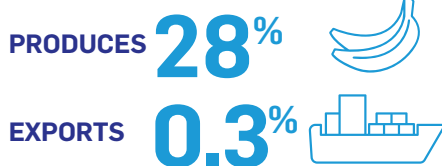
IN BRIEF:

- The COVID-19 pandemic has exposed some of the weakest links in the global food model, a system that already loses or wastes a third of all food intended for consumption.
- Investment in the cold chain remains one of the most effective ways to ensure the reliable and safe movement of food and pharmaceutical products during a pandemic, and in adapting to a post-pandemic world.
- Cold chain investment in the developing world means targeting individual trade corridors that can leverage a nation's agricultural advantages, reduce loss and drive an attractive financial and social return.
- Cold chain investment in the developed world means creating additional flexibility and resiliency by improving information-sharing among all stakeholders and making data a part of the strategic assets for each.
- Every public and private player with a stake in the global food and life sciences cold chains can contribute to reimagining, developing and advocating for this vision.

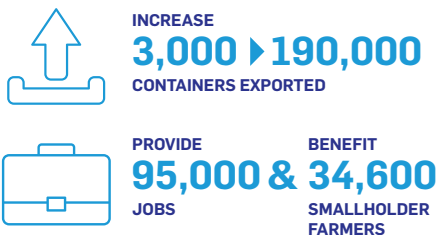
Reimagining the Cold Chain

Developing and developed countries face different challenges in establishing and restoring a stronger food model.

INDIA: THE WORLD'S BANANAS SUPPLY



An upgraded cold chain infrastructure could:



In developing countries, where less than 15% of perishable foods are protected by the cold chain,⁸ two-thirds of loss is in harvest and postharvest activities. Smallholder farmers struggle to move cereals and perishable produce, meat and dairy products from their fields to consumers. These farmers often lack adequate pre-cooling, cold storage and refrigerated transport, and must sell their products in open-air wet markets.⁹

In some developing countries, 80% of the population relies on agriculture for its livelihood.¹⁰ Reducing food loss through cold chain creation can lift a nation. For example, *Food Foolish* highlights banana farmers in India, where the potential impact of a modern cold chain could increase exports from 3,000 to 190,000 containers a year, and benefit nearly 35,000 smallholder farmers.¹¹

In developed countries where the cold chain is mature, about two-thirds of food loss occurs in consumer-facing businesses and homes. In the U.S., for example, more food reaches landfills and incinerators than any other single material, comprising 22% of discarded municipal solid waste.¹²

With every nation, every segment of society and every link of the supply chain contributing, global food waste totals 1.3 billion metric tons annually. The suffering from this staggering loss has been further aggravated in 2020 by the disruption to the food model caused by the COVID-19 pandemic.

Investment in programs to drive higher agricultural yields and develop new food sources will continue to play an important role in feeding humankind. But, a more practical and immediate solution to reducing hunger and healing the earth is to preserve and consume the food already produced. “Billions of dollars are currently invested in genetic modification, advanced agricultural chemicals and farm machinery,” says Jonathan Foley, executive director of Project Drawdown. “Where is the comparable investment in reducing food waste?”¹³

In the U.S., for example, more food reaches landfills and incinerators than any other single material, comprising 22% of discarded municipal solid waste.

The cold chain — a network of uninterrupted, temperature-controlled transport and storage — plays a critical role in ensuring the movement of food from farm to fork. In North America, where the cold chain is mature and robust, losses of food in postharvest, handling and storage are estimated at 3% for fruits and vegetables, 2% for meat and less than 1% for seafood and milk.¹⁴

In life sciences, cold chain logistics spending globally exceeds \$13 billion and must protect some \$283 billion in products.¹⁵ The industry has carefully migrated in recent years from air shipments to ground and ocean transport, which is now complicated by the COVID-19 pandemic and lockdowns, in addition to tariffs and border crossings. In addition, the life sciences cold chain will soon be expected to deliver billions of COVID-19 vaccine doses around the world. And, there remains uncertainty about whether the broad application of a COVID-19 vaccine will cause a surge in flu and other more traditional vaccines.¹⁶

Leaders in both the food and life sciences segments must adapt to the challenges of the “new normal,” a world in which the COVID-19 pandemic may be a 12- to 18-month battle, where traditional distribution patterns have been upended, and where extreme weather and future pandemics threaten to further disrupt production, supply chains and consumer segments.

Below, an expanded global cold chain is reimagined that will become pervasive, flexible and robust enough to regroup and withstand these new pressures.

Exposing the Weak Links

The pandemic has brought hardship to nations around the world, exposing some of the weakest links in the global food model.

In an April 2020 story headlined, “Instead of Coronavirus, the Hunger Will Kill Us,” journalist Abdi Latif Dahir reports that, as a result of COVID-19 school closures, 368 million children worldwide have lost access to school meal programs. Lockdowns and business closures have led to the sudden loss of income for hundreds of millions.¹⁷

A sobering report by the Food Security Information Network (FSIN) concludes that more than a quarter-billion people could face starvation by the end of 2020.¹⁸ “We’ve never seen anything like this before,” Arif Husain, chief economist at the World Food Program says. “It wasn’t a pretty picture to begin with, but this makes it truly unprecedented and uncharted territory.”¹⁹

Farm and supply chain disruption, unemployment and food insecurity are on the rise. Women, who account for 60% of hungry people worldwide, are most susceptible to the food security and nutrition effects of COVID-19.²⁰ And urban areas, given their high population density, are particularly vulnerable to the COVID-19 pandemic; as the world witnessed during the 2007-2008 world food-price crisis, disruption of an urban food system can lead to civil unrest.

“The shortage is forcing production cuts and may mean wasting thousands of tons of produce that suddenly has nowhere else to go.”

In Europe, demand for refrigerated storage has swelled with the closing of restaurants and other food service providers, forcing suppliers of vegetables and meat to warehouse their products while seeking new buyers. “The shortage is forcing production cuts,” Bloomberg reports, “and may mean wasting thousands of tons of produce that suddenly has nowhere else to go.”²¹

In Europe, North America and other regions where cold chains are effective but often specialized, the sudden consumer shift from food service to food retail has exposed the urgent need

for enhanced flexibility. With meal-making shifting back into homes, for example, the National Restaurant Association anticipates the loss of up to 7 million jobs in 2020.²² One unintended, yet positive consequence of this shift is that people appear to be eating healthier, consuming more fruit and vegetables, and wasting less.²³

A relief plan developed by U.S. produce industry groups estimated the loss, in a single five-day period, of 100 million restaurant meals, 30 million school lunches and 15 million school breakfasts. “The entire fresh produce industry supply chain is reeling from this sudden and immediate shut down of an estimated 40% of all produce consumed in America,” the plan says.²⁴

As online shopping surges, grocery stores face stock-outs and find themselves with less to donate to food banks, which must compete on the open market to feed the hungry. As a result, some food banks in the U.S. are spending up to 10 times their monthly budgets to make food purchases. Feeding America, which oversees the largest network of food banks in the country, projects a \$1.4 billion shortfall in the next six months.²⁵

It is presumptuous to think that investment in the cold chain alone can solve all the complex problems of a broken food model now stressed by global pandemic. While the cold chain can't solve every problem, it offers a set of proven, practical solutions and a glimmer of hope amid the complex problems of a broken food model and disruptive global events.

Expanding the Cold Chain

The goal in developing countries is not to “build the cold chain” but to incrementally target investment in individual cold chain “corridors” that can leverage a nation’s food advantages, reduce egregious food loss and drive an attractive financial and social return.

Carrier partnered with smallholder farmers in India, for example, to spearhead a [pilot study](#) designed to measure the impact of cold storage and refrigerated transport on kinnow, a small citrus fruit rich in micronutrients that is grown in the Punjab region of India and Pakistan. Best preserved at 4-5 degrees C, kinnow faced temperatures along its 2,500-kilometer route from Abohar to Bangalore as high as 30 degrees C. Before the installation of a modern cold chain, losses could reach 32%.



REACH

The connected cold chain has allowed kinnow to be exported for the first time, to countries such as:

- Bahrain
- Bangladesh
- Kuwait
- Oman
- Russia
- Saudi Arabia
- Sri Lanka
- Ukraine
- United Arab Emirates
- United Kingdom

The introduction of pre-cooling units and refrigerated truck trips into this transport corridor resulted in a 76% reduction in postharvest losses and a 16% reduction in carbon dioxide (CO₂) equivalent emissions from the harvest and transport of kinnow that could not be sold. The grower’s profits increased by 15%, the refrigerated transporter’s by 23%. From a base of zero, the number of pre-cooling units now in use has increased to 10, and there are 400 refrigerated truck trips being made between Abohar and Bangalore during the harvest season. With an expanded window of availability, growers began exporting kinnow for the first time, reaching 10 countries in Asia, the Middle East and Europe. The grower’s payback on cold chain equipment ranged from two to four years.

This successful pilot demonstrates how a targeted investment in a single product and trade lane can rapidly heal a broken food model.

The introduction of cold chain transport and refrigeration inevitably creates new carbon emissions. Measured against food loss, however, the benefit is indisputable. A study commissioned by Carrier examined several scenarios, including one in which cold chain penetration in developing countries equaled that of developed countries.

"In all prospective scenarios," the study concluded, "the decrease of FLW [food loss and waste] carbon footprint from cold chain expansion clearly outbalances the newly created emissions, by a factor of 10 approximately."²⁶ In other words, for every unit of carbon-equivalent introduced by the cold chain, perishable foods with embedded carbon roughly 10 times greater make their way successfully to a hungry consumer. As recent technology innovations such as natural and ultra-low refrigerants with low global warming potential (GWP), and all-electric powered transport refrigeration equipment replaces older, less sustainable equipment, new cold chain emissions will be reduced even more. An unmeasured benefit in this study is the impact on biodiversity and carbon emissions of a stable agriculture footprint, the result of consuming what is already produced.

If food waste were a country, the 4.4 Gt of GHG it emits would make it third in size behind only China and the U.S. As noted in *Food Foolish*, if the 820 million hungry people in the world were a country, it, too would be the world's third largest country, meaning that in both hunger and climate change, food waste is the world's third largest country.

Reducing food loss and waste is the only public policy goal that helps to feed more people and addresses climate change. To this end, in November 2019, Carrier was privileged to sign the "Rome Declaration" on the Contribution of the Montréal Protocol to Food Loss Reduction through Sustainable Cold Chain Development, tying food loss and waste to climate change. This, in turn, will create opportunities for countries to gain access to U.N. climate funds that can be used to develop sustainable cold chains.

In 2010, the U.N. established the Green Climate Fund (GCF). The mission of the GCF is to invest in low-emission and climate-resilient projects in developing countries. The GCF has raised more than \$10 billion, committed to 129 projects with a value (including co-financing) of \$19.7 billion, and anticipates the avoidance of 1.6 Gt of carbon emissions.²⁷ Many of the fund's projects support more sustainable and resilient agriculture and transportation practices. Cold chain investment should fall squarely into the GCF mission.

As a founding member of the Global Food Cold Chain Council (GFCCC), Carrier collaborates with other public and private organizations to develop technology-neutral policies and actions to reduce the food cold chain waste contribution from GHGs.²⁸ This commitment is demonstrated in a variety of products, including emission-free, high-performance cab climate control, natural refrigerant carbon dioxide with a GWP of one, all-electric trailer refrigeration systems, and real-time and historic temperature and location monitoring data. (See Carrier's [Sustainable Cold Chain](#) website for more information on these products and services.²⁹)

Carrier is working with government ministries in ASEAN to stand up sustainable, connected cold chains to allow increased exports of fruits and vegetables to the U.S. and Europe using pre-cooling, cold storage warehouses, transport refrigeration,

In all prospective scenarios, the decrease of FLW [food loss and waste] carbon footprint from cold chain expansion clearly outbalances the newly created emissions, by a factor of 10 approximately.

controlled-atmosphere and tracking and monitoring technology. Demonstration projects such as these present opportunities for the introduction of a modern cold chain to expand and extend reach and raise the standard of living for growers, while helping to reduce food waste, GHG emissions and hunger, and drive an attractive financial payback for stakeholders.

The investment opportunity and potential benefits of cold chain creation around the world are enormous.

To measure this opportunity, we use data gathered by the Global Cold Chain Alliance (GCCA) comparing the volume of refrigerated warehouse space in a country to its urban population — the growing middle class seeking a diet that includes produce, meat and dairy.³⁰ In 2018, the U.S. had 131 million cubic meters of refrigerated warehouse space compared to 485 million cubic meters in the rest of the world. With an urban population in the U.S. of 269 million people, the country’s cold chain “intensity” was 488 cubic meters of refrigerated warehouse space per 1,000 city dwellers.

In 2018, the urban population of countries outside the U.S. was nearly 3.9 billion people. For those countries to establish refrigerated warehouse space that matched the cold chain “intensity” of the U.S., they would need to add 1.4 billion cubic meters — nearly three times their current capacity.

Stated differently, a global network of cold chains comparable to that already established in the U.S. would require the addition of refrigerated warehouse capacity equivalent to more than 10 times U.S. capacity. By 2030, the U.N. estimates the addition of 1 billion more urban dwellers around the world, adding another 25% in cold-chain growth potential.³¹

	Refrig WH Space 2018 (M m3)	Total Pop. 2017/8 (B)	Urban Pop. (%)	Urban Pop. (B)	Cold Chain “Intensity” (m3/000 urban pop.)	Cold Chain “Intensity” @ U.S. Rate	Potential New WH Space (M m3)
United States	131	0.327	82.3%	0.269	488		
Rest of World	485	7.183	53.8%	3.862	126	488	1,398
Total	616	7.510	55.0%	4.131	149		

Cold Chain “Intensity” Based on Refrigerated Warehouse Space (GCCA, Carrier)

Obviously, creation of a cold chain involves investments in pre-cooling, truck, trailer, air and marine container transport equipment, people and information systems alongside refrigerated warehouses. But the expertise to assemble these assets is readily available, the costs predictable and the financial returns attractive. In food security and climate terms, the payback can be incalculable.

In a world where pandemic and extreme weather require a resilient food model — especially in developing countries where food loss is greatest during harvest and postharvest, and can approach 50% — the connected cold chain is an attractive investment option.



Investing in a Smarter Cold Chain

Cold chains in the developed world are efficient because they specialize around distinct producers, consumers, products and routes. In a stable economic environment, these tailored cold chains keep costs low and promote just-in-time ordering.

As the result of the COVID-19 pandemic, however, the food model has struggled to meet rapidly shifting demand. Consumers in the developed world have witnessed vivid images of farmers destroying crops set against scenes of empty supermarket shelves. “Today the U.S. actually has two separate food chains, each supplying roughly half of the market,” writes food activist Michael Pollan. Farmers are linked to grocery stores by one cold chain and to food service providers by another. “But because of the way the industry has developed over the past several decades,” Pollan adds, “it’s virtually impossible to reroute food normally sold in bulk to institutions to the retail outlets now clamoring for it. There’s still plenty of food coming from American farms, but no easy way to get it where it’s needed.”³²

Today, the cold chain is often fragmented, with different providers and platforms at each stage that do not offer the necessary compatibility to provide the full picture.

The pandemic has depleted warehouse, processing and transportation workforces. It has shuttered entire segments of the consumer economy, including restaurants, schools, sporting venues, hotels, cruise ships and food service establishments. By itself, the cold chain cannot solve all the complex problems related to packaging, transportation, or the location of manufacturing and warehousing sites. But as part of a broader food security strategy, and because it touches each of these links, a smarter cold chain can provide considerable flexibility.

“Smart” is based on better and more connections: The cold chain becomes more flexible and resilient as knowledge is more quickly and broadly shared among its partners. Data become part of a firm’s strategic assets.

Some sharing has sprung up organically in response to the pandemic. The creation of temporary food hubs using data and e-commerce, for example, has proven effective as a way to distribute food in urban areas. Wuhan, China, is using e-commerce to establish new links between farmers and consumers, in an effort to improve food safety. Lima, Peru, has gathered data to map those vulnerable to food insecurity. In Milan, Italy, the “Food Aid Systems” have supplied nourishment to the elderly and vulnerable by converting one food bank to a logistics center, creating seven temporary food hubs with expanded storage, and converting minibuses for food delivery.³³

Greater connectivity is essential to the success of the future cold chain. Customers in developed countries are already asking for more real-time information, data analytics and prognostics so they can have greater visibility into the location,

condition and handling of their cargo at any given point in the cold chain. Today, the cold chain is often fragmented, with different providers and platforms at each stage that do not offer the necessary compatibility to provide the full picture.

As one of the world's largest providers of cold chain assets and intelligence, Carrier is already an important hub in the global cold chain. We envision and are working to build an end-to-end "connected" cold chain that will reduce cost and waste across the network. This will drive faster, more intelligent data-driven decisions related to perishable cargo, while improving efficiency and sustainability. As the cold chain grows in developing countries, so too should they have the same access to these digital technologies.

Once data is being shared across a common platform, the use of a richer mix of analytics becomes possible. The ability to forecast delivery times and/or incentivize transport companies based on cold chain performance will become more common. Equipment maintenance can be scheduled before a cooling unit breaks down. Eventually, product can be rerouted based on real-time supply and consumer demand, disruptions caused by weather and pandemic can be moderated, and partners can share location, temperature and other critical measurements of in-transit product from farm to consumer.

Sometimes referred to as the "digital supply chain," the ability to share data may lower procurement costs by 20%, reduce supply chain process costs by 50% and increase revenue by 10%.

Sometimes referred to as the "digital supply chain," the ability to share data may lower procurement costs by 20%, reduce supply chain process costs by 50% and increase revenue by 10%.³⁴ And this benefit will only increase as the volume of information created doubles every three years. As data "pours in from digital platforms, wireless sensors and billions of mobile phones," McKinsey reports, data-storage capacity has increased while its cost has plummeted. "Data scientists now have unprecedented computing power at their disposal, and they are devising algorithms that are ever more sophisticated."³⁵

The cold chain differs in an obvious way from dry supply chains, because maintaining temperature in the cold chain is essential. This difference generates a unique stream of critical information that can be combined with location and product attributes to increase the intelligence of the cold chain.

A study for the *Journal of Food Science* says that there is "strong evidence" that management systems based on time-temperature measurement for perishable food "improve the efficiency of the cold chain, decrease food waste and improve food safety."³⁶

In the mission-critical life sciences segment, cold chain analytics will help to reduce risk performance, tying together security, transparency and authenticated chain of custody — from packaging and transportation to the warehouse and the end-user — all part of an increasingly holistic view of cold chain visibility aimed at avoiding product shortages in the pharmaceutical segment, which could lead to increased pressure on our already stressed healthcare systems.

Conclusion

The cold chain plays an essential role in both developing and developed countries, especially in moments of food crisis such as that brought about by the COVID-19 pandemic.

With less than 15% of perishable foods protected globally by the cold chain, the opportunity for investment and impact in the developing world is vast. In the developed world, the emphasis on data sharing and richer analytics can strengthen the ability of a mature cold chain to adapt to disruptions in supply and demand.

In stable times, the cold chain reduces hunger, food insecurity and GHG emissions. In times of disruption, it becomes even more essential for the most vulnerable populations to continue receiving enough nutritious, affordable food and safe, effective medicine.

Investment in a smart cold chain to create flexibility and resiliency also complements the U.S. Food and Drug Administration's recent announcement of the "New Era of Smarter Food Safety." This innovative approach will include the introduction of blockchain, sensor technology, the Internet of Things and artificial intelligence to improve food traceability and transparency along the cold chain. The food system is becoming "increasingly digitalized," Deputy Commissioner Frank Yiannas says. "When you look at how other industries are able to track, through digital means, the real-time movement of planes, ride-sharing and packaged goods, we should be looking quickly to adopt and fully implement the next technologies in food."³⁷

Likewise, the U.S. Food and Drug Administration announced plans to pilot new technologies, including blockchain, to help track and trace pharmaceuticals — an industry that falls victim to counterfeit pharmaceuticals estimated at \$200 billion. This effort will continue to push life science cold chains to become fully interoperable — which means manufacturers, repackagers, wholesale distributors and dispensers could share information on product location and movement.³⁸

The technology and know-how to build a robust cold chain exists. Attractive financial paybacks are attainable. The underlying challenges of both the food and life science models will continue to exist even as disruptions from viruses and extreme weather increase.

At Carrier, we take very seriously the responsibility to help preserve, protect and extend the world's supply of food and medicine, while reducing environmental impact. As the world emerges from the current pandemic, it is important to reimagine a global cold chain that is bigger, smarter, more connected, more resilient, and helps provide food security and safe medicines for billions more around the world. Carrier invites your help in developing, advocating for and advancing this vision.



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