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# Blog: Edible sustainability - How food systems work and why they matter

You don't have to look far to find "farm to fork" on a restaurant menu or a product label in your local grocery store. It might mean that the food is organic, locally grown, or made in a transparent, ethical way. It tells a story that matters to consumers.

But is this the *whole* story when it comes to food? What happens to the food we don't eat? What resources does the farm need to grow food? What does it really take to get food from the farm to your fork? These are the kind of questions many today are asking when it comes to sustainability and food.

Food—how we make or grow it, move it around, eat it, and get rid of it—draws heavily on natural resources and drives a global economy, all while being essential to our most basic survival. Because it touches so many aspects of our world, sustainability researchers and policymakers now see food as a one of the most important pathways for tackling climate change, promoting health, and reducing economic inequality.

## Food as a system

Sustainability researchers and planners describe everything that we do in relation to food using systems thinking. They look for how events relate to others, even if displaced by large spans of time or great distances.

A food system is like an ecosystem: Nothing happens in isolation. One action can trigger a ripple effect, setting off positive or negative consequences for the environment and human society alike. Whether it's how the ingredients for a cookie are sourced, how that cookie is packaged, or where that package ends up after the cookie is eaten, a system involves many players who each make decisions that influence subsequent events.

## Food's impacts

The methods we use to make or grow food, transport it, and consume it have changed over the course of human history. Over time, hunting and gathering gave way to farming, which has since developed over thousands of years to become the global industrial sector it is today. Many factors have influenced how food production has evolved, but the significant rise in population growth and economic demand in the last two centuries are exceptional.

Technological advances have led to large-scale food production like never before. Harvesting machines became super-efficient and far more powerful thanks to fossil fuels. New forms of fertilizers and pesticides multiplied crop yields like never before. The threat of crop failure has been nearly eradicated thanks to bioengineering resistance to common diseases. Innovations like these made it possible to produce once unimagined volumes of essential crops, meats, and other food products. Yet these incredible advances in how food is produced and distributed have left us today with unintended consequences.

Since humans began farming, forests have been cleared, breeds of plants and animals have been favored over others, and natural waterways have been diverted into artificial stores. Scientists at the University of Wisconsin-Madison found that just seven percent of the Earth's land was farmed in 1700 compared to today, where half of the habitable land on Earth is used for human food production. According the United Nations Food and Agriculture Organization, of all the land used for agriculture (51 million square-kilometers), 77 percent is used for the cultivation of livestock for meat and dairy, providing only 18 percent of the global calorie supply and 37 percent of its protein. Processing and industrial manufacturing occupies just one percent of Earth's habitable land.

Such an extensive economy of production and consumption puts incredible pressure on natural resources and life systems. This has reduced the planet's biodiversity, disrupted food chains, and weakened the resilience of ecosystems to recover from stress. For governments and businesses alike, there is a catch-22 when it comes to food and sustainability: If more food is made to feed a growing population, the delicate balance of resources that existing food systems rely on will fail, leading to food scarcity. However, if more food isn't produced, there won't be enough food to feed a fast-growing population, exacerbating conflict and poverty.

## Food wastage and loss

The most visible form of where the world's predominant food-system model fails is food wastage and loss. Globally, more than 1.3 billion tonnes of food is produced every year that never gets eaten—this is surplus food. In 2019, the U.S. food system alone produced 229 million tons. Thirty-five percent of that did not get sold or eaten, about 54 million tons.

Some surplus food is lost, which means it becomes inedible before it ever reaches our plates. That might be on an assembly line or in a processing plant, or it might spoil while it's being distributed or stored. Food loss is typically the unintended result of technological or logistical choices.

Wasted food, on the other hand, is any food that is good to eat but that gets thrown out and ends up in a landfill or sewage system. It also includes food left to rot in fields due to unfavorable market factors.

Food can go to waste in many ways. Leftovers, put in the refrigerator with the best intentions, don't get eaten. Products that a company was sure would be a hit fail expectations, lingering too long on grocery store shelves until their expiration date passes. Scraps from a busy restaurant end up in the dumpster out back.

ReFed, a nonprofit in the United States that was launched to end wasted food, estimates that consumers and businesses together lost $408 billion last year by making and buying food that didn't get eaten. That's 2 percent of the country's total gross domestic product.

However it gets wasted, food that doesn't end up eaten is a source of immense environmental pressure. The food that goes uneaten in the United States—20 percent of all food that is purchased—is about more than the individual meals or snacks that get tossed. In total, this mountain of waste represents 14 percent of all fresh water used to make food, 18 percent of agricultural land farmed, and 24 percent of material taking up space in landfills where it releases methane, a greenhouse gas (GHG) that is 28 times more potent that carbon dioxide as a heat-trapping gas.

*Where* food gets wasted matters, too. For example, produce that is thrown out at home has a carbon footprint (also known as a "foodprint") that is six and a half times greater than produce that never gets harvested. The reason for this goes back to the systems approach: All the emissions spent on picking, transporting, and refrigerating it add up.

The impacts of uneaten surplus food are not only ecological and economic, but social. A hefty portion of food that gets wasted is still perfectly edible. While some of this is donated to support hunger relief programs, most of it ends up spoiling. There remains considerable room for growth for improving how much nutritious food is diverted to people who need it, including in countries like the United States, where one out of every seven Americans is food insecure.

**Strategies for tackling wasted food**

The best strategy for reducing how much food goes uneaten is, of course, to prevent it from going to waste in the first place. Tactics range from meal-planning at home, smarter inventory methods in restaurant kitchens, and more efficient processes for food manufacturers. Additionally, prevention includes diverting edible food to hungry people.

But what happens when prevention isn't possible?

Environmental agencies have spent considerable effort to find practical ways that municipalities and businesses can use to recover value from wasted food that they can't prevent. For example, Melissa Hall and Ava Labuzetta, who manage the New York State Pollution Prevention Institute's (NYSP2I) sustainable food program, developed a series of tools to help organizations incorporate existing food-waste recovery and recycling methods into their strategic planning.

**Common methods**

Of course, not every food item we throw away is edible. Food scraps like orange peels or chicken bones can't be eaten. It's also unrealistic, sustainability experts admit, to think that absolutely no food will ever be thrown away, especially in large facility kitchens and institutional cafeterias.

Composting is a recovery method that turns waste into nutrient-rich soil. It has come a long way in recent years, evolving from a go-to for serious gardeners and organic farmers into a scalable industrial process.

Anaerobic digestion is another method that can be applied to a wide range of organic material in addition to inedible surplus food, like cow manure and sewage. It is popular in the dairy industry, where farmers use "digesters" to turn cow manure and other wastes into valuable materials, like animal bedding, fertilizer, and biofuels. It can be applied to multiple kinds of biomass simultaneously, making it an attractive pathway for recycling wasted food along with other problematic organic wastes.

**Policy efforts in the United States**

The COVID-19 pandemic has led to a boom in compost sales as people spent more time at home. But the rise of a "compost market" didn't happen by itself.

The U.S. Composting Council (USCC) has made significant gains in attracting federal support for the creation of composting infrastructure, establishing a code of standards, and advocating for organics-specific strategies among municipal solid waste planning.

In 2016, California passed a law, Senate Bill No. 1383 (SB 1383), setting targets for reducing emissions of methane. SB 1383 intends to reduce the statewide disposal of organic waste, a major source of methane, by 50 percent by 2020 (based on 2014 levels), and by 75 percent by 2025. The law also stipulates that at least 20 percent of uneaten food that is still edible must be recovered for human consumption. As a mandate, it gives the California Department of Resources Recycling and Recovery (CalRecycle) the authority to put in place strategies to achieve these targets.

In New York State, the Food Donation and Food Scrap Recycling Act will go into effect in 2022. The state's biggest generators of wasted food will be required to separate edible food from what they discard and to recycle the rest (if a recycling facility exists within 25 miles of where they are located). The New York State Department of Environmental Conservation predicts that the law will keep more than 250,000 tons of food out of landfills each year while getting food to nearly 2.5 million people in the state who do not have adequate food to eat.

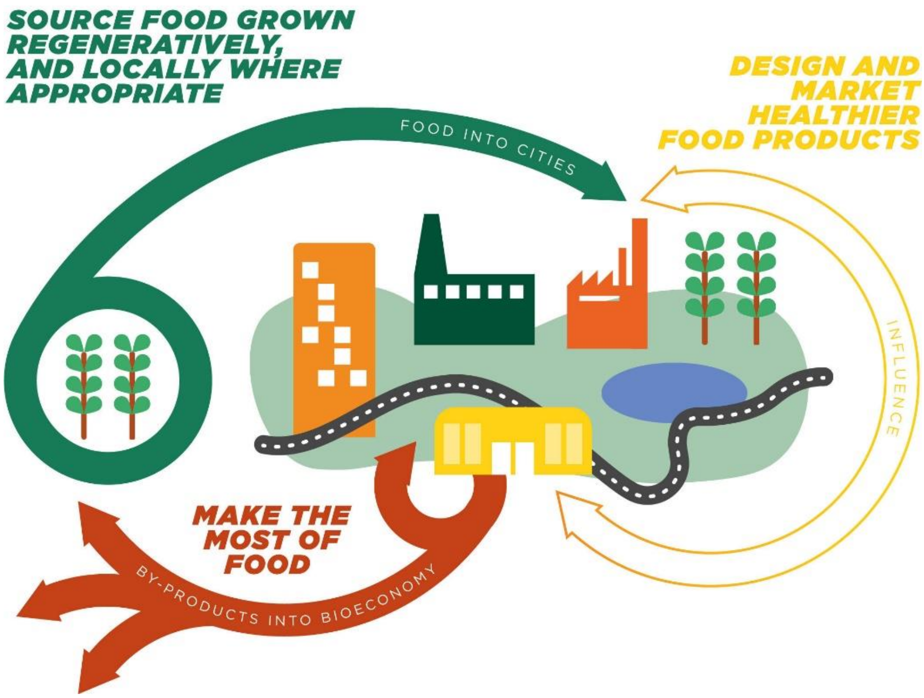
Like California's, New York's legislation will create a positive economic environment for investment and innovation within organic-waste recycling. The states expect to see significant growth in composting and anaerobic digestion facilities. Such policies may not see immediate results but, when it comes to sustainability, they have the long-view in mind. They are not only laying the ground for existing solutions, like those described above, but are creating an atmosphere where new ideas, methods, and technologies can thrive.

## Food in a circular economy

Our current food system, a hallmark of industrial progress during the twentieth century, has fueled record levels of growth for most societies. But, today, the benefits of such productivity gains are in danger of becoming outweighed by the threat of climate change, resource scarcity, and rising costs. Many researchers, policymakers, businesses, and technology innovators are looking for new ways to make and consume food that regenerate, rather than strain, Earth's natural systems; that provide everyone with access to healthy food; and that ensure long-term economic prosperity. A model that a growing number believe can meet these three objectives is the circular economy.

So, how would food look in the circular economy?

The Ellen MacArthur Foundation (EMF), a pre-eminent global voice for the circular economy, answered this question by designing a completely new food system based on circular principles. It sets out to pursue three ambitions: source food grown regeneratively (and locally, where appropriate); make the most of food; and design and market healthier food. EMF estimates that strategies based on these ambitions, described in more detail in the 2019 report *Cities and Circular Economy for Food*, would realize a reduction in GHG emissions worth 4.3 billion metric tons of carbon dioxide equivalents, save $550 billion in health costs, and create new markets with a total value of $700 billion.




*A circular food system, graphic by Ellen MacArthur Foundation*

A unique focus of EMF's vision is that cities are put at the center of a circular food system. This is because population trends show that cities are where most people tend to live, where most food is consumed, and where most food goes to waste.

Food in the circular economy would be produced in ways that improve the health of the surrounding ecosystems while also being profitable. Known as "regenerative food production," it's when farming and manufacturing is done in ways that actively restore habitats and protect biodiversity while reducing GHG emissions. Farmers, fishers, ranchers, and other workers also depend on a sustainable food system, and so regenerative food production means ensuring their health and prosperity.

**Valorizing wasted food**

In a circular economy, what we treat as waste becomes a resource that can be used to make more food, new products, or meet another need in some way. A circular economy designs waste out of our production and consumption systems, re-incorporating post-consumer materials into new cycles of use. Food matter that can't be eaten, as an organic material, represents value if paired with the right technologies or methods. It can be used to make bioenergy, organic fertilizers, and sustainable industrial materials. In other words, uneaten food, as a form of biomass (which is any matter made from plants and animals) can serve as a viable feedstock to produce energy and to manufacture new products.

Circular-economy thinking is a model for combining existing technologies like anaerobic digestion and pyrolysis in new ways to fully *valorize*—that is, extract value from—food waste. As mentioned earlier, food waste can be converted into fertilizer and biogas through anaerobic digestion. Backed by the circular economy, the limits of such strategies can be stretched to include emerging technologies, like biochar production: Researchers at GIS are currently exploring how pyrolysis—the thermochemical process for making biochar—can be used to concentrate and stabilize carbon in biomass while making valuable industrial materials from organic waste like food and wastewater biosolids. This work is led by Thomas Trabold, faculty member and head of GIS's Department of Sustainability.

**Thinking regionally**

In New York State, most anaerobic digestion happens on dairy farms in the state's western counties. If policymakers plan to make anaerobic digestion a part of its strategy to tackle food waste (which they do), new facilities will need to be sited closer to cities like New York City and Albany where large volumes of wasted food is generated.

How will this affect local food-energy-water (FEW) systems? Are there enough hauling services in operation? What will be the emissions associated with transport? Should facilities be fitted with biochar kilns and dry digesters? How will processed products like biogas or liquid digestate get to market?

The answers to these questions—which are just a slim sample of what might be asked—would vary considerably between different regions. The logistics of a sustainable food system reflect where it is and who makes it up. Some conditions are ecological: A food system in New York State's northernmost region, where winters are long, may have a shorter growing season for farmers than one in Georgia. Other factors are social or economic: A seaside resort might have to deal with far more food waste at the height of the tourist season compared to off-season months when tourists are few.

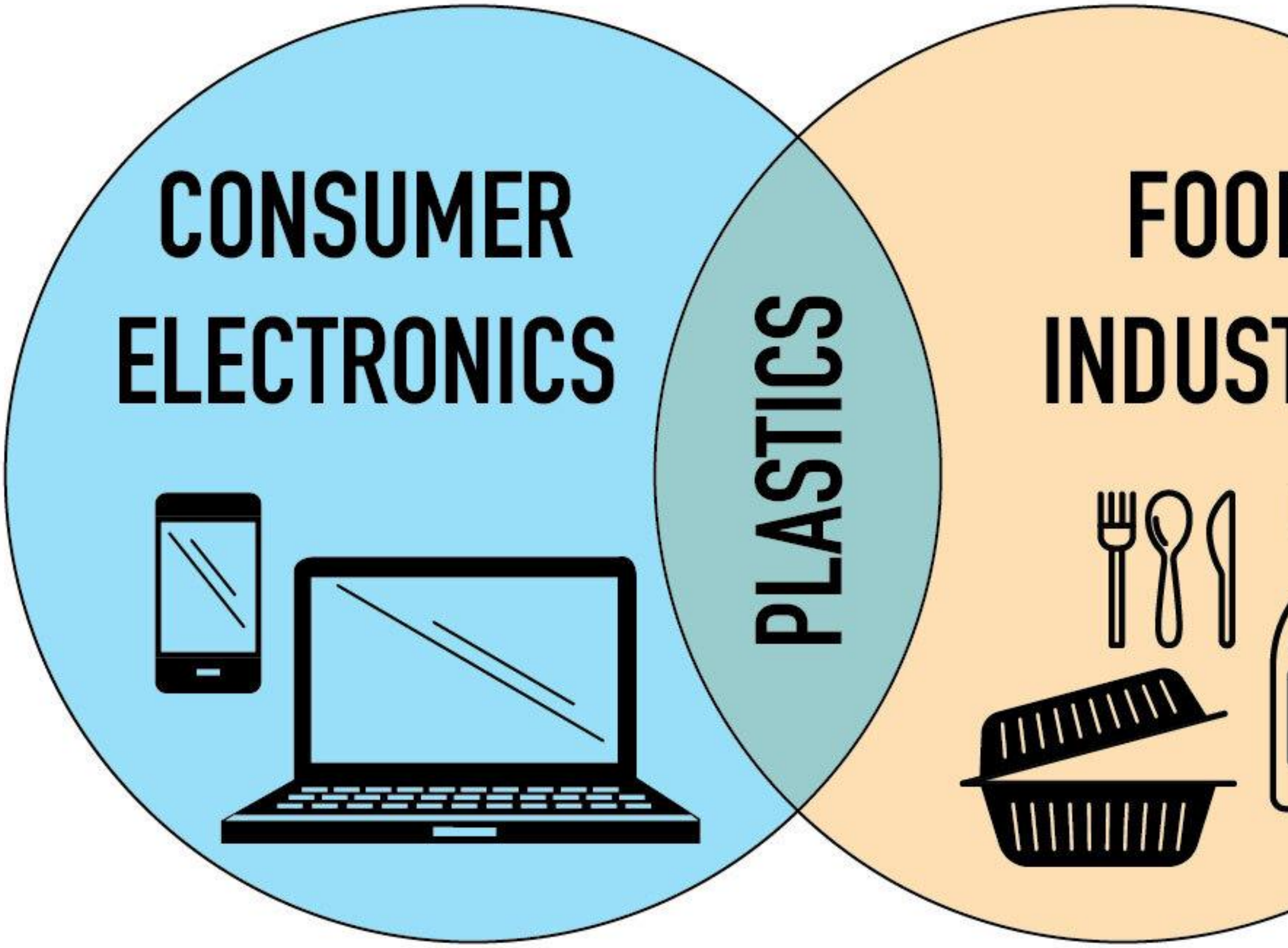
**Uncovering blind spots**

Most food waste policies in the United States are informed by the Environmental Protection Agency's (EPA) food-recovery hierarchy triangle. It shows graphically the most preferred method for addressing food waste (prevention) and the least preferred (landfilling). It has been a powerful instructive tool for raising public awareness of wasted food and how to counter it.

Callie Babbitt, an associate professor at GIS, has focused much of her research on discovering what policymakers need in order to design policies based on circular economy principles. She has found that broad, general approaches like the EPA's food recovery hierarchy may gloss over important differences between geographic regions and other local nuances.

A policy that might work well in one region may not be right for another. Babbitt looks for ways to account for the factors and contingencies that really shape food systems at the local, regional level. She is interested in collecting data about a food system, whether that's determining flows of material or performing life cycle assessments (LCAs) of specific products. Her goal is to give policymakers a methodology for mapping out opportunities and dead ends when they are considering different policies. Say a new technology for recycling food waste has been introduced, decision-makers could use Babbitt's model to predict the economic, ecological, and social tradeoffs that would come with it.

**Eyes on the big picture**




*Venn diagram showing how the food and consumer electronics industries both rely on plastic.*

The FEW nexus concept portrays how food systems interact with industrial and economic systems. Consider a smartphone. On the surface, how it's made has little in common with how a bag of potato chips was made. Yet the picture changes when you consider that the consumer electronics industry and the food industry both heavily rely on a common material: plastic. Circuit boards perform how they do thanks to properties that only plastic can offer. Likewise, most of the products we expect to see in a grocery store aisle would go stale or rot before making it to the shelves without plastic packaging.

A single food system doesn’t exist in a closed circuit. It intersects with many different systems. Some of these are part of local ecosystems, like water and soil. Others are industrial, like energy. Sustainability researchers characterize how these systems relate as the FEW nexus. In 2016, a team of researchers from RIT were awarded a grant from the National Science Foundation to better understand the FEW nexus as it affects food systems. Their research—Babbitt was the initiative’s principal investigator (PI)—has shown how a systemic approach to food can illuminate new ways of thinking about food and the far-reaching impacts of how we make and consume it today.

Circular economy researchers like Babbitt and organizations like EMF have a critical role to play when it comes to transforming food systems. They give decision-makers the ability to see the larger systemic view in order to make use of the subtle interactions and tradeoffs that might otherwise pass them by.

https://www.rit.edu/sustainabilityinstitute/news/blog-edible-sustainability-how-food-systems-work-and-why-they-matter