# SEEDS OF DISRUPTION

HOW TECHNOLOGY IS REMAKING THE FUTURE OF FOOD

A GLOBAL FOOD OUTLOOK MAP OF THE DECADE 2013–2023

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# SEEDS OF DISRUPTION

## **TECHNOLOGY AND STRATEGY** AT THE LIMITS OF OUR PLANETARY FOOD SYSTEM

**Human experience is deeply rooted in food—in the cycle of human activity that includes food production, distribution, manufacturing, shopping, and finally, eating. This cycle shapes our daily lives at work and at rest, in politics and in play, in our bodies and in our imaginations.**

For many of us, these food experiences are professional as well as personal. Food scientists and farmers alike experiment with ways to produce more, and hopefully higher quality, food. Entrepreneurs and innovators engineer processes to manufacture a cornucopia of flavors from a few staple ingredients. They design distribution systems that bring diversity to our markets, kitchens, and tables. They create shopping experiences that speak to our personal desires and foretell pleasures to come. And as mealtime approaches, they help busy humans, including themselves, make those pleasures both convenient and real in ways that range from healthy to hedonistic.

Over the last few decades, our planet's complex food system has thus developed several core strategies for optimizing this cycle of food experiences. Production aims for intensification. Distribution requires efficiency. Manufacturing is at its best when it can be standardized. Shopping centralizes food in a common marketplace. And when it comes to eating, convenience and affordability still dominate diners' considerations.

These strategies have been well honed by generations of people engaged in the experience of food. But today, these strategies are encountering their limits. Technological innovations are poised to take us beyond those limits, to transform the way we experience food in all our encounters with it. Over the next decade, we will re-experience food as we look to these technologies—not just to help us breach these limits, not only produce the food we need, but also to fulfill our evolving desires for ourselves, our children, and the planet.

# **CORE STRATEGIES** ENCOUNTERING LIMITS

PRODUCTION

## REORGANIZING **INTENSIFICATION**

Over the past 50 years we've gotten more out of less: increasing yields, intensifying aquaculture, factory farms. But in the 50 years to come, this path will widen the gap between what we need and what we can produce. Degraded land, collapsing fisheries, and carbon-intensive production are problems that need action now to close the gap. **Technologies, and an ecological understanding of how to use them, will reorganize how and where we focus our quest for abundance.**

DISTRIBUTION

## REBALANCING **EFFICIENCY**

The shipping container transformed efficiency: flexible units stack together the power of ships, trains, and trucks. Efficiency rules for food headed to factories, restaurant kitchens, and markets. But we've made tradeoffs. Foods are not as tasty and nutritious as they once were. Some operations struggle to reconnect to local sources, while others must scale up: and efficient systems are often inflexible and brittle. **We will see a rebalancing towards resilience, local sources, and deliciousness.**

MANUFACTURING

## REMIXING **STANDARDIZATION**

Consistency of taste and texture was a 20th century breakthrough. From Kraft's homogenized cheese to Coke's algorithmic orange juice, we have standardized even the most unruly ingredients. But this has meant selecting and processing—and some question whether the results are truly "food." **As commodity economics squeeze suppliers and consumers become skeptical of foods filled with sugar, corn, and additives, we'll remix standardization. Processing will become transparent.**

SHOPPING

## RETHINKING **CENTRALIZATION**

The past decades saw the rise of one-stop shopping. Supermarkets and big box retailers turned food shopping into a once-a-week activity where everything was offered in one place. This behavior is reaching its limits. Food waste plagues retailers and consumers want the real-time convenience of the Internet in the physical world. **Shopping will no longer be an episodic event, but rather something that can be done anytime, anywhere.**

EATING

## REDEFINING **CONVENIENCE**

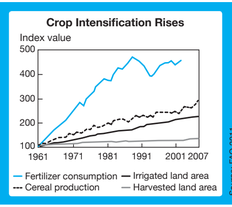
For decades, speed and ease have defined eating: fast food, ready meals, and "on-the-go" products. But the OECD has found that as we spend less time preparing our food, we're packing on pounds. Mindless eating is driving lifestyle diseases among the affluent, while billions of others go hungry. To address this dilemma, **we will need to redefine convenience from being about getting food fast to making mindful and healthful eating accessible for all.**

# FOOD: A CYCLE OF HUMAN EXPERIENCE

**CORE STRATEGIES** ENCOUNTERING LIMITS | **DISRUPTIONS** POINTING TO NEW PATHS | **STRAINS OF UNCERTAINTY** UNEARTHING EXTREME POTENTIAL

## PRODUCTION

### INTENSIFICATION




Source: FAO 2011

#### GROWING FOOD ON EVERY SURFACE

Communities' increasing demands for sovereign food systems will drive a shift from monocropping rural land to ubiquitous microfarming. Advances in film farming, aeroponics, and aquaponics will allow urban communities to grow food crops with minimal soil and water use, indoors and outdoors. Urban farming will transform from scattered rooftop gardens into dense local production, ranging from state-of-the-art vertical farms to derelict warehouses. Swarming robots and other autonomous machines enable cultivation on hard-to-reach surfaces in cities, and on depopulated rural farms.

#### TRANSFORMING PROTEIN

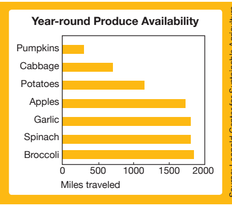
Substitutes and in-vitro creations are transforming animal husbandry. While biologists have begun exploring the use of stem cell technologies to create "in-vitro" meat, synthetics made from soy beans and other plants that are virtually indistinguishable from animal proteins are already hitting store shelves. Often cheaper and easier on the earth, these substitutes have the potential to reinvent protein. We'll see a shift from concentrated animal raising to synthetic substitutions. However, the opinions of consumers about these options will prove volatile as well.

#### CLIMATE-RESILIENT AGRICULTURE

While today agriculture is the eighth-largest contributor to greenhouse gasses, it could quickly become one of the most powerful tools for mitigating climate change. Technologies and techniques are emerging to provide scalable solutions to thorny problems of waste management, soil depletion, and desertification. Re:char's model of selling the tools necessary to make profitable and ecological agricultural input exemplifies locally-appropriate replication of key technologies, combined with global knowledge-sharing and coordination.

## DISTRIBUTION

### EFFICIENCY




Source: Leopold Center for Sustainable Agriculture

#### TAPPING DISTRIBUTION NETWORKS

Today's distribution networks can quickly reach remote areas, but are dominated by large producers. Social technology platforms are poised to disrupt this system by allowing small-scale producers to piggyback on existing shipping, trucking, and rail infrastructure. This cuts out middlemen, automates administrative tasks, and provides logistical support to enable dynamic economies of scale. Seamless integration of small producers will allow procurers to meet demands for locally sourced food and reduced-waste.

Source: ColaLife

**Filling supply chain gaps**

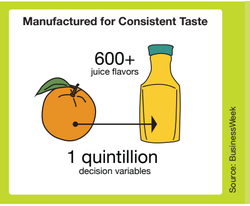
ColaLife is a non-profit that delivers essential medicine and nutritional supplements to remote regions by leveraging unused capacity in Coca Cola's supply chains.

#### SUPPLY CHAIN SABOTAGE

The current emphasis on efficiency and the deep integration of hackable technologies leave food systems vulnerable to intentional disruptions. Additionally, the incredibly complex global supply chain for much of the world's food has proven itself difficult to monitor effectively. While profiteering and negligence already threaten this chain, intentional sabotage of the food supply chain could cause significant illness and casualties on a near global scale, as well as mass panic.

## MANUFACTURING

### STANDARDIZATION



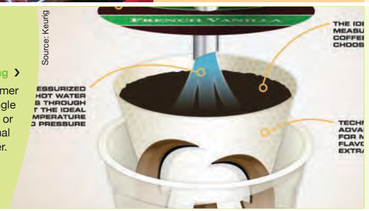

Source: BusinessWeek

#### TAKING MANUFACTURING LOCAL

As improvements in small-scale electronics continue over the next decade, an increasing number of food manufacturing tasks that previously required large-scale factories and equipment will move to supermarkets and, at times, even into homes. Already, direct-to-consumer devices such as Soda Stream are enabling people to create soda in-home, while prototypes of 3D food printers point toward a future where local ingredients processed by lightweight equipment will disrupt large-scale manufacturing processes with locally customizable foods.

**Automating precision coffee making**

The K-Cup machine is a consumer device that precision brews a single cup of coffee, tea, hot chocolate, or other hot beverage with minimal effort from the user.



Source: Keurig

#### OPEN FOOD MANUFACTURING COMMONS

Technology has already greatly reduced the cost of producing many foods due to vast economies of scale. In the next decade, advances in digital manufacturing, sustainable energy, citizen-led bioengineering, and automation could reach a tipping point. The convergence of these technologies could make even very sophisticated food processing systems accessible around the world, reducing the set up cost of such systems to the point where communities could create self-sustaining food commons that rival the technical sophistication of large-scale multinationals.

## SHOPPING

### CENTRALIZATION


Source: FAO 2009

#### GROCERY SHOPPING WITHOUT THE STORE

Over the next decade, conventional food retail channels will be disrupted by a variety of new services promising on-demand home delivery. Offerings like Tesco's virtual grocery store in a South Korean subway, as well as more recent efforts like Starbucks' car dashboard that enables coffee ordering while driving, point to a retail future where food purchasing is independent of purchase location. These technologies will converge with systems such as Kiva's automated warehousing robots and self-driving cars to create just-in-time home delivery services.

Source: Matternet

**Delivering by drone**

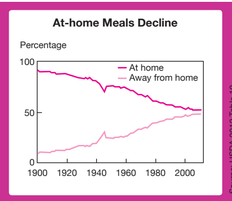
Matternet aims to leapfrog road infrastructure in developing countries by using drones to offer more convenient and precise just-in-time delivery.

#### DECISION-FREE SHOPPING

As our refrigerators, cabinets, packages, and even bodies become connected in a tapestry of networked matter, shopping turns into a wholly automated process that requires no human decision-making. Food orders are determined by our inferred preferences and health needs and are triggered automatically when supplies dwindle. In this landscape, shoppers cease to consciously look for new options, rendering packaging and other aspects of persuasion irrelevant.

## EATING

### CONVENIENCE




Source: USDA 2012 Table 10

#### LEVELING UP COOKING SKILLS

As the appliances in our kitchens—from refrigerators and stoves to pots, pans, cutting boards, and spatulas—gain the ability to communicate with us and with each other, cooking fresh meals will become increasingly easy and convenient, drastically reducing purchases of processed or pre-cooked meals. Kitchen helper tutorials and games will interface with numerous appliances and brands. Chefs and video game companies, food companies, grocery stores, and everyday people will create programs to promote cooking skills.

#### AUGMENTING MINDFUL EATING

Technologies have become the nemesis of a mindful eating experience. But in the next decade, instead of just being a distraction, technology will be put to use to encourage eating mindfully. Visual, tactile, and other sensory feedback will reinforce positive habits, such as actively paying attention to food, body cues, and social company. The benefits of these practices will continue to be quantified and successfully deployed to prevent weight gain and to make eating experiences more social and enjoyable.

#### TASTE REWIRED

People trying to lose weight have one obstacle above everything else: their own biology. Humans are hardwired to find sugary, fatty, calorie-rich foods delicious. However, in the next decade, new kinds of permanent surgeries will arise to change how our brains process taste and hunger; in other words, a gastric bypass for the brain. While today's food landscape is built around natural food preferences, the ability to effectively hack our brains could result in massive shifts in the quantity and types of foods we consume.

## HOW TO USE THIS MAP

Start at the center. Five food **experiences** make up the cycle of our interactions with the food web: Production, Distribution, Manufacturing, Shopping, Eating.

REDEFINING CONVENIENCE

Each of these have been guided by **core strategies,** which are being remade as they encounter new limits.

Technological **disruptions** point to new paths forward. They are represented on this map by signals, examples from today's world that indicate the direction of future change.

At the edges of possibility are **strains of uncertainty,** wild cards that are low probability but with the potential for high impact.

# SEEDS OF DISRUPTION

## EATING

### TASTE REWIRED

**Deceiving the brain**

Ghost Food is an experiment by artists Miriam Simun and Miriam Songster that uses scent to give people the illusion they are eating a different food than what they are actually consuming.

Source: Miriam Simun and Miriam Songster

**Bypassing the need for real food**

Rob Rhinehart, a 24-year-old man from Atlanta, GA, has found a way to live "without food" by exclusively consuming an odorless beige drink called Soylent that contains every nutrient required by the body to function. In October 2013 he received $1.5M in VC funding to mass produce the mix.


Source: Soylent

### LEVELING UP COOKING SKILLS

**Perfecting technique with 3D cameras**

UC Berkeley researchers have experimented with using the Microsoft Kinect device in a kitchen environment to help people learn to cook with individualized, real-time feedback based on movement.

Source: UC Berkeley

**Networking smart appliances**

The Smart Manager system for LG's refrigerator recommends meals based on the foods inside, and can even coordinate with other appliances, like the oven.

Source: LG

### AUGMENTING MINDFUL EATING


Source: Hapilabs

**Quantifying eating speed**

The HAPIfork electronic fork monitors your eating habits and alerts you with lights and gentle vibrations when you are eating too fast.

Source: Kit Kat

**Forcing digital sabbaths for uninterrupted snacking**

In Amsterdam, Kit Kat's "No WiFi benches" disrupt all wireless signals within five meters, allowing people to focus on eating and being present with friends.

## REDEFINING CONVENIENCE

from on-the-go eating
to mindful food experiences

## DISTRIBUTION

### GROCERY SHOPPING WITHOUT THE STORE

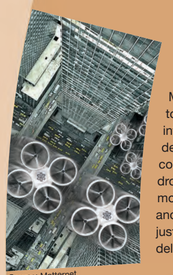
**Augmenting vacant space**

Chinese online grocery retailer YiHaoDian has created one thousand virtual supermarkets in vacant lots where shoppers can "browse the aisles" and purchase foods for delivery with an augmented reality app.


Source: YiHaoDian

**Delivering by drone**

Matternet aims to leapfrog road infrastructure in developing countries by using drones to offer more convenient and precise just-in-time delivery.


Source: Matternet

### RETHINKING CENTRALIZATION

from centralized
shopping sites
to just-in-time
delivery

## SHOPPING

### DECISION-FREE SHOPPING


Source: David Rose

**Automating purchases**

The Amazon trash can is an MIT Media Lab concept product that scans items as you throw them away and allows you to automatically reorder them.

Source: Rosie

**Anticipating purchasing needs**

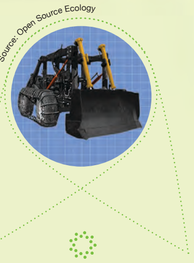
Rosie is a mobile shopping platform that learns users' purchasing behavior for home goods and food and anticipates when it should order more.

## MANUFACTURING

### REMIXING STANDARDIZATION

from standardized
to personalized
formulation

### TAKING MANUFACTURING LOCAL


Source: Open Source Ecology

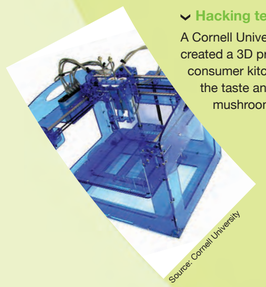
**Constructing industrial machines**

The Global Village Construction Set, from open-source ecology, is an open technological platform that allows for "fabrication of the 50 different industrial machines that it takes to build a small civilization with modern comforts."

### OPEN FOOD MANUFACTURING COMMONS

**Hacking texture**

A Cornell University team has created a 3D printer that can fit in a consumer kitchen that replicates the taste and texture of bananas, mushrooms, and mozzarella.


Source: Cornell University

**Automating precision coffee making**

The K-Cup machine is a consumer device that precision brews a single cup of coffee, tea, hot chocolate, or other hot beverage with minimal effort from the user.


Source: Keurig

**Replacing line cooks**

Momentum Machines' robots can make hamburgers more precisely than humans at a minimal cost.


Source: demonstech.com

## PRODUCTION

### REORGANIZING INTENSIFICATION

from resource-intensive agriculture
to low-impact alternatives

### GROWING FOOD ON EVERY SURFACE

**Growing crops without water or soil**

Dubai-based Agricel enables no-soil low-water growing in indoor and outdoor conditions.


Source: Agricel

**Swarming robot farmhands**

Prospero is a working prototype autonomous robot that uses swarm and game theory to automate complex agricultural tasks.


Source: Dorhout R&D

### TRANSFORMING PROTEIN

**Reformulating eggs**

Hampton Creek Foods' Beyond Eggs, a cheaper, more sustainable, and healthier plant-based egg substitute is now available for sale at Whole Foods, and has been used as a replacement in industrial scale baking and mayonnaise production.

Source: Hampton Creek Foods

**Fooling food critics**

Beyond Meat's faux chicken is nearly indistinguishable from the real thing, even fooling *New York Times* critic Mark Bittman.

Source: Beyond Meat

## FOOD EXPERIENCES

### TAPPING DISTRIBUTION NETWORKS

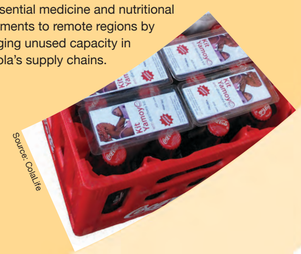
**Aggregating B2B demand**

Local Food Systems, Inc., allows small suppliers to sell to large procurers by using business-to-business technology to aggregate products.

Source: localfoodsystems.org

**Filling supply chain gaps**

ColaLife is a non-profit that delivers essential medicine and nutritional supplements to remote regions by leveraging unused capacity in Coca Cola's supply chains.


Source: ColaLife

**Sourcing local**

United States Northwest-based FoodHub partnered with Massachusetts-based FoodEx to expand alternative distribution systems for local and regional producers.

Source: Food Hub

### REBALANCING EFFICIENCY

from large-scale efficiency
models to distributed resilience

## SUPPLY CHAIN SABOTAGE

**Exposing inspection gaps**

In 2011, the FDA inspected just 6% of domestic food producers and 0.4% of importers, according to *Bloomberg*. Under the Food Safety Modernization Act there are still no requirements for microbiological testing to confirm the efficacy of safety programs.


Source: The U.S. Food & Drug Administration

**Speculating no more**

Acknowledging the danger of the "financialization" of food, Barclays, Crédit Agricole, and BNP Paribas have agreed to close agricultural commodity speculation funds. According to Oxfam, in the past five years financial speculation on food has nearly doubled from US $65 to $126 billion annually.


Source: Flickr user foodiesfeed

## CLIMATE-RESILIENT AGRICULTURE

**Replicating carbon-negative farming**

Systems like re:char, which makes kilns that convert waste into a carbon-negative soil amendment that helps farmers grow up to 144% more food while sequestering carbon, illustrate farming methods that improve the environment, instead of minimizing damage.


Source: re:char

**Grazing to reverse desertification**

According to Allan Savory, rather than segregating livestock and wilderness preservation, combining them could reverse desertification and improve livelihoods across vast areas of the earth's surface, making livestock key to reversing climate change.


Source: CIAT International Center for Tropical Agriculture

## STRAINS OF UNCERTAINTY

# ABOUT THIS MAP

This map is a tool for starting conversations about how technologies can be used wisely to close important gaps in the food system. These gaps are between what we can make and what we need, between the haves and the have-nots, between the foods and eating practices that are healthy and those that are harmful. From wherever you stand in the world food web—from food scientists to farmers, entrepreneurs to politicians, to all of us eaters—we invite you to engage in this conversation, and seek the disruptions that will be useful in the long term.

Use this map to get a high-level overview of the possibilities that technologies will create in the next decade. Combine it with *Remaking Food Experiences,* our set of companion forecast perspectives, to develop insights into how technologies intersect with human values, and remake the future of the food system.

**IMMERSE** YOURSELF
in the cycle of food experience and how it is being remixed, realigned, and remade.

**IDENTIFY** OPPORTUNITIES
to leverage technological disruptions to make a better future today.

**ENGAGE** WITH UNCERTAINTY
to recalibrate the fears and hopes we all hold about technology's potential.

**REMAKE** THE FUTURE OF FOOD
for people and the planet.

### ABOUT GFO

The Global Food Outlook Program's research and forecasts explore the tensions and possibilities of food futures, from people's everyday food habits and choices, to the dynamics of global food markets, to the complex environmental issues that sustain food production. For seven years, we've worked with organizations to use foresight to think through disruptions and dilemmas in food and agriculture. By thinking systematically about these future possibilities, we help our clients, sponsors, and collaborators develop more resilient strategies for a decade of volatility and change.

### ABOUT IFTF

The Institute for the Future is an independent, nonprofit strategic research group celebrating 45 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research generates the foresight needed to create insights that lead to action and spans a broad territory of deeply transformative trends, from health and health care to technology, the workplace, and human identity. The Institute for the Future is based in Palo Alto, California.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