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Food for thought

Technology-driven solutions offer the promise of feeding a growing global population while limiting the burden on the environment.

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MONTHLY
Focus

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Food for thought

Today's realities and tomorrow's challenges are calling for new, technology-driven food production and distribution solutions spanning a range of activities from farm to table. In the fifth article in the SusTech series, we look at technologies that offer the promise of feeding a growing global population while limiting the burden on the environment.

One of the biggest challenges of the coming decades is how to feed a growing world population despite limited scope to expand agricultural land and reduced labor supply due to urbanization. And all of this is coming against the backdrop of unpredictable and extreme weather patterns arising from climate change.

It is a task of herculean proportions. A University of Washington study forecasts that the world population, currently at 7.8 billion, could peak at 9.7 billion in 2064, an addition equivalent to close to six times the U.S.'s current population. To sustain current food consumption patterns, the Food and Agriculture Organization (FAO) of the United Nations predicts food production would have to rise by a whopping 50 percent.

The massive environmental impact makes this scarcely sustainable. Agriculture is the single-largest user of freshwater, accounting for over 90 percent of global annual freshwater consumption, according to our national research correspondent, while single-handedly generating 18 percent of greenhouses gases (GHGs) worldwide (for more, see our article on climate change). Too many harvests can also lead to soil degradation.

Consumers are doing their part. Concerned about the carbon footprint of their food as well as their own health, they are becoming more discerning. Healthy eating is a priority for many, and preferences are undergoing a seismic shift.

To meet the challenges, agriculture and food industries have to adapt, the former by delivering more food from fewer resources, the latter by producing healthier food via methods that are less harmful to the planet. Demand for tools and solutions to increase productivity and boost profits has increased as it is clear that technical innovations are needed.

In this report we look at some of the innovative agricultural methods offered by AgriTech that aim to optimize crop yields and efficiencies, and the FoodTech solutions that seek to satisfy consumers' new demands.

AgriTech

Technical solutions from farm to table that increase crop yields while reducing stress on the environment

We highlight a few key strategies to deliver more with less: increasing yields on agricultural lands; controlled environment farming; and supply chain efficiencies. Many of the innovative solutions driving these strategies are already in use in some parts of the world, but we believe their adoption will become increasingly widespread over the next decade.

Increase yields on agricultural lands

Precision farming

Tractors, harvesters, and other self-propelled farming vehicles have come equipped with GPS capability for the past couple of decades. More recently, drones equipped with autonomous controls, crash avoidance systems, and an array of sensors are making farming more precise and productive by assessing soil moisture and nutrient deficiencies, as well as crop density and health. This can save valuable work hours and reduce costs while improving farm knowledge through the collection and processing of millions of data points.

Drones can be used to spray powdered insecticide or fertilizer on specific areas to sow seeds, as well as be employed to monitor weeds and pests. Drone-enabled infrared mapping can allow a farmer to assess crop conditions at a cost as low as $5 per acre, according to a 2018 paper from Deloitte. The study argued that the information provided by a drone could permit farmers to boost crop yields by up to 20 percent. As the technology evolves, it noted that farmers will be able to see all the problem areas on a field within minutes, whereas with the traditional method of walking and observing, they would detect a mere 10 percent of them.

Another precision farming solution is smart irrigation, which uses sensors to determine and apply the exact amount of water required by plants. A valuable alternative to flood irrigation, still the most common form of irrigation throughout the world, smart irrigation can enhance yields while

Some AgriTech strategies to deliver more with less

Some innovations are already adopted but will become increasingly widespread

Strategies	Solutions
Increase yields on agricultural lands	• Precision farming – Satellite imaging, drones, sensors – Smart irrigation and soil technologies – Data analytics with artificial intelligence and big data – Internet of Things and connectivity • Gene technology – Disease and pest resistance – Biofortified plants – Plant phenomics and smart phenotyping
Controlled environment farming	• Greenhouse and indoor farming technologies • Vertical farming • LED lighting systems • Aeroponics and hydroponics
Supply chain efficiencies	• Direct farm-to-consumers (meal kit delivery, e-groceries) • Waste reduction technologies – Crop waste reuse – Cooling and storage solutions – Cold chains – Smart packaging

Note: Phenomics measures the phenotypes (physical and biological traits) that can be produced by a plant as it develops and as it responds to its environment

Source - RBC Wealth Management

dramatically reducing water and electricity consumption. Despite these savings, the upfront costs of installing the technology can be prohibitive, thus making it challenging to be widely accessible.

Further into the future, but perhaps not that much further, Deloitte expects big data analysis will be used to direct robotic systems to spot pests on a plant and blast the appropriate amount of pesticide, or even to recognize ripe fruit and pick it. Thanks to machine learning, robots could be used to harvest a crop, perhaps even predicting harvest periods while anticipating packing and logistics requirements.

In a report issued in 2020, consulting firm McKinsey found that in the U.S., only a quarter of farms have adopted connected equipment, and most of these use the more limiting 2G or 3G networks. With better wireless connectivity, including 5G, it is possible to imagine a world where all the equipment on a farm is synchronized, sharing data to make optimal decisions and implement them from seed to end product. McKinsey posits that advanced connected infrastructure will cover four-fifths of the global agriculture landscape (excluding Africa) over the next decade.

All this change will require substantial reskilling of farmers. Dealers and vendors of farming equipment will likely play an instrumental role in educating and training farmers to the extent that their business success will no longer depend solely on product sales, but equally on how successfully farmers utilize equipment.

Precision farming through digital technologies can improve efficiency, reduce costs, and increase farmers' returns on investments. According to our national research correspondent, precision farming via artificial intelligence, drones, autonomous machinery, and smart irrigation systems could yield productivity increases of up to 70 percent by 2050.

Gene technology

In the past, fertilizers and seed technologies have been the key drivers of increasing yields. Farmers have been cross-breeding to obtain more robust, productive plants for thousands of years. Genetically modified (GM) crops can be higher-yielding, more tolerant of both drought and heavy rain, and display greater resilience to pests and diseases. Despite widespread consumer resistance to GM foods, such products are unlikely to go away given the challenges outlined at the outset of this article. In fact, there very well may be more pressure to use them. In 2016, more than 100 Nobel laureates signed a letter in support of GM crops and foods, pointing out that distrust is misplaced and outlining their advantages in feeding a world population that is increasing while environmental challenges are escalating.

Controlled environment farming

With several major regions that have traditionally supplied much of the world's food now struggling with disasters brought on by climate change, safe and economical food procurement has become front of mind. Canada is a case in point. In the winter months it is highly dependent on California, where crops have been imperiled by droughts and wildfires, to supply fresh fruits and vegetables. Shortages stemming from the COVID-19 pandemic have only exacerbated supply disruptions, with the realization that a global crisis can freeze supply chains and force trading partners to withhold exports. Moreover, in most developed countries, urbanization has led to a scarcity of farmland around cities. Transportation and intermediary costs can be more than 50 percent of total food costs, according to our national research correspondent, so a solution to ensure economical food supply security has become a priority.

Controlled environment farming is becoming an increasingly compelling option to combat these challenges. Often located on the outskirts of cities, vertical farms grow produce by vertically stacking large trays containing seeds and plants. Within the vertical farm, critical environmental factors are controlled, including light (with efficient LED technology using only the red and blue light spectrum needed by the plants), humidity, and temperature. Pests are largely eliminated. Vertical farms can optimize yields as, for example, they can produce 20 times more lettuce than agricultural fields.

Vertical farms can make use of a variety of cultivation methods. Aeroponics consists of growing crops in the air and spraying the roots with a nutrient-filled water solution. Our national research correspondent points out that according to vertical farming leader AeroFarms, this method uses 95 percent less water than traditional farming. Alternatively, hydroponics, where plants grow in a nutrient-water solution, can also be used. Our national research correspondent estimated that this method requires 12.5 times less water per kilogram of lettuce per year.

Beyond shielding crops from unfavorable weather conditions and using less water, controlled environment farming has many other advantages: avoiding soil erosion, reducing the distance between farm and market, lowering dependence on climate-threatened imports, and largely eliminating pesticides and herbicides as input costs. But we acknowledge there are drawbacks. For example, should a technological problem arise, it could shutter the entire production process. It is also true that so far the applications have mostly been limited to the production of leafy greens. More innovations, such as a new generation of LED lights and seeds that are optimized for indoor environments, will be needed to make these techniques economically feasible for the production of a broader selection of fruits and vegetables and to lower operating costs.

To be clear, controlled environment farming is not about to replace traditional farming altogether. Challenges such as the availability of low-cost land and prohibitive zoning laws remain significant hurdles and are the main reasons why Canada, for instance, is struggling to keep pace with the leaders in this field, including the Netherlands, Israel, the U.S., and Singapore. But to the extent that controlled environment farming can generate a much higher production yield—without being subject to the vagaries of the weather while consuming only a fraction of the freshwater—these approaches can go a long way towards improving food supply security.

Supply chain efficiencies

According to the World Wildlife Fund, a whopping third of the food produced globally goes to waste, or enough to feed three billion people. As it rots, this wasted food produces methane, an especially damaging GHG that is 25 times as potent as CO_2 in trapping heat in the atmosphere, according to the U.S. Environmental Protection Agency. Reducing the amount of waste could see more food reach growing populations and also lower GHG emissions. Several solutions, including "cold chains" and smart packaging, can help to optimize various stages along the supply chain.

Techniques to reduce waste

Efficiencies can be gained all along the supply chain

Harvesting →	Handling & storage →	Processing & packaging →	Distribution to wholesale or retail markets →	Consumption (home, foodservice)
• Improve harvesting techniques • Convert unmarketable products into process products	• Improve storage techniques • Introduce cold chains	• Improve order management • Improve factory equipment efficiency • Introduce smart packaging • Alter production process	• Improve food date labeling system • Modify cosmetic standards to improve salability of imperfect (blemished) products • Modify promotional strategies	• Reduce package sizes • Promote imperfect products

Source - RBC Wealth Management, national research correspondent

A cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of refrigerated production, storage, and distribution activities, along with associated equipment and logistics, which maintain quality through stable, low temperatures. This process can help preserve and extend the shelf life of produce, seafood, and other perishable foods.

Improving product traceability for just-in-time delivery can reduce inventories and, to the extent that information such as shelf life, moisture, and freshness is available to a tracking device, enhance supply chain efficiency. One solution is smart packaging, which uses sensors or smart labels to monitor product quality and storage conditions. Some forms of smart packaging can trace tampering within the supply chain or alert a distributor/grocer/consumer to spoiled or contaminated food. Smart packaging is widely used in health care, and is increasingly finding its way into the food supply chain. More widespread use could meaningfully reduce spoilage and extend shelf life.

FoodTech

Technologies that aim to ensure food habits are sustainable, reducing the burden on the environment

The food industry has benefited from many technological innovations in recent years. As an example, Sufresca, an Israeli company, has developed edible coatings that extend the shelf life of fruits and vegetables and reduce the need for plastic packaging.

Some FoodTech strategies to deliver more with less

Alternative proteins will continue to gain share

Strategies	Solutions
Shelf life enhancement	• Edible coatings
Alternative proteins	• Look-alike – Cell-based or lab-grown meat – Plant-based dairy, meat, fish, eggs • Non-look-alike – Products made from beans, soy, mushrooms, chickpeas – Algae and insects

Source - RBC Wealth Management

However, the most talked about innovations of the past few years are the development of plant-based proteins, which stand out for their much lower environmental impact. RBC Capital Markets explored the potential for plant-based proteins in a recent report titled "Uprooting tradition: What plant-based alternatives mean for the future of protein" from the RBC Imagine™ series. Concerns about the environment, personal health, and, to a lesser extent, animal welfare have escalated in recent years. A 2019 Euromonitor survey found that as much as 46 percent of consumers globally restrict their consumption of animal products. Developments regarding taste, availability, and price are increasingly enabling consumers to align their purchases with their values, and without compromising their lifestyles. For example, oat milk, once a niche product, is surging in popularity. It is now very creamy and able to froth, and is thus taking share from traditional dairy as well as from other plant-based milk, such as rice milk and soy milk.

Plant-based meat substitutes which replicate processed meat products, such as burgers, chicken strips, or sausages, are a particularly interesting innovation. These are often made by altering pea proteins or fermented mycoproteins, also known as fungal proteins, to recreate the texture and appearance of real meat.

Early evidence suggests that such plant-based products have a materially less environmental impact than livestock farming, which is responsible for a significant proportion of methane emissions and water usage (see our SusTech article). A University of Michigan study on Beyond Meat, a U.S.-based producer of plant-based meat substitutes, estimates that the production of one of the company's identical meat substitute burgers uses 99 percent less water and emits 90 percent less GHGs than that of an equal-sized meat burger. Even allowing for the fact that so far the environmental impact data comes only from the manufacturers, it is unlikely, in RBC Capital Markets' view, that plant products could ever have a greater environmental footprint than animal products.

The market share of plant-based meat is currently low, as consumers remain very discerning about taste in this "indulgent" category, according to RBC Capital Markets. Plant-based meat substitutes have only achieved low single-digit penetration, paling in comparison to plant-based milk, which enjoys a market share ranging from 10 percent to 15 percent in developed markets, and as high as 40 percent in Asia given the prevalence of lactose intolerance among people in the region.

But its market share should increase, in our view. Accelerating investment and innovation are driving marked improvements in taste, availability, price, and convenience (e.g., easy to cook). The category grew by 12 percent annually in the two years to 2019, and given continued advances as well as consumer interest, RBC Capital Markets thinks brisk growth is sustainable, forecasting an annual growth rate of 10 percent until 2030.

Still, our national research correspondent notes that while market penetration should increase, it is unlikely to reach the market share levels that plant-based milk has achieved, at least in the short term. Milk, after all, is mostly a commodity while meat isn't.

Beyond this, cell-based or lab-grown meat has generated a lot of attention since news broke of the first lab-grown burger in 2013. This food product is grown in labs from animal cells but with a very low environmental impact and without requiring the industrial-scale slaughter of animals. Currently on sale only in Singapore, this type of meat is years away from commercialization elsewhere and isn't likely to have a large impact on the market in the short term.

Barriers to wider adoption of these meat "look-alikes" include the difficulty in replicating whole muscle cuts, with visible fat marbling and muscle fiber textures. The category has been successful mostly at replicating ground or processed products. The often substantial price premium that plant-based identical meat commands is another barrier, though costs should come down, in RBC Capital Markets' view, as supply chain capacity increases and producers scale and consolidate. Finally, while plant-based substitutes that look like meat are vegetable-based, they are highly processed, which somewhat tarnishes their "health food" credentials.

Other than these plant-based look-alikes, there are a number of products that are a substitute for meat but are not meant to taste or look like it. These derive from high-protein vegetables, such as beans, soy, mushrooms, and chickpeas, and have gained consumer acceptance in recent years, with the exception of the soy stand-in. An early leader in alternative protein, soy's market share has declined over concerns regarding potential allergenic and estrogenic effects.

Other protein-rich replacements to meat include algae- and insect-based alternatives, sold whole or in flour. But after years of promise, the new plant-based technologies discussed above make these two sources less compelling as a primary animal protein substitute. This is unfortunate as, according to a paper from McKinsey, insect protein is very efficient in converting feed into edible weight, requiring just over two kilograms of low-quality feed to produce one kilogram of live animal weight. By contrast, beef requires significantly more feed and of better quality (close to nine kilograms of feed to produce one kilogram of live animal weight).

In the long term, RBC Capital Markets thinks it's likely that the plate of the future will be a mix of traditional, plant-based, and cell-based meat. Depending on the proportion each achieves, cell-based could eventually pose a threat to the plant-based category, in its view.

Animal protein will likely continue to dominate for now, however, especially as meat consumption increases in developing nations as standards of living rise. But plant-based proteins are likely to continue to gain market share as technology improves and prices fall.

So as not to be left behind, many food companies are making the required investments in alternative proteins. Those that saw the opportunity and acted on it early will likely benefit from a first-mover advantage with regards to recipe, processing technology, and relationship with distribution channels, be they retailers, food distributors, or even consumer goods companies. For global, multi-brand and multi-product food companies, plant-based alternatives have yet to make a sizeable difference to their operating performance, though in RBC Capital Markets' view, as the category expands, it should become more meaningful for sales growth and valuation. It points out that Nestlé's revenues are more than 200 times those of Beyond Meat, a pure play, plant-based alternative meat producer, but its market capitalization is only 50 times larger.

Feed off the changes

Feeding a growing population in the face of shrinking farmland worldwide and all-too common extreme weather events that wreak havoc on food production is an enormous task. Technological advancements in both the agriculture and food industries can help mitigate these problems. These two industries will see important changes over the coming years. We believe companies that innovate and bring their solutions to the mainstream and those that adopt new technologies early should be in a good position to reap the benefits of their forward-looking strategies.

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