Why Agriculture needs reinventing and how we plan to do it

The food industry is a complex system of growers, processors, and distributors. Traditional agriculture faces complex problems including balancing finite natural resources, managing pests, and protecting against unpredictable weather while supplying a large variety and quantity of produce to stores around the world. In order to meet the demands of a large-scale food economy, farms have turned to chemical pesticides, herbicides, and fertilizers to guarantee a consistent yield. These practices have led to several contentious issues including contamination of ground water, exposure of workers to harmful chemicals, harming of local wildlife and non-targeted vegetation, and persistent chemical residues on consumer products. Furthermore, the large-scale, global food system relies on a complex transportation network. To supply fresh produce at all times of year to customers around the world, produce is shipped by truck, ship, and air. This creates emissions that have contributed to the current climate crises seen today. Another prevailing issue facing food production today is the high cost of food waste. Across the world, food is wasted in staggering amounts. Food waste is found throughout the supply chain from farms to grocers to consumer households.

The complex problems detailed above describe the challenges facing today's food industry. Solutions to these issues come in many forms. One promising contributor to positive change is the use of in-home food production. New technology in this field has created a system of aeroponic indoor plant production that can be used in individual households. This allows produce to be grown much faster while preserving the environment better than traditional agricultural methods.

Pesticide Use and Harm

Pesticides and herbicides are used in traditional agriculture to fend off insect and rodent pests as well as to prevent weeds from growing. It has been shown that some pesticides pose a risk to humans and animals as well as having damaging effects on the environment. Globally, 1 million people per year are poisoned by pesticides which cause chronic diseases and death. This is mostly found in production workers, sprayers, mixers, and farm workers. There is increasing research to suggest that pesticides known as endocrine disruptors, which work by mimicking natural hormones in the body, have been linked to human health degradation in the form of immune suppression, hormone disruption, reproductive abnormalities, and cancer after long-term, low-dose exposure (Aktar, 2009).

Moreover, Organo Chlorine compounds (a common pesticide) can pollute people and animals on earth, in the air and in water. When pesticides are introduced to oceans they can infiltrate the fish population and as a result the birds that feed on the fish. In 1996, the European Union program "Monitoring of Pesticide Residues in Products of Plant Origin in the European Union" found that, of 9,700 produce samples analyzed, 5.2% had pesticide residues. In 1999, the same program found that of 4,700 samples, 22% contained pesticide residues with 8.7% being above the Maximum Residue Level established by the EPA. (Aktar, 2009).

Pesticides contaminate the soil, water, and vegetation surrounding farm fields. Beyond killing the intended insects and weeds, pesticides can prove toxic to birds, fish, beneficial insects, and non-targeted plants. Pesticide drift to neighboring vegetation can occur at a rate of 2-25% of the chemical level being applied depending on the method of application. It can spread over several yards up to

hundreds of miles. Pesticides can contaminate surface water through runoff from farm fields. A study in the mid-90's by the U.S. Geological Survey found that more than 90% of water and fish from all streams sampled in major river basins across the country tested positive for several pesticides. This included 99% of samples in urban streams. The levels of pesticides were found to be higher than the guidelines for the protection of aquatic life. Once the ground water is contaminated, it can take many years for the chemicals to dissipate (Aktar, 2009). Consequences for contaminated ground water can be significant. Plants can absorb chemicals from contaminated water which pass to humans and animals when eaten (OECD, 2017). The U.S. Fish and Wildlife Service has recognized 74 endangered plants that are threatened by glyphosate alone (Aktar, 2009).

Another issue with pesticides is their effect on the microbial populations of soil. As the pesticides kill off the beneficial soil microorganisms, increased levels of chemical fertilizers need to be used to allow plants produce good yields. Heavy use of pesticides and fertilizers may work for the short term but after a while the soil will no longer be able to hold necessary nutrients (Aktar, 2009).

Many consumers are concerned with the possibility of pesticides residue on the produce they eat. The EPA sets standards for the amounts of pesticide residues legally allowed to be present in food. States sample and test produce for the presence of pesticide residues. One example of such sampling is a report issued by the State of California. In 2014, 3,471 samples of produce were sampled by the California Department of Food and Agriculture. 52.69% of samples tested positive for one or more pesticide residues at less than or equal to the established limits. 1.07% contained illegal pesticide residues at levels beyond the allowable standards. 5.5% of samples had illegal residues of pesticides not approved for the produce analyzed. These samples of produce included fruits and vegetables grown in California as well as those imported from other countries. Produce grown in the U.S. showed residues mostly within the legal standards. However, produce from other countries including Mexico and China showed higher percentages of produce with illegal levels of pesticides. These samples included limes, papaya, squash, and chili peppers from Mexico, and ginger from China. For U.S. produce sampled, those with illegal levels of pesticide included spinach, nectarines, and kale ("2014 Pesticide Residues in Fresh Produce," 2014).

Unsustainable Water Usage

As plants require consistent water to grow, sprinkle and irrigation watering techniques traditionally employed on farms are essential to successful yields. However, Agriculture is facing risks due to water shortages, floods, and degraded water quality. These factors impact production, food security, and trade. The impact of climate change is expected to hit the Agricultural sector through increased variability in rainfall and increased extreme weather events. The World Economic Forum identified water crises as having the greatest impact on global economies in the medium term. This is due to water stresses affecting more than 40% of the population, flood risk to nearly 20% of the global population, ground water depletion, and decreased water quality. Water quality is expected to decline due in part to increased soil salinity and soil erosion due to irrigation. This will affect the availability of freshwater for agriculture. (OECD, 2017).

Agriculture is accountable for 70% of global water withdrawals as well as 85% of fresh water consumption. 60% of the world's crop production is watered strictly by rainfall while 40% of global crop production is irrigated (OECD, 2017). In the United States, Agriculture accounts for

approximately 80% of water consumed. As of 2012, 55.8 million acres of land in the U.S. is used for irrigated agriculture (*Irrigation and Water Use*, 2018).

Moreover, climate change has many impacts on crop production including increased crop evapotranspiration due to rising temperatures which means that crops will need more water to survive. Increased water shortages in Spring and Summer, reduced snowpack leading to less surface water, and increased flooding risks are all results of climate change. Heavy rainfalls from climate-induced weather patterns can lead to increased sediment, excessive nutrients, and high pollutant loads from water runoff (OECD, 2017).

Food Transportation Costs

Bringing fresh food to consumers around the world throughout the year requires a vast transportation network. This transportation comes at both a financial and environmental cost. These costs are often overlooked when consumers think about the food they eat. The impact of transportation varies on the growing conditions and climate of each region. Countries with short growing seasons such as Britain have particularly large demands for imported produce. According to the British environmental agency DEFRA, Britain imports 95% of its fruit and more than 50% of its vegetables. This amounts to 25% of the truck shipments in Britain (Rosenthal, 2018). This holds true for different regions within a country as well. For example, in the U.S, Florida and California are responsible for a large percentage of the country's total agriculture. As of 2002, 33.2% of fruit, nut, and vegetable production in the U.S. was located in California and Florida alone (Roeger, 2011).

As consumers expect a wide variety of fresh produce to be easy accessible year-round, produce imports have become vital to the food system. U.S. consumption of imported fresh produce grew from 25.3% in 1970-1971 to 45.3% from 2007-2008. A great deal of this international transportation has to be under refrigerated conditions to preserve the quality of the produce (Roeger, 2011). This refrigerated transport increases the energy needs for transportation.

The energy used and emissions created by produce transit is largely uncompensated. A 1944 treaty called the Convention on International Civil Aviation paved a way for goods (including food) to travel by air or ocean freighters tax-free. This continues today wherein fuel for international freight by air and sea is not taxed. This means that the environmental impact of international food trade is not being paid for by food producers. Three percent of emissions from food production are created through transportation and that level is growing rapidly. Additionally, the packaging and refrigeration required to ship produce across great distances leads to increased emissions and waste (Rosenthal, 2018).

Costs of Organic Produce

Many consumers turn to organic produce to avoid the pesticides used in traditional agriculture as well as to support environmentally-friendly growing practices. Organic produce relies on ecosystem management versus doctoring of the agricultural environment. Therefore, it avoids using pesticides, synthetic fertilizers, veterinary drugs, genetically modified seeds or breeds, preservatives, additives, or irradiation ("Organic Agriculture," 2019).

However, these products often come at a premium price. There are several reasons for the increased price of organic products including a limited supply chain compared to the relative demand,

higher production costs due to increased labor needs and less scale, less efficiency due to the handling of smaller quantities of produce, and inefficient marketing and distribution due to small volumes ("Organic Agriculture," 2019). In a study of more than 100 products (organic and non-organic pairs), organic foods were 47% more expensive than non-organic equivalents. However, there was a wide range of price differences found. Price varied depending on the grocery store in which it was sold ("The Cost of Organic Food," 2015).

Food Waste

Food waste is a problem across the world. A study by the Food and Agriculture Organization of the United Nations found that one-third of food produced globally is lost or wasted. This adds up to 1.3 billion tons of wasted food per year. This means that large amounts of resources that went into producing and transporting food is spent in vain. The amount of food wasted depends on the supply chain and practices of individual countries. In general, in industrial countries most food waste happens at the point of consumption in individual households. A second major source of waste is early in the food supply chain. (Gustavsson, 2011). A study by the Natural Resources Defense Council (NRDC) found that Americans throw out the equivalent of $218 billion each year this equates to 3.5 pounds of food wasted per person per week. Most of this ends up in landfills where it rots and gives off greenhouse gasses. The largest portion of the food wasted were fruits and vegetables. This study found that 66-74% of food waste (depending on the city studied) came from individual households, restaurants, and caterers. When the NRDC surveyed households for reasons they wasted food, the top reason edible food was wasted was that it was moldy or spoiled. The next most common reasons were that people didn't want leftovers or that it was left out too long (Hoover, 2017).

Most of the food waste that occurs at the agricultural level is due to post-harvest grading standards. In North America this adds up to 20% of total fruit and vegetable waste. Supermarkets have high standards for weight, size, and appearance and can reject produce from the farmer if it does not meet their standards. Consumers expect supermarkets to supply a large quantity and wide variety of products. As a result, often food is not sold before it reaches its sell-by date and is therefore wasted (Gustavsson, 2011).

Adding to food waste at the farm level is the planning needed to supply a dynamic food chain. Farmers are expected to supply certain quantities of produce to customers. They have to plan around unpredictable weather and pests. Therefore, to meet their required demand, farmers often err on the side of caution and over produce (Gustavsson, 2011).

Aeroponic Gardening: A Solution to Traditional Agriculture's Issues

As described, traditional agriculture poses significant problems. We believe the solution to these troubles is to bring growing to the individual household with an advanced, hyper-productive aeroponic growing system.

Aeroponics is the process of growing plants in air instead of soil, or water. The plants are suspended their roots are directly sprayed with a nutrient rich solution periodically. Growing in air allows the plant to take in more oxygen and more efficiently utilize nutrients and water, as a result aeroponic systems need 99% less water than traditional methods. This protects scarce potable water resources and is particularly beneficial to areas prone to drought. Furthermore, due to the increased

oxygen uptake, aeroponic systems grow plants faster than other methods. This means that families using this growing system would need to devote only a small area making it practical to grow food for individual consumption without needing a supermarket. Since the consumer already controls the climate of their home, additional energy resources are not needed to control the temperature and humidity of the environment. This provides an advantage over large-scale indoor farming which requires energy input to control the climate in which the plants grow.

Another significant advantage of in-home aeroponic growing is that there are nearly no transportation costs associated with the produce. Once the system is in the home, produce does not need to travel farther than from the vine to the table. Food waste can also be reduced by this system. Food can remain on the plant until the time it is eaten. This means that surplus produce is not needed and is not wasted. Families can use exactly as much produce as they need per meal, eliminating leftovers which are frequently discarded as food waste.

The combination of no transportation, no pesticides, and in-home labor equates to cheaper, healthier produce. Moreover, growing food directly in the home encourages families to eat healthier, cook at home more, and better understand where their food comes from. Research has shown that when children are exposed to gardening, they are more inclined to eat fruits and vegetables. One such report completed by the University of Wollongong, Australia found that 3rd-6th grade students who participated in gardening at school improved their food choices. This translated into changed behavior in the home as well. 20% of parents of students in the study indicated that they cooked at home more after students were exposed to gardening at school. Further, 77.4% of parents indicated that their children asked them to make food grown in the garden and 71.9% said that their children were more willing to cook at home after gardening at school. Another study found that 4th and 5th grade students showed that being exposed to vegetable gardening and cooking improved preference for vegetables and increased students perceptions that vegetables taste good. Yet another study found that gardening increased nutrition knowledge and preference for vegetables for 4th-6th grade students in California (Yeatman et al., 2013).

Aeroponic growing is the future of food production. It is more efficient and cheaper than traditional agriculture. It brings produce directly to the consumer and encourages healthy eating habits. It reduces food waste and water usage. Aeroponic production creates new opportunities for consumers. It increases choices and simplifies the food chain by bringing food directly to the homes of consumers.

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