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WHITE PAPER • UPDATED AUGUST 2021

An Inclusive Transition to a Sustainable and Resilient Meat Sector

Lee Recht, PhD
Head of Sustainability, Aleph Farms

Didier Toubia
Co-Founder and CEO, Aleph Farms

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Executive Summary

Meat plays a significant and valuable role in our global society as a central part of many diets, cultures, and religions. However, the unsustainability of today's meat consumption and production methods requires immediate attention and action. Meat production by current industry standards has created a cascade of environmental issues, from high levels of greenhouse gas emissions to soil degradation and the loss of biodiversity necessary for future environmental health and food chain resilience (Poore and Nemecek, 2018). The COVID-19 pandemic has further highlighted the lack of resilience in our global food system, with supply chain disruptions disproportionately affecting the most vulnerable populations. For the first time since 1998, global poverty and hunger is increasing (FAO, SOFI Report, 2021). Meanwhile, widespread use of antibiotics in animal agriculture has increased the systemic burden of antibiotic-resistant infections as well as zoonotic disease transmission (IACG Report, 2019).

For many meat eaters, red meat is one of the primary sources of complete protein and invaluable minerals and vitamins, specifically zinc, iron, selenium, and vitamin B12 (Baltic and Boskovic, 2015). Nevertheless, when overconsumed, meat and in particular processed red meat, is correlated with a variety of severe health-related issues (Zheng et al., 2019). Although many of the national and global health organizations recommend reducing meat consumption, the overall global demand in meat is increasing (Gerhardt et al., 2020). Today, policymakers, educators, food suppliers, and consumers are at a crossroads, in need of an inclusive solution that will unite and drive the world towards a more sustainable meat ecosystem. The solution must reflect the complexity of the problem and involve multiple strategies working in concert with education and policy: 1) responsible meat consumption and the adoption of sustainable and healthy diets, 2) sustainable agriculture practices incorporating incremental innovation to increase efficiency, and 3) transformational innovation that can complement sustainable agriculture practices to meet the growing demand for food.

To succeed, this system-based approach will require two types of innovation: Incremental innovations intended to make our existing sustainable agriculture practices more productive, and transformational innovations offering new solutions outside of the boundaries of today's current production practices.

Incremental innovation in today's existing food ecosystems, such as soil monitoring and software solutions for livestock management, can drive efficiency while allowing for a shift to more sustainable agriculture practices that preserve and enhance soil health to help mitigate climate change. However, such innovation does not address the main issue with our food system. Our global food system was established at the start of the 20th century, when there were 1.6 billion people on the planet. It is not suitable for feeding the world population of today and certainly not that of the future. This is a challenge of scale for which transformational innovation is necessary.

Transformational innovation includes meat alternatives such as plant or fermentation-based meat and cultivated meat, an alternative to the current meat production process. Cultivated meat is grown directly from animal cells rather than the entire animal. It has the potential to drastically cut down on the overall environmental footprint of meat production, reducing greenhouse gas emissions by 92%, land use by 95%, and water use by 78% (Odegard and Sinke, 2021) compared to intensive livestock farming. Furthermore, cultivated meat eliminates the need for antibiotics and increases supply chain resilience by reducing the production timeline to three to four weeks, compared to an average of two years for conventional production methods.

Such transformational innovation should co-exist and complement the production capacity of sustainable livestock farming methods to meet the growing market demand for meat. This can be successfully integrated with current food systems through supporting and investing in local producers, empowering communities, and giving existing farmers the opportunity to forge new revenue streams alongside conventional production. Incorporating 'Just Transition' practices while collaboratively integrating cultivated meat with animal agriculture can ensure economic security and social equity for farmers as the sector transitions to become a more sustainable and nature balanced overall system.

As a guiding framework, resilient food systems should implement four key pillars of sustainability:

1. Prioritize **ENVIRONMENTAL** conservation, utilizing resources in an efficient, circular manner and minimizing waste while moving towards carbon neutrality.

2. Provide access to food that satisfies the **SOCIOCULTURAL** needs of all, supporting growers, collaborating with local communities, and preventing inequalities within the system.

3. Promote and advance human **HEALTH** and wellbeing, preventing disease and providing nutritional accessibility through a sustainable diet.

4. Ensure **ECONOMIC** viability with affordable products and a resilient and traceable supply chain that reflects the True Cost of food production, considering health and environmental impact.

A number of these measures are already underway, with many countries having declared and defined a clear roadmap towards carbon neutrality. Meanwhile, consumers and younger generations in particular, are demanding more sustainable and transparent food systems across the globe. However, despite this positive momentum, there remains low consumer awareness of sustainable food options, as well as a lack of policies to educate and empower the population to make more sustainable choices. Both policymakers and consumers remain the main drivers and will play pivotal roles in the transition to more responsible and transparent food systems. Consumer choices steer the overall system, emphasizing the need to invest in education towards responsible consumption. Local policies and regulations focused on climate and public health must adopt healthier, more sustainable solutions, including integrating the true cost of food by recognizing externalities such as our food systems' impact on public health and the environment.

Creating a resilient and sustainable meat ecosystem will need to overcome challenges as it requires to break silos. An inclusive solution would combine a multi-disciplinary, multi-stakeholder, system-based approach with various strategies, ultimately realizing the complexity of relationships between different activities and stakeholders. It shall account for socio-cultural differences, and adapt to different geographies. Food systems touch all people. From policymakers to food suppliers and consumers, a diverse set of constituents each serve an essential role in the global movement towards a resilient meat ecosystem and, most importantly, a more sustainable future.

Introduction

Meat consumption has become one of the most controversial discussions of the past decade. Concerns over animal welfare, climate change, overconsumption, and health issues related to animal proteins have increasingly brought criticism to the way meat is produced in industrialized systems. It is clear that the meat sector cannot continue with business as usual.

Meat plays a valuable role in our global society as a central part of many diets, cultures, religions, and ways that people connect across the globe. When produced and consumed with caution and responsibility, taking into consideration the full life cycle of the planet and all animals and people in it, meat can have a lasting and meaningful role for the future.

Despite growing awareness of the meat sector's effect on human health and climate change, consumers continue to demand meat. Meat consumption is expected to grow by 50% in the coming decades to a market valued at $1.8 trillion USD by 2040 (Gerhardt et al., 2020). Meat consumption is here to stay, but there is an opportunity to evolve its production towards a healthier future for both humans and the planet.

Issues at Stake

Climate Change and Loss of Biodiversity

On a global scale, the average annual consumption of all meat is 80 kg per capita in developed countries and 27.9 kg in developing countries, with a world average of 38.7 kg per capita (Poore and Nemecek, 2018). Beef is the third most-consumed meat (after pork and poultry), with a global average of 9.1 kg per capita per year (OECD/FAO, 2021). But industrial, conventionally raised beef, produced by today's sector standards, has the largest impact on the planet and climate change.

Conventional beef has an average protein conversion efficiency of only 3.8% and an energy conversion efficiency of 1.8%. One kilogram of conventionally raised beef requires 25 kg of feed, 326.21 m2 of land, and 1,451 liters of fresh water to produce, and it creates 60 kg of CO2eq (greenhouse gases, GHG) and 301.41g of PO4eq eutrophying emissions (Poore and Nemecek, 2018). Multiply these numbers by the 71.6 million tons of beef produced in 2018 alone, and it is clear we are in the depths of a serious crisis. Additionally, most of the common farming techniques for animal feed, including artificial fertilizer application and monocropping, have degraded soil over time, contributing to desertification and biodiversity loss that further contribute to climate change (IPCC Special report, Climate Change and Land, 2019).

Lack of Food Supply Resilience and an Increase in Food Insecurity

The ongoing COVID-19 pandemic has highlighted a critical need for more resilient global food supply systems. Unprecedented quarantine restrictions and border closures have disrupted trade and created labor shortages, while farmers' cash liquidity has become increasingly limited, impeding their ability to efficiently produce and market food. All segments of the meat supply chain were affected. Large processing plants were forced to close due to COVID-19 outbreaks, which created bottlenecks in processing and packaging that led to an oversupply and consequently lower prices for livestock. Farmers in several countries had to cull their livestock due to excess capacity, feed shortages, and an inability to move them to market (ILO Brief, 2021). This lack of resilience posed a significant threat to the global meat supply and contributed to increasing global hunger and poverty as a result of the pandemic, especially for the world's poorest and most vulnerable populations. According to the United Nations Food and Agriculture Organization (FAO), food insecurity increased in 2021 and has hit a six-year high, while global poverty rose for the first time since 1998, reversing decades of progress against hunger and malnutrition (FAO, SOFI Report, 2021).

Inputs and Outputs of Conventional Beef Production (1 kg of beef)

Poore and Nemecek, 2018

A Public Health Crisis

Although COVID-19's global impact is unprecedented, it is not the first disease that has disrupted the food industry. Seventy-five percent of emerging infectious diseases are zoonotic, all of which have emerged in recent decades and caused tremendous challenges across the meat sector (Espinosa et al., 2020; Jones et al., 2008). Some zoonotic diseases directly impact the animals and have been intensified through industrial farming, such as Bovine Spongiform Encephalopathy (BSE/Mad Cow Disease), African Swine Flu (ASF), Bovine Tuberculosis, Brucellosis (Mediterranean Fever), and Avian Influenza (Bird Flu). Other zoonotic diseases such as Type A Influenza, Salmonellosis, and Severe Acute Respiratory Syndrome (SARS) can impact the workforce, shutting down meat facilities. In fact, any workers in contact with agricultural livestock are at higher risk for catching zoonotic diseases (WHO, Technical report of the TDR Disease). These risks can result in high morbidity and mortality rates in humans and animals, cause disruptions to regional and global supply chains and trade, and strain national and global public health resources (Belay et al., 2017).

Moreover, treating and preventing zoonotic diseases among livestock are increasingly driving the overuse of antibiotics within the meat sector. Approximately two-thirds of antibiotics that are considered medically important to humans are now being used in food animal production in the United States (Sameer et al., 2020). Widespread antibiotic use in animal farming contributes to the increasing burden of antibiotic-resistant infections, with major consequences for human health. Drug-resistant diseases already cause at least 700,000 deaths globally per year, a figure that is expected to increase to 10 million deaths globally per year by 2050 if no action is taken (IACG Report, 2019).

Collective Movement Towards a Resilient Meat Sector

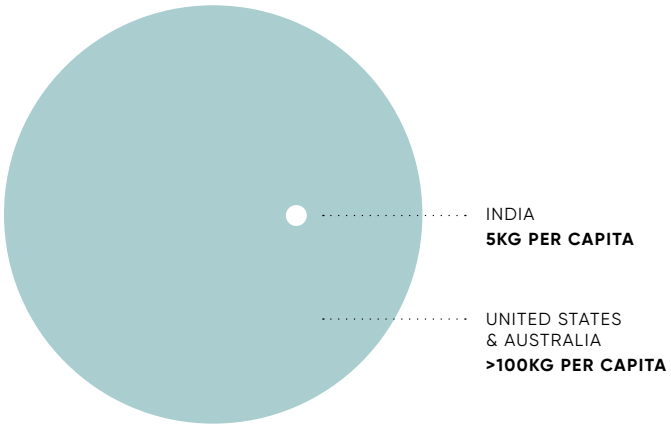
The COVID-19 pandemic highlighted the urgent need to assess the meat sector's role in global warming and climate change. As new food systems emerge amidst our economic recovery, it is time for our society to rethink our actions and roles in order to move forward in solidarity towards a common goal.

No single solution will solve our food system crisis and create an environmentally sound, resilient meat sector with the ability to safely feed the world's growing population. Consumer interests are diverse and ever-changing, influenced by geography, education, culture and tradition, socio-economic status, and other factors. Meanwhile, industrial systems will continue to be influenced by globalization, shifting policies, economic change, and more. Mass adaptation will require a multi-faceted, holistic, and collaborative approach.

Responsible Consumption

Meat plays a meaningful role in cultures and global traditions. Its nutritional composition is important to the human diet, affecting growth as well as physical and cognitive development (Baltic and Boskovica, 2015). Red meat is one of the primary sources of complete protein and energy for eaters in many countries. Diets containing lean red meat can lower plasma cholesterol and contribute significantly to omega-3 fatty acid intake (Mann 2018), and red meat contains invaluable minerals and vitamins, specifically zinc, iron, selenium, and vitamin B12. In addition, studies have shown that modifying the composition of livestock feeds can increase the healthy fatty acid content in beef (Howe, 2007), and, thus, in the human diet. Consumption of animal-sourced protein varies between regions, cultures, and traditions, ranging from an annual intake of more than 100 kg per capita in the United States and Australia to 5 kg per capita in India (Poore and Nemecek, 2018).

Range of Annual Meat Consumption (per capita)



Poore and Nemecek, 2018

Overconsumption of meat, particularly processed red meat, has been correlated with health-related issues including Type 2 diabetes, cardiovascular disease, and certain types of cancer (Zheng et al., 2019). Conversely, diets that eliminate or minimize meat consumption too severely, without appropriate substitutions to provide adequate protein, vitamin, and mineral intake, can compromise nutrient delivery, especially in children and other vulnerable populations (Leroy and Cofnas, 2019).

Recommended meat intake varies between different national and international food and health organizations (e.g. WHO 2018; USDA Dietary Guidelines for Americans 2015-2020; BCFN's Double pyramid and One health approach, 2021). However, in the Global North, there is an overall overconsumption of red meat and a need to adapt to healthier diets, including reduced and more responsible consumption of red meat, salts, sugars, and fats, and an increase in consumption of plant-based foods such as fresh and unprocessed fruits, vegetables, legumes (e.g. lentils and beans), nuts, and whole grains (WHO recommendations, 2018).

GLOBAL NORTH AND GLOBAL SOUTH :
There is no single definition of the terms Global North and Global South. The terminology has emerged in recent public discourse in an effort to diminish the implied hierarchy when using terms such as "developed" and "undeveloped" parts of the world. In terms of defining attributes, member countries of Global North and Global South share broadly similar socio-economic and political characteristics. States in the Global North generally tend to be wealthier, to have less inequality and to be democratic while Southern states are generally known as low-medium income economies (according to the World Bank) with younger, more fragile democracies.

Movement Towards Sustainable Agriculture Supported by Incremental Innovation

Sustainable agriculture takes a systemwide approach to farm management, considering environmental, social, and economic factors in food production. Farmers in sustainable agricultural systems integrate a diverse range of livestock and crops, leading to both profitability and healthier food products (Sandhu, 2021).

The environmental aspect of sustainable agriculture can be defined as good stewardship of the animals, natural systems, and resources farms rely on. It operates in perpetuity without degrading natural resources and can play a significant role in efforts to reverse environmental damages. By aligning with the science of agroecology and managing farms as ecosystems, sustainable farming builds and maintains healthy soil, through soil stabilization and formation, water infiltration, carbon sequestration, nutrient cycling and availability, increased biodiversity, cumulatively resulting in minimizing climate pollution and increasing ecosystem and economic stability and resilience (Teague and Kreuter, 2020). Sustainable agriculture includes a socio-economic approach, as well, that considers farmers' welfare, farmworker rights and equity, fair pay, promotion of farmers' skills, and collaborations for knowledge sharing (Brodt et al., 2011). Moreover, sustainable agriculture systems also give farmers more flexibility to adapt to climate change and market fluctuations. They can provide more diverse, nutrient-dense, and culturally appropriate diets while enhancing the environmental benefits of agriculture (Carlisle et al., 2019).

Sustainable agriculture can include different agricultural methods, such as regenerative agriculture, permaculture, biodynamic, organic farming, agroforestry, conservation tillage, integrated hydroculture, and more. However, it is important to note using these methods does not automatically translate to sustainability, and it is critical to have a clear and structured method to classify sustainable agriculture.

While there are many efforts to shift towards more sustainable farming methods due to an increasing awareness of its advantages, sustainable agriculture does come with its challenges. It often requires more land, particularly land with adequate access to water, upfront investments in soil health and ecosystem function, and compatible equipment, causing these sustainably grown and raised foods to typically be sold at premium prices. In addition, there is currently no systematic approach to assist farmers in transitioning to sustainable management, particularly with respect to managing soil, securing diverse crop insurance, creating circular ecosystems, and setting expectations. Furthermore, there is still not enough quantified and scientific data allocated from sustainable or agroecology farming to support policy makers in promoting such a systemic change.

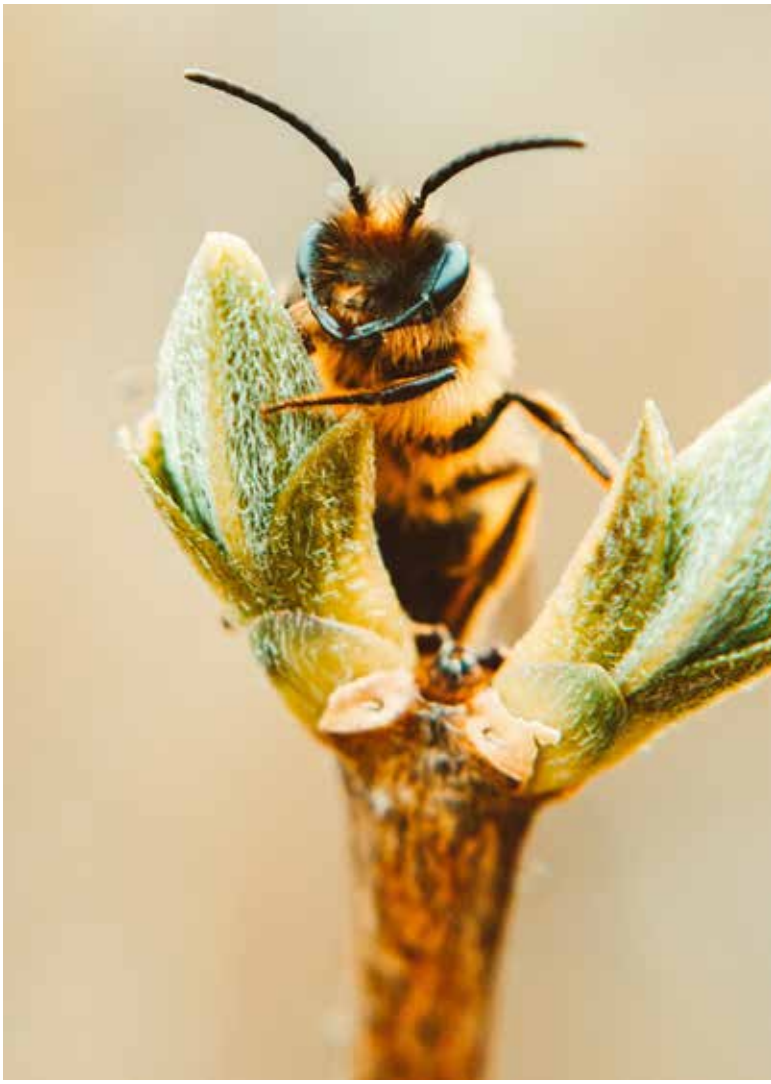
Incremental innovation plays a vital role in increasing the efficiency of and gathering data on sustainable methods. Incremental innovation focuses on improving an existing product's development efficiency, productivity, and competitive differentiation. For livestock farmers, this can include soil monitoring systems, microbiome functionality measurement, software solutions for livestock management, and more, all aimed towards preserving the sustainable approach while improving its effectiveness.

Despite sustainable agriculture's many benefits, transitioning to sustainable agriculture is a time-consuming process. Considering today's supply chain disruptions and a growing demand for food, we cannot depend solely on sustainable practices of agriculture to provide unconditional access to healthy foods for all . Rather, to increase our resilience, we must incorporate a diverse set of tools, technologies, and models to address the most fundamental threats to our food supply chains.

Championing Biodiversity

In aligning our collective vision to incorporate more sustainable farming practices, we must consider the important role that agrobiodiversity will play for future generations. While climate change is increasingly seen as an urgent issue across public dialogues, another environmental crisis silently threatens the world's food supply: the dramatic loss of agrobiodiversity (Gonzalez, 2011).

Agrobiodiversity consists of the biological resources that are important for food production, including the diverse varieties of animals, plants, and microorganisms that sustain the functioning of agroecosystems. Biodiversity plays a vital role in food security, nutrition, sustainable livelihoods, ecosystem resilience, climate change solutions, and the management of biological processes needed for sustainable agriculture and food production (Pörtner et al., IPCC-IPBES Report, 2021). To ensure long-term food security and climate resilience, food systems, and the meat sector in particular, must better manage farm biodiversity, including genetic conservation.



Transformational Innovation in the Meat Sector: Alternative Meat and Methods

While incremental innovation focuses on improving an existing product or practice, transformational innovation combines structural, integrative, and systemic change. These types of innovation do not compete, but rather complement each other. Transformational innovation goes beyond the boundaries of a single organization to create its impact, including multi-stakeholder processes that aim to have a long-lasting economic and social impact. With a systems approach, this kind of innovation acknowledges the need to preserve the values, preferences, strategies, and resources of the different societal groups involved while progressing towards a more resilient future (Scrace et al., 2009).

Meat Alternatives

Plant-based meat alternatives have existed for decades, however, a new generation of meat alternatives have emerged in recent years as a result of a growing understanding of the biochemical composition and three-dimensional structure of meat, as well as the ability to replicate these features using non-animal ingredients and novel manufacturing techniques. Meat alternatives can be classified as plant-based (soy, pea, gluten, etc.), fermentation-based (fungi and mycoproteins), microalgae (spirulina), and even insects. These alternatives closely simulate animal meat in texture, flavor, and appearance and mimic processed meats such as burgers, nuggets, etc.

A major driver of this burgeoning category is consumers, as a result of their increasing awareness of health, ethical considerations of animal welfare and environmental concerns (Tso et al., 2021). This has created a growing interest in solutions that can support consumers in transitioning to flexitarian or fully plant-based diets. In the ability of meat alternatives to deliver a close-to-realistic meat experience, this category has witnessed a surge in consumer demand, demonstrating that product design is critical to shifting consumer behavior. While the category has experienced tremendous momentum, there are hurdles remaining, specifically regarding the nutritional integrity of these products and perceptions of being a them being processed foods.

Embracing Technology for New Production Methods: Cultivated Meat

While it is important for the meat sector to transition from industrial methods to sustainable agricultural practices, a gap remains between the limited meat production capabilities of sustainable agriculture and the growing global demand for meat. Cultivated meat can be a solution to such a gap.

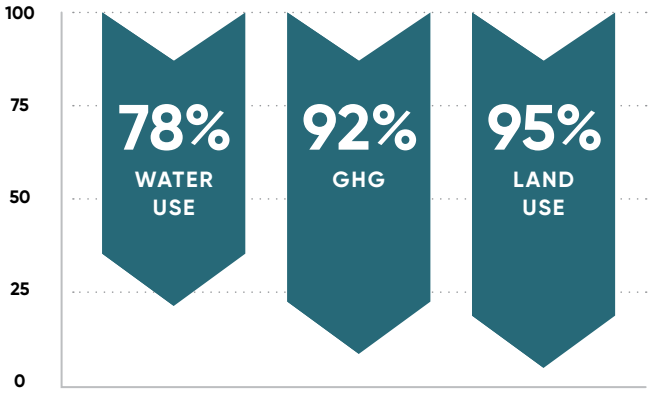
Cultivated meat is defined by growing meat products directly from their building blocks, the cells, rather than the entire animal. Although often categorized as "alternative protein," cultivated meat is an alternative to the current production process of meat. Cultivated meat products allow consumers to maintain the culinary and sensory qualities of the meat they have always loved, eliminating the need for the major behavioral shift of removing meat as a central part of our diets.

The core concept behind this method is the tissue regeneration process, which naturally occurs in all animals: tissues renew themselves by reproducing cells to repair and maintain overall health. Cultivated meat replicates this process under controlled conditions. It begins with taking a number of cells from an animal and nurturing them in a nutrient-rich, animal-free growth medium, where they are capable of multiplying. Subsequently, the cells can be stimulated to differentiate into muscle, fiber, or fat cells, and through tissue engineering techniques supporting the three-dimensional organization of the cells, a tissue is grown that mirrors traditionally produced meat (Post et al., 2020).

This process consumes only a fraction of the time and resources required for conventional meat production. Conducted under controlled conditions, it eliminates the need for antibiotics. It also reduces the timeline of farm to fork to three weeks, as compared with an average of two years using conventional methods of producing meat. This sharp cut in product supply timeline offers the market a tremendous advantage in flexibility to adapt to market needs, especially in times of crisis. It can be a major steppingstone towards a more resilient supply chain and safer standards within the meat sector.

The driving force behind cultivated meat is the need to develop a sustainable production system for animal products, addressing the overuse of antibiotics, food and water security, food safety, environmental footprints, and poor animal welfare conditions (Ben-Arye and Levenberg, 2019). Several studies have attempted to quantify the potential environmental impact of cultivated meat based on the Life Cycle Analysis methodology (Odegard and Sinke, 2021; Tuomisto, 2019). These studies concluded that, when compared to conventional beef production, cultivated meat has the potential to substantially lower greenhouse gas emissions by 92%, reduce land use by 95%, and reduce water use by 78% (Odegard and Sinke, 2021).

Potential Environmental Impact of Cultivated Meat in Comparison to Conventional Methods



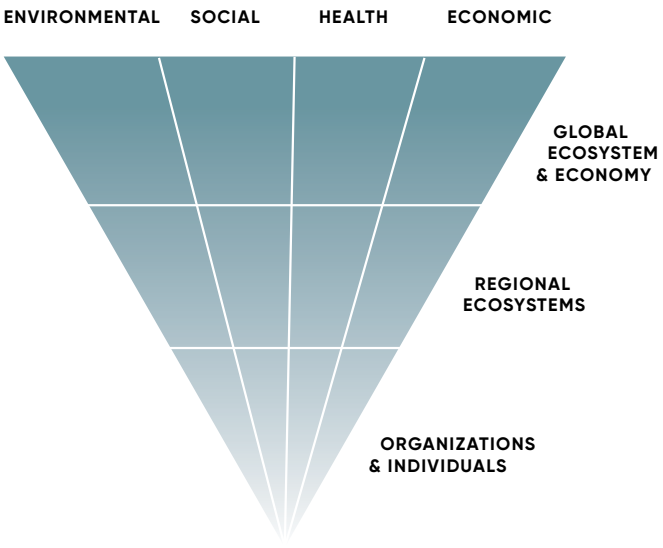
Source: Odegard and Sinke, 2021

If substantiated, cultivated meat could potentially provide the largest drawdown of GHG in history (Foley et al., 2020).

In late 2020, Singapore made headlines by concluding the world's first regulatory process to bring cultivated meat to the market. This news has propelled the cultivated meat movement from a long-term vision to a realized, practical solution, and more regulatory clearances are expected throughout 2021 and 2022. Effectively managing consumer expectations and efficiently increasing production scale while reducing production costs, allowing products to become a viable, affordable option for all, will be key to the continued success of this movement.

Four Pillars of Sustainability to Build a Sustainable, Resilient, and Secure Food System

Four Pillars of Sustainability



Transitioning towards sustainable food systems will require a holistic and comprehensive approach, allowing for the institution of long-lasting production lines and supply chains that can consistently provide nutritious food and enable prosperous communities with minimal impact on global agroecology systems. All players, at all levels of the ecosystem, from farmers and food manufacturers to regulators and policy makers, to retailers and consumers, must take responsibility and become accountable for our production methods and the pivotal roles we each play.

The food ecosystem as a whole and each food system within, needs to incorporate four key foundational components 'pillars of sustainability' as part of a transition towards a resilient food system and meat sector:

Environmental:

Food systems must prioritize the conservation, protection, and enhancement of natural resources. This includes developing manufacturing facilities and supply chains that utilize all resources in an efficient and circular manner, minimizing waste and overuse of resources. It is pivotal that organizations adopt carbon-neutral strategies and roadmaps for both their operations and supply chains, based on three main stages:

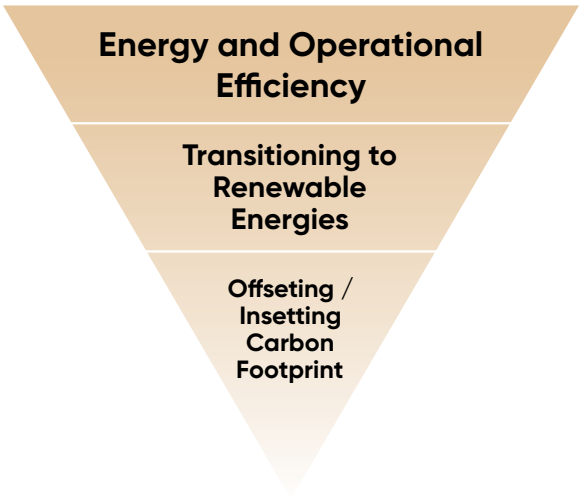
ENERGY-EFFICIENT and circular practices throughout all operations (scope 1 and 2) and supply chains (scope 3)

↓

Sourcing **RENEWABLE ENERGY**

↓

Remaining carbon footprint to be **OFFSET AND/ OR INSET** via reinvestment in the production lines and supply chains, allowing local suppliers to strengthen their sustainable practices and decarbonize their production, as well as creating new platforms for carbon sequestration



★ **CARBON NEUTRALITY** ★

SCOPE 1, 2 & 3 OF CARBON EMISSIONS:
According to the leading GHG Protocol corporate standard, a company's greenhouse gas emissions are classified in three scopes.

Scope 1: direct emissions from owned or controlled sources

Scope 2: indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company

Scope 3: all other indirect emissions that occur in a company's value chain

CARBON OFFSETS VS. CARBON INSETS:
As opposed to Carbon Offsets, where an organization pays for projects to capture atmospheric carbon dioxide somewhere else, Carbon Insets are actions taken by an organization to fight climate change within its own value chain, generating multiple positive sustainable impacts. Carbon Insetting includes investments in a company's own sustainable practices in order to decarbonize their production line and supply chain, thus strategically reducing their long-term incremental cost of carbon.

Social:

Food systems should provide access to food that adequately satisfies the sociocultural needs of all. This includes ensuring that both small and large-scale farmers and ranchers have adequate support with fair trade relationships, preventing and opposing the creation of inequalities within the food system. The transition to more resilient food systems must include collaborations and partnerships with farmers to promote their prosperity and introduce new economic opportunities and/or support career changes. Supporting and investing in local production, empowering communities, and giving control back to farmers is a critical part of the overall social and systematic change required of the agricultural and food sector.

Health:

Food systems must promote and advance human health and wellbeing while providing nutritional accessibility through their products and addressing issues of both under and overnutrition throughout the world. This holistic approach includes the "One Health" initiative, which serves to connect multiple sectors in working together to achieve better public health outcomes, such as ensuring food safety, controlling zoonoses, and combating antibiotic resistance (FAO).

Economic:

Companies need to shift their organizational principles and connect sustainable practices with economic growth. Food systems should ensure that food-related businesses are economically viable, creating affordable products and finding the right local-to-global ratio to maintain a resilient and profitable supply chain and economy. Food systems must promote collaboration and trust by fostering transparency and encouraging information disclosure and alliance between producers and consumers, leading to a healthier, more robust system for the future. While cheap food increases food access, health services, the environment, farmers, and farming communities often bear the ultimate cost of cheap food production and are left with negative long-term consequences from unsustainable production methods. Although there is criticism that sustainable foods come at a premium cost to the consumer, food systems, together with government regulators, need to redefine the True Cost of food production, supporting responsible consumption and incorporating externalities such as the cost of public health and environmental consequences. Adapting economic models to consider this True Cost of food is a necessary step towards a robust and resilient economy that can enforce more sustainable means of production, signaling the footprint of various food items to consumers (Barbara et al., 2021) and encouraging them to make choices in line with the United Nations Sustainable Development Goal 12 on responsible production and consumption (Sachs et al., 2021).

Building Our Future Today

Since the 2015 Paris Agreement, more than 190 countries worldwide have made commitments to reduce their carbon emissions. The growing list of countries that have declared a clear roadmap to carbon neutrality includes those in the European Union, Japan, China, Chile, and many more.

A number of countries have since embedded carbon neutrality goals into law, including the United Kingdom, Scotland, Sweden, France, Denmark, and New Zealand. The European Union revealed its Green Deal plan in 2019, allocating $1 trillion EUR for green investments until 2030. Although the United States officially withdrew from the Paris Agreement in 2020, its new administration has returned to the agreement, having allocated $2 trillion USD towards a carbon-neutral economy by 2050.

Millennials, together with Gen Z, with passion for change and shared social responsibility, are shepherding advancement in the food sector, demanding a more sustainable, transparent, and equitable ecosystem. These generations are loyal to brands that are straightforward, engaging, and conscientious.

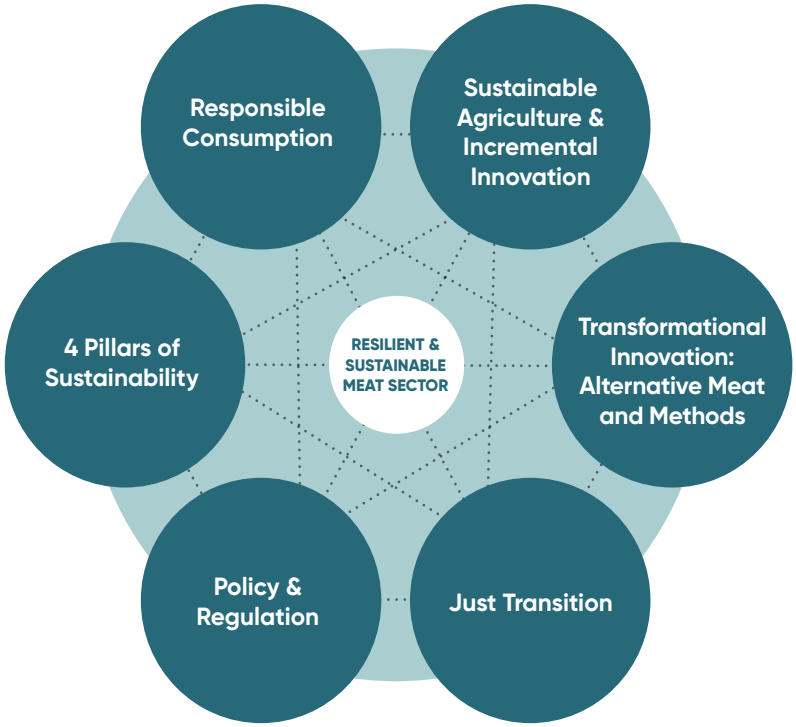
Although a growing community, vegetarians and vegans remain a small minority in the Global North. However, Millennials and Gen Z are more likely to adopt a flexitarian lifestyle that includes higher amounts of fruits and vegetables and more sustainable proteins, due to concerns about the environment and their health. These preferences are driving investments in both alternative proteins and sustainable practices within the meat sector (Credit Suisse, 2020). Incorporating diverse populations and younger generations in food system decision-making processes will be critical to ensure that a comprehensive vision is executed correctly and wisely.

While considering these shifts in consumer behavior, it is important to remember that, on a global level, consumer awareness of sustainable food options remains low. Further, there is a lack of international guidance on how to convey sustainable product information clearly and credibly to consumers. Food systems, together with government agencies and educational programs, must develop platforms to codify and clearly convey recommendations for responsible consumption of foods and beverages. Labeling, for example, plays an important role in responsible consumption. Incorporating a standardized rating for sustainability on package labels can help to educate and promote transparency and trust between food systems and their consumers.

An Inclusive Solution For a Sustainable and Resilient Meat Sector

Enhancing Global Food Security

Inclusive Solution for a Resilient and Sustainable Meat Sector



The global human population is set to reach more than 9 billion by 2050. To meet the growing demand for more and diverse types of food, global agriculture must significantly increase its scale. Meat plays a vital role in supplying nutrition to large populations, while farming also provides a livelihood for 12% of the world's population (FAO, Livestock and Food Security report). However, our current animal agricultural system is using available basic resources for food production at an unsustainable rate, rapidly depleting agricultural land, fresh water, and biodiverse habitats. To continue feeding the global population, a healthy and sustainable global agricultural system must significantly increase current levels of production using already limited resources. We must create food systems that overcome the current trajectory of negative environmental and public health impacts while also ensuring global food security and safety for the future (FAO, SOFI Report, 2021).

Successful food security campaigns promote universal access to a continuous supply of safe and healthy foods. They can be broken down into three main components:

1. Affordability of food, with consideration to local preference (social, religious, cultural preferences)

2. Nutritional accessibility through healthy diets and safe foods

3. A resilient supply chain that can withstand and recover from disruptions in a way that ensures a continuous and sufficient supply of desirable and accessible food for all

To achieve such resilience, food systems need to increase diversity, allocate resources to crisis management, improve knowledge about future possibilities, and improve their own ability to innovate and anticipate change. Moreover, there is a need to prioritize the conservation of natural resources and biodiversity in the food, beverage, and meat sectors.

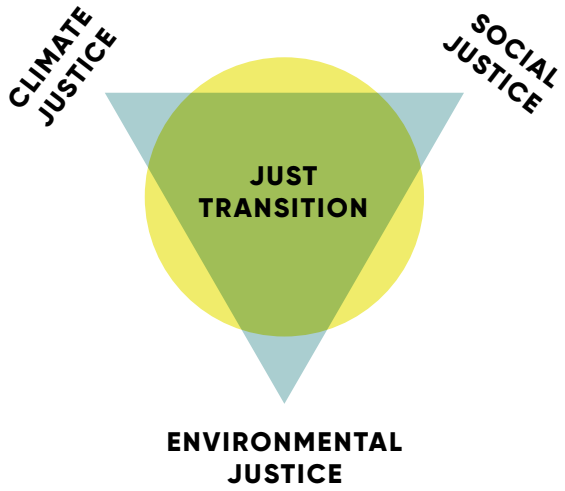
No single approach will accomplish a truly resilient and sustainable meat sector. An integrated and inclusive system, combining a series of solutions is needed.

To transition the meat sector, we must combine sustainable methods of agriculture, supported by incremental innovation and complemented by transformational innovation, all while supported by local regulation and policies. The two types of innovation presented in this paper are both critical for the overall transition. While incremental innovation is essential to improve existing methods, on its own, it does not have the ability to create the fundamental change that transformational innovation can. However, to truly create an inclusive solution, transformational technology and innovation must incorporate 'Just Transition' business models and go-to-market strategies that create value to all players throughout the existing supply chain.

JUST TRANSITION:

Just Transition is a framework designed to ensure that the substantial benefits of the green economy transition are equally distributed, while also supporting those who stand to lose economically, including countries, regions, industries, communities, workers or consumers. The concept of Just Transition was originally developed by the trade union movements to incorporate workers' rights and livelihoods when economies are shifting to sustainable production, primarily combating climate change and protecting biodiversity.

Fortunately, we are already equipped with the technologies and resources to deploy high-impact solutions that can shift not only the meat sector but the entire global food system. This movement will continue to be a learning process for stakeholders. It will require investment in transitioning towards sustainable agriculture projects and innovative practices that can increase the efficiency of meat production, enhance public health, and minimize impact on the climate.



Introducing transformational technologies, such as cultivated meat, as part of, and in collaboration with, livestock agriculture has the potential to support farmers in a transition to more sustainable methods of meat production, incorporating 'Just Transition' practices that offer economic and social security to the farmers. Additionally, recent market research has shown that those who work in animal agriculture or meat production tend to be more accepting of cultivated meat than the general population (Bryant et al., 2020), indicating a potential for future mutually beneficial collaboration between cultivated meat producers and the agricultural sector.

To fully embark upon the inclusive solution, people and businesses throughout the value chain and within all levels of society must commit to championing the four pillars of sustainable, resilient, and secure food systems.

Our food systems need to prioritize environmental protection, social equality, public health, and resilient supply chains, while promoting growth and enabling long-term profitability.

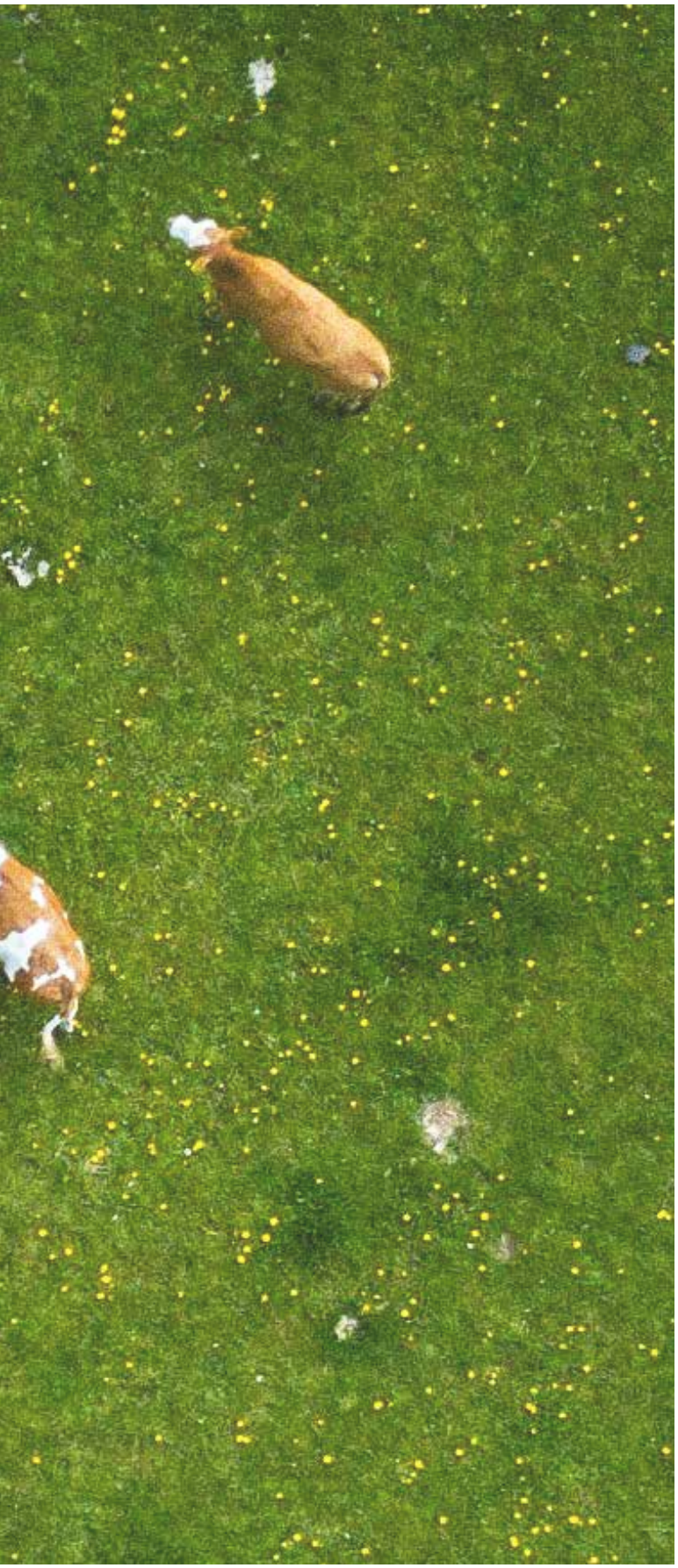
In such an inclusive model, consumers and regulators play vital roles in the overall solution. They remain the main drivers of the food sector as it transitions to become more responsible and transparent. Governments have the opportunity to create platforms for public-private collaborations that can incentivize the agri-food industries towards more sustainable and 'Just' practices while promoting transparency and consumer education. The impact of consumers' choices, both in quality and quantity, emphasizes the importance of investing in consumer education around responsible consumption. Local policies and regulations focused on climate and public health need to be adapted to include both the positive and negative externalities of food systems.

Finally, there is a need for collaboration between all partners and stakeholders, including livestock farmers, local suppliers, innovators, meat producers, retailers, regulators, and consumers. Each party plays an essential role in this global movement towards a resilient meat and food ecosystem, and most importantly, a more sustainable future.

Conclusion

As our society faces a clear need to transition to a resilient economy, the food ecosystem and meat sector have a considerable part in this complex challenge, and there is an immediate need to act now and in a coordinated way. Our perspectives on meat, however diverse they might be, are deeply rooted in our culture and our social environment. Addressing these challenges are sometimes polarizing, and in order to create an inclusive transition, we must break from our silos and work together. This will require openness, humility, and attention to the needs of each player in the value chain. As society consists of people, businesses, policymakers, farmers and food producers, each of us has a different role to play, but we all share the same goal, to create a resilient future for many generations to come.

Acknowledgments



We would like to express tremendous gratitude for Aleph Farms' Sustainability Advisory Board, Danielle Nierenberg, Aimee Christensen and Marc Buckley, who have not only shared their wisdom with us during the course of writing this white paper, but have been supporting Aleph Farms and all our sustainability efforts since 2019. We would like to thank Kate Burgess, FoodTank and Dani (Nierenberg) in particular for all their editing comments that have greatly improved this manuscript. We also thank designer, Shannon Beauchaine McNulty, for making our ideas come to life visually and Global Counsel for helping us share it with the world. We thank our colleagues from Aleph Farms, with a special appreciation to Nicky Quinn, Helene Miller and Yoav Reisler, who provided insights and expertise that greatly assisted the formulation of this paper.

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ALEPH FARMS

Aleph Farms grows beef steaks, from non-genetically engineered cells isolated from a living cow, without harming animals and with a significantly reduced impact to the environment. The company was co-founded in 2017 by Didier Toubia, The Kitchen Hub of the Strauss Group, and Professor Shulamit Levenberg from the Biomedical Engineering Faculty at the Technion - Israel Institute of Technology. Aleph Farms released the world's first cultivated steak in December 2018 and the world's first cultivated ribeye steak in 2021. The company's vision is to provide secure and unconditional access to high-quality nutrition for anyone, anytime, anywhere.

Aleph Farms has received top accolades for its contribution to the global sustainability movement from the World Economic Forum, UNESCO, Netexplo Forum and EIT Food. Aleph Farms is also part of the Private Sector Mechanism to the UN Committee on World Food Security (CFS).

ALEPH FARMS
10 Plaut Street,
Rehovot 7670609, Israel

info@aleph-farms.com
www.aleph-farms.com

Cite this content as:
Recht and Toubia, (2021) An Inclusive Transition to a Sustainable and Resilient Meat Sector; White Paper by Aleph Farms; available online: https://www.aleph-farms.com/white-paper