JPMorgan Chase & Co.

Establishing a Framework for Food and Agriculture Sustainability Transition ("FAST")

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Executive Summary

The global food system represents one of the greatest challenges but also one of the greatest sector opportunities to address both climate change and broader environmental sustainability. While the food system's scale and complexity are daunting, there are two fundamental imperatives often recognized as being of primary focus:

- **Feeding the World's Growing Population:** The world confronts a severe threat of systemic food insecurity as the global population grows to a projected 10 billion people by the year 2050 and overall food requirements are forecasted to increase by more than 50 percent.
- **Reducing Emissions:** Twenty-four percent of global Green House Gas (GHG) emissions can be attributed to the food system and international climate change targets cannot be achieved without action on food sustainability.[1]

A successful action plan needs to be anchored in private and public sector leadership, investor and market realignment, and a broad-based agreement and focus on the most impactful solutions. It will require the leadership of the private sector and the United States government in the adoption of FAST as a domestic and foreign policy priority:

- **Establish Private Sector Leadership:** As the second largest climate change opportunity behind energy, FAST will demand substantive, long-term change throughout the food system value chain. This transformation can only be accomplished with strong conviction from the business community and a thoughtfully correlated strategy, including a clear framework and metrics, for sector and individual corporate action. This action needs to be supported by key corporate stakeholders including, for many sector investors, a realistic "reset" around their compact with their companies about their latitude to effect long-term change.
- **Augment and Realign Capital Flows to FAST:** Capital is flowing into sustainability initiatives in the food and agriculture sectors but not at the scale and prioritization needed to meet both the challenges and opportunities it affords. There is a funding gap for both incumbent companies looking to transform and for emerging companies looking to drive growth and constructive disruption. Food transition to a more sustainable future is one of our best tools for fighting climate change yet it continues to be neglected.
- **Support the Most Promising Solutions for Food Insecurity and Emissions Reduction:** There is a wide range of fundamental market innovations that are being explored but the need for prioritization is becoming increasingly apparent—alternative proteins, new farming practices and reducing food waste appear to be emerging as the most promising pathways for the future.
- **Cultivate and Deploy Broad-Based Public Sector Support:** The United States, like many major food producing and consuming countries, has a deep history of support of the agriculture and food sectors and therefore has a large base of both capital dedicated as well as regulatory, tax and subsidy infrastructure that can be modified to achieve a more sustainable system.
- **Elevate FAST to a Domestic and Foreign Policy Priority:** Food security is widely recognized as a defining geopolitical challenge of the next decade and has historically been a priority for both U.S. domestic and foreign policy. FAST should play a more prominent role in the climate and foreign policy agenda. The United States and China, as the world's largest economies, have an opportunity to capitalize on both cooperation and competition to drive this essential transition.

Throughout this paper, we will reference Food and Agriculture Sustainability Transition as "FAST"—an acronym that also signifies the sense of urgency in the situation. In the shadow of the energy sector, mindshare dedicated towards "FAST" remains limited across both public and private constituents.

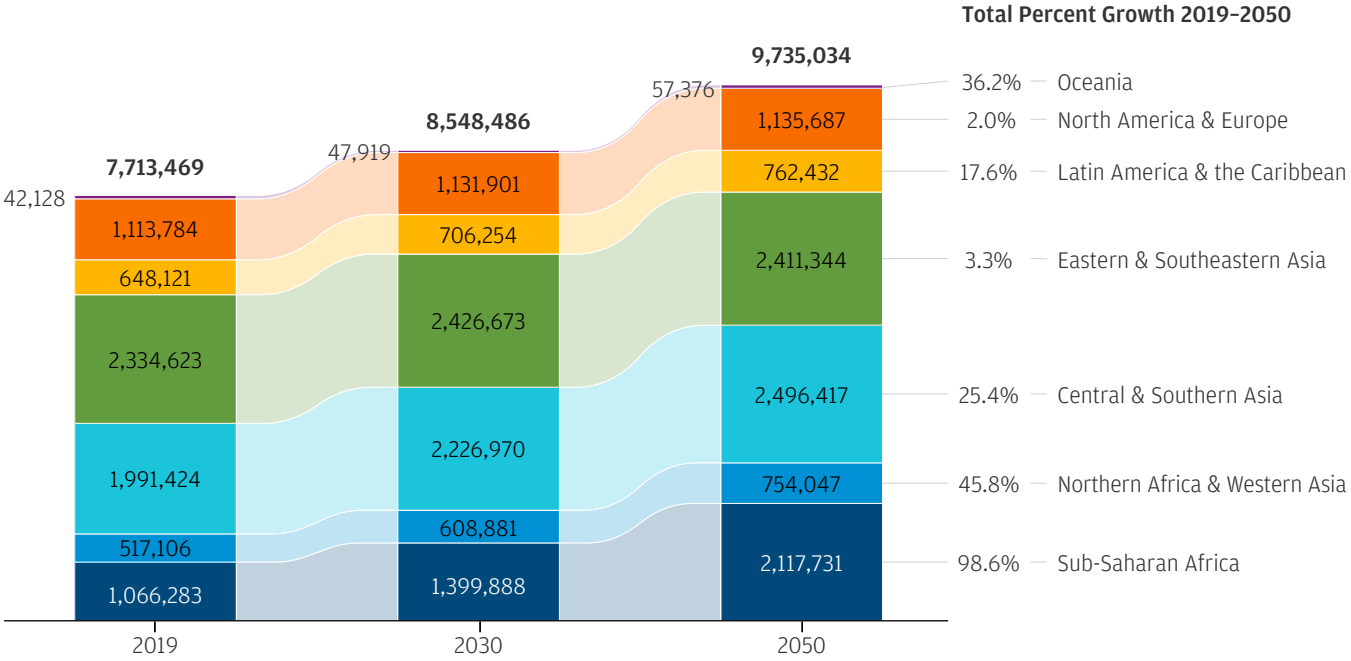
Background: Assessing a Severe Hunger and Climate Threat Environment

Failure to mitigate the growing crisis in the sustainability of our global food supply chain will fundamentally compromise the international effort to arrest the inexorable process of climate change. Even with the complete elimination of fossil fuels, it is likely that GHG emissions from the food system will prevent the world from limiting warming to the 1.5°C target now at the center of global climate collective action.[2] The transition to food and agriculture sustainability must be variables in the complex equation to both realize the 2050 climate goals—preventing the most extreme degradation to the global environment—as well as the need to feed a hungry planet. The necessity for a comprehensive action plan can be illuminated by a review of multiple intersecting trends related to demography, land use and deforestation, GHG emissions, overconsumption and waste, and water scarcity.

THE DEMOGRAPHIC CHALLENGE: HOW TO FEED 10 BILLION PEOPLE BY 2050?

As the global population grows to a projected 10 billion people by the year 2050, with a concurrent growth in income, overall food requirements are forecast to increase by more than 50 percent from current levels.[3] Developing countries will constitute 98 percent of future population growth and put unprecedented stress on the global food supply chain.[4] The demand for resource-intensive foods like meat and dairy is projected to grow by 70 percent.[5]

Current and Projected Global Population (mm)



The world's population is projected to grow from 7.7bn in 2019 to 9.7bn in 2050 (26 percent increase), 98 percent of which will come from developing markets.

Source: UN Department of Economics and Social Affairs: World Population 2019

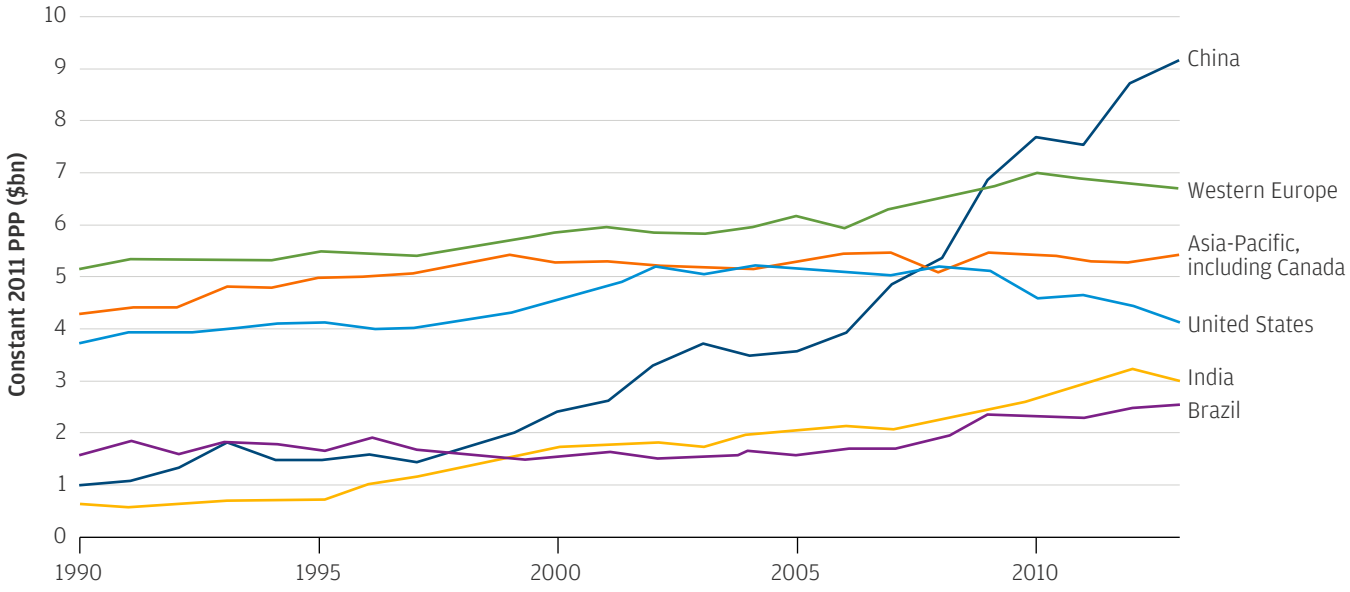
According to an analysis by the Rockefeller Foundation, American consumers alone spent $1.1 trillion on food, a figure that fails to include "the present and future costs of the food system's contributions to water and air pollution, reduced biodiversity, or GHG emissions, which cause climate change." Taking those external costs into account "the true cost of the U.S. food system is at least three times as big—$3.2 trillion per year."[6] Underpinning these costs, is the wide reliance the American economy has on the food system with 19.7 million full- and part-time workers. That is 10.3 percent[7] of the U.S. workforce operating in agriculture, food and related industries. As exemplified by the COVID-19 pandemic, a shockwave to the food system could have far reaching impacts across the economy.

As steady population growth generates increased demand in the decades ahead, precious forests and pastures will be massively depleted under current food production practices. Climate change has already diminished global food productivity by more than 20 percent over the past sixty years.[8] Today one thousand football fields worth of forest are lost every hour, totaling almost thirty million acres annually.[9] Due to drought and desertification, twelve million hectares of land are lost every year, translating into twenty million tons of lost agricultural output annually.[10] As one study observed, "Cattle, feed production and fish farming are the primary cause of deforestation, whether it is the forests of the Amazon, the savannahs of the Cerrado or the mangrove forests in Asia."[11]

A NECESSARY AGRICULTURAL LAND MASS TWICE THE SIZE OF INDIA?

If current trends continue, by 2050 agricultural land to feed the planet will need to grow by an area nearly twice the size of India.[12] In this projected future, roughly 70 percent of all habitable land would have to be allocated to agriculture.[13] Despite this dire prediction, U.S. investment in agricultural research and development has declined precipitously. The global landscape for food and agriculture R&D spending has shifted, with public spending by developing countries such as India, Brazil and China surpassing higher-income nations.

U.S. Public Sector Funding for Agricultural R&D Falls as Spending by China and India Rises



Source: USDA, Economic Research Service and Agricultural Science and Technology Indicators (ASTI), Organization for Economic Cooperation and Development
Note: PPP = purchasing power parity

FOUR COUNTRIES PRODUCE IN AGGREGATE THE LARGEST AMOUNT OF EMISSIONS

Roughly 40 percent of GHG emissions from agriculture are clustered in four countries: the United States, China, India and Brazil.[14] In these nations and others, the reliance on meat and dairy is a central source of environmental distress. Cattle account for approximately 10 percent of total global GHG emissions, including 50 percent of methane. Cattle and dairy cow GHG emissions are greater than the GHG emissions from any single country other than China. Methane produced by the agriculture industry is particularly damaging; methane is at least thirty times, and perhaps as much as eighty times, as deleterious to the environment as carbon dioxide.[15]

Livestock farming is responsible for more than 14 percent of GHG emissions, roughly as much as the entire transportation sector.[16] Ruminant livestock occupy two-thirds of global agricultural land and consume one-third of all cereal crops produced, equal to a total water requirement of about 1,800 gallons per pound in contrast to soybeans which require 216 gallons and corn at 108 gallons.[17] Consumption of ruminant meat is projected to rise 88 percent between 2010 and 2050. Beef, the most commonly consumed ruminant meat, requires twenty times more land and emits twenty times more GHGs per gram of edible protein than common plant proteins such as beans, peas and lentils.[18]

SOIL PRACTICES EXACERBATE THE THREAT

Another central source of GHG emissions comes from soil management practices that release nitrous oxide into the atmosphere. Roughly half of all agricultural GHG emissions in the United States come from soil practices such as tillage, fertilization and irrigation.[19]

INADEQUATE DISTRIBUTION OF FOOD LEADING TO WASTE

Compounding the challenge of rationing the global food supply is a systemic paradox of hunger, over-consumption, caloric inequality and waste. The current food system does not adequately deliver food resources. On a global basis roughly 800 million people are hungry or malnourished while approximately 1.9 billion of the population are obese or overweight. In the United States alone more than 23 million people live in low-income areas with poor access to healthy food.[20] According to the Food and Agriculture Organization of the United Nations, one-third of the world's food is lost or wasted every year.[21]

ACCESS TO WATER IS AN ACUTE RISK

Water usage is yet another variable exacerbating the threat of food insecurity. The World Bank estimates that agriculture uses 70 percent of annual freshwater deployments despite the estimate that more than one billion people do not have access to this basic natural resource. Based on current trends, by 2025 two thirds of the global population could be living under water-stressed conditions. By 2030 approximately 700 million people may be geographically displaced due to water scarcity.[22] According to the Food and Agriculture Organization, the livestock sector is the largest consumer of freshwater resources.

CONSUMER PREFERENCE AND DEMAND WILL DRIVE A SHIFT IN PRIORITIES

The growing awareness of the environmental impact of the current food system and increased dissatisfaction with its role in the state of public health will continue to increase consumer pressure towards change. Currently this issue is a focus primarily in wealthy, developed populations which are not faced with acute food insecurity issues. As the current system's limitations related to environmental sustainability and adverse health impacts are amplified by the challenge of population growth, the pressure on corporations and investors will become more pronounced. The proposition that affordable food products are incompatible with sustainability objectives will become increasingly untenable in both developed and developing economies. Food system participants will face consumer pressure to establish plan for achieving food and agriculture sustainability transition that is realistic, clear and measurable. Furthermore, improving the nutritional profile of the food system or the notion of "food as medicine" is one of the most powerful weapons available to fight both spiraling healthcare costs and many of the food related health issues that currently exist in countries like the United States.

1.2 Corporate Commitment to Transition-Related Efforts are Accelerating

COMPANIES ARE INCREASINGLY COMMITTING TO NET ZERO EMISSIONS BY 2050 OR EARLIER

Since the Paris Agreement was announced in 2015, policymakers have been attempting to drive an agenda mitigating the impact of climate change. Amidst a backdrop of the COP26 Glasgow conference and heightened focus on achieving net-zero emissions by 2050, climate action has been at the top of corporate agenda.

ISSUANCE OF CAPITAL TO FUND "GREEN" PROJECTS

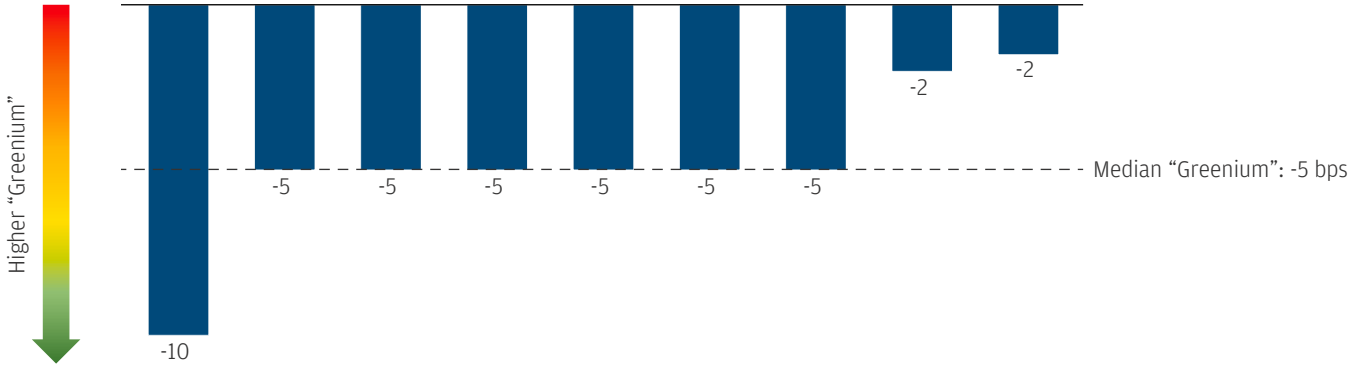
Public equity markets are applying significant premiums to companies that are addressing the energy transition, which have resulted in many companies assessing strategic alternatives such as carve-outs, spinoffs and SPAC mergers to raise capital for "green" assets. Similarly, private investors have also raised dedicated funds to help address carbon transition, such as TPG's Rise Climate fund, which has $6 billion of assets under management.[30] Green and Sustainable debt issuance is at all-time highs and corporates are rewarded in debt markets for better sustainability performance and increased ambition. Corporate sustainable bond issuance—green, social, sustainability and sustainability-linked bonds—has jumped from $38 billion in 2014 to a record high of $1 trillion in 2021.[31]

The issuance of sustainable debt has continued to set new records as firms seek not only the reputational benefits of sustainable investment, but attempt to realize the emerging cost of capital benefits, as well. Evidence suggests that the current benefits remain relatively modest in absolute terms. But the benefits are increasing, and the advent of sustainability-linked products expands the applicability to more potential issuers.

As the market generally supports sustainable issuances with lower costs of capital due to embedded incentives from the lender or perceived long-term reduction in a company's risk profile, borrowers at the forefront of the industry may be able to reap the benefits of a lower discount rate.

Issuers of Green and Sustainability Debt have Enjoyed a Modest "Greenium"

Each bar represents the basis point savings ("Greenium") issuers of green and sustainability bonds received over the last year



Source: J.P. Morgan; Note: "Greenium" has been defined as the number of basis points by which the ESG instrument is expected to have outperformed the regular bonds, as estimated by the JPM syndicate. The analysis includes nine green and sustainability USD bonds issued between February 2020 and March 2021.

1.3 Standardized Disclosure Will Likely be Followed by Increased Regulatory Scrutiny

Many jurisdictions are quickly moving forward with new ESG disclosure requirements for corporate issuers. Climate disclosure is a top priority and many regulators are basing their new disclosure requirements on the framework developed by the Taskforce for Climate-related Financial Disclosures (TCFD).[32] Although the initial focus is on climate, many regulators are expected to also mandate broader sustainability disclosures that include enhanced environmental and social information disclosures.

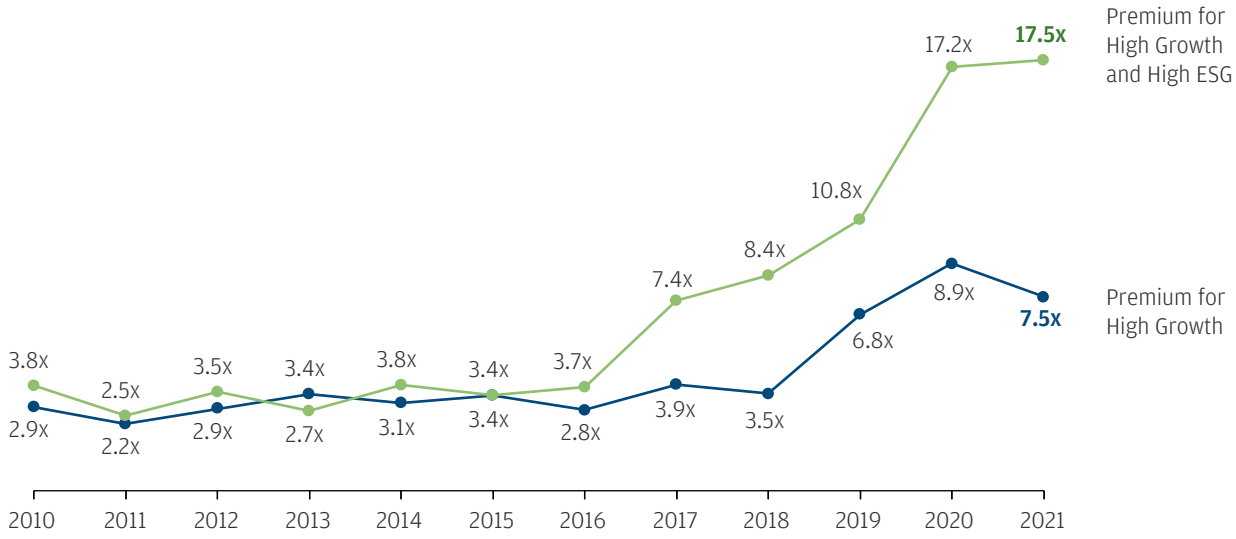
In the United States, the 2023 Farm Bill affords a timely opportunity to advance a longer term FAST agenda around key areas past bills have addressed including commodities, nutrition, conservation, credit markets and sector R&D. Separately, the SEC is expected to release a proposal on public company climate disclosure in early 2022, to be followed by proposals on human capital management (workforce) disclosure and disclosures on board diversity. The climate disclosure proposal is expected to be based in part on the TCFD framework. Globally, there are efforts to develop international sustainability disclosure standards through the IFRS Foundation's International Sustainability Standards Board (ISSB).[33] The ISSB is currently working to draft an international climate disclosure standard, to be followed by other sustainability disclosure standards. The ISSB initiative has the support of regulators globally and is expected to inform evolving disclosure requirements in many different jurisdictions.

Many jurisdictions are also moving forward with adopting "taxonomies," which are frameworks that define when an economic activity can be considered environmentally sustainable or contributing to the transition to a low-carbon economy. The EU was the first to adopt a taxonomy, and the U.K. and several APAC jurisdictions are moving forward with their own taxonomies. While taxonomies are classification frameworks, they are beginning to be linked to disclosure requirements as well as standards for green and sustainability-focused financial products. For example, the EU will require certain corporate issuers to disclose how "green" their balance sheet is according to the EU Taxonomy.

1.4 Companies That Can Demonstrate "Sustainable Growth" Are Achieving a Premium Valuation

Companies with strong ESG characteristics are often viewed as inherently having attractive long-term fundamentals supporting the business, comparable to how the market used to view value investing. This has translated to companies that pair both growth and high ESG scores trading at a substantial premium to the rest of the market.

Value of Growth and ESG Performance Over Time for S&P 500 Firms



Median Multiple	7.9x	7.5x	8.2x	9.9x	10.5x	10.1x	10.9x	11.8x	10.6x	12.8x	14.2x	14.4x

Source: FactSet as of 12/31/2021; Note: Sample set consists of S&P 500 as of 12/31 of each year, excluding Financials; Note: Premium for High Growth is calculated as the difference between (1) median EV / NTM EBITDA multiple of S&P 500 companies with two-year forecasted revenue growth CAGR in the top 25th percentile, and (2) median EV / NTM EBITDA multiple of S&P 500 companies with two-year forecasted revenue growth CAGR in the bottom 25th percentile; Premium for High Growth and High ESG is calculated as the difference between (1) median EV / NTM EBITDA multiple of S&P 500 companies with two-year forecasted revenue growth CAGR in the top 25th percentile and MSCI ESG scores within the top 25th percentile of High Growth companies, and (2) median EV / NTM EBITDA multiple of S&P 500 companies with two-year forecasted revenue growth CAGR in the bottom 25th percentile.

Further to the above, an analysis of companies across the S&P 500 with top quartile ESG ratings implies a slight valuation premium compared to those in the bottom quartile.

Comparing Metrics of ESG Leaders vs. Laggards

Source: J.P. Morgan Corporate Finance Advisory, FactSet, J.P. Morgan; S&P 500 constituents as of December 2021; Market data as of 12/31/2021; Note: Values calculated are based on median of top quartile and bottom quartile companies using MSCI ESG scores; Excludes Financials and Real Estate; FV / EBITDA based on NTM EBITDA metrics; P / E based on NTM Earnings metrics; Equity beta based on 5-year historical beta compared to the S&P 500.

1.5 Considerations for a Corporate Sustainability Framework

Commit	Invest	Fund
Develop plans to measure and reduce emissions —including by engaging with supply chain	Develop in-house capabilities in sustainability and transition business models	Raise growth equity for transition focused assets in your portfolio
Set ambitious targets to reduce emissions and communicate progress at least annually	Identify growth areas for organic investment	Issue sustainable debt to fund green projects and/or align with strong ESG KPIs
Engage with top shareholders proactively to align on priorities	Pursue acquisitions to enhance capabilities in green sectors	Develop plan to attract investments from fast growing ESG funds
Appoint E&S focused leadership to Board of Directors	Pursue venture investments in emerging transition business models	Divest non-core assets as needed to free up additional capital

EXAMPLE STRATEGIC OPTIONS FOR COMPANIES TO CONSIDER:

i. **Strategic Portfolio Realignment:** Perform ongoing portfolio assessments using a transition-focused lens. Achieving the optimal mix of assets is likely to require additional strategic corporate actions and innovative structures. The most advantageous structure for companies with transition business segments will be situation-specific, taking into account a number of considerations, including execution requirements, capital raising potential, valuation optimization potential, maximizing control and minimizing public scrutiny, and potential synergy benefits.

ii. **Acquire in Growth Areas:** Evaluate acquisition targets with strong transition capabilities to reinforce the asset portfolio. Subject to considerations about the counterparty and the potential for public scrutiny, divestitures may be an attractive way to streamline the portfolio and reallocate capital to other transition-focused businesses.

iii. **Venture Investments in Emerging Technologies:** Strategic venture investments into transition-focused businesses should also be part of the corporate playbook. Venture investments in strategically aligned business will likely lead to diversification, a robust pipeline of M&A opportunities and learning synergies. Target investments may include internal initiatives to reduce a company's emissions footprint, including a repurposing of by-products into upcycled processes. To their credit, many large companies such as Cargill[34] and ADM[35] recognize the severity of the problems facing the food system and have supported new businesses through both capital investments and mentorship.

iv. **Raise Capital in Growth Assets:** Growth equity for transition-focused assets can be an attractive catalyst for accelerating development and commercialization. Investors are actively looking for opportunities to fund the sustainability transition, and companies can utilize various structures to capitalize "green" segments of their business at attractive valuations with corresponding uplift for the overall enterprise. For example, a company can contribute green assets and related intellectual property into a new subsidiary ("Green Sub") and raise capital via an equity private placement in the subsidiary. Similarly, this approach may be replicated using a carve-out IPO structure, where the new subsidiary ("GreenCo") can raise public capital on up to 20 percent of GreenCo while the Parent retains the rest. Contingent Value Rights (CVRs) and tracking stocks are other structures that could yield similar results.

v. **Sustainable Debt:** Consider pursuing sustainable debt issuances to transparently fund key transition initiatives. Innovation in the fixed income market in recent years offers a wide variety of sustainability related instruments that companies can consider.

vi. **Partnership:** Explore opportunities to reduce emissions across the supply chain by partnering with customers and suppliers on innovative environmental practices. For example, incumbents could help smaller partners accelerate their transition to regenerative farming practices or in the development of a system for farm-based carbon credits. Large corporations could also leverage R&D and IP of startups creating sustainable products, and pair them with their own strong manufacturing capacity and distribution and marketing channels. For example, ABInBev and and Nestle have R&D partnerships with The Every Company and Future Meat, respectively.[36, 37]

J.P. Morgan aspires to service the needs of all its clients, irrespective of where they are in their sustainability transition journey. Companies at the early stages of their transition will need to formulate a transition strategy and allocate the appropriate capital and resources towards the effort. Proactive stakeholder engagement to outline the company's transition plans will both help align agreement with its core shareholders about their strategy and its impact on expected returns. In addition, a thoughtful transition strategy may help mitigate the risk of avoidable, sustainability-focused activism campaigns.

2 Driving a Realignment of Capital Flows and Stakeholder Priorities

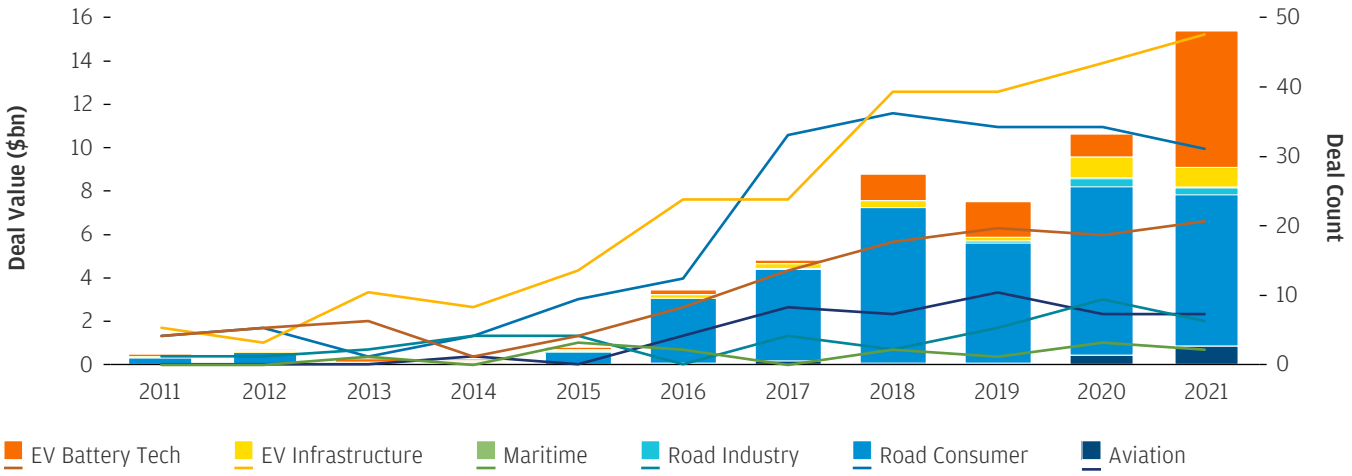
ACCELERATING CAPITAL FLOWS

Capital is flowing into food and agriculture sustainability transition, but not at the scale and with the prioritization necessary to meet both the challenges and opportunities facing the sector. The need for investment will only continue to grow over time as the food sustainability issue achieves greater salience and recognition. Achieving the net-zero objective, as outlined in the 2021 United Nations Climate Change Conference held in Glasgow, will require the mobilization of large amounts of capital towards climate change adaptation and mitigation efforts, especially in developing countries.

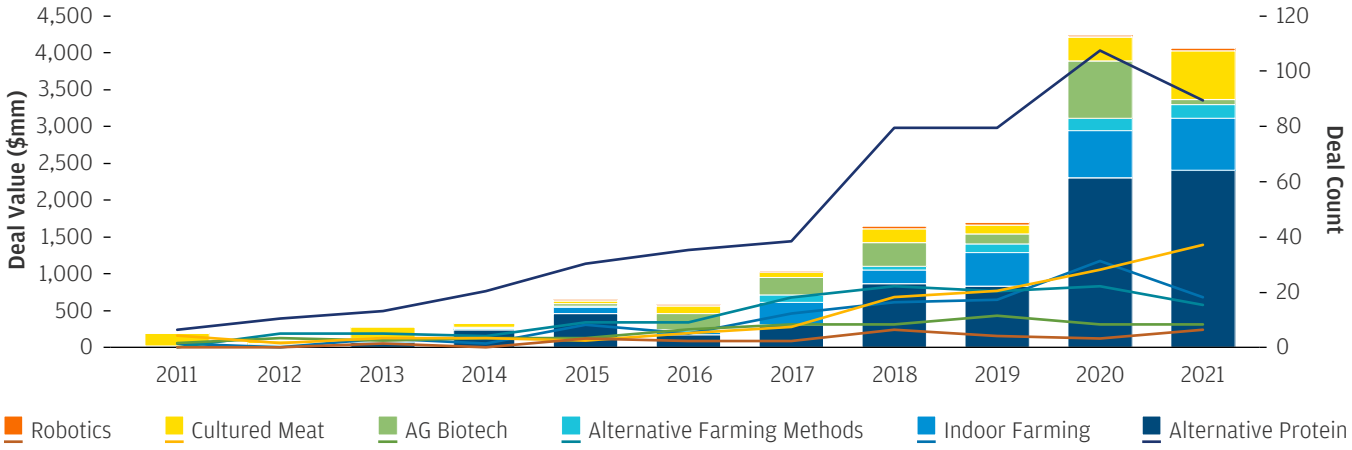
PRIORITIZATION OF ENHANCED SCALE AND CAPITAL FLOWS INTO FOOD TRANSITION WILL BE CRITICAL

The amount of private capital flowing into food and agricultural transition has accelerated, but the amount is still small in context of the magnitude of the problem. According to PitchBook, Food Systems is "the second-largest category in the climate tech ecosystem, with $4.1 billion in total investment in 2021 YTD—13.2 percent of the total VC through Q3 2021." In comparison, "VC activity into electric transportation continued to dominate in 2021, with startups raising almost 50 percent of all VC invested in climate tech: $14.9 billion across 111 deals through Q3—44.6 percent more investment value YTD than in 2020."[38] The year 2020 was the first in which investment into "upstream" technologies surpassed "downstream" technology, such as consumer food delivery systems and eGrocery, which have a limited impact on the key environmental, waste and food insecurity issues.[39] For developing countries without the United States' natural abundance of land and water, upstream technologies are more critical to addressing the long-term food needs of their population. Despite the positive momentum, the sector remains heavily underfunded relative to other climate-focused subsectors. Using the electric vehicle market as a proxy, food and agriculture is still five to seven years behind in both total transaction value and average deal size. This private capital is a key catalyst but needs to work in concert with direct public sector funding and realignment of the current subsidy structure. There is no shortage of companies attempting to address issues in the sector which should allow for a number of attractive investment opportunities as FAST garners more investor mindshare. The Good Food Institute has identified over 1,300 companies focused on the alternative protein ecosystem alone.[40, 41]

Electric Transportation VC Deal Activity by Category



Food Systems VC Deal Activity by Category



Source: PitchBook 2021: Introduction to Climate Tech, A Taxonomy overview; Note: As of September 30, 2021.

Key areas of interest for investors align strategically with initiatives that will enable more sustainable food production:[42]

- **Agricultural Biotechnology:** On-farm inputs for crop and animal agriculture including genetics, microbiome, breeding and animal health.
- **Innovative Food:** Alternative protein such as plant-based, fungi-based, cultivated meat and other alternative food products and ingredients.
- **Farm Management Software and the Internet of Things:** Software, sensing and capturing devices for data analytics.
- **Midstream Technologies:** Food safety and traceability technology, logistics and transport.
- **Agribusiness Marketplaces:** Commodities trading platforms, online input procurement and equipment leasing.
- **Bioenergy and Biomaterials:** Non-food extraction and processing feedstock technology.
- **Farm Robotics, Mechanization and Equipment:** On-farm machinery, automation and drone-based monitoring.
- **Novel Farming Systems:** Controlled environment agriculture, aquaculture and algae production.

THERE IS A FUNDING GAP FOR COMPANIES SEEKING LARGER-SCALE GROWTH EQUITY INVESTMENTS

Only a small number of capital providers including Temasek, BlackRock, SoftBank, QIA (Qatar Investment Authority) and Blue Horizon have led more than one large-scale ($100 million+) investment round.[43] Sovereign wealth funds have in recent years served as a critical source of capital for companies in this sector, consistent with underlying food security concerns in their home markets. While many venture capital funds are focused on early stage investments in food and agriculture, there is a substantial gap in the mid- to late-stage funding sources.

PUBLIC POLICY AS A LIKELY ACCELERATOR

As exemplified by the energy sector, policy changes across the globe can occur quickly. In food and agriculture, a change in policy could help facilitate the sustainability transition with tax incentives or grants, or conversely disincentives to high emissions products through incremental taxes or the removal of existing subsidies. Europe is already ahead of the global curve on transitioning businesses to sustainable practices and Asia has a significant incentive to reduce reliance on the rest of the world for food supply. It is likely that a major change in policy in the United States could catalyze the development of multiple FAST-oriented technologies similar to what was observed in the California renewable diesel market.

COST EFFICIENCY OF CLIMATE ACTIONS

Companies can reduce costs while cutting emissions by becoming more energy-efficient and switching to lower-cost renewable power. For example, Unilever achieved €800 million ($900 million) in savings by sourcing low-cost renewable electricity, which more than offset the premiums paid to sustainably source plastic and palm oil.[44] BCG analysis of actual decarbonization projects shows that companies across essentially all major sectors can realize significant cost savings through Scopes 1 and 2 decarbonization. Almost all companies can realize at least one-third of emissions reductions at net-zero costs to their business.[45] The pace of improvements in efficiency of capital deployment and cost parity is occurring much faster than the market recognizes. For example, in less than a decade cultivated meat companies have reduced the cost of producing a pound to meat to less than $10.[46]

FOOD TRANSITION IS ONE OF OUR BEST TOOLS FOR FIGHTING CLIMATE CHANGE YET IT CONTINUES TO BE NEGLECTED

Food and agriculture-related initiatives rank amongst the top options for reducing emissions. According to Project Drawdown, one of the leading non-profits addressing climate solutions, reducing food waste and shifting to plant-rich diets rank #1 and #3, respectively, in their analysis of how to limit the temperature rise to 2 degrees Celsius by 2100.[47] Despite the clear recognition of the impact such changes could have, there are very few governmental, academic, corporate or NGO assessments of the estimated capital required. According to Net Zero Financing Roadmaps, one of the few publications allocating significant resources and attention to food and agriculture, investments of at least $150 billion per year will be needed across agriculture, food and land use over the coming decades.[48]

To reap the benefits of these solutions, it must be recognized that all climate solutions are interconnected as a system and, combined together, have the greatest impact. The Food and Agriculture Organization of the United Nations (FAO) demonstrates how simple integration of food and energy production at both a small and large scale has produced successful results to combat climate change.[49] Other organizations have been instrumental in providing necessary funding, such as the Rockefeller Foundation with their New Climate and Resilience Initiative as well as the Gates Foundation and their various funding initiatives to combat climate change.

It can be argued that funding needs would be substantially alleviated with even a minor modification in asset allocation decisions by sovereign wealth funds, pensions, mutual funds, insurers, private equity and other strategic investors. For context, the total estimated investment required in food and agriculture for initiatives such as nature restoration, alternative proteins, regenerative agriculture and food waste reduction by 2030 is $1.5 trillion. This total equates to less than 10 percent of the $16.0 trillion estimated for the transition to a comprehensive system of electricity over the same time period despite the quantum of emissions in both sectors being similarly severe.[50]

3 Promising Strategies and Solutions

As argued by the World Resource Institute (WRI), three gaps must be filled to feed ten billion people sustainably by 2050, the projected population of the earth's population by mid-century.

- **Calorie Deficit:** A 56 percent food gap between crop calories produced in 2010 and those required on a global food basis in 2050.
- **Arable Land Shortage:** A 593 million-hectare land gap—noted previously as twice the size of India—between global agricultural land areas in 2010 and anticipated agricultural expansion by 2050.
- **Emissions Crisis:** An 11 gigaton GHG mitigation gap between expected agricultural emissions in 2050 and the level needed to hold global warming below 2 degrees Celsius and avert the world's worst climate impacts.[51]

These metrics should induce a sense of urgency among private and public sector participants in the food sustainability dialogue. The literature on the security of the food supply chain—which has grown voluminously in recent years—has generated scores of useful recommendations ranging from modified fishing practices to the protection of peatlands. All merit study and discussion. It is this report's thesis that three initiatives are particularly vital and can achieve near-term gains: The transition to healthier and more sustainable protein alternatives; the implementation of enhanced farm practices; the application of systems to ensure the dramatic reduction in food waste; and the creation of new carbon markets and financial products.

3.1 Alternative Proteins

A transition to the wider adoption of alternative proteins is essential to combating climate change and feeding a hungry planet by mid-century. The transition to healthier and more sustainable diets, however, will demand a major shift in consumer behavior and habits. If daily ruminant meat consumption were limited to 52 calories per person, the GHG mitigation gap would be reduced by 50 percent. Yet that would require consumers to limit their beef consumption to about 1.5 hamburgers per week. In North America alone this would require slashing meat and lamb consumption by almost half. Thus, instead of asking consumers to sacrifice their meat consumption, which has been historically unsuccessful, the alternative protein industry aims to provide consumers with the meat, eggs and dairy that they love, just produced in a more sustainable and resource-efficient manner. If alternative proteins are able to reach taste and price parity with conventional animal proteins, as is the industry's goal, the transition to healthier more sustainable diets becomes much more palatable. To achieve this goal, WRI advocates the more robust marketing of plant-based food; improving the variety and appeal of meat substitutes; and innovative government and commercial policies that favor the consumption of plant-based foods.[52] In line with the massive step forward in comparability between plant-based and traditional meat products achieved by companies in recent years, continuing innovation in alternative proteins should further accelerate penetration of the total market.

Some experts are particularly sanguine about the transition to a more sustainable diet of protein alternatives. The Boston Consulting Group (BCG) and Blue Horizon forecast that by 2035, every tenth portion of meat, eggs and dairy eaten around the globe will be an alternative protein. If it were a country, the alternative protein market by that time would be a top 50 economy.[53]

BCG and Blue Horizon anticipate that in 2023 greater parity will be established between conventional and alternative proteins, after which "a five-year period of soaring interest and deeply increasing adoption will occur."[54] The authors also offer a note of caution and resulting recommendations: "Today the cost of goods sold for realistic plant-based alternative proteins is still about two times the cost of conventional animal proteins. To improve this ratio, the industry must optimize and scale up every step of the way. Improving sourcing and growth are prerequisites for reduction at scale, while perfecting extraction, formulation and texturizing still significantly reduce costs."[55] Alternative proteins are vastly more efficient than conventional animal agriculture, requiring significantly less land, water, and other inputs than what's typically required to raise livestock. Going from crop to meat involves calorie loss. Even after decades of selective breeding and optimization, there are upper limits to how efficiently an animal can turn feed into meat. By growing meat directly from plants or cultivating meat from cells, the input to output ratio can be drastically improved.

The transition to alternative proteins, while holding great promise, also presents prodigious challenges. As FAIRR concluded in its study, "Any protein diversification strategy cannot simply focus on adding a few new alternative protein products to the current portfolio. It requires companies to develop a comprehensive strategy to expand product and research, explore the applicability of new food technologies and acquisitions, leverage their market power to influence consumers to embrace new products and engage their supplier community to mitigate impacts of farmer livelihoods."[56]

PLANT-BASED MEAT

Plant based meat is produced in a four-step process. Food scientists first select the best source material for the product, often pea, wheat or soy, but also novel plant sources such as certain types of fungi, algae, and mung bean. Second the plant source is optimized to give it higher protein or the reduction of undesired flavors. Third, the desired raw materials are isolated through mechanical or chemical processes to create optimal ingredients for the final product. The final step is to create the desired taste, texture, smell and appearance of the food product.[57]

Plant-based diets help to reduce the demand for meat, dairy and seafood, which subsequently reduces land clearing, fertilizer use, methane produced from livestock and other GHG emissions.[58] Water use is reduced by 72 to 99 percent and land use is reduced by 47 to 99 percent for the production of plant based meats.[59]

CULTIVATED MEAT

Cultivated meat borrows technology from the cell therapy industry. A small biopsy of cells is obtained from an animal, which is placed in a bioreactor or cultivator and then nourished with nutrients that allow the cells to divide and multiply exponentially. Over time, when the cells have increased to a sufficient quantity, the conditions in the cultivator are altered and the cells transform to create meat, specifically muscle, fat and connective tissue, in a process that takes only six to eight weeks, far faster than the life span of raising an animal for slaughter. This synthetic process of food creation omits the need to raise or slaughter an animal and the agricultural requirement of nourishing livestock.[60] According to a market projection from McKinsey, the market for cultivated meat could reach $25 billion by 2030.[61] This technology is also used for cellular aquaculture to provide sea food alternatives, helping to alleviate the overwhelming decline in the marine species population over past years due to surging demand. The environmental benefits of cell-based beef are powerful: An estimated reduction of land use by more than 95 percent, climate change emissions reduced by 74 percent to 87 percent and nutrient pollution diminished by 95 percent.[62]

The capital requirements for a major transition to alternative protein will be significant. Almost 30 million tons of bioreactor capacity for microorganisms and animal cells will be needed to reach the baseline case of 11 percent user adoption by 2035.[63] But the potential is significant for many stakeholders to contribute to a food future elevating the consumption and benefits of alternative proteins. As the Good Food Institute concludes: "A high degree of public, private and nonprofit sector participation can accelerate the success of the alternative protein industry. Governments, investors, NGOs, academic institutions and private companies can use their purchasing power, financing, influence and expertise to accelerate the industry."[64]

PRECISION FERMENTATION

Precision Fermentation (PF) uses microbes in the traditional process of fermentation in order to produce complex organic molecules, including enzymes, hormones, fats and vitamins. Current applications of PF include producing human insulin, replacing an expensive and laborious process of extracting insulin from cows and pigs. In addition to producing insulin, PF today produces growth hormone and more recently collagen to promote healthy and smooth skin as well as rennet used in cheese production. The cost of PF is declining rapidly, opening the door to food production. Progress in PF should catalyze growth in both plant-based and cultivated meat by creating novel ingredients with the ability to improve multiple attributes including taste, texture and costs of production.[65]

Specifically, the authors of a recent RethinkX report believe PF will make a meaningful impact on the trajectory of both plant-based and cell-based foods: "Turning plants into consumer food products involves specialized ingredients, and PF will allow micro-organisms to produce an infinite number of these ingredients to enhance and improve plant-based products." PF is also likely to facilitate new growth factors for the production of cell-based meats.[66]

BIOMASS FERMENTATION

Biomass fermentation leverages the fast growth and high protein content of many microorganisms to efficiently produce large quantities of protein. The microbial biomass serves as the main ingredient of a food product or as one of several primary ingredients in a blend. The cells either stay intact or are minimally processed and can be broken open to improve digestibility or be utilized to enrich protein content.[67] Some biomass products comprise a significant portion of an end product's mass while others impart special functionality to the end-product. Traditional and biomass fermentation processes offer well-established opportunities for scalability and cost reduction suitable for alternative protein applications.[68]

Both biomass and precision fermentation will require a broader ecosystem, including the buildout of manufacturing capacity, for new technologies to scale. Currently, advanced food-grade fermentation capacity is effectively non-existent. This dynamic presents an interesting infrastructure-style investment opportunity similar to the co-manufacturing model in traditional food production.

3.2 Enhanced Farming Practices

CONTROLLED ENVIRONMENT AGRICULTURE

Controlled Environment Agriculture (CEA) is the growing of crops inside controlled environment structures such as greenhouses and vertical farms. By using this method, food producers can reduce pests and disease, increase yield, lower costs and enhance sustainability. CEA utilizes various technology-driven growing methods. In hydroponic systems, plants are grown in water rather than soil. Nutrients are then added to ensure healthy growth with maximum output. In aeroponic growing systems, plants are nourished with their roots exposed to the air. The roots are then misted regularly with water and vitamin solutions.

CEA allows for the more efficient water and land use, reduced need for fertilizer and pesticides and reduced emissions as operations can be located closer to end-users. One key limiting factor with vertical farming specifically is the significant amount of energy needed in order to create artificial sunlight for the plants to grow.

AGRICULTURAL BIOTECH

Agricultural biotechnology encompasses a range of tools, including traditional breeding techniques that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses.

Biotechnology is being harnessed in agriculture to address feed-related emissions from multiple angles, ranging from the development of new, low-carbon feed options to substitutes to traditional fertilizers.

Genetically modified organisms are applied to make important crops such as grains and oilseeds resistant to common threats, including drought and pests. These past breakthroughs have historically mitigated climate change by reducing the amount of land required by the agriculture sector. Due to improved productivity, there were fewer acres of cropland in production in the U.S. in 2012 than there were in 1945, despite the large increases to the population that occurred over that time.[69] In addition to the on-farm applications, biotechnology is also being leveraged to improve the carbon efficiency of animal agriculture through genetic engineering of the animals themselves.

PRECISION AGRICULTURE TECHNOLOGIES

Precision agriculture technologies (PAT) can be divided into three main categories: Guidance systems, which include all forms of automatic steering and guidance for tractors and self-propelled agricultural machinery; recording technologies which include soil moisture mapping, canopy mapping and yield mapping; and reacting technologies, which include variable rate irrigation and weeding and variable rate application of seeds, fertilizer and pesticides. All three categories of PATs require the use of Global Navigation Satellite Systems (GNSSs).

As an example of PAT benefits, variable rate irrigation can provide 8 to 20 percent reduction in irrigation water use.[70] Lower quantities of water irrigation in turn then require lower pumping energy which, when powered by either fossil fuel motors or electricity, indirectly influence GHG emissions as well. In a study conducted in 2016 to analyze the impact of controlled farming on GHG emissions, an approximate reduction of tractor fuel requirements of more than 40 percent was observed, in contrast to conventional tillage.[71]

REDUCE ENTERIC FERMENTATION

As noted previously, the largest amount of agricultural production emissions come from ruminant livestock. Of these emissions the largest source is "enteric methane," also known as cow burps. Ironically such a prosaic animal function constitutes a major challenge to the environment. There are promising technologies on the horizon to alleviate the problem. A chemical additive that inhibits microbial methane known as 3-NOP was tested in New Zealand and cut methane emissions by 30 percent and may have increased animal growth rates as well. As WRI recommends: "Governments should expand public research into compounds like 3-NOP and require or incentivize adoption of the most promising."[72]

According to McKinsey, genetic selection and breeding programs could significantly reduce overall emissions by 2050. In single herds, intentional breeding for methane efficiency has achieved variation in methane production of about 20 percent.[73] Their finding comes with a caveat, specifically the lack of economic incentives for agriculture producers and farmers in the form of market payments or credits for methane reduction.

Less ambitiously, agricultural producers could expand their use of animal feed additives, some of which have proven effective at reducing methane production. A McKinsey analysis on the value of a modified feed mix finding is promising: "The combined impact of direct-enteric-fermentation-rate reduction (approximately 13 percent) and productivity improvement (approximately 2.5 percent) generates potential for an approximately 15 percent reduction in CO_2 emissions per ruminant."[74]

Finally, improved animal health generally is a goal all industry participants should share both as a means to improve animal productivity and reduce animal mortality. According to McKinsey, improved animal health management in North America alone could enhance overall cattle herd productivity by a weighted average of about 8 percent.[75]

BOOSTING PASTURE PRODUCTIVITY

As WRI has noted, the productivity of livestock varies significantly on a global basis. "Given that demand for animal-based foods is projected to grow by 70 percent by 2050 and that pastureland accounts for two-thirds of agricultural land use, boosting pasture productivity is an important solution. A 25 percent faster increase in the output of meat and milk per hectare between 2010 and 2050 could close the land gap by 20 percent and the GHG mitigation gap by 11 percent." To achieve this outcome governments can set productivity targets and support farmers with financial and technical assistance (as a point of reference, agricultural support currently amounts to approximately $540 billion a year on a global scale).[76] Other measures include improving fertilization of pasture, feed quality and veterinary care; raising improved animal breeds; and employing rotational grazing.[77]

IMPROVE CROP BREEDING

New advances in molecular biology can, according to WRI, generate additional yield gains by diminishing the cost and accelerate the speed of mapping general codes of plants. The test for desired DNA traits, turn genes on and off and purify crop strains. The expansion of public and private crop-breeding budgets could facilitate this promising goal.[78]

An adjunct to genetic engineering is to plant croplands more frequently or increasing "double cropping," the planting of a pair of crops in one field in the same year. Increasing annual cropping intensity by 5 percent beyond the 2050 baseline of 87 percent would diminish the land gap by 14 percent and the GHG mitigation gap by 6 percent.[79]

IMPROVE RICE CULTIVATION

Flooded rice paddies in the form of warm, water-logged soil provide ideal bacterial conditions that produce methane. Improved fertilization practices in rice cultivation could reduce methane emissions by about 40 percent, according to McKinsey's analysis, which stresses the use of fertilizers containing sulfate as one modification that can produce meaningful results over time. Sulfate application on rice fields today is estimated to be only 1 percent.[80]

3.3 Decreasing Food Waste

An essential feature of food sustainability is diminished waste. As noted previously, approximately one third of food produced for human consumption is wasted; the loss occurs all along the food chain from field to fork.

Obstacles to reducing food waste are varied. Breakthrough Energy, an organization initially established by Bill Gates focused on achieving a path to net zero emissions by 2050, identifies four primary impediments. The first is the lack of visibility and measurement; most businesses and households do not track or measure their food waste, rendering it an invisible cost on a day to day basis but a significant factor in the broader food sustainability equation. Second is a misalignment of incentives. "Food businesses may prioritize hiring fewer workers or providing customers more options, even if it means more food is thrown out," the report notes. "Additionally, many food businesses drive through high volume sales, leading to large portions and promotions that encourage overbuying—which in turn leads to waste at the consumer level." Third, food safety requirements induce caution with respect to the salvaging of wasted food. "Companies and regulations… give a wide berth to anything that would incur increased food safety risk," leaving huge amounts of food being discarded as a precautionary measure. Finally, in developed economies, as much as 20 percent of agricultural production can be lost to agronomic pests and pathogens amplified by "herbicide resistance and emerging pests pushed into new geographies by climate change."[81]

Reducing food loss and waste by 25 percent by 2050 would close the food gap by 12 percent, the land gap by 27 percent and the GHG mitigation gap 15 percent. Tactics to achieve these outcomes include a new system to measure food waste, now a metric that is imprecise and not globally standardized; streamlining food expiration labels to make them more informative, setting reduction targets and improving food storage in developing countries.[82]

PACKAGING INNOVATION AND COATINGS

According to the 2018 Wasted Food Report, the EPA estimates that 35.6 percent of the nearly 103 million tons of food wasted gets sent to landfills.[83] The resulting GHG emissions reached approximately 111 million tons.[84] Preventing food waste is a key mitigating factor to climate change, and making changes to packaging is one of the most effective ways to reduce the climate emissions from food waste.

Whether it's made from glass, plastic, metal, paper or bamboo, packaging plays an important role in keeping food fresh, ensuring it is safe as well as extending its shelf-life to reduce loss and waste. The role of flexible packaging in reducing food waste and the extension of shelf life achieved with packaging systems such as Modified Atmosphere Packaging (MAP), vacuum and active packaging are frequently cited as a response for food waste.

The principle of MAP is the replacement of air in the package with different fixed gas mixtures and the use of flexible films to control the dispersion of gas into and out of the package. Oxygen, nitrogen and carbon dioxide are the three main gases used. These gases are applied individually or in combination to alter the atmosphere surrounding the food. Every type of food has an ideal atmospheric condition for preserving its freshness and the goal of MAP is to alter the normal gas concentration of air to an ideal atmosphere that delays the decay of the food product.

Additionally, new technological advances in edible coatings for food may hold promise in extending shelf life, reducing packaging layers and meeting food safety and quality requirements. Among various coatings, edible coatings have been proven to be one of the best biologically safe preservative coatings for different types of foods because of its film-forming properties, antimicrobial actions, biodegradability and biochemical properties. It acts as a natural barrier to moisture and oxygen, which are the main agents of deterioration of fruits and vegetables. Edible coatings have the ability to prolong shelf life of fruits by minimizing the rate of respiration and maintaining quality attributes.

UPCYCLED FOODS

Upcycling food means repurposing the edible part of wasted food and making it suitable for human consumption. Upcycled foods are made from unmarketable ingredients such as sub-grade, damaged or imperfect food produce, food by-products and scraps from food preparation.[85] The production of upcycled foods is beneficial to the environment as it helps to repurpose food that would otherwise be wasted, as a value-added food product. One example of this practice is the production of biscuits from sunflower flour or apple pomace.

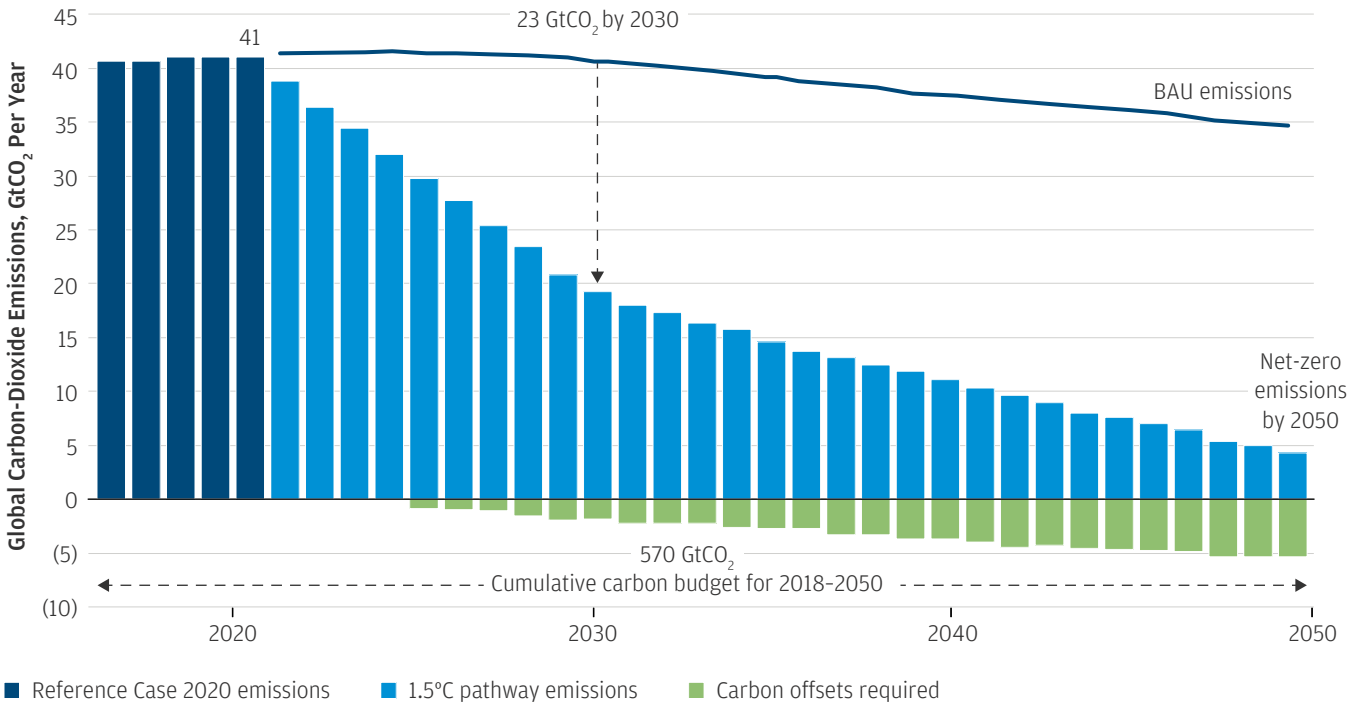
The word "upcycled" evokes not only food waste reduction, but also the broader goals of environmental sustainability and community nutrition. Decreasing food waste reduces resource depletion, including inefficient use of land and water, and limits the carbon emissions from growing, transporting and disposing of food.

ReFED and Upcycled Food Association—leading national nonprofits working to reduce food loss and waste across the food system and attract more investment—have launched the first-ever Food Waste Funder Circle. It is a dedicated network to support private, public and philanthropic funders who want to use their capital to scale a full range of solutions to food waste. It also offers a curated platform for education, collaboration and investment to close the gap in capital needed to reach the national goal to reduce food waste by 50 percent by the year 2030.

3.4 Accelerated Development of Voluntary Carbon Markets

One of the most significant developments coming out of COP26 was the agreed upon Article 6 rules related to carbon markets. The two key developments were: (i) guidance on measures that need to be taken by countries generating credits to avoid double counting; and (ii) credits produced between 2013 and 2020 under the Kyoto Clean Development Mechanism can be used for 2030 commitments by paying a 5 percent fee that will be funneled into an "Adaptation Fund" for developing countries as a way to fund their energy transition and climate mitigation efforts. These developments coupled with record net-zero commitments by countries and companies will likely jump-start the evolution of voluntary carbon markets.

Role of Carbon Offsets in Reaching Warming Target (Global Emissions, $GtCO_2$ Per Year)



Source: Taskforce on Scaling Voluntary Carbon Markets and Institute of International Finance

Carbon markets are in a phase of rapid growth and could have significant market expansion potential. S&P forecasts that international carbon markets can generate up to $1 trillion per year in financial flows by 2050.[86] Article 6 could potentially open the door for SBTi to give companies credit for carbon offsets when approving emission reduction targets.

Carbon offsets can be generated through nature-based and technology-based solutions. Nature-based sequestration captures carbon in the biosphere through practices like reforestation and restoring soil, mangroves and peatlands using improved agricultural practices. Technology-based solutions remove and store CO_2 from the atmosphere in secure places through Carbon Capture, Utilization and Storage (CCUS).

Nature-based sequestration has significant benefits such as positive impacts on surrounding biodiversity, water and soil quality. Despite these advantages, it is regularly called into question because of the long-term ability to sequester carbon and the vulnerability of the process to reverse.

REGENERATIVE AGRICULTURE PRACTICES CAN SEQUESTER CARBON

Regenerative agriculture is a system of farming principles and practices aimed at promoting soil health by restoring its organic carbon. Research continues to reveal the damaging effects to soil from tillage, applications of agricultural chemicals and salt-based fertilizers and carbon mining. Regenerative agriculture reverses climate change by rebuilding soil organic matter and restoring degraded soil biodiversity—resulting in both carbon drawdown and improving the water cycle.

The objective of regenerative practices as a climate mitigation strategy is to sequester carbon. Sequestration means maximizing the carbon dioxide pulled from the atmosphere by plant growth and minimizing the loss of that carbon once it is stored in soil. When plants photosynthesize, they take carbon dioxide from the air and—using the sun's energy, water and nutrients from the soil—transform it into carbon the plant uses to grow. The excess carbon created through this process is transported down the plant and is stored in the surrounding soil, sequestering the carbon in the ground. The carbon in the soil is known as soil organic carbon and it feeds microbes and fungi, which in turn provide nutrients for the plant.

Carbon can remain stored in soils for thousands of years—or it can be quickly released back into the atmosphere through farm practices like plowing and tillage, where soil is prepared for planting by mechanical agitation methods such as digging, stirring and overturning. Soil carbon testing technology that is economical, accurate and standardized would help to incentivize farmers to participate in regenerative agriculture practices.

Regenerative agriculture practices and alternative protein are complementary methods to combat the climate crisis. One of the most significant advantages of alternate protein is the decreased land use and that in turn opens up options for regenerative farming practices. Several of the common crops used in alternative proteins, such as peas, are well suited for crop rotations. Crop rotations are a scalable regenerative agriculture practice that can be used to improve soil health and build resilient systems.[87]

FEDERAL AND REGULATORY REMEDIES

Perhaps more than other sectors, the deep history of U.S. agricultural policy as a partner to industry has produced a regulatory infrastructure that can be modified to produce a more sustainable food future. One mechanism featured in the Breakthrough Energy report is the Federal Crop Insurance Program (FCIP), described as "a powerful policy lever that can accelerate the adoption of conservation practices that GHG and sequester soil carbon." Common sense reforms, Breakthrough Energy suggests, can improve FCIP's long-term efficacy and cost-effectiveness, although change will not necessarily occur quickly: "They could… drive GHG reductions by linking the producer's actual risk…to their insurance premiums and federal subsidies." Iowa and Illinois, notes the report, are already running pilot programs that reduce premiums for farmers who plant cover crops. Additional reforms have the potential to:[88]

- Improve FCIP's overall risk-management performance by reducing long-term risk and taxpayer cost;
- Increase carbon sequestration;
- Reduce erosion and increase the efficiency of nitrogen use;
- Align with corporate and philanthropic sustainable supply-chain efforts;
- Facilitate the growth of the carbon market; and
- Enhance long-term agricultural productivity.

4 Making Food and Agriculture Environmental Sustainability a Foreign and Domestic Policy Priority

FOOD INSECURITY IS WIDELY RECOGNIZED AS A DEFINING GEOPOLITICAL CHALLENGE OF THE NEXT DECADE

The last Intelligence Community Assessment of global food security from the Office of the Director of National Intelligence in 2015 judged that "the risk of food insecurity in many countries of strategic importance to the United States will increase during the next ten years because of production, transport and market disruptions to local food availability, declining purchasing power and counterproductive government policies…in some countries declining food security will almost certainly lead to social disruptions or large scale political instability or conflict, amplifying global concerns about the availability of food."[89]

The first National Intelligence Estimate (NIE) requested by the Biden administration in 2021 focused on the risks of climate change. It was the first NIE to explicitly address this threat. The resulting report, released as both a confidential and public document, is a product of the consensus among scientific advisers and seventeen different U.S. intelligence agencies, including the Central Intelligence Agency, the Defense Intelligence Agency, the National Security Agency and the State Department's Bureau of Intelligence and Research. The study concludes that climate change was coalescing with formidable challenges to political and economic cohesion around the world.

As summarized by the Center for Strategic and International Studies, the Global Food Security Strategy (GFSS) for 2022 to 2026, released in October, 2021 provides "the foundation for Feed the Future, a whole-of-government approach to global hunger and food security, which initially focused on agricultural production and market systems. After the severe droughts in the Horn of Africa—often cited as a primary driver of the existing conflict in the region—Feed the Future adopted an additional focus on resiliency in development programming in fragile contexts." The analysts criticized the assessment, however, for failing to delve more deeply into the impact of climate change on food security and stability.[90] The authors, Eilish Zembilci and Rod Schoonover, also note that a new U.S. government initiative may better address the important connection between climate change, food security, and national security. Announced in Spring 2021, the Agricultural Innovation Mission known as "Aim for Climate," a joint initiative between the United States and the United Arab Emirates. The program seeks to address the climate crisis by accelerating investment in agricultural and food system innovation "as specific as enhancing investments in digital tools and as broad as inclusive, equitable and sustainable food systems."[91]

CHINA WILL BE A RIVAL TO THE UNITED STATES FOR INFLUENCE ON GLOBAL FOOD SECURITY

A Chinese idiom proclaims that "people regard food as their heaven," evidence of the historic importance of food security for leaders in Beijing and across the country over hundreds of years. Among the reforms launched by former President Deng Xiaoping, domestic food production dramatically increased in tandem with economic growth. But consumption also jumped in response to increased demand, changing diets, increased food waste and the loss of farmland to urbanization.[92] Today Beijing is pursuing a primarily dual track strategy: Increase capacity and productivity at home while concurrently launching an ambitious program of agricultural diplomacy encompassed in its "Food Silk Road," which aspires to substantially diversify food imports from multiple regions around the world, including Africa and Latin America.

The importance of this national policy was recently emphasized by Chinese President Xi Jinping, who in April 2021 declared "food security is an important foundation for national security." China included cultivated meats and other "future foods" like plant-based eggs, in its five year agriculture plan released in January 2022.[93] Tang Renjian, the minister of agriculture and rural affairs called seeds "the computer chips" of agriculture and cultivated land the "lifeblood of food production." For the first time, grain security was included in the central government's 14th five-year plan encompassing the period of 2021 to 2025. According to the strategy, China must achieve an annual grain production of more than 650 million tons a year. And in an acknowledgment of the severity of a persistent global problem, the Standing Committee of the National People's Congress passed an "Anti-Food Waste Law" supplemented by a comprehensive public affairs campaign. The action followed a report by the Chinese Academy of Sciences concluding that in 2015 residents in mega-cities such as Beijing wasted 17 to 18 million tons of food, or enough to feed 30 to 50 million people.[94]

Matching the boldness of its domestic strategy, Beijing's "Food Silk Road" straddles the globe in search of a diversified network of food supply markets. Leveraging relationships cultivated in its massive global infrastructure effort, the Belt and Road Initiative, China has signed over a hundred agricultural cooperation agreements with countries around the world. As one analysis notes, the Food Silk Road program "is also attempting to reconstruct global food supply chains through overseas free trade agreements, infrastructure investments and farmland acquisitions in foreign countries, as demonstrated by agreements with countries like Egypt, Cambodia and Pakistan."[95]

THE WORLD'S TWO LARGEST CONSUMER ECONOMIES HAVE AN OPPORTUNITY TO CAPITALIZE ON BOTH COOPERATION AND STRATEGIC COMPETITION

The battle to create and export a sustainable food model that provides democratic nutrition and health at scale will be one of the key elements of Washington's competition with Beijing. China has substantive issues that will require it to look to food transition as means to feed its growing population, address its limited access to fertile land and water, address climate concerns and reduce their considerable reliance on other countries in the West. As they have done in other segments of the economy, China may elect to "skip" major phases of food and agricultural development. Beijing may not pursue the creation of an American-modeled protein industry and leap to a government and private sector-driven, mass-scale transition to plant-based meat or cultivated meat.

Through "Belt and Road" and other programs of investment, China has been pursuing the massive global land acquisition of property, food resource cultivation and transportation infrastructure, assets which some believe are pursued for their future potential geopolitical influence. America's dominant agricultural position and natural resources provide it with assets that a true global power needs. But like all great athletes, the United States is at its best when it has strong competition. As is the case in the technology industry, the United States food and agriculture system currently is the envy of the world but relies too heavily on unsustainable methods. The United States has the time, capital and culture of innovation to accelerate the sustainability transition among new and incumbent companies as well as through a more coordinated global agriculture and food security strategy.

A robust flow of public and private capital into research and development has historically been a powerful force in supporting American leadership in innovation and technological development across most sectors. According to a recent report from the American Academy of Arts & Sciences, Chinese investment in R&D exceeded U.S. R&D investment for the first time last year. This shift in overall R&D spending is mirrored in food and agriculture where the U.S. percentage share of such spending is declining, shaped by an increase in spending by China and other countries where food security is a strategic priority. It appears that Chinese spending on both public and private food and agriculture R&D now exceeds that of the U.S. on a purchasing power parity basis. Analysis of the public/private composition of this investment indicates that there is a point of commonality between the U.S. and China, with approximately two thirds of the investment in both countries now coming from the private sector. As the United States seeks to maintain its leadership in innovation in the food sector, continued focus on R&D intensity, particularly as measured by the relationship to overall agricultural GDP, will be a critical pillar of our role in promoting sector dynamism and global influence. The 2023 Farm Bill affords a timely opportunity to advance a longer term FAST agenda around key areas past bills have addressed including commodities, nutrition, conservation, credit markets and sector R&D.

FOOD SECURITY REMAINS A HISTORICAL AND LOGICAL PRIORITY FOR U.S. FOREIGN POLICY

At the core of the last "green" agricultural revolution in the second half of the 20th century was the application of research and technology to augment productivity and food access and security. With this Western led revolution in agricultural productivity came broader global food access, lower prices and better nutritional content as well as global "soft power" influence. The coming sustainability and technology revolution in food and agriculture is certain to bring similar spoils to the companies and countries who drive it. To conclude that the current competitive battle for global influence through technology that is occurring in arenas like fifth generation telecommunications technology, robotics, artificial intelligence and nanotechnology will not extend into agricultural technology ignores both the historical importance of food in both geopolitical stability and the competition for soft power.

As the technology anchored food transition revolution gathers steam, its role in the global food supply chain will become increasingly critical. The companies and countries that are the leaders in this segment will have powerful influence not only on the critical flow of the food supply but also the intellectual property, information and data that is embedded in its related supply chain. This dynamic merits serious consideration as companies and countries contemplate the competitive, foreign policy and intelligence implications that come along with this next era of development and competition.

Today there is only a limited effort to use United States agricultural technology as a soft power tool as Washington did so successfully in the seed revolution in the 1960s and 1970s. The United Sates has a natural existing global infrastructure of agricultural influence which includes the large multi-national food and agricultural companies based there, and the long-standing U.S. government aid programs to developing countries.

Throughout the 20th Century, coordinated efforts between industry, academia, government agencies and the intelligence and investment communities has been instrumental to Washington's soft power success. Technologies for the coming age of enhanced focus on the augmentation of productivity and yield to address food security and sustainability will play a role similar to food-export programs and communications, aerospace and defense technology in the past.

THE U.S. FOOD SYSTEM IS PROVIDING POOR HEALTH OUTCOMES AND IS BOTH ENVIRONMENTALLY UNSUSTAINABLE AND INEQUITABLE

The current American food system provides poor and inequitable health outcomes for a large cross section of the U.S. population. The pandemic, which has led to over fifty million Americans facing food insecurity,[96] has exposed the weaknesses in our food system and supply chain resiliency. Access, affordability and nutrition education are critical issues for the poorest and most vulnerable citizens. Americans in lower income segments spend 27 percent of their household income on food.[97] Changes in food prices, access or health outcomes create a cycle of inequality and instability. This problem is even more prevalent in minority communities and is having a major impact on health outcomes.

Food transition, as the second biggest climate and sustainability undertaking behind energy, will require a formidable transformation across the food value chain. Successful implementation will require support to address socioeconomic and environmental hurdles while simultaneously protecting vulnerable American jobs. Complacency on this issue may result in drastic consequences for 19.7 million agriculture and food-related workers in the U.S., particularly the 2.6 million linked to farming.[98] Key to the FAST approach will be enabling those workers to benefit when embracing the necessary changes to the food system.

FAST SHOULD PLAY A MORE PROMINENT ROLE IN THE BIDEN CLIMATE AND FOREIGN POLICY AGENDA

FAST is not currently a priority focus in the Biden climate agenda. The Biden plan is ambitious and food transition is a logical potential anchor to it based on the domestic and foreign policy opportunities food transition affords and its parallel focus on innovation, expanding the notion of infrastructure, equity and job creation. Washington embarks on this challenge from a position of strength with the breadth and depth of its incumbent food and agricultural economy which gives it an inherent advantage in the race to transform, innovate, influence and build a more resilient and sustainable global food system.

In pursuit of this vision, it is one of the principal recommendations of this report that the White House convene a public-private blue-ribbon commission with leaders from the range of relevant government agencies and leaders from the food industry and business community, among other stakeholders. Its mandate should be to create an American action plan to address the environmental, geopolitical and domestic dimensions of the global crisis in food security.

PROPOSED NATIONAL FAST COMMISSION

	Potential Commission Members to be Drawn from Across the Public and Private Sectors:
Key Participants	• The Department of Agriculture • The Office of the Special Envoy for Climate Change • The Department of Commerce • The U.S. Agency for International Development • The U.S. Intelligence Community • The Food and Drug Administration • Industry Leaders from Key Food and Agriculture Companies • Financial Institutions • Sector Trade Associations • Academic Institutions and Policy/Research Institutes

	A National FAST Strategy Could Address the Following Priorities:
Threat Assessment	• The Impact of Demographic Demands on Food Resources • Land Use and Deforestation Implications • The Role of Consumption and Waste • Future Water Scarcity Risks • The Transition to Healthier and More Sustainable Alternative Proteins • The Deployment of More Rigorous Conservation Practices and the Enhanced Use of Advanced Technology

	Enabling Strategies to Support the Success of the Commission Could Include:
Enabling strategies	• Public and Private Policy Dialogue and Development • Augmented Sector Research • The Creation of Financial Products and Markets to Facilitate Food and Agriculture Transition • Increased Scale and Flow of Capital to Accelerate Food and Agriculture Transition • The Enhanced Alignment of Federal and Regulatory Policies

The United States is blessed with a powerful food system based on inviable access to fertile land, water, and strong corporate leadership across the food chain with a tradition of food innovation. The U.S. food system is like a well-established company with dominant market position, strong cash flow and limited near term motivation to face the change that is coming on the horizon. Yet like a company in this position, the U.S. food system can make a thoughtful and measured transition—to invest, to innovate and gradually change its portfolio to adapt. While the phrase is used too often, foreign policy begins at home. The health of the population, food security and sociopolitical stability are all linked.

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