

FOOD

2040

The Future of Food and Agriculture in East Asia



U.S. GRAINS
COUNCIL

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(Research Supplement is attached as a separate document.)

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Disclaimer

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Executive Summary

The past decade has seen a rising drumbeat of reports on the future of the world’s food supply. Many of these have emphasized the challenge of providing for a growing, increasingly wealthy population, or potential obstacles such as climate change. **Food 2040** is a different kind of study. It’s more than facts and data—though it’s built on careful research. It’s more than quantitative forecasts—though it includes solid forecasts. It’s more than a picture of the future—though it paints plausible future outcomes. Focusing on the driving forces reshaping food and agriculture in East Asia, **Food 2040** recognizes potential problems but seeks to discover how ingenuity, technology, and resilience could create positive outcomes for the region, its inhabitants, and the organizations that operate there. At its heart, **this report is an optimistic, forward-looking exploration of future opportunities for the agriculture and food sectors in East Asia through 2040.**

A wide variety of potent, interacting forces will drive the food system in the developed and developing nations of East Asia over the next three decades. While the short-term economic situation is challenging, over the longer term developing East Asian economies will grow rapidly. Demographic forces will create aging societies and change the composition of households. Environmental limits and climate change will challenge agricultural productivity. Cultural flows will continue to mix Eastern and Western views of food and health. New bioscience, information technology, and nanotechnology will be applied to meet agricultural and food challenges. Over time, this global meta-system is likely to give rise to novel relationships and to generate counterintuitive, even surprising results. Yet in the face of this highly uncertain environment, timely decisions need to be made today to prepare to serve billions of future customers in East Asia, in the context of a sustainable global food system.

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To help decision-makers in business, government, and nonprofits understand how these forces will drive the development of agriculture in East Asia, the US Grains Council requested a preliminary study, which identified five key research themes:

- Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia
- Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards
- Research Theme 3. Food Technology: Biotech and Agricultural Innovation
- Research Theme 4. Agriculture and Food Distribution and Packaging
- Research Theme 5. Environment and Resources: Impacts of Global Growth

Building on these themes, the Council then commissioned an in-depth look at the future of agriculture, food, and consumers in East Asia. Because decisions made today will have long-term impacts on the future agricultural system, the year 2040 was selected as a guidepost to support effective long-term planning and decision-making.

The engine driving this report is futures methodology, fueled by broad expert input and in-depth research. The report presents six key insights that emerged from the process, important research findings in each of the five research themes listed above, and the research supporting them (Research supplement attached as a separate document).

Food 2040 will enrich the global conversation about agriculture's future by supplying actionable insights and opportunities, identifying new opportunities, and inspiring new dialogue.

Insights

The six insights that form the heart of **Food 2040** describe ways in which the future may unfold for agriculture, food, and consumers in East Asia through 2040. These insights are not predictions: there is more than one possible future. Rather, they are plausible futures designed to uncover new opportunities for food and agriculture.

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Insight 1. Bioscience Marches East

East Asia is on a path to global leadership in bioscience, driven by huge investments and huge food needs. Consumer doubts about biotechnology may be swept away by necessity, as the region seeks food security and more sustainable agriculture that can help alleviate resource quantity and quality constraints—needs that are arguably most acute in China. Japanese resistance to biotechnology will face market and industry pressures from within, and an external environment that will increasingly be shaped by China.

Leading implications

- China is on a trajectory toward leadership in many areas of bioscience.
- Global bioscience work will reflect the needs and priorities of East Asia.
- There are immense opportunities in meeting the agriculture and bioscience needs of East Asia: yield, nutrition, climate resilience, consumer attributes, safety, and so forth.
- China will provide many opportunities for investment, though it could prove a challenging business partner.
- Japan needs a new level of effort in biotechnology if it wants to retain relevance in the sector.

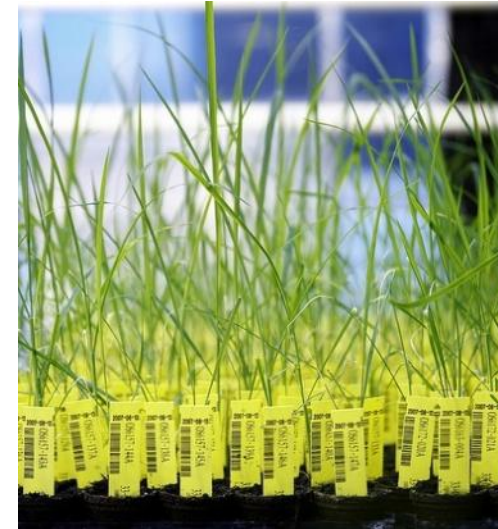


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Insight 2. Whatever China Wants

In 2040, the global food and agriculture market will be heavily shaped by Chinese preferences, needs, and developments. As China develops its food and agriculture system and the supporting infrastructures—and as its growing income boosts food consumption—the country’s influence in global markets will be far-reaching, well beyond the impact of market size alone. It will shape and redefine global agribusiness, biotechnology, food processing, logistics, and trade—increasingly from a position of strength. The expansion of China’s commodity exchanges, likely in partnerships with exchanges in developed countries, will further increase global sensitivity to developments in China.

Leading implications

- Trading markets in China will become increasingly important pricing points for global trade.
- Japan's trading environment in food and agriculture will increasingly be shaped by China.
- Consider that “Asian agriculture” could reach out beyond Asia.
- Partner with China as it develops food and agriculture infrastructure.
- The US, Japan, and others will have counterbalancing opportunities in the face of rising Chinese power.
- Test leapfrog technologies in East Asian markets, then roll out the results to the rest of the world.
- Expect that when China goes green, it will change the market dynamics for green agriculture worldwide.



Image: familymwr (Flickr)

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Insight 3. Harvesting Trust

In 2040, verifiable information about a food product will deliver an important part of the product's value. East Asian markets will belong to suppliers whose customers trust them because they can demonstrate the safety, quality, and identity of their food. Trustworthy products will command a substantial price differential. Much of East Asia will have state-of-the-art food safety and security systems offering transparency throughout the supply chain. To build this system of trust, East Asia will adopt effective regulations, develop and implement new food safety technology and systems, implement traceability and transparency, and improve enforcement. As a result, overall food safety and quality will improve. China, by participating in the system of trust, will gain entrance to the global food and agriculture network. As the system of trust grows, consumers will be able to move past safety concerns to choose foods based on other values and preferences.



Image: iStockphoto.com

Leading implications

- Solving the trust issue is a key to tapping into East Asian consumer markets. Trustworthy products can command a price premium.
- Implementing traceability will provide an opportunity to add value to products and win consumer trust.
- Invent new sensing and verification technology.
- Supply the know-how and technology to verify the information customers want about products.
- Lead the third-party consortium that provides independent credentialing.
- Build, maintain, and guard regional and national brands.
- Prepare for the day when East Asian consumers take quality for granted.

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Insight 4. Asia's Traditional High-Tech Diet

Asian health traditions and modern science will combine to enhance dietary health as East Asians confront aging and diseases of affluence. Asia has a long cultural tradition of using foods to achieve specific health results (e.g., improved physical stamina) or promote overall health. In the West, science has made tremendous gains in understanding the relationship between diet and health, including isolating specific beneficial compounds that may be used to fortify other foods, and unraveling the interactions of diet and gene expression. Now growing technological capabilities in East Asia, plus a desire to address aging and emerging diet-driven health issues, will lead to combining tradition and science for enhanced dietary health—backed by markets large enough to stimulate the necessary investments in R&D.

Leading implications

- Science will both prove and improve traditional foods and medicines.
- East Asia, and especially China, will be a leading global player in science-based functional foods.
- East Asia will be an important market for foods targeted to genetically homogeneous populations.
- East Asia's future elderly, raised more Western-minded than previous generations, will be a key market for these enhanced foods.
- “Traditional high-tech” diets will spread from East Asia to the rest of the globe.
- Commodity growers can support “traditional high-tech” diets by growing crops that provide specific health benefits or serve as biofactories for needed functional compounds.



Image: IRRI Images (Flickr)

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Insight 5. Food as a Service: Asia without Kitchens

In 2040 more than 70% of food in Japan may be prepared outside the home. As a result, food will shift from being a product to being a service. Consumers will rely on trusted brands, stores, and foodservice outlets for most of their food, most of which will be processed or pre-prepared. Japan will serve as a bellwether, as this trend will spread to other parts of urban East Asia. The entire food system, from farm to fork, will be impacted by the shift away from home cooking. Successful food-industry players will be those that anticipate and adapt to a market characterized by intensified competition; a shift away from ingredients and toward brands, retailers, and restaurants; far greater diversity of consumer tastes; and continuous technical innovation.

Leading implications

- Restaurants, foodservice chains, convenience retailers, and other outlets will become consumers' primary interface with the food system.
- Producers and processors will have a greater focus on foodservice and a less-direct connection to consumers. Marketing will shift toward Japanese/Asian food processors and retailers and away from consumers.
- Competition to serve highly differentiated markets with targeted products will be fierce.
- Distribution and logistics will be highly unitized and complex.
- The consumer end-market for ingredients will shrink.
- Radical new technologies to produce, protect, preserve, test, deliver, and prepare food will proliferate.
- Countries with cheaper labor, such as China, could become Japan's kitchen by exporting pre-prepared meals to Japan.



Image: Trishhhh (Flickr)

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Insight 6. A New Era of Hyper-Nichification

A proliferation of specialty and value-added foods and ingredients will form a growing share of East Asian agricultural consumption. Driven by rising incomes and increasingly sophisticated tastes, East Asian trade and consumption will be marked by “nichification,” creating opportunities for production and distribution of specialty products. Although growing demand for meat in Asia will continue to fuel demand for bulk grains, new specialized grain products will dominate future long-term agricultural trade growth. Agricultural crops will increasingly be identity-preserved to segregate the various streams of higher-value crops by nutrient enhancement, organic production, and myriad other traits. East Asia will develop an advanced intermodal logistics system to monitor and transport the specialty grains needed to satisfy consumers’ demand for specialty and niche food products.

Leading implications

- Develop high-specification, branded commodities to reflect quality perceptions of Asian consumers.
- Develop, produce, and trade value-added foods and ingredients.
- Link specialty crops and food products to emerging Asian niche markets.
- Track the development pipeline for new value-enhanced crops.
- Build relationships with emerging East Asian food processors to develop targeted specialty food categories.
- Promote specialty feed grains to market niche meat products.



Image: agrilifetoday (Flickr)

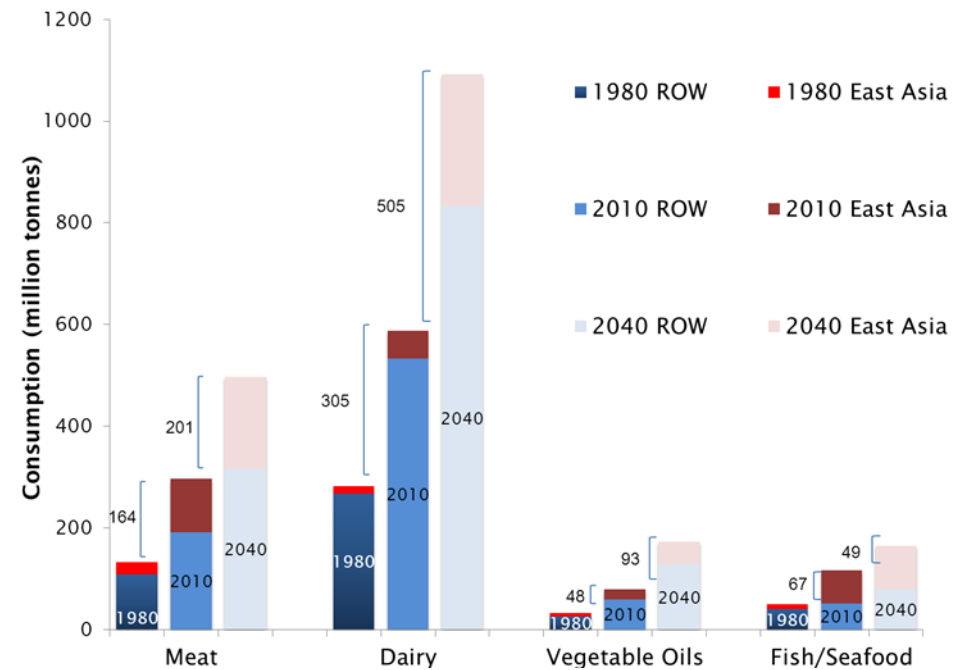
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Projecting food demand to 2040

High levels of prosperity and membership in the middle class will be important economic drivers of change in the quantities and types of food that will be desired in East Asia. Analysis of a quantitative model reveals a future with great potential and prosperity for agriculture.

- The next 30 years will offer great opportunity to expand agricultural production to support greater demand growth for meat, dairy, vegetable oils, fruits and vegetables, fish, and other food products (Exhibit 1).
- This prosperous future will be driven by increased consumer purchasing power, growing population, and diets becoming richer in protein, fat, and less dependent on grain or root-based carbohydrates.
- This future presents a challenge to the food industry to further develop the building blocks of food production: grains and oilseeds production, storage, logistics infrastructure—and more importantly technology, including biotechnology, that will allow farmers around the world to produce more food with potentially less land, less water, and reduced inputs. This is the challenge to the farmers of 2040.

Exhibit 1: World Food Consumption 1980–2040



Source: Informa Economics

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Five research themes

The five core themes—Consumers, Competitive/ Regulatory, Food Technology, Distribution/Packaging, and Environment/Resources—developed in the first phase of the **Food 2040** project served as the framework for this research effort. Within each theme, research included systematic review of drivers, trends, and emerging issues.

Research Theme 1. Consumer Trends: Upper- and middle-class Asia

Emerging issues

- Growth in Asia’s middle classes is a key driver of Asia’s future markets, especially in China, India, Indonesia, and the developing economies.
- As the East Asian population, and world population, ages, nutrition/functional foods are seen as a way to prevent or address health issues.
- Demographic shifts will transform food demand in Japan over the next 30 years—with fewer domestic consumers and greater focus on higher-value food products for the elderly and affluent.
- Declining Japanese consumer purchasing power in the long term will increase consumer focus on food prices.
- Japan’s diet is shifting from fish protein to meat and dairy proteins.
- The changing role of Asian women is altering food consumption patterns.
- Japan’s away-from-home food industry is expanding rapidly.
- China’s foodservice sector is where Japan’s was 10–20 years ago, but will likely be bigger than Japan’s by 2040.

Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards

Emerging issues

- Asian companies are investing in offshore farmland to expand their dedicated agriculture supplies.

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- Asian consumer groups and consumers may demand more product labeling to provide better assurance of safety and quality, as well as stellar reputations for food safety.
- Food safety concerns limit China’s potential as a food exporter.
- High and volatile food and fuel prices will likely continue for the foreseeable future.

Research Theme 3. Food Technology: Biotech and Agricultural Innovation

Emerging issues

- Bioscience has immense potential in East Asia, led by China.
- Biotech advances could help deal with climate shifts and resource constraints.
- Diverse technologies—from basic mechanization to nanotechnology—can help change the East Asian food system.
- GM foods are expected to gain acceptance in much of East Asia, but products labeled “non-GMO” will maintain a market among East Asian consumers.

Research Theme 4. Agriculture and Food Distribution and Packaging

Emerging issues

- Containerization will continue to grow as demand for processed products (cheese, yogurt, meals, specialty crops) and meat increases; commodity crops will remain in bulk.
- China’s expected economic growth by 2040 will require expanded and improved transportation infrastructure, traceability, and identity preservation.
- Japanese consumers will want smaller-portioned food products and more information about these products.
- Japanese crop and livestock agriculture production will be flat at best, but more likely will decline by 2040.

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Research Theme 5. Environment and Resources: Impacts of Global Growth

Emerging issues

- Global overfishing is limiting wild-fish availability and fueling aquaculture growth.
- Environmental constraints—principally water and land scarcity—will affect agricultural production in East Asia.

Methodology

Food 2040 is based on primary and secondary research, interviews with a wide spectrum of industry, government, and academic experts, and proven futures methodology. To complete **Food 2040**, Informa Economics and Foresight Alliance:

- Interviewed selected experts and conducted extensive secondary research to explore each theme in depth and uncover important issues.
- Conducted a Delphi survey to gather expert consensus on important questions raised by the initial research.
- Created a set of preliminary hypotheses about how the future might unfold.
- Conducted online panels with experts in the US and UK and in-depth interviews with experts in Japan, Taiwan, China, Korea, and South Africa to test our hypotheses and explore remaining questions.
- Summarized the most important findings across this entire spectrum of research for each of the five core research themes identified in the preliminary study.
- Performed a targeted outlook analysis to understand aggregate demand impacts.
- Examined the interactions among those important findings to generate six key insights about the future of agriculture, food, and consumers in East Asia through 2040.
- Developed the implications of each key insight, including implications arising from the interactions among the six insights.

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A call for ongoing dialogue

It is the intent of **Food 2040** to inspire and facilitate ongoing dialogue among decision-makers influencing the future of East Asian food and agriculture. The future holds abundant opportunities, as well as significant challenges, and all stakeholders—regardless of their particular interests—share a goal of assuring a mutually healthy and prosperous future for the region, its inhabitants, and the organizations that do business there.

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Introduction to Food 2040

This study was conducted by Informa Economics, Inc. and Foresight Alliance LLC, and commissioned by the US Grains Council (USGC). Informa Economics is recognized worldwide as the premiere and accepted source of global agricultural economic analysis and information. Foresight Alliance is an innovative consulting firm that applies foresight, strategy, and research to build organizations' resilience in today's increasingly complex and fast-changing environment.

Purpose of Food 2040

Agriculture in the 21st century will be influenced by a broad array of fast-changing factors—geopolitical, consumer, technological, environmental, economic, legal, trade, and regulatory—interacting in complex ways. Over time, this global meta-system is likely to give rise to novel relationships and to generate counterintuitive results. Yet in the face of this highly uncertain environment, decisions need to be made today to prepare to serve billions of future consumers in East and Southeast Asia, all within the context of a sustainable global food system.

Food 2040 is an ambitious study designed to deeply examine the drivers of change in East Asian food and agriculture, and to explore and illuminate their plausible outcomes within a 30-year time horizon. The objective is to help decision-makers in business, government, and nonprofits understand these forces—particularly with an eye to their potential impacts in economically significant markets in East Asia—so that they can develop more robust strategies and position their organizations to succeed in a fast-changing future.



Image: USDA.gov (Flickr)

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Methodology

Food 2040 gathered input from a broad set of relevant experts—thoughtful leaders in a wide range of fields, whose views were mobilized to shed light on the evolution of major trends, driving forces, and potential outcomes that could materialize through 2040. This research effort was structured around five core themes:

- Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia
- Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards
- Research Theme 3. Food Technology: Biotech and Agricultural Innovation
- Research Theme 4. Agriculture and Food Distribution and Packaging
- Research Theme 5. Environment and Resources: Impacts of Global Growth

Food 2040 explored and identified key issues, driving forces, and potential implications and opportunities within each theme. Initial interviews were conducted with eight subject-matter experts to refine and develop the research questions. The study team then conducted a Delphi survey to solicit expert responses to research questions, get expert feedback on the plausibility of potential future outcomes, and develop a framework for the ongoing expert dialogue for the study. The Delphi survey was conducted in two rounds.

Experts participating in **Food 2040** were identified by the study team in collaboration with USGC. More than 80 experts participated in the individual interviews, Delphi survey, online expert discussion, and onsite interviews conducted in Japan. Experts interviewed for this study included industry experts, government officials, academics, and other subject-matter specialists from the United States, Japan, Taiwan, South Korea, China, Singapore, Canada, the United Kingdom, and South Africa.

Key topics and research questions identified by the Delphi survey were explored in interactive online panels with participating experts. Participants were asked to explore the implications of key topics, and offer their own hypotheses about how the future might unfold in areas of interest. Additional phone interviews were conducted in multiple regions, including Japan, Taiwan, and Korea, to verify the earlier findings and identify

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and fill in gaps in the research. The study team was also assisted by USDA's Foreign Agricultural Service in Tokyo (FAS Tokyo) in arranging a series of nearly 40 individual interviews with industry experts, academics, and government officials during a one-week onsite trip to Japan.

From this multifaceted process, the research team compiled research findings and identified overarching insights spanning multiple research themes. Additionally, an econometric model was built to evaluate potential changes in demand (volume only, not value) for food products including meat, dairy, vegetable oils, and others, given the outlook for key economic and demographic trends such as rising incomes, rising average ages, and the expanding urban middle classes of East Asia's emerging economies.

Structure of the study

The study is divided into the following major sections:

- Executive summary
- Introduction
- Six key insights
 - Describes and analyzes key insights emerging from the study
 - Explores implications and opportunities to 2040
- Projecting food demand to 2040: an economic analysis
- Five research themes supporting the findings
 - Emerging issues and their drivers
 - Implications and opportunities for US-Asia trade
- Research supplement (attached as a separate supporting document)
- Appendices



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A call for ongoing dialogue

It is the intent of **Food 2040** to inspire and facilitate ongoing dialogue among decision-makers influencing the future of East Asian food and agriculture. The future holds abundant opportunities, as well as significant challenges, and all stakeholders—regardless of their particular interests—share a goal of assuring a mutually healthy and prosperous future for the region, its inhabitants, and the organizations that do business there.



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Six Insights for the Future of East Asian Food and Agriculture

Introduction to the insights

A primary output of **Food 2040** is six key Insights, or future transformations of the East Asian food and agriculture system. These Insights were developed through a foresight process that mapped out key findings for each of the five previously established research themes and then identified areas where trends and drivers could interact across themes, systemically converging and reinforcing each other over time.

The resulting clusters of trends and drivers were refined into the six most relevant, impactful, novel, and provocative “insights” about the future of East Asian food and agriculture. (For more information on the process, see [Appendix 1: Methodology](#).)

These six transformations represent plausible ways that the future may unfold, effecting substantial change while also presenting significant opportunity. The six Insights that emerged from this foresight process are:

- **Insight 1. Bioscience Marches East.** East Asia is on a path to becoming a bioscience leader, driven by huge research and technology investments and huge food needs.
- **Insight 2. Whatever China Wants.** In 2040, the global food and agriculture market will be heavily shaped by Chinese preferences, needs, and developments.
- **Insight 3. Harvesting Trust.** In 2040, verifiable information about a food product will deliver an important share of the product’s value. East Asian markets will belong to suppliers whose customers trust them because they can demonstrate the safety, quality, and identity of their food.



Image: Jakob Montrasio (Flickr)

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- **Insight 4. Asia’s Traditional High-Tech Diet.** Asian traditions and science will combine for enhanced dietary health as East Asians confront aging and diseases of affluence.
- **Insight 5. Food as a Service: Asia without Kitchens.** In 2040 more than 70% of food in Japan could be prepared outside the home. Consumers will rely on trusted brands, stores, and foodservice outlets for most of their food, a majority of which will be processed or pre-prepared. This trend will spread across other parts of urban East Asia as well, especially the cities of China, Taiwan, and South Korea.
- **Insight 6. A New Era of Hyper-Nichification.** A proliferation of specialty grains and other crops will form a growing share of East Asian agricultural flows. East Asia will not just demand crops, it will increasingly demand segregated and identity-protected crops for food processors adapting to increasingly sophisticated consumer tastes.

Each of the detailed sections that follow outlines roughly a dozen opportunities or implications that can inform and shape the actions of decision-makers who are preparing businesses, governments, and NGOs to meet the future.

A lot can happen in 30 years

The six Insights below may appear at first glance to represent a great deal of change in a short amount of time, making it tempting to say, “This could never happen.” But it can be instructive to look at what has happened in the past 30 years as a way to gain perspective. In 1980, some things that would have seemed improbable include:

- The Soviet Union collapsing—and Russia becoming a grain competitor
- Japan not ruling the world, as many in the 1980s expected
- China emerging economically under a hybrid communist/capitalist system
- Agricultural policy evolving to be more market-oriented—Freedom to Farm
- Bioengineered crops moving from theory to occupying millions of acres

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- Computers and the Internet permeating all aspects of food and agriculture, from grain trading to food marketing
- Biofuels becoming a reality, not just wishful thinking
- Japanese and other East Asian consumers actually liking and consuming large amounts of pizza and fast foods
- Japanese consumers switching from a diet high in fish to one high in meat and dairy

As these examples show, unanticipated outcomes—often with far-reaching, even global, impacts—can be the norm rather than the exception over a 30-year period. While the Insights in **Food 2040** may appear improbable, they are rooted in robust research and expert assessments, and represent plausible futures for East Asian and global food/agriculture in 2040.



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Insight 1. Bioscience Marches East

East Asia is on a path to become a bioscience leader, driven by huge research and technology investments and even greater food needs.

Leading implications

- China is moving toward leadership in many areas of bioscience.
- Global bioscience work will reflect the needs and priorities of East Asia.
- There are immense opportunities in meeting the agriculture and bioscience needs of East Asia: yield, nutrition, climate resilience, consumer attributes, safety, etc.
- China will provide many opportunities for investment, though it could prove a challenging business partner.
- Japan needs a new level of effort in biotechnology if it wants to retain relevance in the sector.

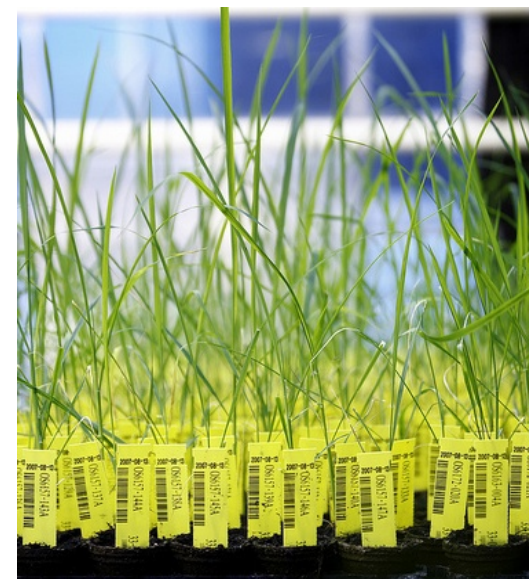


Image: BASF - The Chemical Company (Flickr)

Insight summary

East Asia is on a path to bioscience leadership, driven by huge investments and huge food needs. Consumer doubts about biotechnology may be swept away by necessity, as the region seeks food security and more sustainable agriculture that can help alleviate resource quantity and quality constraints—needs that are arguably most acute in China. Japanese resistance to biotechnology will face market and industry pressures from within, and an external environment that will increasingly be shaped by China.

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Outcomes

- **Opening nature's toolkit.** Although biotechnology has progressed rapidly over the last three decades, its future potential remains massive. Advances such as synthetic biology should make it possible to engineer simple organisms starting from the foundations of their DNA, enabling the creation of novel organisms with carefully engineered characteristics. Microorganisms like algae, for instance, can be an order of magnitude more efficient than plants in converting energy and CO₂ into proteins, fats, and carbohydrates. Fifty million different genes for algae have been identified, providing the foundation of a vast genetic toolkit that can be used to engineer new microorganisms, or identify new traits for insertion into plants.¹ (For background, see [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))
- **Asian priorities.** A steadily growing percentage of global bioscience work will reflect the needs and priorities of East Asia.
 - **Japan's choices.** Japan has not been a strong player in biotech; it will need to decide how to respond to this push from other parts of Asia, especially China. It could abstain, jump in wholeheartedly, or pursue a technology strategy that reflects current Japanese doubts about biotechnology. For now, Japan is choosing to let others lead in biotechnology, and would need a new level of effort to be a leading contender in biotechnology research.²
- **China leads.** China is on a trajectory for leadership in many areas of bioscience. Huge investments in universities and research establishments will gradually pay off.
 - **China as innovator.** China will gradually emerge as a developer of new lines of GM crops. It will seek to protect its fledgling agricultural biotech companies, and will likely create barriers to prevent foreign biotech companies from dominating the biotech market in China.
 - **Yields supplement imports.** Rapid gains in biotech R&D or implementation could enable China to boost yields rapidly. This could allow China to support its growing food demands through a combination of yield improvements and food imports.

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- **Chinese trust.** To compete effectively in the bioscience market, China and Chinese science will need to earn international trust. This will require attention to a wide variety of issues, including the integrity of research and intellectual property issues. (See [Insight 3. Harvesting Trust.](#))
- **GMO acceptance.** A Chinese-led push for biotech would increase the chances of GMO acceptance spreading among East Asian producers and consumers. Chinese acceptance of GM foods would enhance the global reputation of GM food, and give food suppliers additional incentives to embrace GM crops. Abstainers might become niche markets.
- **Gray-area biotech.** Weak enforcement of regulations could make China a center of biotechnology forms that would not be allowed in other places, created both by less responsible organizations and increasingly by individual biohackers. This behavior is likely to rise, then later subside over the next 30 years, as the Chinese state gains enforcement capabilities and the industry polices itself better.
- **Bioscience for consumers.** East Asian bioscience will be increasingly shaped by the needs and preferences of consumers. (See [Insight 6. A New Era of Hyper-Nichification.](#))
 - **Price gradients.** It is possible that divergent levels of acceptance of GMOs will drive price gradients between genetically modified foods and unmodified crops. Sufficiently widespread GM crops could turn non-GM crops into a kind of niche.
 - **Genetically targeted Japanese food.** East Asian consumers—and Japanese in particular—are likely to respond to the concept of foods that are genetically ideal for a particular population, even before there is sound science to support this notion.³ (See [Insight 4. Asia’s Traditional High-Tech Diet.](#))
 - **Pharming.** As East Asia applies science to health, and contends with an increasingly elderly population, biotech may be seen as an important tool for reducing costs and producing solutions. This may include “pharming”—growing engineered functional foods and pharmaceutical-producing plants.
 - **Large genomic segments.** Agricultural products and foods that are optimized for particular genetic groups might find larger target populations in East Asia, as some countries in the region have more genetic homogeneity than many other markets.

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- **Supporting green agriculture.** Bioscience will have roles in supporting more sustainable East Asian agriculture, in China and beyond. (For more, see [Research Theme 5. Environment and Resources: Impacts of Global Growth](#).)
 - **Attention to water.** China may pay particular attention to water issues in using biotechnology: creating plants with low water demand, or crops that can make use of water supplies that are saline, polluted, or otherwise compromised.
 - **China input reduction.** China's approach to green agriculture may differ from other countries'. A green Chinese agriculture system could prioritize reducing inputs for agricultural production: embracing crops that require reduced nitrogen supplementation or reduced water needs. This could create new opportunities for conventional hybrid or GMO crops that express traits that minimize supplemental inputs and still produce enhanced yields.
 - **Changing nature of arable land.** Bioscience advances will make some previously unusable land available for various types of crops.
 - **Urban agriculture.** East Asia may turn to vertical farming—or other forms of advanced urban agriculture—to produce more food in the face of land constraints. Biotechnology would be important in producing plant varieties ideal for these systems.
- **Discontinuity: The emperor's new clothes.** It is possible that even with huge investments in biotechnology, results will be modest and incremental rather than major breakthroughs. Such an outcome would take energy out of bioscience research.
- **Vertical farming in China.** China's expansion of high-intensity agriculture could include high-intensity processes in urban areas. Such “vertical farming,” based on hydroponics, aeroponics, and/or aquaponics, could enable production of high-value foods in the heart of urban China. Vertical farming could bring production closer to consumers, and minimize the need to expend energy on distribution and transport. (For more, see [Insight 5. Food as a Service: Asia without Kitchens](#) and [Research Theme 3. Food Technology: Biotech and Agricultural Innovation](#).)

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- **Traceability critical.** The need for traceability to ensure provenance will increase as biotech products proliferate, especially if national regulations or consumer demand require separate streams of GM and non-GM products. (See [Insight 3. Harvesting Trust.](#))
- **Accelerating innovation.** Increased funding and attention, as well as entirely new players in the industry, will drive new products and discoveries in bioscience and propel a positive feedback loop within the whole biotech innovation process.

Drivers and trends

- **Increased funding.** Governments concerned with feeding their populations and with future competitiveness are funding R&D in biotechnology. China considers biotech a strategic pillar, and is investing a significant portion of the more than \$300 billion devoted to science and technology in its 12th Five-Year Plan.⁴ This is in the midst of a rapid buildup of Chinese science: Britain's Royal Society estimates that Chinese scientists may author more articles in international science journals than American scientists as early as 2013.⁵ The quality of Chinese science has yet to catch up with volume, however. (For more on this, see [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))
- **Increased sustainability infrastructure.** China is rapidly developing into a global leader in renewable energy technologies. Although it remains heavily dependent on coal and other fossil fuels, its strategic investments in solar panel and windmill manufacturing are making China a dominant global supplier of both. Given its plan for massive biotech investment, China's renewable-energy growth may foreshadow its potential for acceleration of the biotechnology sector.
 - **Methane digesters.** China has 35 million small-scale methane digesters that convert animal wastes into biogas, and Chinese policymakers are increasingly looking to methane digestion as a solution for managing wastes on large-scale factory farms. The Chinese government now requires farms with more than 1,000 cows, 10,000 pigs, or 100,000 chickens to install biogas digesters.⁶
 - **Eco-compensation.** China is exploring the possibility of a nationwide eco-compensation scheme that would charge wealthy coastal regions for the environmental services provided by poorer inland areas. In

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an initial step, the government has calculated that China's forests provide the equivalent of \$1.5 trillion worth of eco-services—resources that are currently free, but which under the contemplated program would become an input cost. Currently the government is drafting a plan for this concept, which—if enforced—would provide mechanisms to finance wildlife preserves, impose new levies on polluters, and monetize the inland natural resources that coastal China requires to thrive.⁷

- **Sustainable supply chains.** Chinese manufacturers and food producers are learning from foreign partners how to produce, package, and transport their products more sustainably. Wal-Mart's commitments to sustainability extend to its network of 30,000 Chinese suppliers, and the company is working with this supply network to reduce waste and energy consumption. By sourcing food directly from large farmers' cooperatives, Wal-Mart is better able to track food sourcing, ensure food quality, and eliminate supply chain inefficiencies.⁸
- **Increased food demand.** Rising consumer incomes coupled with population growth are driving up food demand. China currently has 22% of the world's population with 10% of the world's farmland. (See [Projecting Food Demand to 2040](#).)
- **Biotech as Japanese solution.** Biotechnology is seen by some as a way for Japanese agriculture to move up to higher-value, competitive products. Some prefectural governments are seeking to further local biotech research to boost their economies.⁹
- **Biotech crop expansion.** Globally, there has been a 10% sustained growth in hectares planted in biotech crops over the last 15 years. This trend is expected to continue or accelerate.¹⁰ (See Exhibit 2 below.)
- **Biotech acceptance growing.** GMOs and biotech are increasingly accepted by East Asian publics. One study found that 80–90% of the Taiwanese public accepts GM products,¹¹ and eventual acceptance by the Japanese public is widely foreseen.¹²
 - **China GMO approval.** In 2009, China granted approvals for new strains of GM Bt rice and GM phytase corn. Both crops were developed using Chinese research resources and public-sector institutions. Phytase corn improves the nutritional efficiency of animal feeds, and reduces the environmental damage caused by runoff from animal wastes. The approval of GM rice and corn is a significant indicator of China's support for GM foods, and could speed up adoption of GM crops elsewhere in Asia.¹³

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- **Resilient crop needs.** Crop production will need to adapt to increased variability in climate conditions while meeting increased demand for food.¹⁴ (For background, see [Research Theme 5. Environment and Resources: Impacts of Global Growth.](#))

Implications and opportunities

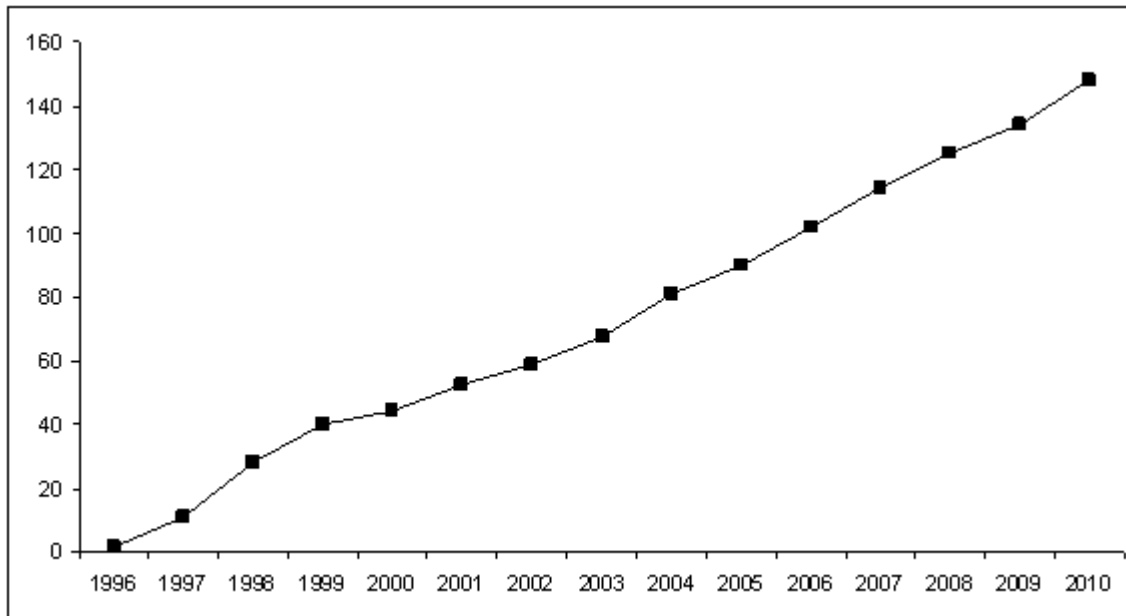
- **Leadership opportunities.** An era for setting rules and norms in the global biotech system is dawning. Opportunities will open up for organizations and/or governments to take leadership roles in the unsettled period that is beginning in transnational regulation of biotechnology.
- **Asian competition.** Asian companies—especially Chinese firms—will go from peripheral players to global competitors in biotech. They will gradually develop world-class capabilities in almost any area of bioscience they pursue. (See [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))
- **China: partner and competitor.** China will be both partner and competitor as its bioscience capacities rise.
 - **A challenging partnership.** China will be a challenging business partner in the near and medium term, as Chinese institutions may engage in strong formal and informal efforts to extract expertise from Western bioscience companies. Chinese leverage will grow in both commercial and policy spheres.
 - **Planning bioscience investment.** It will be increasingly important to examine Chinese research directions and goals in developing R&D strategies for bioscience.
 - **Building Chinese science.** China will need continuing help from universities and organizations in building the quality and integrity of its scientific establishment, so the vast investments going into the field produce the best possible results.
 - **Equipping green China.** China needs greener agriculture to increase output while decreasing environmental impact. Chinese bioscience will produce innovations in this area, and China will also be a market for technologies and systems to accomplish impact reduction—for example, lower-impact fertilizer. Chinese biotechnology might specialize in reducing inputs to agriculture.

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- **Chinese intellectual property.** China will make legal protection of intellectual property in biotechnology and other areas of science more effective as its institutions and companies produce more of their own IP and seek to take it to world markets.
- **China as advocate.** China may increasingly become a partner for those advocating biotechnology as a solution for the world's agricultural needs.
- **Chinese bioscience.** China will have distinct approaches and issues in bioscience.
 - **Beyond commercial biotech.** China may in some instances pursue agricultural biotechnology that lacks huge commercial payoff—applications that tend to be neglected by large Western companies. For instance, Chinese institutions might try to develop crops that work with non-industrial agriculture, or that are important in only certain regions of China.
 - **Winnowing Chinese seed companies.** An early arena for Chinese industry may be a shakeout of the fragmented seed industry, which is composed of many companies that lack the resources to compete in the field.¹⁵
 - **Certifying China.** As in other areas of Chinese agriculture, certifying the integrity of Chinese biotech products and systems could offer opportunities for organizations and companies.
 - **Seeking reduced crop losses.** As China works to modernize its agricultural system, it will seek solutions to losses in the pipeline from field to consumer. It will also turn to its own biotech industry to produce such solutions, generating increasing innovation in the area.
- **Biotracking.** Biotaggants and inbuilt genetic markers will be increasingly needed in general tracking and identity preservation. (See [Insight 3. Harvesting Trust](#) as well as [Research Theme 4. Agriculture and Food Distribution and Packaging](#).)

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Exhibit 2: Global Area of Biotech Crops, 1996–2010 (million hectares)



Source: Clive James, 2010.¹⁶



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Insight 2. Whatever China Wants

In 2040, the global food and agriculture market will be heavily shaped by Chinese preferences, needs, and developments.

Leading implications

- Trading markets in China will become increasingly important pricing points for global trade.
- Japan's trading environment in food and agriculture will be increasingly shaped by China.
- Consider that “Asian agriculture” could increasingly reach beyond Asia.
- Partner with China as it develops food and agriculture infrastructure.
- The US, Japan, and others will have counterbalancing opportunities in the face of rising Chinese power.
- Leapfrog technologies could be tested in East Asian markets, then rolled out to the rest of the world.
- Expect that when China goes green, it will change the market dynamics for green agriculture worldwide.



Image: familymwr (Flickr)

Insight summary

As China develops its food and agriculture system and supporting infrastructures—and as its growing income boosts food consumption—the country’s influence in global markets will be far-reaching, well beyond the impacts of market size alone. It will shape and redefine global agribusiness, biotechnology, food processing, logistics, and trade—increasingly from a position of strength. The expansion of China’s commodity

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exchanges, likely in partnerships with exchanges in developed countries, will further increase global sensitivity to developments in China.

Outcomes

- **21st century Silk Roads.** China's rising importance and power as a global trader will amplify the impacts of its domestic developments and shape the environment in which much of the world (including Japan) trades. Like global trading centers in the EU and United States, Shanghai, Zhengzhou, Dalian, or most plausibly Hong Kong could sharply expand their role as financial and trading centers where global players will want to have a presence.
 - **Leverage.** Commerce will equip China with fungible power, allowing it to apply leverage in one area to others. The rest of the world will experience an unsettling period as it adapts to the new—Chinese—ways of doing business.
 - **Counterbalancing opportunities.** The US, Japan, and others will have counterbalancing opportunities in the face of rising Chinese power. They could pursue trade and business goals in concert in order to maximize their leverage.
 - **Global impacts.** Global interdependencies will mean that China's internal issues and opportunities become of vital interest worldwide.
 - **Efforts to limit competition.** Experts expect that China will continue to attempt to limit the reach of the market into its domestic food system, in order to assure domestic access to food supplies and constrain price volatility. It will have to balance this with the need to maintain access to export markets that are vital for Chinese industrial goods.
 - **Internal pressures.** China's food and agriculture policies will be shaped by a variety of policy needs and political pressures, including the desire for some kind of food self-sufficiency, the need to keep food affordable, and efforts to preserve sufficient agricultural jobs and boost rural incomes.
 - **Price distortion.** China's fiscal resources and its desire to control inflation will likely lead to price-distorting policies. In an expert survey, 86% of respondents estimated that the average degree of

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price distortion (the difference between domestic and global agricultural prices, driven by factors such as subsidies and tariffs) in the next few decades in China will be medium high to very high (with as many as 59% believing it could be high or very high).¹⁷

- **Japan on board.** Japan's extensive investments in Chinese ventures could tie Japan's fortunes to China's rise fairly strongly and positively, and increase Japanese influence on outcomes.
- **Virtual borders: from neocolonialism to agribusiness.** Japan, Korea, Taiwan, and especially China all face challenges in modernizing, consolidating, and mechanizing their agricultural sectors. With East Asian countries expanding their production regions abroad, however, foreign plantations in Africa, South and Southeast Asia, and South America offer the potential to implement full capital-intensive agricultural production with fewer potential disruptions. This foreign food production is essentially intended for use back home, with uncertainty about how much of its output will flow into global agricultural markets.
- **A plausible scenario.** Overseas food production for East Asia might be devoted initially to augmenting domestic food security (while avoiding the competition and volatility of global markets).
- **Dedicated supplies.** Overseas lands may be used to supplement—and in part bypass—the global food market.¹⁸ Large tracts in Ethiopia, Kenya, and Madagascar have been purchased or contracted, including land that was previously held as commons. Chinese firms are installing tenant farmer systems to work this land, or bringing in their own labor.¹⁹
- **Pushback.** These programs may be constrained by pushback from local governments. Host governments are implementing or considering new land-ownership policies that can be expected to limit these efforts over the longer term. In 2011, a government that was perceived as too pro-Chinese was voted out of office in Zambia.²⁰
- **China as development catalyst.** These policies also present an opportunity for China to become a catalyst in bringing areas that have long suffered from underinvestment into the global agricultural system. New technologies, practices, seeds, and much-needed capital could benefit economies in Africa and elsewhere. These could be developed through joint partnerships with local operations of development institutions or non-Chinese agribusiness firms.

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- **Market distortions.** China's investment in dedicated supplies could propel it into a position to distort some agricultural markets for its needs, developments that will be monitored closely by trading partners.²¹
- **Part of a larger system.** Ultimately, as a large-scale trader China will not be able to separate itself from global systems. That will limit how much China can attempt to isolate its agricultural systems, inside and outside China.
- **To grow green is glorious.** Large potential exists for China to adopt high-intensity agriculture, especially for specialty foods. Labor-intensive quasi-organic farming practices with high-value products and higher yields could emerge over time, helping to boost rural incomes and employment. China could put its own signature on sustainable farming, emphasizing minimization of inputs, high productivity despite large labor inputs, and resilient and enhanced crops using advanced biotechnology. (For background, see [Research Theme 5. Environment and Resources: Impacts of Global Growth.](#))
- **Climate change champion.** Later in the forecast period, China could begin to push climate-change issues both internally and externally. Analysts suggest that China will increasingly feel that it has much to lose due to climate change, and could begin to act as a stakeholder on the issue.²²
- **Rising biotech giant.** China is set to become a rising giant in agricultural biotechnology, within a larger Asian biotech community. Its huge population, with growing numbers of consumers able to eat higher on the food chain, combined with competition for agricultural land and water from development, sharpens its need for agricultural leapfrogging. China's shift to GMOs in crops and imports would help to tip producer countries more firmly toward agricultural biotech, and could further isolate holdouts such as Japan. (See [Insight 1. Bioscience Marches East](#) as well as [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))

Drivers and trends

- **New financial centers.** The Hong Kong Mercantile Exchange (HKMEx) opened for business in May 2011, and is a precursor of things to come. As global demand for core commodities has lately been driven mainly

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by Asia, Hong Kong is seen as the perfect combination of location, high concentration of demand, and a regulatory and legal environment of strong repute. However, China likely will turn increasingly to joint venture partners to expand these futures exchanges, in its efforts to challenge current leaders in price discovery.

- **Food self-sufficiency.** China's quest for food self-sufficiency will continue, but its reality includes very significant dependence on global markets. These competing visions will shape its trade, biotech, and environmental policies internally—and, increasingly, internationally.
- **Land grab.** Asia's investments in farmland beyond Asian borders continue despite controversies. These include Korean investments in Mozambique, Japanese investments in Indonesia, and Chinese investments in both Africa and South America.²³ (For more on these overseas land acquisitions, see [Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards.](#))
 - **China modernizes African farming.** In Ethiopia, the Chinese are building roads and putting mobile phones into the hands of many farmers. According to one expert, the Chinese call these farmers on their China-supplied mobiles in order to check on their production, then buy up the crops before they go to market. As an aside, these phones are also enabling women farmers to gain access to financial services.²⁴
- **Next-generation infrastructure issues.** China will require and will invest in the development of a domestic world-class distribution infrastructure. (For more detail, see [Research Theme 4. Agriculture and Food Distribution and Packaging.](#))
 - **Logistics: A top 10 priority.** As China works to develop its own consumer markets, it will increasingly need to move goods around inland, and will invest heavily in its intermodal transport and distribution system to support this. In 2009, the central government added logistics to its top 10 priority industries for revitalization.²⁵
 - **Ports of excellence.** In just a decade, China has succeeded in incorporating more advanced port structures than those of Japan in some places.
 - **A modern nationwide intermodal transport system.** Cost-effective inland transport is key to whether China's inland farms will be able to compete for consumers' food dollars in its coastal cities and in other

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Asian markets. Given the government's focus on building up the interior economy, this will further motivate the government to create an effective nationwide intermodal transport system.

- **China as food processor and exporter.** China has a rapidly evolving food processing industry. (See also [Insight 5. Food as a Service: Asia without Kitchens.](#)) Japanese companies already send food to China to be processed.²⁶ By 2040, China could become an exporter of technologies for food production and an exporter of high-value processed foods.²⁷ In the intervening decades, Chinese firms will be cooperating extensively with Western firms to develop the technologies it needs.
 - **The income equation.** Chinese agricultural labor costs started from a low base but are rising. However, as China advances its manufacturing and processing capabilities these will offer new employment opportunities to domestic workers.
 - **Proven export potential.** China will emerge as a quality niche food provider. It is already a major exporter of apples and apple juice, for example.²⁸ (For more, see [Insight 3. Harvesting Trust.](#))
 - **Tradition as niche.** Chinese traditional medicine ingredients have export potential. (See [Insight 4. Asia's Traditional High-Tech Diet.](#))
- **Land reform.** The 2020s could bring reform to China's land tenure and subsidy system. A consolidation of today's patchwork of small farms is expected as farmers continue to age—and will be essential to increase Chinese agriculture's efficiency.²⁹
- **Sustainable farming.** China will increasingly feel pressure to develop environmental sustainability, and this will constrain its efforts to intensify food production. However, it could make strides via more efficient use of resources.³⁰
- **High growth and investment in biotech.** China is currently making major investments into biotechnology research, and is already a leader in rice research. (See [Insight 1. Bioscience Marches East.](#))

Implications and opportunities

- **China as price setter.** China's market size gives it a central position in the global marketplace, and this position will strengthen in the coming decades. In addition, China is likely to attempt to carry out its global

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market activities with the goal of avoiding domestic market disruptions; it will meet with only partial success in this. These dynamics will demand increased flexibility from Chinese investors and policy-makers alike.

- **Expansion of China’s commodity exchanges.** Commodity exchange markets likely will expand in China by 2040—with implications for global pricing of food and agriculture products in the 2020s and 2030s as global markets accommodate the growth of China-denominated trade. China could attempt to use these traditional Western market institutions to, in effect, reject commodity price formation that does not conform to its own domestic price objectives.
- **Yuan convertibility.** As China matures economically and liberalizes its currency (i.e., making it freely convertible and without restrictions on foreign withdrawals and exchanges), this will remove the disincentive to conduct trade in terms of the yuan. In turn, this will increase pressure on the US dollar’s reserve currency status.
- **Currency implications.** As China’s financial centers and exchanges develop, they will likely prefer to conduct trade in Chinese currency both for convenience and to minimize risks from exchange rate fluctuations. This implies that their commodities contracts will be denominated in Chinese yuan.
- **Rule of law.** For China’s financial system to become trusted enough to set prices, it will have to demonstrate a commitment to transparency and the rule of law. Establishment of the Hong Kong Mercantile Exchange is an interim effort to capitalize on the territory’s reputation.
- **India.** India may find opportunity as an alternative financial center to China, both because it will be a large and growing food market, and because it may offer superior business conditions.³¹
- **Cooperation for counterbalancing.** The United States, Japan, India, and others may find it increasingly fruitful to coordinate policy to balance Chinese power in business, trade, and other matters. Applying leverage from other areas may help counter pressures in agricultural markets—or agricultural trade might be a point of leverage, though China will be highly sensitive to any perceived threats to its food supply.
- **China creates niches.** “Nichification” of Chinese consumer preferences may be particularly important in driving the expected differentiation of grains and other agricultural products. (See [Insight 5. Food as a Service: Asia without Kitchens](#) and [Insight 6. A New Era of Hyper-Nichification](#).)

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- **Extracting foreign biotech knowledge.** Historically, China has leveraged its market size by controlling foreign firms' access. In manufacturing, the Chinese model has been the joint venture—an approach that it may decide to apply to biotech as well, creating a mechanism for extracting and transferring foreign expertise to China's domestic industry.
 - **Japanese opportunity.** Japanese biotechnology companies may find partnerships in China useful as ways to pursue work that would not be welcome on Japanese soil. Nonetheless, both Chinese and global consumers will still expect Japanese biotech companies to uphold standards and ethical practices.
- **Unilaterally sourcing bulk commodities.** Asian nations' expansion into overseas agricultural production could produce an increased flow of primary commodities into the managing countries.
 - **Impacts of unilateral sourcing.** Asia's foreign production could reduce the demand for bulk agricultural grains sourced competitively, increasing volatility both in the countries where the products are grown and in the larger global export markets.
 - **Exporting environmental problems.** China could also use increased imports of bulk commodities from large-scale foreign plantations as a way to reducing agricultural impacts on its own environment, as part of a comprehensive “greening” strategy.
 - **Japan's experience.** Japanese companies have a very long history of operating globally, and so may be more adept at running foreign agricultural operations than other East Asian nations, in terms of complying with host-country and global norms. Japanese companies might be suited to run such operations for companies from other countries.
- **Policy implications.** International policy efforts could help ensure that Asia's overseas agricultural endeavors stay within the market system. The WTO and other trade-governing bodies may consider ever more stringent regulations and penalties on governments restricting or banning exports of commodities, thus guaranteeing a disciplined, rules-based international trading system in the face of rising prices, including food prices. With China becoming the world's biggest exporter as of 2010, at 10.6% of total world exports, it will clearly have rising stakes—and weight—in trade disputes.³²



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Insight 3. Harvesting Trust

In 2040, verifiable information about a food product will deliver an important share of the product's value. East Asian markets will belong to suppliers whose customers trust them because they can demonstrate the safety, quality, and identity of their food.

Leading implications

- Solving the trust issue is a key to tapping into East Asian consumer markets. Trustworthy products can command a price premium.
- Implementing the traceability demanded by consumers will provide an opportunity to add value to products and win consumer trust.
- Invent new sensing and verification technology.
- Supply the know-how and technology to verify the information customers want to know about products.
- Lead the third-party consortium that provides independent credentialing.
- Build, maintain, and guard regional and national brands.
- Prepare for the day when East Asian consumers take quality for granted.



Image: iStockphoto.com

Insight summary

Unlike Western agriculture, Asian agriculture does not have a long history of trading safely handled commodities, and Asian consumers cannot assume that food is generally safe. By 2040 Asian consumers will demand information about safety, provenance, nutritional value, and so forth—and this information will provide a significant part of the value of a food product. Trustworthy products will command a substantial price differential. Much of East Asia will have a state-of-the-art food safety and security system offering

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transparency throughout the food chain. To build that system of trust, East Asia will adopt effective regulations, develop and implement new food safety technology and systems, implement new traceability and transparency measures, and improve enforcement. As a result, overall food safety and quality will improve. Participating in the system of trust will provide China entrance to the global food and agriculture network. As the system of trust grows, consumers will be able to move past safety concerns to choose foods based on other values and preferences. These shifts are of course predicated on rising incomes, which support the ability of consumers to pay for valued-added safety and quality.

Outcomes

- **Safe Chinese food.** China will upgrade standards and practices for food safety and processing, changing internal, regional, and global perceptions of Chinese food safety. This process will take 10 to 20 years³³ and may require consolidation of small farms, but there is internal and external consensus that change is essential.³⁴ By 2040 China may not be able to eliminate all quality problems, but China and its trading partners will at least be able to implement technology solutions to identify such products before they reach the market. (See also [Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards.](#))
- **Major foreign investment in food safety.** Improvements in food safety in China and other developing nations will be driven in part by global investment. There is a widely recognized opportunity for multinational firms to invest in food safety infrastructure, systems, and training in Asia, and specifically in China.³⁵ Japanese companies are already operating in the Chinese food system, and have experience in sourcing quality products from China.
- **New food safety technology.** New sensing and monitoring technology will be developed and deployed. At the producer level, new analytical technology will verify where food originated and how it has been processed.³⁶ Food nanotechnology can provide new sensing and detection methods. Bioscience may assist in tagging products and ingredients with DNA markers. At the consumer level, e.g., for ready-to-eat meals in Japan, smart packaging innovations like freshness indicators, time/temperature indicators, microbial

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growth indicators, and leakage indicators will be added to provide consumers with more transparent food safety information.³⁷ Information technology will be applied to facilitate complex tracking schemes. “Smart dust” sensors could be deployed to monitor and track products throughout the value chain. (See also [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))

- **Food chain transparency.** The Asian food system will offer transparency through a variety of mechanisms.
 - **Traceability.** Traceability will become a standard feature of most East Asian supply chains by 2040. It is the most important element of food safety and will be an ever more common requirement for participating in global agricultural trade.³⁸ In an expert panel, 90% of experts agreed or strongly agreed that tracing and identity preservation will become much more ubiquitous as well as more precise and functional through 2040.³⁹ Traditional supply systems that do not offer traceability will persist for standard commodities that are cost/bulk-driven (e.g., undifferentiated feed), but will become less prevalent and acceptable over time.
 - **Asian differences.** There are important differences between the East Asian and US agricultural systems, which will shape how traceability is implemented in East Asia. East Asian agriculture was not developed as a commodity system, and has a shorter history of global trade. The historic US system of trading safely handled commodities may be irrelevant in Asia—which ultimately may surpass the US both in the ubiquity of its traceability implementation, and in the quantity and quality of information about individual items.
 - **Labeling.** In the shorter term, the growth of Chinese food exports will spur national-origins labeling.⁴⁰ Labeling requirements for GM foods will expand; three-fourths of experts surveyed expect China to adopt GM labeling requirements at least by the 2020s.⁴¹
 - **Certification.** Certification and credentialing of products will also provide assurance of safety and quality to East Asian consumers and importers. Some nations and suppliers already use certification systems, though this is far from universal.⁴² By 2040 there could be a regional or global certification system through which a third party assures that products are safe and conform to established guidelines.
- **Consumers pay for safety.** As East Asian consumers’ food spending rises, they will devote increased spending to processed products, premium products, and products that provide assured food safety.⁴³ About

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65% of experts surveyed believe that as Asian consumers become wealthier they will be willing to pay “much more” for food safety.⁴⁴ Japanese consumers place an extremely high priority on safety; stable or declining incomes will not affect this preference. Foods may offer explicitly defined levels of trust associated with different price points.

- **Trade and regulations.** The current global regulatory system will not be able to handle the pace of change in agricultural biotech in coming decades. Systems of trust will be key enablers of the harmonization of food safety and quality regulations across Asia and globally. These same systems of trust will support new bilateral and multilateral trade agreements. (For more, see [Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards.](#))
- **Consumers move up the “concern chain.”** As consumers identify trusted sources of food, their primary concerns will shift from assuring quality (e.g., absence of adulterants) to satisfying preferences (e.g., flavor preferences, convenience, preferred provenance, and so forth).
- **Gray-market biotech.** Illegal markets may spring up to bypass difficult approval processes for GM products, compounding trust issues in the food chain. This issue may rise, peak, and fall during the next 30 years, as biotech capabilities ramp up and diffuse faster than regulations and enforcement can keep up, especially in China and other emerging markets.

Drivers and trends

- **Consumer demand.** East Asians are highly concerned about food safety. Unlike Western agriculture, Asian agriculture does not have a long history of safe commodity trade, and Asian consumers cannot assume that food is generally safe. Thus, East Asians already seek food products and ingredients they can trust to be safe and wholesome. Consumers are looking for retailers they can trust to deliver such foods; food businesses are looking for trustworthy suppliers; and governments are looking for trading partners they can count on to deliver safe products.⁴⁵ Two-thirds of experts surveyed believe that “fear of unsafe or contaminated foods” will have a major or major-to-moderate impact on East Asian views of healthy eating through 2040.⁴⁶ Poor consumers may be especially vulnerable to unsafe food.⁴⁷

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- **Adulteration scares in China.** Asian consumers are especially concerned about adulterated food.⁴⁸ Observing ongoing food safety problems in China, many Asians are unwilling to trust products from China,⁴⁹ and those with sufficient food budgets have developed a preference for products imported from Japan, the US, and the EU, as these food systems are considered more credible. Many middle-class Chinese parents, too, turn to global fast-food chains and supermarkets as trustworthy sources of unadulterated food.⁵⁰
- **Supplier demand.** National, regional, and global retailers sourcing goods in East Asia will demand trustworthy products. For example, Wal-Mart has demanded environmentally responsible practices from its Chinese suppliers while providing various kinds of technical assistance to help them improve environmental practices.⁵¹
- **Regulatory demand: China focusing on food safety.** Like other Asian consumers, Chinese are concerned about food safety and increasingly demand assurance of food quality, including from their own domestic producers.⁵² As a result the Chinese government is giving high priority to improving domestic food safety; for instance, it is enlisting technical assistance from the US Food and Drug Administration.⁵³
- **Economic growth.** Because East Asian consumers entering the middle class are willing to invest some of their growing income in food that is safer and offers higher quality, economic growth is a driver for systems of trust in general and for traceability systems in particular. (For more detail, see [Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia.](#))
- **Earthquake aftermath.** Trust in government is an essential component of the food system of trust. The Japan earthquake of 2011 shook citizens' trust in their government, a breach that some experts see persisting into the medium-term future. Questionable responses to the nuclear power plant emergency by power company officials also hurt trust in corporations.⁵⁴
- **Growth of Chinese agriculture.** Because of ongoing concerns about food safety and quality in China, the growth of Chinese agriculture and its increasing impact on global markets will heighten food trust issues.
 - **China as emerging trading partner for selected agricultural products.** Chinese food exports will grow. China is already a major exporter of apples and apple juice, for example.⁵⁵ China will emerge as a

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more important importer, too: it has an agricultural productivity gap that, if not resolved, will compel it to increase its agricultural raw-material imports, e.g., feed ingredients.

- **China as processor.** China has a rapidly evolving food processing industry. (See [Insight 5. Food as a Service: Asia without Kitchens.](#)) Japanese companies already send food to China to be processed.⁵⁶ However, this dynamic is based on current Chinese labor costs, which are rising quickly.
- **Pressure to produce.** As China strives to increase food self-sufficiency, pressure to produce more food could lead to further quality and safety problems, including abuse of pesticides and herbicides.
- **Supply chain vulnerability.** Vulnerability of the food distribution system to disaster and deliberate attack is perceived as high.⁵⁷ The same changes that make the system more secure will make it more trustworthy. (See [Research Theme 4. Agriculture and Food Distribution and Packaging.](#))
- **Environmental awareness.** Consumer environmental awareness in China will continue to grow, and with it concerns about food quality and safety.
- **Information flows.** Growing digital information flows will drive consumers' expectations of transparency, as well as their ability to share information (positive or negative, accurate or inaccurate) about the foods they purchase.⁵⁸
- **Traceability.** Going forward, economic growth in Asia will demand parallel growth of traceability systems for agricultural commodities, food ingredients, and food products. Traceability is already in place in some markets, though available systems are by no means universally used. Traceability systems that reach the consumer are in place in both Japan and Taiwan, and are in use for some products.⁵⁹
- **Testing and sensor technology.** A raft of new food safety technologies are under development. For example, Korean researchers are looking for ways to determine whether food and ingredients imported from China have been irradiated. (Irradiated foods must be labeled in Korea, but not in China.)⁶⁰
- **Decommodification of many commodities; segregation of GM products.** Decommodification and the potential need to segregate GM and non-GM materials are also drivers for creating the infrastructure needed to deliver trusted foods and ingredients. About half of experts surveyed agree or strongly agree that GM and non-GM foods will be available globally through separate supply chains by 2040.⁶¹ (See [Insight 6. A New Era of Hyper-Nichification.](#))

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Implications and opportunities

- **Unique challenges.** Harvesting trust in East Asia will be significantly different than establishing trust in the West, in part because of the different development paths of Western and East Asian agriculture and trade, as noted above, and in part because of cultural differences surrounding trust. Attitudes about what institutions are worthy of trust vary by culture, and Asian consumers have a variety of views of the relative trustworthiness of governments, authorities, and institutions. Also, Asian food-safety concerns differ at the most basic levels: e.g., in Asia, organic certification emphasizes cleanliness and safety, while in the West certification serves to guarantee naturalness and supposed health and nutrition benefits. Finally, culture itself is a driver of trust: Japanese consumers have generally been suspicious of non-Japanese foods and goods, though this appears to be waning among younger generations.⁶²
- **Unique opportunity.** East Asians' concerns about food safety, contamination, and adulteration will lead them to demand credible assurance that food is safe. Traceability systems that provide consumers detailed information about product history, provenance, safety, and quality will provide an important opportunity to deliver this assurance. Western companies seeking to establish trust will want to add value to their products by providing the traceability that East Asian consumers increasingly will demand.
- **Unique implementation.** Because East Asia may surpass the West in traceability implementation, Western producers must commit to implementing traceability practices consistent with East Asian systems, in order to take advantage of new opportunities in East Asia.
- **Trusted Japan.** Japanese companies are already trusted in East Asian markets and may serve as a model for developing trust relationships in the region. Japanese consumers believe that their food system produces the highest quality available anywhere, so the bar for winning trust inside Japan is very high.
- **China becomes a source.** Japan and other East Asian nations will source a greater share of fruits, vegetables, processed products, health food ingredients, and other products from China.⁶³
 - **Food processor to the world.** China will leverage its food processing capabilities and its newfound reputation for quality to become a global center of food processing—at least until the cost and

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availability of labor shift from competitive advantage to a sufficient competitive disadvantage to outweigh technical expertise.

- **Trust but verify.** Persistent corner-cutting in China could lead to a situation in which trustworthy food is ensured not because adulteration is no longer practiced, but because sophisticated technology and handling systems detect and eliminate adulterated products before they reach the marketplace.
- **Japanese experience.** Japanese companies have experience sourcing from China while maintaining exacting standards. They could serve as models and partners for Chinese and foreign companies attempting to upgrade food systems in China and elsewhere.
- **Price pressure.** Tracking additional aspects of a product’s history and keeping it attached to the product throughout the value chain will add cost, in an era when food prices are already rising steadily. Still, rising incomes will put safe food within the reach of most East Asian consumers, and the percentage of household income spent on food will still decline, on average, despite the added cost of ensuring safety. The lowest tiers of food consumers will increasingly benefit from the food safety system, but it will reach them more slowly, and guarantee lower levels of quality.
- **Price advantage.** Offsetting at least some of the added costs of food safety, secure systems could make it possible to simplify other aspects of quality systems and customs processes for foods and ingredients.
- **Price transparency.** As transparency with respect to safety, quality, and other factors rises throughout the food supply chain, consumers, too, may demand and receive more transparency about how food prices are set and where profits are taken along the value chain.
- **Supplying safety and quality systems.** There will be many opportunities for US, Japanese, and other global companies to build safety and quality systems in East Asian markets—as suppliers to local companies, suppliers to governments, or while establishing a local business presence. For example, it might be possible to develop modular secure systems that can be rolled out all the way down to individual famers, connecting them to the food system of trust.
- **Technology for food safety, security, and quality.** Companies might partner with academic institutions, instrument companies, food packaging suppliers, and information technology companies to develop

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new sensing and measurement technology to detect food adulteration, determine food provenance, record food handling history, and ensure that food is safe to eat.

- **Biotech for food safety.** Opportunities exist in increasing research on the application of biotechnology to food safety; for example, to create crops that resist disease or otherwise contribute to maintaining their own safety and purity,⁶⁴ or to embed identity information in products through genetic taggants that are harmless, edible, and organic. (See [Insight 1. Bioscience Marches East.](#))
- **East Asia as technology leader.** The confluence of East Asian focus on food safety, strong sensor technology capacity in Japan, and growing technology capabilities in China could position East Asia to pursue global leadership in food safety technology development.
- **Implement new technology.** Producers and exporters should carefully track emerging food safety technology and be prepared to implement it promptly.
- **Brands matter.** One thing won't change—safety-conscious consumers will look for trusted brands and trusted retailers.⁶⁵
 - **Nation and region as brand.** There will be opportunities for nations and regions within nations to proactively build, maintain, and communicate their own brands as guarantors of food safety and quality, both overall and with regard to specific food products or varieties.⁶⁶
 - **Maintaining brands.** Over the next three decades, trust will become a much more important component of food brands. US and Japanese brands already have “badge value” in Asia, but this brand advantage could diminish if Asia builds a system of trust that guarantees quality. Other regions will become viable exporters as the system locks out unsafe products. An active program to sustain a reputation for quality and safety could pay large dividends in terms of consumer preference and demand.
 - **Guarding brands.** The reputation of brands deployed in Asia need to be carefully guarded. As adulteration scares involving China clearly illustrate, Asian consumers are deeply concerned about food safety and slow to forgive lapses, so the risk to brands from a well-publicized incident is high.
- **Third-party certification.** Trade associations could assume the role of third-party certifiers of safety and quality, in effect creating their own brands.

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- **Labeling.** It is very likely that a variety of new labeling requirements will be instituted by 2040 in various jurisdictions, including national origins labeling and some form of labeling for GM content. In order to ensure that these requirements are as compatible as possible across borders, it will be important for trade associations to participate in the process of developing the requirements. It might be useful to create proposed model legislation. (For background on labeling, see [Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards.](#))
- **Prepare for ubiquitous traceability.** Producers and exporters should prepare for a world in which sophisticated traceability is the norm.
 - **Traceability for consumers.** The same systems that provide traceability to ensure and enforce food safety (e.g., to facilitate product recalls) can be leveraged to deliver a variety of consumer benefits. Companies in the food system of trust can go beyond traceability targeted at food safety, to offer traceability to the end consumer. While food purity and safety will be basic expectations for East Asian consumers by 2040, detailed traceability information could still be a consumer delighter. Asian consumers will be increasingly receptive to information about food provenance, including regional origin, ethical production, GM content, and natural and organic status, all of which can be preserved through secure distribution systems and verified through transparent consumer information systems.
- **Other attributes will supersede food safety.** By 2040 food safety will be a “must have” for East Asian consumers, but other positive “delighters” will be the top-of-mind food attributes consumers seek. Companies should track consumer attitudes about food safety in East Asia, watching for the “tipping point” when concerns about food safety are replaced at the top of consumers’ minds by positive desires for healthy, convenient, nutritious food products.
- **Input to regulations.** A major outcome of the journey to a trustworthy global food system will be harmonization of food safety regulations across jurisdictions. Industry will want to take an active part in the negotiations that lead to this harmonization. The development of enhanced traceability could create the opportunity to streamline regulatory systems.



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Insight 4. Asia's Traditional High-Tech Diet

Asian health traditions and modern science will combine for enhanced dietary health as East Asians confront aging and diseases of affluence.

Leading implications

- Science will both prove and improve traditional Asian foods and medicines.
- Commodity growers can support “traditional high-tech” diets by growing crops that provide specific health benefits, or that serve as biofactories for needed functional compounds.
- East Asia, and especially China, will be a leading global player in science-based functional foods.
- East Asia will be an important market for foods targeted to genetically homogeneous populations.
- East Asia's new elderly, raised more Western-minded than previous generations, will be a key market for these enhanced foods.
- “Traditional high-tech” diets will move from East Asia to the rest of the globe.

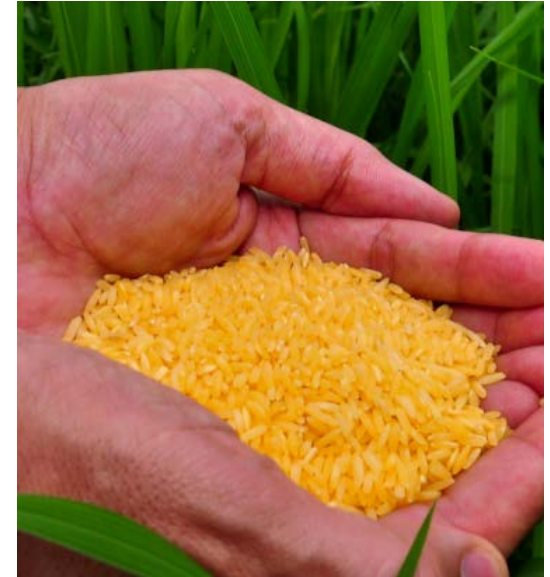


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Insight summary

East Asia has a long cultural tradition of using foods to achieve specific health results (e.g., improved physical stamina) or promote overall health. In the West, science has produced tremendous advances in understanding the relationship between diet and health, including isolating specific beneficial compounds that may be used to fortify other foods, and unraveling the interactions of diet and gene expression. In East Asia, growing technological capabilities and a desire to address aging and emerging diet-based health issues will lead to

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combining tradition and science for enhanced dietary health—backed by markets large enough to stimulate the necessary investments in research and development.

Outcomes

- **Science will develop a broad array of functional foods.** The complex process of developing new functional foods is highly dependent on sophisticated bioscience techniques, from identifying the health effects of macro- and micronutrients, to isolating and boosting natural compounds and nutrients in foods, to applying genetic modification to create health-trait-enhanced GM crops. As biotechnology continues to develop without significant health or environment incident, opposition in Asia will recede.⁶⁷ (See also [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))
- **Functional foods meet individual needs.** As research continues, the ability of functional foods and nutrigenomics to deliver nearly personalized benefits will increase.⁶⁸
 - **Genome**—Different genetic populations have different functional food needs; e.g., Japanese consumers may develop diabetes without Western-style weight gain.⁶⁹ Functional foods that address genetic aspects of health could be popular. Asia could lead in this area due to relatively large genetically similar populations (compared, for instance, to the United States).
 - **Gender**—Specific gender-based needs, such as menopausal issues or prostate cancer, might be addressed by new functional foods.
 - **Age**—With large elderly populations in Asia, new functional foods that help to both slow the effects of aging and promote overall health will be a mainstay of the functional foods market. Asia’s new elderly, raised more technologically minded than previous generations, will be a key market for enhanced foods.
- **Eastern ways spread.** As Asian societies expand their commercial and media reach, their ideas about food, diet, and health will go global. For example, rather than a focus on “good” vs. “bad” ingredients (one of today’s Western approaches), an Asian view of balanced eating could spread.
 - **Belief in Western diets falling.** As concerns grow about the role of Western diets in the spread of “diseases of affluence,” Western thinking about food will increasingly be called into question.

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- **Commercializing Chinese tradition.** As experts in traditional Asian medicine, Chinese companies will have the opportunity and ability to modernize and commercialize traditional products. At the same time, Chinese scientists will explore and further refine the Chinese view of health.
- **Globalizing Chinese tradition.** The Chinese view of health will be commercialized and globalized beyond China. As the resulting products proliferate, they will offer alternatives to Western ideas about food and medicine.⁷⁰
- **China as a food science hub.** With the world’s largest market for advanced foods by 2040, China will be in a position to develop and test products in health, science, and diet.⁷¹ Additionally, China’s large, relatively homogenous population could make it an attractive market for nutrigenomics. (For more on China’s growing influence over diet, see [Insight 2. Whatever China Wants.](#))
- **Science proving (and improving) traditional medicine.** One of the ways that science-derived functional foods will win over an Asian populace wary of technology-enhanced foods is through “proving” the efficacy of traditional Asian medicines. This verification will come either through identifying and isolating the effective ingredients in traditional medicinal remedies, or through the scientific addition of ingredients that give the food the powers that have been ascribed to it by tradition.

Drivers and trends

- **Increasing acceptance of biotechnology.** While Asians—particularly Japanese—have been leery of biotech and “unnatural” foodstuffs, there are indications this attitude is evolving. Many Asian countries have adopted GM products as ingredients, and the absence of any health incidents involving GM crops may be fostering greater trust.⁷²
 - **Beneficial outputs.** As more crops are engineered to produce products or outputs beneficial to consumers—such as high oleic oils with less fat, or crops with boosted omega-3 fatty acid content—these consumer-oriented traits will increase the popularity of biotechnology.
- **Aging populations in Asia.** Asian populations are getting older, with the percentage of elderly in East Asian nations expanding.⁷³ These aging consumers will demand products that keep them as healthy as

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possible for as long as possible.⁷⁴ Governments are also motivated to keep the elderly healthy to manage national medical costs.

- **Asian traditions of food and health.** The idea of food or plants as medicine is prevalent in many Asian cultures. This tradition works in concert with the idea of nutraceuticals and nutrigenomics. According to one expert the practice of traditional medicine is a key support in the expansion of functional foods.⁷⁵
- **Diseases of affluence.** Diseases of affluence such as obesity, heart disease, and diabetes are spreading through East Asia.⁷⁶ The move away from traditional diets to more Western diets is one cause. Growing awareness of the role of unhealthy diets is pushing Asians to re-adopt traditional diets and seek new ways to mitigate the impacts of unhealthy eating.⁷⁷
- **Growing economic prosperity.** As Asian consumers grow wealthier, they not only eat better—they are more able to afford specialty foods such as nutraceuticals. This emerging middle class will expand the market for functional foods.⁷⁸ (See also [Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia.](#))
- **Growth of Asian biotech sector.** Asia’s biotech sector is growing as companies proliferate; it is expected to grow global market share as well. Trust in “native” companies by Asian consumers will help to drive the market as much as products developed by Asian companies for Asian consumers.⁷⁹
- **Eating for health.** Increasingly, East Asian consumers are eating foods that they believe afford them some protections against disease, such as cancer.⁸⁰ Emerging products in the nutraceutical sector can harness this interest to drive growth.
 - In Japan, food company executives have seen a return to more traditional foods, such as miso, and an attendant rise in physical exercise as a way for consumers to “self-medicate” and stave off health problems.⁸¹

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Implications and opportunities

- **Improving traditional foods and ingredients.** Traditional functional foods and ingredients may be the best delivery vehicles for new functional benefits, because consumers already accept them as helpful. The best combinations may be those in which the traditional food and the added ingredient deliver compatible benefits—e.g., a traditional food associated with digestive health combined with a new probiotic ingredient.
- **Commodity opportunities.** Commodity growers will have opportunities to play a role in creating “traditional high-tech” diets, whether by growing crops with specific health benefits or by developing GM crops that serve as biofactories for needed functional compounds.
- **Safety as an entry point.** Because East Asians are highly concerned about food safety and contamination issues, applications of bioscience that help to ensure safety and purity could pave the way to acceptance of biotechnology in other aspects of food and health. (See [Insight 3. Harvesting Trust.](#))
- **R&D opportunities.** East Asia will have to build slowly toward full capabilities in advanced food science. In the interim, Western companies and universities will have abundant opportunities to do basic science and develop and roll out products. Even as Chinese companies improve their capabilities, there will be a long window in which Western companies might partner with them on both fundamental science and product development.
- **Japan as potential leader.** Despite Japan’s reputation for wariness toward GMOs, a number of Japanese experts suggest that the country could respond well to mixed traditional and GM foods—citing societal views of food and well-being, falling levels of concern about GMOs, new attitudes about biotech among the young, and growing interest in using functional foods to address diseases of affluence.⁸²
- **Assuring biotech safety.** By acting as third-party certifiers of quality and authenticity, Western agricultural organizations may be able to promote the safety and benefit of GM functional foods to wary consumers.
- **Nature’s way.** East Asians will be most receptive to foods that deliver health through ingredients already found in nature, even if those ingredients are added to the food through technology.

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- **Role of diets.** Because Asian consumers may start with the concept of balance in healthy eating, they may be more receptive to comprehensive diet plans than North Americans, who are more focused on “good” and “bad” foods and ingredients.
- **Proliferation of products.** The opportunity to design foods that meet dietary needs specific to gender, age, etc., could cause the number of retail product offerings and restaurant menu offerings to grow, straining shelf space and distribution systems. Businesses that can find ways to simplify this potentially cluttered system (e.g., by creating tailored diets out of a manageable number of building block foods and ingredients) may have an advantage.
- **The Functional Food Store.** There are opportunities to build new businesses around advanced functional food products. One model could be the diet foods regimen, where users sign up to participate in a healthy food system, as they do now with Weight Watchers or Jenny Craig. This healthy food system could offer add-on services such as optimal diet diagnostics, and feature branded functional foods products.
 - **Other services.** As mentioned, there are opportunities for diagnostic services, diet counselors, or—depending on the product—some type of dispensary service.
 - **Personalized distribution.** Increasingly personalized food implies increasingly personalized distribution, with gradual creation of systems to manufacture and deliver foods to small groups or even individuals.
- **Meal replacement.** As the overall nutrition content of functional foods increases, the need to create balanced meals could fall away—as a single product, such as a health bar or nutrition drink, delivers a meal’s worth of nutrition in a single serving. This concept could prove popular with younger people on the go who regard food as fuel, especially in emerging markets in which consumers are looking for any advantage to help them get ahead.
- **Orphan genetic diets.** If China dominates Asian nutrigenomics-based food demand, smaller genetic pools may be neglected by food companies, who find such groups too small to be profitably offered the benefits of nutrigenomics. Such “orphan diet” groups might be championed by NGOs and receive government support for the development of foods targeted to their genetic makeup.

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- **Ethnic health food.** As Asians continue to develop their own versions of healthy eating, and cultural flows carry these concepts around the globe, the genre of ethnic cuisine could morph into a genre of ethnic health food, replete with restaurants, prepared meals, cookbooks, and the like.
- **Farther, faster.** Because many Asian cultures associate food with health more deeply than many Western cultures, it is possible that Asian cultures may advance the application of emerging bioscience, nanoscience, and IT to health more rapidly than Western cultures do.



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Insight 5. Food as a Service: Asia without Kitchens

In 2040 more than 70% of food in Japan will be prepared outside the home. As a result, food will shift from being a product to a service. Consumers will rely on trusted brands, stores, and foodservice outlets for most of their food, a majority of which will be processed or pre-prepared. Japan will serve as a bellwether, as this trend will spread beyond Japan to other urban areas of East Asia, especially the cities of China, Taiwan, and South Korea. The entire food system, from farm to fork, will be impacted by the shift away from home cooking.

Leading implications

- Restaurants, foodservice chains, convenience retailers, and other outlets will become consumers' primary interface with the food system.
- Producers and processors will have a greater focus on foodservice and a less-direct connection to consumers.
- Marketing will shift toward Japanese/Asian food processors and retailers and away from consumers.
- There will be fierce competition to serve highly differentiated markets with targeted products.
- Distribution and logistics will be highly unitized and complex.
- The consumer end-market for ingredients will be a shrinking slice of the food dollar.
- With the family cook no longer a trusted buffer between food producers and eaters, brands and retailers will be under greater pressure to win and maintain consumer trust.
- Radical new technologies to produce, protect, preserve, test, deliver, and prepare food will proliferate.
- Countries with cheaper labor, such as China, could become Japan's kitchen by exporting pre-prepared meals to Japan.



Image: Trishhhh (Flickr)

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Insight summary

As home cooking moves toward the margins, food supply chains in East Asia will be profoundly transformed from focusing on food as a product to food as a service. While this is currently a leading-edge urban phenomenon dominated by Japan's younger generations, there is a steady trend to outsource cooking in other parts of urban East Asia as well, including in China. Successful food-industry players will be those that anticipate and adapt to a market characterized by intensified competition; a shift away from ingredients and toward brands, retailers, and restaurants; far greater diversity of consumer tastes; and continuous technical innovation in all aspects of food production, distribution, and preparation.

Outcomes

- **Self-reinforcing shift to outsourced preparation.** Home food preparation has been steadily declining in Japan for decades, driven by self-reinforcing trends including shrinking families, women's movement into the workforce, the rise of younger generations with few role models for home cooking, and proliferation of US-style fast food and other foodservice chains. As a result, food prepared away from home is expected to expand from 38% of Japanese consumer food expenditures in 2010 to 70–80% by 2040.
 - **Countertrend: Foodies.** There will of course be enthusiastic cooks, and in China, increasing numbers of “foodies.” Experts suggest there are subgroups of Japanese young people, including men, who are turning to cooking even as it diminishes as a mainstream activity.⁸³
 - **Countertrend: Income divergence.** Consumer incomes in Japan are diverging between high-end and low-end consumers. Japan will remain wealthy, but consumer expenditures could be constrained by its slow-moving economy and the demographic burden of aging.
- **Regional spread of outsourced food prep.** With similar drivers in play across East Asia, the decline in home cooking is likely to accelerate beyond Japan. For example, one powerful Asia-wide driver is urbanization, which tends to increase consumption of processed foods and restaurant meals.

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- **Faster rise in China.** The decline in home cooking has already started in China, and is expected to proceed faster there than it has in Japan due to awareness of the model from Japan's experience.
- **Fewer, wealthier Chinese women.** Marriage is still nearly universal in China, but by 2040 this will change for two reasons: first, sex-ratio imbalances triggered by the one-child policy and sex-selective abortion mean that more men will be unable to find wives. Second, urban Chinese women will gain income and financial independence—leading many to forsake children and/or marriage, following the example of women in developed East Asia. This combination of single men with no families and Chinese women with significant discretionary income will spur the trend to outsourced cooking.
- **China processes.** China might effectively become Japan's kitchen, providing an abundance of processed and pre-prepared foods tailored to Japanese tastes.⁸⁴
- **China's food industry goes upscale.** To cater to Japan's consumers, other foreign markets, and its own consumer classes, China will develop a trustworthy, innovative processed-foods industry.
- **Smaller consumer markets for ingredients.** Consumer markets for ingredients will shrink. Food producers and processors will have an even less direct connection with consumers and an even greater focus on the retailers, foodservice chains, and other outlets that become consumers' primary interface with the food system.
- **Outsourcing trust.** As basic functions that historically have been supplied by the family (selecting, purchasing, cooking food) move out of the home, the locus of trust will shift too. East Asian consumers will continue to demand guarantees of safety and quality, but the onus of providing these guarantees will shift toward the brands, retailers, and foodservice outlets that will more often be consumers' chief sources of food. (See [Insight 3. Harvesting Trust.](#))
- **Brands even more important.** Brands will be even more crucial as markers of safety and quality. Processed-food companies will need to work closely with suppliers to safeguard quality.
- **Hyper-local trust.** In many cases trust could go hyper-local—for example, to the corner noodle shop that buys ingredients from a short list of proven sources. This entire value chain may be transparent to the consumer.

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- **Packaging as an ingredient.** Active and intelligent packaging that, for example, enhances or monitors freshness could become a competitive imperative for many food products.
- **Foodservice labeling.** In the same way that nutrition labels provide transparency and trust for packaged foods, restaurants and other foodservice providers might adopt nutrition or origin labeling for their dishes to prove quality. Labeling on packaged foods could also change, to include more traceability and other new kinds of safety/quality data.
- **High-tech urban production.** To reduce transportation costs and reinforce trust, food companies might choose to move food production closer to consumers—including into cities themselves. (For more on this, see [Insight 4. Asia’s Traditional High-Tech Diet.](#))
 - **Vertical farming.** Vertical farming, in which food is grown hydroponically or aeroponically in purpose-built urban towers, could be used to produce high-quality, small-scale horticulture that consumers trust and which can be quickly customized to meet changing demand. (See [Research Theme 3. Food Technology: Biotech and Agricultural Innovation.](#))
 - **3D food fabrication.** “Food printers” that can generate customized dishes on demand are expected for the consumer market.⁸⁵ With their promise of instantly and reliably churning out diverse dishes, food printers could marginalize conventional food preparation and make it easier for East Asians to eat without kitchens.
 - **Robotic delivery.** To boost convenience and serve limited-mobility senior populations, home delivery from neighborhood stores and distribution centers could use robots, which would function relatively well in a defined area such as a residential urban or suburban neighborhood. Japan and Korea are in a position to innovate in this area.
- **Change in import-export mixes.** As East Asian consumers replace home cooking with more processed, pre-prepared, and foodservice meals, import-export mixes will change. For example, Japan could import more frozen beef than fresh chilled beef, since the frozen variety is cheaper to use in prepared meals.⁸⁶
- **Distribution fragments.** End markets will fragment, since consumers will be buying less from central hubs such as supermarkets and more from convenience stores and foodservice outlets. Supply chains could become even more intricate.

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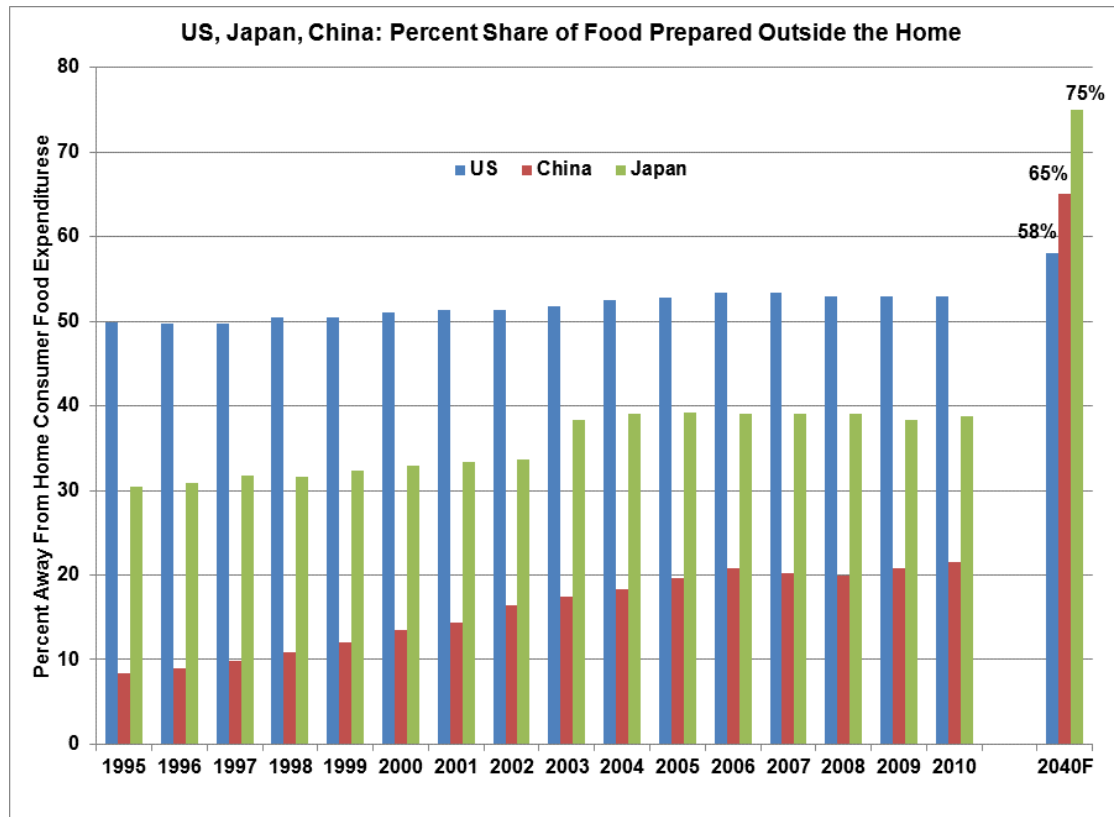
- **Kitchen redesign.** Kitchens may shrink, perhaps to a single counter plus key appliances such as microwaves, refrigerators, and 3D food printers.
 - **Kitchens as test stations.** Home kitchens could become places where the quality of food purchased elsewhere is double-checked before consumption. Sensors embedded in countertops or handheld devices could scan foods and precisely identify the ingredients, along with their quality and freshness. Other sensors might interact with intelligent packaging to reveal more data.
 - **Kitchens as pantries.** Fewer stoves would be needed. Appliances would be for storing and reheating meals created elsewhere.

Drivers and trends

- **Rise in away-from-home food preparation in Japan.** The share of food prepared outside the home in Japan has been rising steadily since the 1960s, from about 11% of Japanese consumer food expenditures in 1963 to nearly 40% in 2010. (See chart below: “US, Japan, China: Percent Share of Food Prepared Outside the Home, 1995–2040.”)
 - **China following.** The trend is already evident in China. Away-from-home food expenditures have increased by more than 250% in the past 15 years, from 8% in 1995 to 21% in 2010.
 - **In US, trend is slower—and different.** In the US, away-from-home food expenditures were about 53% of consumer food spending in 2010, up only 3% in the last 15 years, and may increase only to 58% by 2040. (For more detail on these trends, see [Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia.](#))



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- **Cooking-averse youth.** Japan's younger generations are disinterested in cooking, preferring to spend their time doing other things.⁸⁷ According to one source, a fourth of new mothers in Japan own no knives.⁸⁸
- **Shrinking households.** Aging, delayed marriage, and lack of children are shrinking Japanese households, reducing the incentives to cook for and eat with family members. With smaller households, even older generations who once spent a lot of time in the kitchen are reducing their cooking time.⁸⁹

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- **Modern seniors.** Japanese and other East Asian seniors will increasingly be members of more modern generations, less wedded to tradition than today's seniors, with more exposure to Western-style processed and fast foods.⁹⁰ Most will also have fewer relatives nearby than past generations have had, further favoring a shift to away-from-home food preparation.
- **Rising incomes.** Incomes in Asia, particularly China, are on the rise. By 2030, by one estimate, 1.1 billion Chinese will be in the middle class (defined by the Asian Development Bank as being able to spend \$10–\$100 per day).⁹¹ Wealthier populations will put some of this added income toward healthier, safer food.⁹² (For background, see [Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia.](#))
 - **Japan an exception.** Japan will remain wealthy in comparison to China, but consumer expenditures may be constrained for some time. Tomorrow's seniors may be especially constrained, given that most of their working lives will have unfolded in a stagnant or recessionary economic environment.
- **Proliferating away-from-home options.** Convenient ways to obtain food prepared outside the home are flourishing in Japan, and are on track to become equally popular in China within one to two decades. Convenience stores such as 7-Eleven sell a wide array of fresh, ready-to-eat foods, in addition to myriad restaurants, fast food outlets, and home delivery options.
- **Growing Chinese food industry.** China's food manufacturing and processing capacities are advancing rapidly.⁹³ While standards and practices still require significant upgrading, an increasingly capable Chinese food industry will be able to support this trend as it spreads in China—as well as potentially exporting processed food products to Japan and other parts of Asia.
- **Changing roles of women.** Women's changing roles and lifestyles are a major driver of change in East Asian eating habits.
 - **Marrying later.** In developed East Asia (Japan, South Korea, Taiwan), women are marrying later. The mean age of first marriage for women in these countries is now 29–30—older than in the West.⁹⁴
 - **Marrying never.** Across East Asia, more women are forgoing marriage altogether. For instance, 60% of Japanese women in their 20s are now unwed, up from 20% in 1970, and 37% of Taiwanese women aged 30–34 are unmarried.⁹⁵
 - **Working more.** Two-thirds of women in East Asia are employed.⁹⁶

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- **China's distorted sex ratios.** In China marriage remains nearly universal. However, the divorce rate has been rising since the early 2000s, and the mean age of first marriage is rising. This shrinking pool of married women will be compounded by the after-effects of the one-child policy. By one estimate, by 2030 about 8% of Chinese men aged 25 and over will be unable to marry at all.⁹⁷

Implications and opportunities

- **Repercussions throughout food system.** Every player in East Asia's food systems will be affected by the decline in home cooking.
 - **Shifts in the food dollar.** A move to pre-prepared and branded foods will shift a higher percent of each food dollar to marketing, packaging, and other aspects of the product, rather than the food itself. Somewhat paradoxically, this could stabilize demand for commodities—since crop price fluctuations matter less to consumers, and consumers will be able to shift among different product price points without changing their basic food consumption levels.
 - **More retail competition.** Competition will increase among all types of food retailers, and service providers including restaurants will proliferate at all price levels. However, most growth may occur among quick-service outlets and convenience chains like 7-Eleven—this is already occurring in Japan, and could move even faster in China and other lower-income markets as the Japanese model will be available from the beginning.
 - **Distribution opportunities.** With end markets specializing and supply chains fragmenting, opportunities to build distribution and logistics networks and tools could be substantial.
 - **More pre-processing.** Foods will need to be fully processed before sale, with a variety of cutting, assembly, and cooking by processors and perhaps retailers.
 - **Marketing.** If food is conceived as a service, how it is marketed changes thanks to this basic shift in consumer mindsets.
- **More diversified, affluent markets.** Millions more East Asian consumers will be middle-class or affluent, and will be seeking high-quality branded and processed food products.

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- **Higher-value food markets will grow.** Just as has occurred in developed Western markets, demand for processed foods will grow, providing major new opportunities for food companies, suppliers, and distributors.
- **US and Japanese brands have first-mover advantage.** Global brands are already more trusted by well-off consumers in China and elsewhere, and this trust advantage will become even more important as processed foods supersede home cooking.
- **Constrained Japanese consumers.** Given Japan's ongoing economic slump, food companies will have to continue to meet shifting Japanese demands within tighter price boundaries, and at multiple price levels.
- **Innovative food technologies** will be spurred by this trend. (For more on this theme, see [Insight 4. Asia's Traditional High-Tech Diet.](#))
 - **Long shelf life.** There will be opportunities to innovate processed food products that don't require cooking or refrigeration, and have very long shelf life. However, in markets that demand freshness—including Japan—such products will have to work with consumer perceptions in this area.
 - **Active and intelligent packaging.** Active and intelligent packaging are two emerging genres of smart food packaging. An East Asia moving away from home cooking would offer major opportunities for both kinds. Active varieties interact with the product itself, for example, exuding antimicrobials to prolong freshness. Intelligent versions sense and report on the status of the product and its surrounding environment, and may become integral to traceability systems.
 - **Nutrigenomics.** Nutrigenomics could become an important niche, applied to creating nutritionally appropriate processed foods tailored to particular populations.⁹⁸
 - **Smart ovens.** Food heating technology will need to become more sophisticated. For instance, smart microwave ovens will know how to cook a combination of foods simultaneously.
 - **High-tech production and preparation.** Vertical farming and 3D food printing both have the potential to spawn significant new product pipelines.
- **Prepared meals for the elderly.** As younger generations age, they will be more open to non-traditional and innovative foods than today's seniors. Technical innovations enabled by nutrigenomics or other advances could define a significant slice of the market.

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- **Food preparation centers.** Neighborhood kitchens, perhaps with 3D printers or other high-end preparation devices, could sprout up to serve consumers who want to cook occasionally but lack home kitchens, or who want to cook more elaborately.
- **Pre-processed imports.** Pre-processing and assembly require labor. Relatively inexpensive labor from less-developed markets will be employed to serve Japan and other wealthy markets in East Asia, though sufficient automation could also deliver the same cost savings.



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Insight 6. A New Era of Hyper-Nichification

A proliferation of specialty and value-added foods and ingredients will form a growing share of East Asian agricultural consumption. Driven by rising incomes and increasingly sophisticated tastes, East Asian trade and consumption will be marked by “nichification,” creating opportunities for production and distribution of specialty products.

Leading implications

- Develop high-specification, branded commodities to reflect the rising quality perceptions of Asian consumers.
- Develop, produce, and trade value-added foods and ingredients.
- Link specialty crops and food products to emerging Asian niche markets.
- Identify new food products and food categories emerging in East Asian markets for early signs of fragmenting markets.
- Track the development pipeline for new value-enhanced crops.
- Build relationships with emerging East Asian food processors to develop targeted specialty food categories.
- Promote specialty feed grains to market niche meat products.



Image: agrilifetoday (Flickr)

Insight summary

By 2040, the commodities trade in East Asia will be much more fragmented, with a wide variety of new specialty foods and ingredients reducing the dominance of bulk commodity shipments. Although growing demand for livestock feed grains in Asia will continue to fuel demand for bulk grains, new specialized grain and food products will drive future long-term agricultural trade growth. Agricultural crops will increasingly

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become traceable to segregate the various streams of higher-value crops, based on nutrient enhancement, organic production, and myriad other traits. East Asia will develop an advanced intermodal logistics system to monitor and transport the specialty grains needed to satisfy consumers' growing demand for niche food products.

Outcomes

- **Consumer niche demand.** Rising incomes in East Asia will lead to greater demand for niche products.
 - **Organics.** There is small but growing interest in organic foods in East Asia, and the demand for organics will increase as average incomes rise throughout the region through 2040.⁹⁹ East Asian interest in using foods to enhance wellness will contribute to the growing interest in organics.
 - **Nutritional enhancement.** There will be increased consumer and processor demand for foods that support and enhance health and wellness.¹⁰⁰ Demand will also increase for nutritionally enhanced grain among food processors seeking to satisfy the consumer demand for foods that support and enhance health and wellness. (See [Insight 4. Asia's Traditional High-Tech Diet.](#))
 - **Traceability.** Development of better traceability and food quality protection infrastructures will give East Asian consumers greater access to sourcing information, via either better labeling or better access to online information resources.
 - New East Asian traceability requirements will increase the logistical challenges for agricultural shipping, with the need to maintain more information about crops and to sense and track new kinds of information.
- **Specialty supply chains.** The growth in niche food markets in East Asia will increase the need for specialized shipping, and require both shippers and producers to expand their capacity for product separation and containment. (See also [Insight 5. Food as a Service: Asia without Kitchens.](#))
- **Specialty processing.** The growth of consumer demand in East Asia for specialty characteristics in food will require the adoption of new food processing technologies. From farms to food processing facilities,

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equipment will need capabilities for handling and preserving the unique characteristics of numerous specialty products.

- **New logistics innovations.** Innovations in logistics will increase the cost-effectiveness of containerizing grain shipments. Future implementation of such innovations to decentralize container loading would reduce haulage of grain to intermodal loading yards.
 - Adoption of this kind of innovation in the build-out of Chinese and other Asian freight infrastructures will lower the costs of expanding freight rail into rural areas.
- **Grain fragmentation.** Through 2040 both conventional crop breeding and transgenic techniques will create a much wider variety of specialty grains.
 - **Functional feeds.** The variety of both conventional hybrid and transgenic functional feeds is growing, and new biotechnology methods will accelerate development of new varieties. China has already approved the use of high-phytase GMO feed corn, and by 2020 is expected to include many GMO lines in new, consolidated Chinese seed companies.¹⁰¹ (See [Insight 1. Bioscience Marches East.](#))
 - **Organic grains.** Rising demand for organic foods by increasingly wealthy East Asian consumers will require greater separation and identity protection across the East Asian grain supply chain.
 - **Specifically sourced grains.** Growing interest among East Asian consumers for food pedigrees will boost demand for identity-protected grains.
 - **Biofuel grains.** Current R&D on industrial grains is focused on enhancing traits that boost the output of biofuel production, such as high-amylase corn.¹⁰² In the long term, biofuel grains will decline due to commercialization of biofuel production using non-food biomass feedstocks.
 - **Biochemical grains.** Grains engineered for the production of pharmaceuticals and biochemical components will form a small, growing, and extremely high-value share of grain production through 2040. Although shipments of these grains are likely to be primarily to regional processing facilities, these crops will bring new requirements for containment and separation.
- **Engineered agriculture.** The development of gene stacking techniques that enable easier insertion of multiple traits will cause the number of crop varieties in production to proliferate.

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- **GMO stacking.** Widespread adoption of innovations such as artificial chromosomes will accelerate the development of new GM crops. The ability to stack multiple GM traits into a single genetic modification will lead the number of GM crops to multiply, as traits are stacked in a variety of different applications.
- **Chinese specialty grains.** With China investing heavily in agricultural biotechnology research, China will gradually emerge as a developer of new lines of GM crops.
- **Persistent regulatory divergence.** Intra-Asia variations in food regulations and standards will diminish through 2040, but important differences will remain. With both economies and trade growing throughout the region, regulatory differentials will contribute to the fragmentation of commodity food flows.¹⁰³
- **China as catalyst.** China's future acceptance of GM foods for direct human consumption will have substantial impacts on regional food sourcing. (See [Insight 2. Whatever China Wants.](#)) Although countries like Japan rely predominantly on bulk grains shipments, the embrace of GM foods by China will impact the availability of GMO-free grains among suppliers, and could boost Japanese interest in identity-protected grains and containerized grain shipments.¹⁰⁴
- **Japan super-premium.** Adoption of GM foods could enable non-GMO producers like Japan to market rice and other agricultural products as a "super-premium" non-GMO category in Asia and abroad.¹⁰⁵ But this strategy is only viable as long as a sufficient body of consumers cares about the distinction. (See [Insight 1. Bioscience Marches East](#) and [Insight 5. Food as a Service: Asia without Kitchens.](#))

Drivers and trends

- **Demanding consumers.** Consumers in both developed and developing East Asian countries are demanding more from the food supply system.
- **Asian demand for safety.** Asian consumers are concerned about food safety and demand is growing for quality-assured food products.¹⁰⁶ Many Taiwanese consumers choose expensive organic foods, for instance, because organics offer an assurance of food quality and safety. (See [Insight 3. Harvesting Trust.](#))

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- **Traceability and tracking.** Wealthier East Asian consumers are demanding food traceability and national origins labeling. East Asian food processors also desire greater traceability to maintain and enhance their product quality and efficiency.¹⁰⁷
- **Functional foods.** Demand for functional foods is fragmenting. Health benefits of growing importance include promotion of heart health, probiotics for gut health, and micronutrients.¹⁰⁸
- **Specialized animals.** Chinese consumers are demanding more varieties of meat. For instance, some kinds of pork are being marketed as low-fat, or based on what they were fed.¹⁰⁹
- **Korea demands testing.** Korean consumers are resistant to consuming irradiated food products. Food companies in Korea have responded to this demand by testing China-sourced ingredients to determine if they have been irradiated.
- **Demand polarization in Japan.** Consumer incomes are becoming polarized in Japan, with a greater divergence between high-end and low-end consumers. Japanese food brands are responding to this growing divergence by segmenting their product lines by price and quality.¹¹⁰
- **Chinese demand for novelty.** Unlike Japan, Korea, and Taiwan, China did not experience a slow introduction of new Western food products over decades. Instead, demand for Western products was bottled up for years, then unleashed all at once. Contemporary Chinese consumers have a sustained high demand for innovative and unique Western food products.¹¹¹
- **Biotechnology innovation.** Innovations in biotechnology are making it easier to introduce crops with multiple genetic enhancements. (See [Insight 1. Bioscience Marches East.](#))
 - **Gene stacking.** Gene stacking technologies allow multiple transgenic traits to be inserted into crops. GM crop producers are developing and commercializing GM crops that combine herbicide resistance, pest resistance, and functional characteristics, for example. New “instant stacking” approaches developed by Chromatin allow multiple transgenic traits to be inserted as a heritable artificial chromosome that does not require modification of the base plant genome.¹¹² This enables stable insertion of multiple transgenic traits in a single process of genetic modification.

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- **Separated supply chains.** The growing need to separate GM and non-GM food streams is a long-term driver of change in the handling of bulk grains. Both GM and non-GM foods may require additional separation to preserve beneficial nutritional characteristics.
- **GM product segregation.** About half of experts surveyed agree or strongly agree that GM and non-GM foods will be available globally through separated supply chains by 2040.¹¹³ Future efficiency improvements in grain separation and identity protection may help to narrow cost gaps between bulk and containerized grains.
 - **GM contamination standards.** In countries with strict restrictions on GM food imports, even a trace amount of GM grains can interrupt smooth trade transactions. Until more countries adopt higher thresholds for the presence of trace amounts of GM grains in non-GM grain shipments, the perceived need to strictly separate GM and non-GM foods in the supply chain will continue.¹¹⁴
- **Nutritionally enhanced grains.** Nutritionally enhanced grains have been developed, such as omega-3 soybeans, sorghum with vitamin A, and wheat with enhanced folic acid.¹¹⁵ Preservation of these unique characteristics requires identity-protection throughout the supply chain.
- **Energy and specialty goods.** Rising energy demand from a growing global middle class is likely to place sustained upward pressure on prices for transportation fuel. High fuel prices could favor the shipping of higher-value specialty foods rather than bulk commodities; for example, shipping meat in containers as opposed to feed grains in bulk.¹¹⁶
- **China infrastructure expansion.** Asian countries, and especially China, are upgrading their intermodal shipping infrastructures, expanding the reach of efficient containerized shipping.
 - **China highway shipping.** China is currently building out its inter-city highway system. To support truck shipment of agricultural commodities, trucks carrying agricultural products are allowed to travel toll-free on the new highways.¹¹⁷
 - **China freight infrastructure.** As Chinese incomes rise, China will be able to shift passengers from the conventional rail system to the new high-speed rail infrastructure. This will open up new capacity for freight traffic on conventional railways in China, and could form the backbone of a sophisticated Chinese intermodal infrastructure.

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- **China and containerized grain.** Containerization can enable new agricultural producers to export to Asia without the need for extensive infrastructure upgrades. This would require adequate quantities of empty containers for backhaul moves, based on large-scale imports of high-value products and goods to support headhaul container moves that become backhaul opportunities.
- **East Asia is developing its own distribution system.** The global food trading system was built to handle commodities, not niche products. This traditional system reflected Western preferences. However, East Asia is evolving differently and the transition to more traceable food systems could be achieved as a leapfrog. (See [Insight 3. Harvesting Trust.](#))

Implications and opportunities

- **Branding of commodities.** The diversification of specialty grains offers new opportunities to develop brands for specialty grain products. Branded grains could help ensure trust and quality for East Asian purchasers while the region develops robust quality assurance and traceability processes.
 - **Specialization as strategy.** With East Asian countries investing heavily in overseas agricultural production in Africa and South America, these new production areas may account for a growing portion of the bulk grains flowing to East Asia. For grain producers in North America, marketing specialty grain products to East Asia may be a way to stay competitive in the region.
 - **More labeling information.** Until East Asia develops a robust traceability infrastructure, source and origin information for foods and feed grains can differentiate high-quality imports from competing products. Enacting national-origin labeling for food products in East Asia could be mutually beneficial for both Asian consumers and North American agricultural producers. (For more on labeling, see [Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards.](#))
- **Smaller markets.** The proliferation of specialty grains will fragment commodity markets, narrowing the number of suppliers and purchasers for a given grain variety.
 - **Increased volatility.** These smaller markets will have a higher degree of price volatility, and may require new hedging instruments to control financial risks.

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- **Increased fragility.** Food processors that use specialty grains will have to manage increased risk of supply chain disruptions from natural disasters, economic instability, and political conflicts. They may choose to manage these risks by diversifying their supply networks and increasing their supply buffers.
- **China demand and supply.** China will emerge as both a competitor in specialty foods and grains, and a growing market for agricultural and food products. (See [Insight 2. Whatever China Wants.](#))
 - **Asia a source of specialty food products.** Asian food processors already export many traditional foods to Western markets. Demand among Western consumers for authentic and novel foods could create new demands for specialty Asian foods from specific production regions in Asia.
 - **Niche meat varieties.** Rising incomes for Chinese consumers will lead to increased interest in premium meat products. Premium pork varieties with enhanced flavor from the use of specialty grain feeds could be a source of enduring demand as incomes grow in China.
 - **China as test market.** Chinese consumers are attracted to novel food products, and as this market develops it could be a leading area for early marketing of new specialty food products in East Asia. Foods that offer functional nutritional benefits or perceived health benefits may be best positioned to capture the interest of Chinese consumers.
- **Flexibility and agility.** The fragmentation of food markets will require greater flexibility and agility across the supply chain.
 - **Increased awareness for producers.** Food producers will need to develop greater awareness of new specialty crops and the economic tradeoffs of their production.
 - **New roles for trade associations.** Food producer associations will need to develop more sophisticated ways to track demand fluctuations in emerging Asian markets, and convey actionable information to their membership.
 - **New opportunities and challenges for processors.** Food processors can develop new food category niches and valued-added products, allowing their products to maintain higher margins, but to maintain their position they will need to better manage volatility and risk.

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- **Container imbalance.** Asia's high level of exports to the US creates a sustained imbalance in container shipments, creating opportunities for containerized food shipping thanks to a surplus of empty shipping containers in the US.
- **Opportunities from unconventional energy.** Expansion of unconventional oil and gas production in the Midwest and Plains states of the US is generating new empty containers that are being used to ship bulk drilling sand to fracking operations. Fracking operations in wheat and corn production areas could provide a new source of empty rail containers.
- **Opportunities from Panama Canal expansion.** Widening of the Panama Canal will open the door to shift US container imports to East Coast and Gulf Coast ports, creating new container imbalances and new opportunities to link US crops transported by barge to international container shipping.



Projecting Food Demand to 2040

An economic model was constructed for analyzing the main drivers of changes in the quantities and types of food that may be desired in a global future characterized by high levels of prosperity and membership in the middle class. In addition to confirming some findings of other researchers in this area, we have added to previous research by identifying some of the relationships that are independent of income, to support estimates of the proportion of a national economy that is middle-class in each country.

The model examines nutrition demands based on a variety of drivers, including purchasing power, increases in the size of the middle class, age distribution, and others. Then projections were made to project food demand in 2040. These projections of future food consumption assume that resource constraints will not affect food consumption preferences, and rely on prices to balance supply and demand and ration consumers' access to their preferences. Where resource constraints do limit quantities available, prices will rise and consumption of that food type will fall. Thus, this model does indicate where constraints—and consequently prices—increase.

Findings

- Global population is projected by United Nations (UN) studies to grow to 9.1 billion in 2040. We forecast that real purchasing power parity *per capita* GDP measured in USD will more than double from \$9,727 in 2010 to \$24,697 by 2040. Rising prosperity combined with continuing population growth means people will consume more meat, dairy, vegetable oil, fruits and vegetables, and sugars in average diets worldwide. It also means reduced direct consumption of food cereal grains, both in absolute terms as well as per capita.
 - Increasing dairy consumption will be dramatic in China over the next 30 years. Dairy consumption increases more directly with income, likely because of dairy product components, such as non-fat dry milk, in many prepared or processed foods.

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- Oilseeds, which provide needed protein for livestock rations, and also increasingly in feed for fish farming will drive feed demand increases (i.e., via increased productivity or area) in the next 30 years, while cereal food grains for food use demand will decrease.
- Meat and dairy production are important industry trends to follow because they are relatively land-intensive products to produce. Given that there are land, water, fertilizer and economic limits to the amount of feed and food grain production, and that it is costly to increase cropland area, the simple multiplication of land by yields provides an effective potential production constrain for food availability.

Great potential to increase meat production

- Exhibit 3 shows projected meat consumption growth will continue to grow in East Asia, mostly China as well as the rest of the world which will account for somewhat more of growth in the next 30 years.
 - The prosperity of meat demand in the next 30 years will be better than in the past 30. Although, the rate of growth is declining the total volume of increased meat demand is expected to increase by 201 million tons vs. 164 million tons for the previous 30 years.
 - Driving this change are increase in average incomes and participation in middle class society, particularly in China, although at a slower rate than in the past in the case of China.
 - A counter effect on volume—not value—is Asia’s, particularly China’s and Japan’s, aging population as greater proportions of Asian societies leave the workforce and consume fewer calories and proteins (Exhibit 3).
 - The growth expected for meat products in the Middle East, North Africa, and other parts of Africa is especially important. Meat consumption is expected to be strong outside of East Asia. Brazil, South America, and the United States also account for over ¼ of meat market growth outside of East Asia, driven by rising working-age populations as well as income growth and pre-existing meat consumption preferences.
 - In the past, China’s large population and its successful industrialization has taken it from one of the poorest countries in the world in terms of average per capita income to middle-income status, especially

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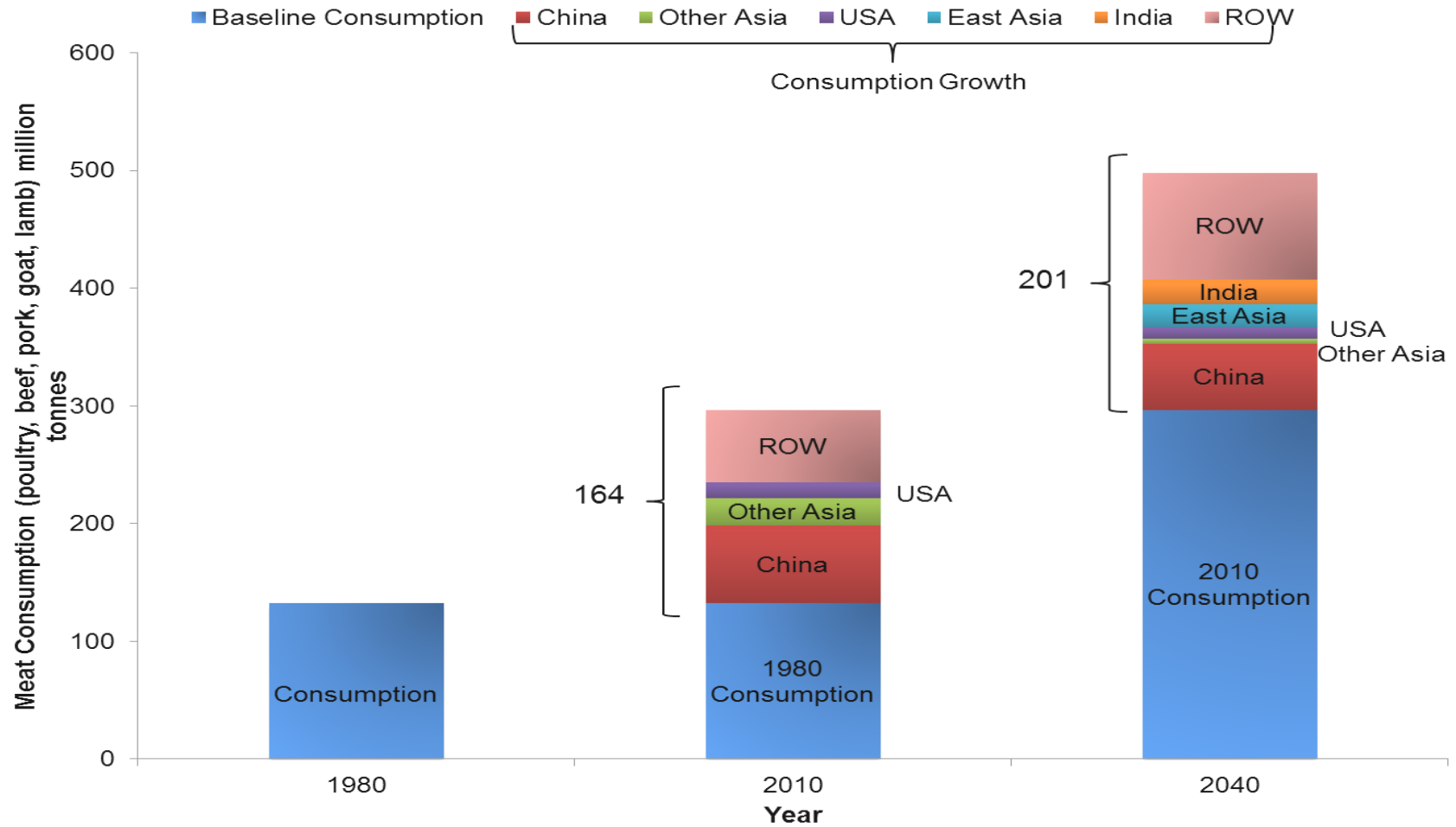
as it has come to dominated agricultural trade in the region. While still very important, meat consumption growth in China, and Asia overall, is projected to be slower over the next 30 years than during the last three decades.

- Meat consumption per capita in China is already higher than in Japan and Korea, and historical trends indicate it is near the per capita saturation point for major groups. Worldwide, growth in meat consumption will continue, but it will be driven by rising prosperity and growth of workforce-age populations.



Food 2040

Exhibit 3: Quantities of Meat Products Consumed, 1980-2010 and 2010-2040



Food 2040

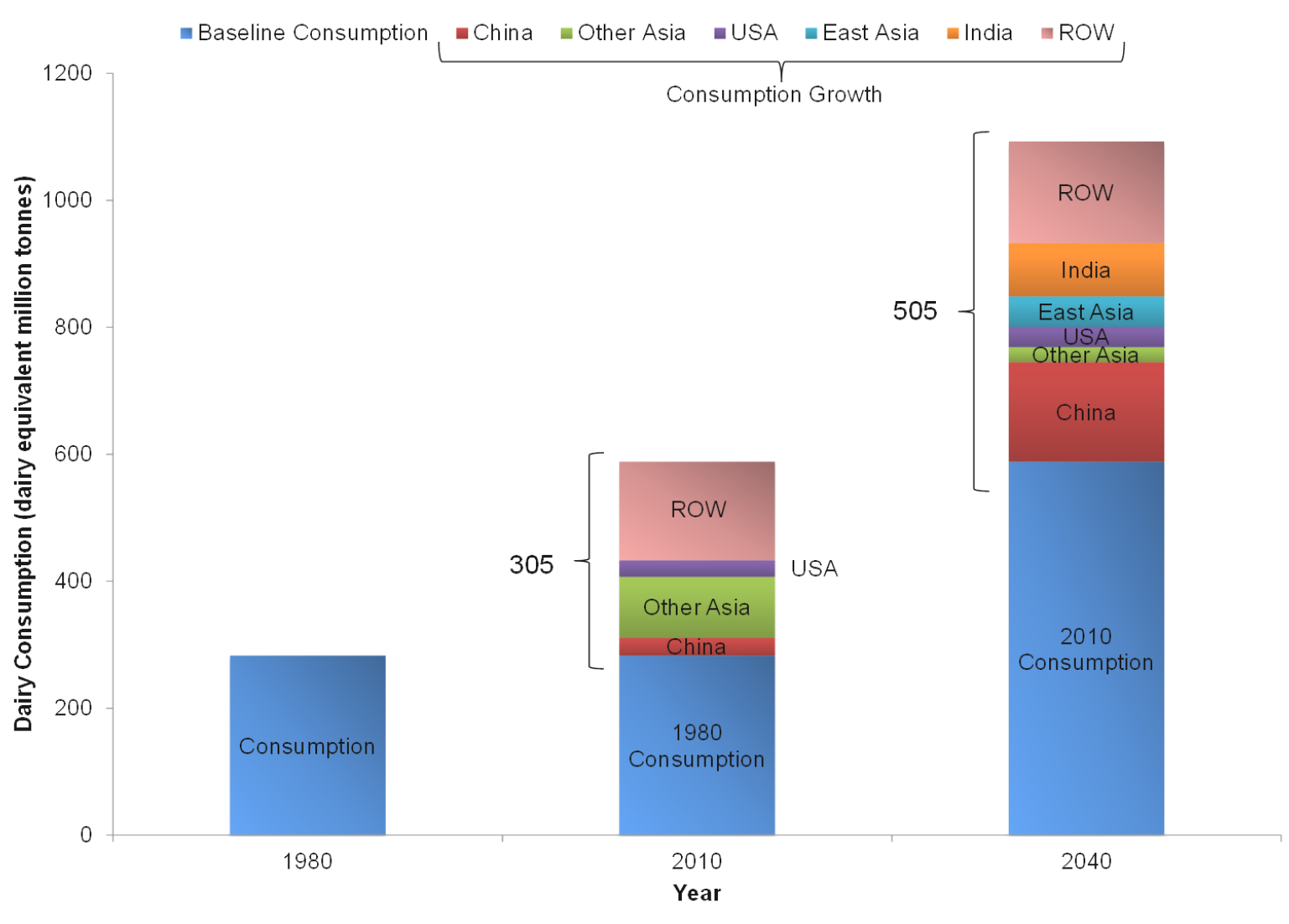
Dairy products: The most rapidly growing food sector

- Dairy consumption is expected to grow significantly in Asia, driven by income and population growth. Dairy consumption is both more sensitive to income increases and less sensitive to aging than other food products.
- In China dairy consumption is expected to increase significantly, providing a growing market for grain-fed dairy based either in Asia itself or in other parts of the world.
- Dairy consumption per capita in East Asia is currently quite low, so the expected growth in dairy consumption in Asia reflects both modest increases in real incomes and the number of people moving to middle-class living standards.
- Even though per capita dairy consumption in Asia will most likely remain quite low compared to other regions of the world, the sheer number of Asians who will be modestly increasing their dairy consumption will amount to a very large rise in total dairy consumption worldwide.



Food 2040

Exhibit 4: Dairy Consumption Growth, 1980-2010 and 2010-2040



Food 2040

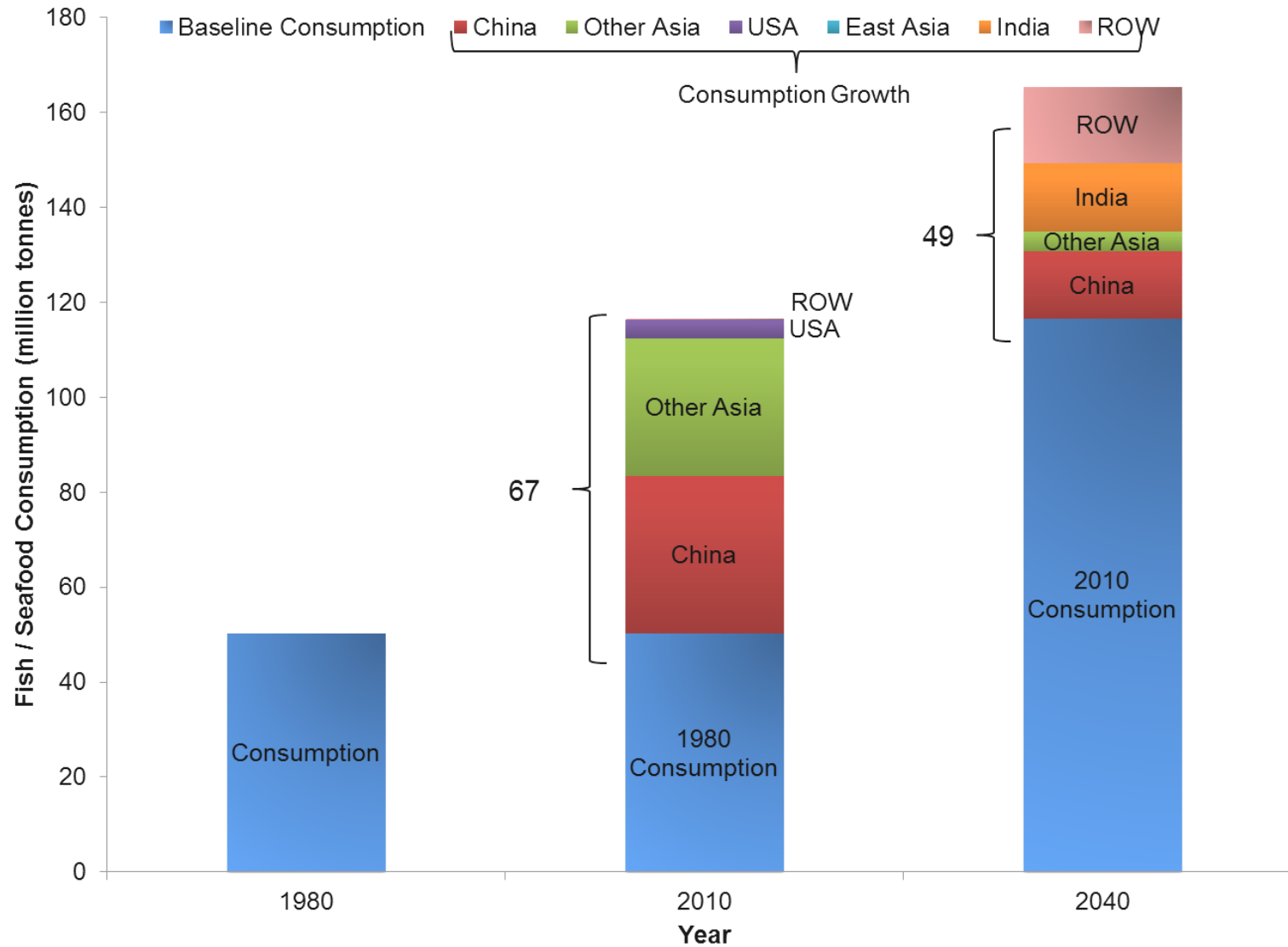
Fish and seafood: An opportunity to develop aquafeeds

- Seafood is a major protein source in Asia, and is projected to continue to grow in the future (Exhibit 5). However, as wild catch continues to decline the region will become increasingly dependent on aquaculture.
- Like meat consumption, fish and seafood consumption have grown dramatically over the last 30 years. The pace of this trend will decline between now and 2040 and the role of *farmed* fish will increase in response to rising prices of wild catch. As a result, by 2040 approximately 60% of fish consumed worldwide will be harvested from aquaculture. This will provide a new market for vegetable meal and other products that can substitute for fishmeal, as well as for oil from aquaculture rations.
- Fish and other seafood, however, are more efficient consumers of protein feed than livestock because fish require less energy per ration of feed, due to their ability to remain suspended in water rather than expending energy to fight gravity as livestock do. As a result, fish farming requires generally less protein feed (such as soybean meal) per kilogram of output than livestock production does. Thus, any expansion of farmed fish in Asian diets—to the extent that it displaces meat consumption—will tend to alleviate pressures on feed crop production, rather than adding to them.



Food 2040

Exhibit 5: Fish and Seafood Demand, 1980–2010 and 2010–2040



Food 2040

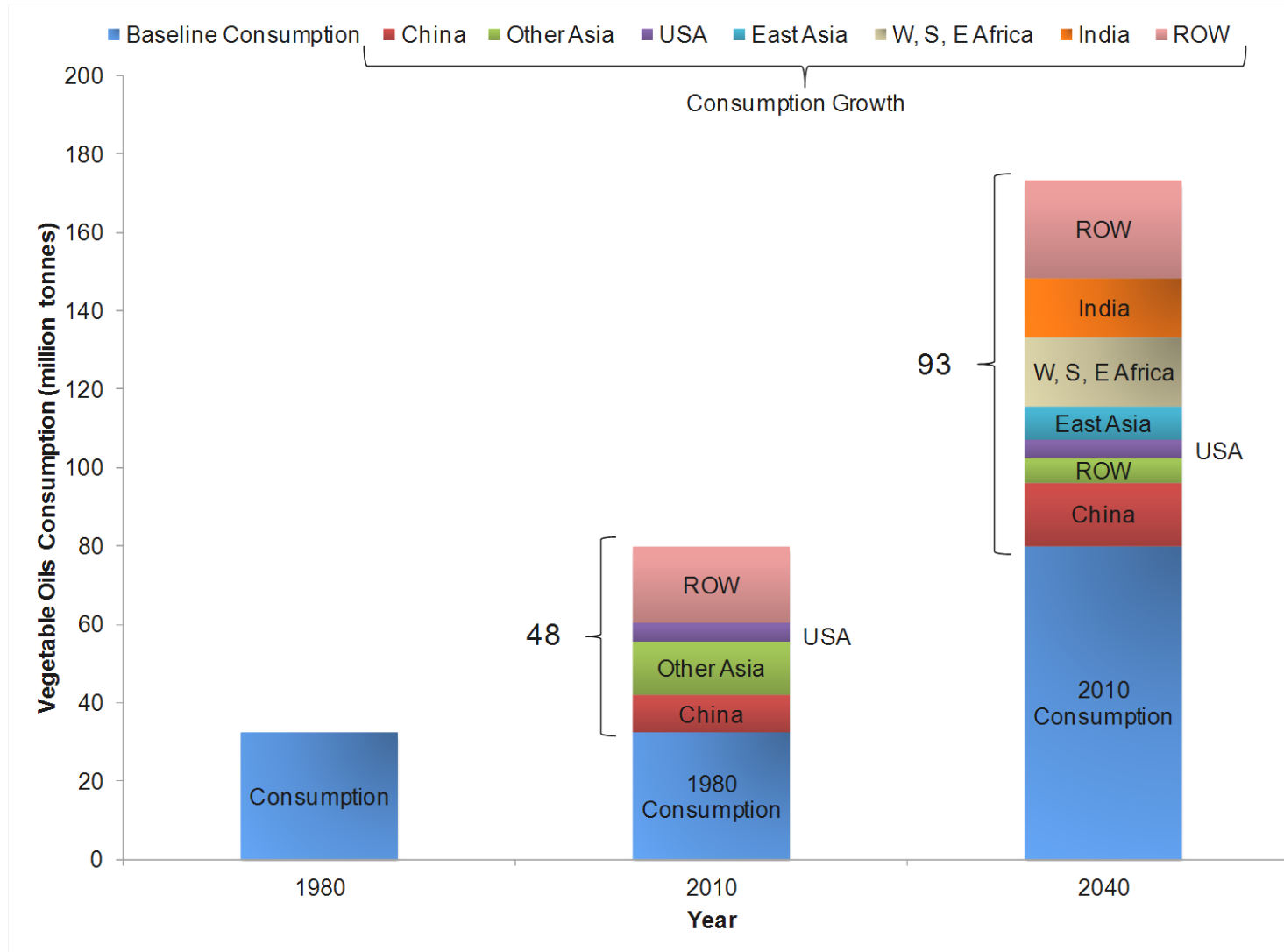
Vegetable oils consumption continues growth trajectory

- A dramatic increase in fats and oils consumption is projected, including a rise of up to 10% in biofuel consumption (Exhibit 6). This trend is mainly driven by increases in income, since it drives up consumption of prepared food, in which fats and oils are common ingredients. As Asian consumers increase their reliance on prepared, rather than homecooked, meals, markets for vegetable oils in particular are projected to grow.
- This trend will be quite rapid, as consumption of vegetable oils is expected to grow almost twice as rapidly—by 92 million tons—over the next 30 years as it did from 1980–2010. China, India, and Africa are likely to account for the largest part of this market growth over the period, again driven by income growth and economic migration to the middle class, with the changes in lifestyles and food preferences that are thus implied (Exhibit 6).



Food 2040

Exhibit 6: Vegetable Oil Market Growth, 1980-2010 and 2010-2040



Food 2040

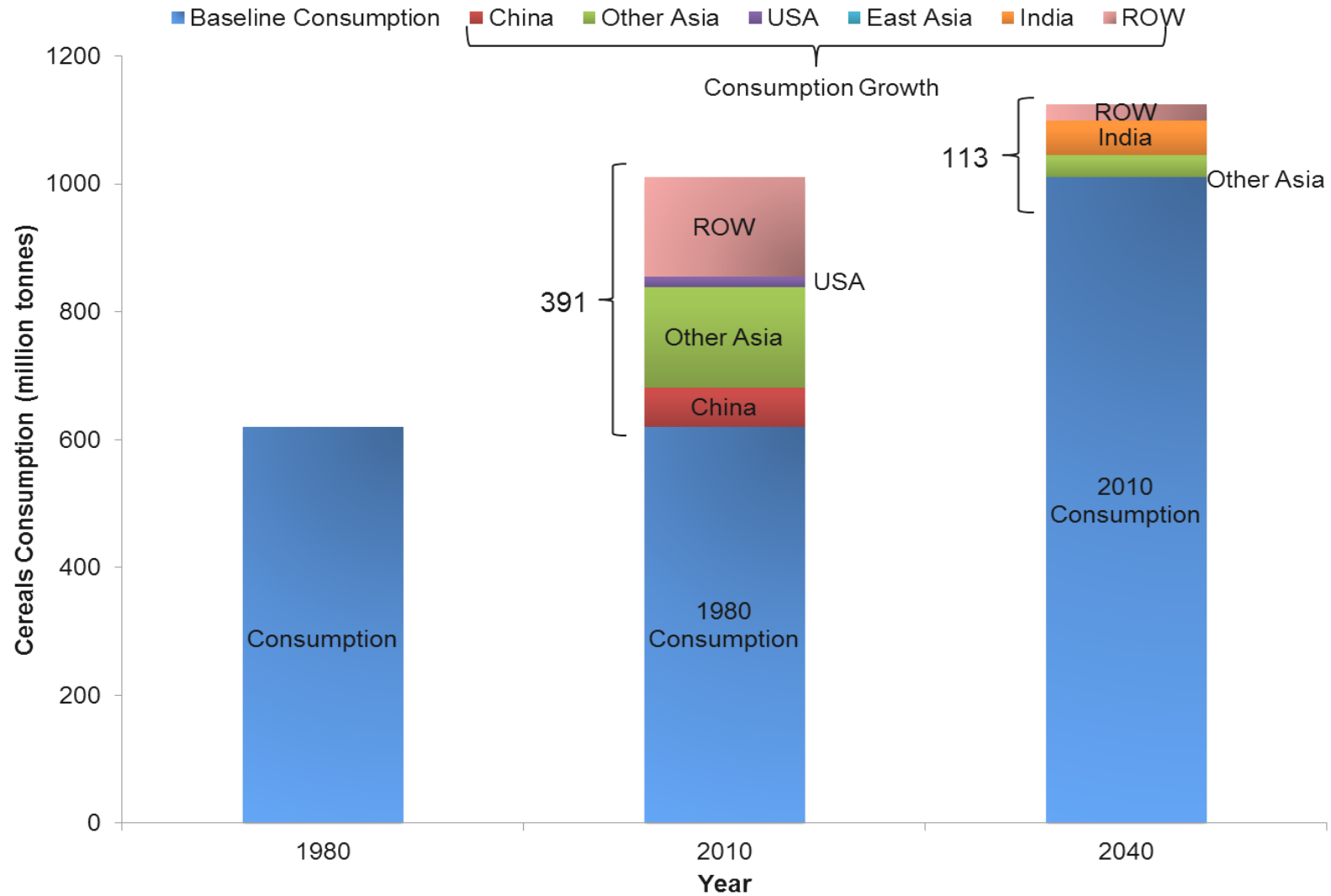
Food grains consumption shifts to higher-value products

- Food grains, which include rice, 81% of wheat, and approximately 40% of coarse grains produced in the world today, account for most of the world's crop area. In 2010, an estimated 1,461 million metric tons of food grains were produced, compared to 744 million metric tons of feed grains worldwide.
- Volumes of cereal and food grain production have changed modestly over time, ranging from 70% of world grain production in the 1970s to near 80% in the past decade, and now trending downward again to 70%.
- Cereals consumption, illustrated in Exhibit 7, is projected to increase in the next 30 years but will be constrained overall by land availability.
- Direct consumption of cereals and food grains is negatively associated with increasing income and social migration into the middle class, as a greater share of average middle-class diets is made up of meats, fats, and dairy—generally displacing rice, bread, and other cereals. However, population growth of 2.1 billion people between now and 2040 will still increase the nutrient energy needs supplied by food grains.



Food 2040

Exhibit 7: Food Cereal Consumption, 1980–2010 and 2010–2040





Food 2040

Peak Farmland: Can Future Food Needs be Met?

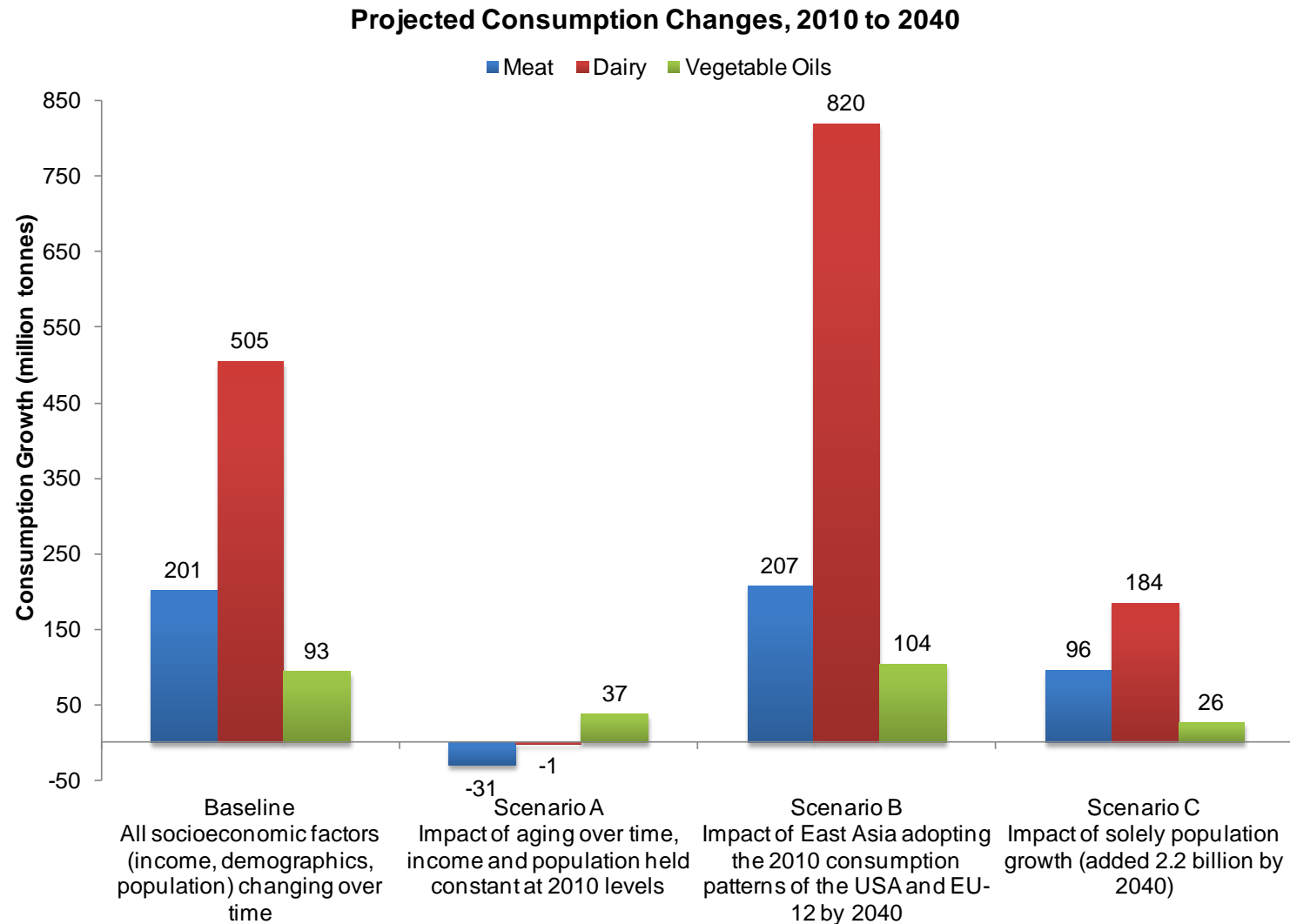
- As the relationship between food consumption projections and future food supplies was analyzed, a key question was whether the production system could provide sufficient quantities and kinds of foods that an increasingly populous, prosperous, urbanized world is likely to prefer.
- Genetic improvements and land development do not happen by accident, and the growth that the world has seen in agricultural productivity since the 1950s reflects a relatively brief historical period—factors that suggest pressures on the investments that will be needed to maintain agricultural productivity in the future.
- The modeled projections suggest a gap between current productivity and land use limitations and future food needs. This gap will begin to be felt relatively soon—within a decade or so, rather than 30 years from now. The implication is that unless sufficient public and private investment in, and support for, agricultural productivity technologies and infrastructure are achieved, conflict between agricultural and environmental uses of land is likely to increase, as are constraints on worldwide economic prosperity.
- Each of the major food categories discussed above is expected to have different needs for grain and oilseed crop areas—so it is important to identify specifically the kinds of food a more prosperous and populated world will want by 2040.
 - Projected additional quantities of meat demanded by increasingly middle-class consumers will require the largest increases in feed crop inputs and corresponding land use.
 - Exhibit 9 details the amounts of grain and the estimated corresponding acreage required to meet those levels of production.
- Exhibit 8 presents four scenarios, which illustrate the importance of the identified drivers of future food consumption in Asia as well as in the rest of the world.
 - **Scenario A** illustrates the impact of aging on food consumption. As a greater proportion of the world's population reaches retirement age—a trend that is expected to occur more rapidly and acutely in Japan, Korea, and China than in most of the rest of the world—per capita meat consumption in these places will cease to grow, and may even decline, since consumption of meat (like other foods) declines with age.

Food 2040

- **Scenario B** illustrates the annual market size in 2040 for meat, dairy, and vegetable oil if one assumes that East Asian per capita consumption will converge with the levels found in the US and Europe. This implies that Asia could be consuming much more if average Chinese, Japanese, and Korean consumers had the preferences, income, and other drivers of food consumption found among typical American and European consumers. The real-world answers to two yet unresolved questions will determine if Asian per capita consumption of meat, dairy, and vegetable oil will converge (increase) with American and European consumption levels:
 - Supply constraints: To what extent has limited availability of meat, dairy, and vegetable oil (due to income constraints, policy constraints, or domestic production constraints) dampened historical consumption of these foods in Asia?
 - Demand constraints: To what extent have long-term, cultural food preferences and tastes constrained Asian consumption of meat, dairy, and vegetable oil?
- **Scenario C** shows the modeled effects on food consumption only from population growth. If all other predictors of food consumption were frozen in 2010 and only population was allowed to expand, as forecast, to 9.1 billion people in 2040, annual meat consumption would expand by 96 million tons and dairy by 184 million tons.
 - While population growth of 2.2 billion people alone will account for almost half of increased meat consumption over the next 30 years, it will account for a much smaller amount of the total expected increase in dairy and vegetable oil consumption.
 - Dairy and vegetable oil consumption are more sensitive to wealth and social class variables than meat consumption, implying that as more people attain middle-class living standards, consumption of dairy and vegetable oil consumption will rise much more than simple population growth projections would suggest.

Food 2040

Exhibit 8: Annual Food Product Consumption Growth, 2010–2040



Food 2040

Food claims on limited cropland resources

- The amount of cropland needed for food will increase significantly between now and 2030, then level off by 2040—that is, if productivity increases as well as lower growth in food cereal consumption both occur.
- Exhibit 9 describes changes in food needs, but converted to hectares of cropland area for grains and oilseeds instead of tonnes of meat, dairy, fish, or cereals. Increased dairy and meat in the baseline scenario increase cropland needs by approximately 53 million hectares over the next 20 years, before leveling off through 2040.

Exhibit 9: Estimated Yields and Cropland Requirements for Grains and Oilseeds

Year	Estimated Yield and Hectares	Food Grains	Feed Grains	Oilseeds	Estimated Total Crop Area	Actual Total Crop Area
1980	Yield	1.79	2.51	1.15	821	822
	Hectares	493	222	114		
1990	Yield	2.23	2.79	1.43	816	820
	Hectares	461	226	128		
2000	Yield	3.05	3.90	2.03	827	827
	Hectares	484	193	175		
2010	Yield	3.31	4.26	2.30	887	892
	Hectares	484	193	210		
2020	Yield	3.31	4.26	2.30	935	
	Hectares	488	207	241		
2030	Yield	3.71	4.70	2.60	940	
	Hectares	452	239	250		
2040	Yield	4.13	5.20	2.90	939	
	Hectares	393	295	251		

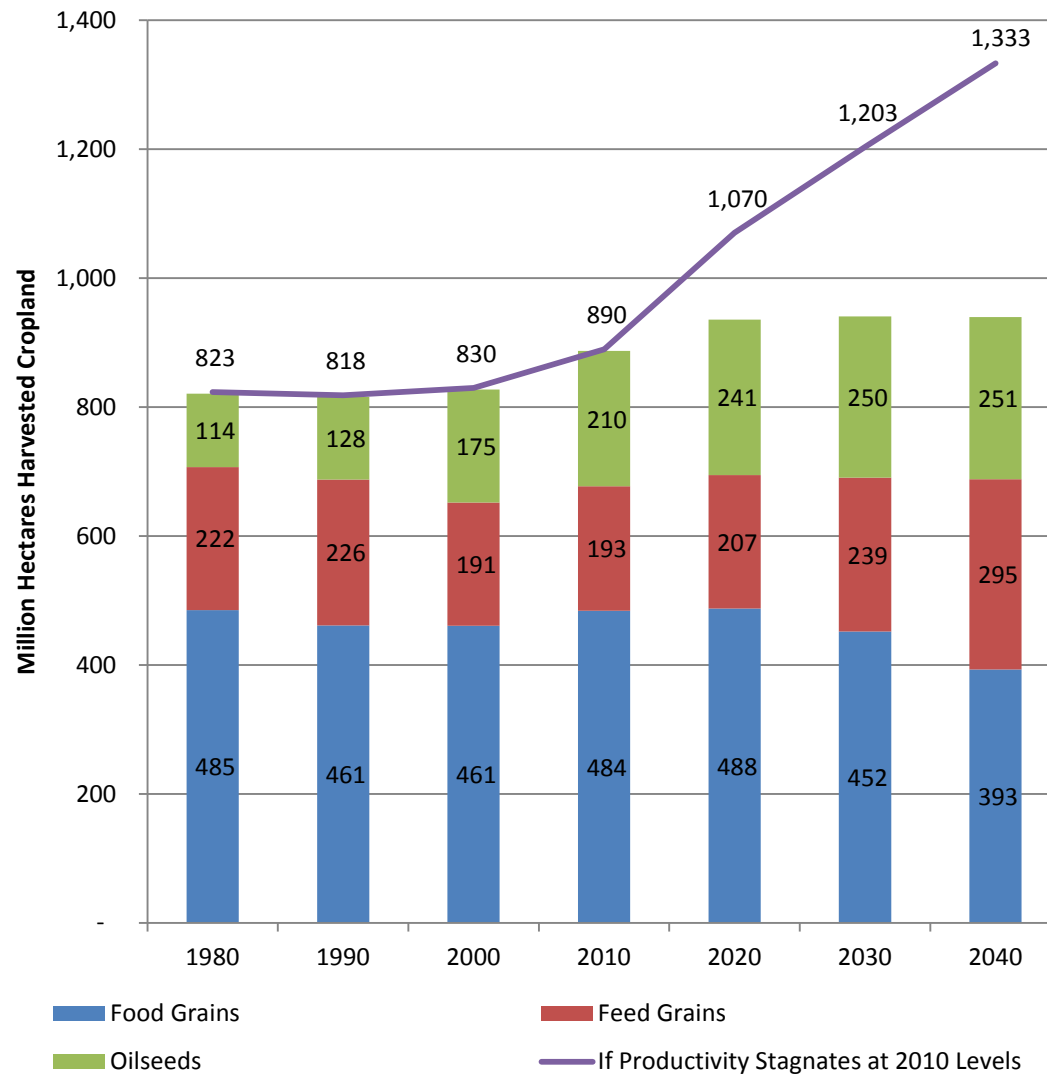
Food 2040

- Exhibit 10 provides food consumption in terms of cropland area instead of metric tons. This implies:
 - Assuming that trends contributing to productivity growth in the last 15 years in technological and other developments provide for higher-yielding seed, more feed-efficient animal genetics, and infrastructure improvements—all of which have resulted in more food output per hectare of land input—cropland requirements are projected to increase dramatically, by *53 million hectares*, during the next decade. That is approximately the amount by which cropland increased worldwide between 1980 and 2010 as well, but through 2040 that growth that would have to come into production three times faster than in the 1980–2010 period, if it is to avoid constraining economic development in much of the developing world, particularly high-growth areas such as China.
 - By 2040, however, actual cropland needs could actually begin to decline from peak (2030) levels if sufficient productivity growth in agricultural production is achieved. Without such productivity increases, higher prices for both food commodities and farmland will ration food demand and, by implication, also ration worldwide membership in the middle class. This implies that farmland may be a potentially critical constraint on economic development:
 - Without sufficient investment and progress in world agricultural productivity growth, the value of farmland can be expected to continue increasing.
 - With sufficient agricultural productivity growth, or with lower levels of economic development overall, farmland prices, in real terms, can be expected to moderate.



Food 2040

Exhibit 10: The Productivity Challenge: Food Consumption in Terms of Required Cropland Area



Food 2040

- If investment in technology and infrastructure are not maintained or increased, and average crop and livestock yields worldwide are allowed to stagnate, needs for land to support the additional quantities of food demanded during the next three decades will increase by around *270 million hectares*, as illustrated in Exhibit 10.
- While UN Food and Agricultural Organization (FAO) research indicates that there is sufficient rainfed land available in the world to meet such an increase, conversion of that land to agricultural use from existing uses, such as timber or wildlife reserves, cannot occur without significant economic or social costs—namely, only if commodity prices were significantly higher, and well-being for many people correspondingly lower.

Food 2040

Five Research Themes

This section explores the five core research themes of **Food 2040** as they pertain to East Asian food and agriculture through 2040:

- Consumers
- Competitive/ Regulatory
- Food Technology
- Distribution/Packaging
- Environment/Resources

For each theme, the following pages summarize findings and emerging issues, key drivers, and implications for 2040. These findings were used to derive the six Insights. This section also highlights findings across the five core themes, as illustrated in Exhibit 11 below.



Food 2040

Exhibit 11: Emerging Issues and Core Themes

Issue Number	Issue	Theme 1: Consumer Demand	Theme 2: Competitive and Regulatory Issues	Theme 3: Food and Technology	Theme 4: Agriculture and Food Distribution and Packaging	Theme 5: Environment and Resources
1	Growth in middle class key in Asia	x				
2	Population aging advances demand for nutrition and functional foods	x		x		
3	Demographic shifts change food demand in Japan	x				
4	Declining consumer purchasing power in Japan	x				
5	Westernization of Asian diets	x			x	x
6	Aging of population is not uniform across Asia	x				
7	Women's role in Asia is changing	x				
8	Expansion of food prepared away from home in Japan	x			x	
9	Chinese food service sector grows	x			x	
10	Asian expansion in overseas agriculture		x		x	
11	Asian demand for better product labeling	x	x		x	
12	Food safety concerns limit Chinese exports		x	x		
13	Food and fuel price volatility continues		x			
14	Bioscience in East Asia		x	x		x
15	Crop biotech advances used to deal with climate shifts, resource constraints		x	x		x
16	Diverse technologies beyond biotech			x	x	
17	GM foods in Asia	x	x	x		
18	Containerization for processed products				x	
19	China must improve infrastructure and		x	x	x	
20	Japanese demand small portions and more information	x			x	
21	Japan agriculture production likely to decline			x	x	
22	Fish production: wild catch down, aquaculture			x		x
23	Ag production and the environment in Asia			x		x

Research Theme 1. Consumer Trends: Upper- and Middle-Class Asia

East and Southeast Asian consumer populations are transforming rapidly, as people move to cities, incomes rise, and middle classes grow. These shifts all change how and what people eat. Consumers' information environment is changing as well, as cultural flows increase, media grows freer, and social media rise—all of which affect perceptions of commercial and governmental messages. Another important shift that will shape dietary patterns is demographics: East Asia, like the developed world, is rapidly aging. By 2040 the share of world population over 65 will be 17%, up from 9% in 2010. Emerging issues, drivers, and implications arising from these trends are described below.

Emerging issue: Growth in middle class is a key driver of Asia's future markets, especially in China, India, Indonesia, and the developing economies



Image: conbon33 (Flickr)

The most affluent consumers will see an expansion in food value, as more higher-value products become available and more consumers have the income to purchase them. For companies that serve middle-class consumers, there is an opportunity for market expansion in terms of both volume and value. For consumers in the lower-income and rural brackets, expansion in sales is still possible on the basis of higher total demand (volume).

Developing-country economic and population growth will continue to generate vast new middle-class demand for food and commodities (volume) as well as for processed and higher-value foods (value). As consumers shift from subsistence to middle-class or above lifestyles, they also tend to shift food consumption patterns away



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from traditional cereals like rice (supplemented with small amounts of fish and other proteins) to animal protein-based foods such as meats, dairy products, and eggs. While these products are themselves grain- and oilseed-based, they require far greater amounts of land and water resources to produce, which will increasingly trigger fundamental changes across markets and production systems—trends now underway across Asia.

Drivers

- Incomes in East Asia, and elsewhere, are rising, creating a broad new middle and affluent class. By 2030, over 75% of China’s population could enjoy middle-class lifestyles, up from 12% today. India’s middle class is smaller than China’s today, but 15 years from now could account for 70% of India’s total population. By 2050, more than 80% of Indonesia’s population could be middle-class and above.¹¹⁸
- By 2050, the upper-class population in China may expand sharply, to 190 million. India’s upper-class population will rise to 210 million; Indonesia’s to 40 million; Japan’s to 40 million, and Korea’s to 35 million.¹¹⁹
- Studies of earlier examples of emerging middle-class behavior indicate that as consumers grow wealthier, they eat “higher on the food chain”—i.e., consuming more animal protein and associated products.¹²⁰ This pattern has been observed in the EU, US, and Japan and is already being observed in China.
- Asia’s total population is also expected to grow, meaning there will be a larger consumer market for food sales—and these consumers will all need to buy food, regardless of their income. China and India will account for nearly one-third of the world’s population in 2040.
- Further melding of Western and Eastern cultures is expected, including at the level of consumer purchasing behavior.
- Concerns about health and aging will be important to many consumers in China, propelling demand for health-related higher-value products.
- So-called diseases of affluence (obesity, heart disease, diabetes) are spreading through East Asia.¹²¹ Rising incomes coupled with the availability of non-traditional foods are two drivers of this trend.



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Implications and opportunities to 2040

- There will be more East Asian consumers, and many will have more money to spend on food, including middle- and upper-income consumers who can afford higher-value foods. What types of food products will this new affluent class want? Foods associated with safety, quality, health, and nutrition will be a priority.
- Increases in demand for convenience foods will provide opportunities for both value and volume sales, depending on the product.
- Markets for processed and value-added products will flourish in East Asia—and larger volumes of meat and basic products will also be in demand.
- There is an opportunity for more trade with Asia, especially: meat, feed to produce meat, processed products, and dairy products.
- Expansion of domestic production in China could also satisfy this increased demand.
- Low-cost producers will continue to make inroads in supplying a portion of the Chinese population.
- Companies that can develop a mix of products to capitalize on the opportunities to sell to multiple income levels and new demographics will benefit most.

Emerging issue: As the East Asian population, and world population, ages, nutrition/functional foods are seen as a way to prevent or address health issues

Populations in Asia will “gray,” transitioning from today’s large working population to a larger elderly population. In higher-end consumer markets, these elders will seek foods that provide health benefits beyond basic nutrition.

Drivers

- The percent of East Asians aged 65 and over is expected to increase sharply from 2010 to 2040.
 - In Japan, the population over 65 will increase from 27% in 2010 to 42% in 2040.

Food 2040

- In Korea, the population over 65 will increase from 16% to 37%.
- In China, the population over 65 will increase from 10% to 27%.
- By 2040, there will be 580 million seniors over 65 living in East Asia (and over 1.5 billion globally).¹²²
 - Not only are there more elderly people in Asia; they are living longer as well.¹²³
- The seniors of 2040 will be more modern in behavior and thinking than previous generations of Asians in this lifestage, and will be more open to new ideas about food, food technology, and health.¹²⁴
- Tomorrow's seniors are today's 35-year-olds. While they may be richer and live longer, the seniors of 2040 could face diseases of affluence (obesity, diabetes, etc.) that previous generations avoided.¹²⁵
- Diseases of an elderly population are different from those of a young population. Seniors with the means to avoid illness will be willing to spend to do so.
- Reflecting long-held ideas of functional foods derived from traditional medicines, Asia is the leading market for nutraceuticals.¹²⁶
- In 2010, China became the world's largest nutraceutical market.¹²⁷

Implications and opportunities to 2040

- The aging of East Asia will happen much more rapidly than the aging of the US and Europe; hence, East Asia will be forced to adapt more rapidly.
- A lack of large-scale societal support programs for older populations in some Asian countries will be a major challenge for governments.
- Older people tend to eat less food than those who are younger, so the quantity of food sales to these populations per capita will decrease. Producers and retailers will need to adapt with strategies for delivering increased value.
- Asia has a rich history of using non-pharmaceutical means to treat health conditions, and this provides opportunity for acceptance of food products that have health benefits.
- New products with health benefits will meet a ready but discerning audience, and health claims will need to be supported.

Food 2040

- A confluence of consumer trends favor biotech as a path to nutraceuticals. The problems arising from aging and diseases of affluence, the popularity of nutraceuticals and of functional foods in general, and the growing acceptance of biotechnology all suggest that biotech-derived nutraceuticals could be a popular tool for dealing with health problems facing the growing “silver market.”

Emerging issue: Demographic shifts will transform food demand in Japan over the next 30 years— with fewer domestic consumers and greater focus on higher-value food products for the elderly and affluent

Drivers

- Japan is on track for “hyper aging”: its over-65 population will comprise 42% of the total population by 2040.
- Japan’s marriage and fertility rates continue to fall.
- Divorce rates among the elderly are high.
- The average age of first marriage is rising, driven in part by the tighter economic outlook for younger generations.
- The structural composition of Japanese households is changing, from extended families (i.e., 3–5 people per household) to 1–2 persons per household.
- Japan’s wealth is concentrated in the older population.
- Similar demographic patterns are emerging in Korea and, over time, the rest of East Asia. By 2040 China will be seeing aging-related issues similar to Japan’s today—that is, unless its population policies change.

Implications and opportunities to 2040

- “Silver products” (i.e., for the elderly) offer a promising future for Japan, Korea, and later, China. Products with the following characteristics will be of high interest:

Food 2040

- Health attributes for seniors, such as support of weight control
- High levels of food safety and quality
- There will be growing opportunities to develop dietary supplements.
- Japanese seniors' health orientation might make them more accepting of GM food products. If biotech crops can offer health benefits, such as reducing blood pressure, Japanese seniors, and perhaps other Japanese consumers, could be more open to GM foods.
- Demand will grow among younger and less affluent populations in Japan for low-cost product alternatives.
- Challenge: The regulatory environment is at odds with market needs for lower-cost foods, as well as with the overall shrinking of Japan's market.
- Challenge: Across the supply chain, companies will shrink or disappear unless they adopt strategies to grow in a shrinking market. These strategies could include:
 - Increase exports. High-value products including vegetables and fruits have the greatest potential. Little potential is seen for the export of raw commodities or meat.
 - Develop products targeted specifically at concerns of the elderly (products for those with impaired digestive functioning, products targeted at specific health conditions, etc.).
 - Compete actively on safety, presentation, and price.
- There is an opportunity to push for immigration or related policy reforms to revive Japan's population growth. However, most industry and government observers expect Japan's immigration policy will not change despite the demographic realities.
- Declining food consumption volume in Japan means food products will have to compete fiercely to maintain market share.

Food 2040

Emerging issue: Declining Japanese consumer purchasing power in the long term will increase consumer focus on food prices

Drivers

- Income levels among younger generations are expected to fall.
 - Currently, seniors (age 65 and older) account for 25% of Japan's total population and 60% of Japan's financial assets.
 - Younger generations will not see the same levels of wealth as they age, because:
 - Japanese inheritance laws limit the wealth passed to heirs.
 - When younger people today retire 30 years from now, they won't have the generous pensions that were received by today's elderly—unless Japan's economic situation significantly improves.
 - The middle class is also becoming poorer.
 - In 1999, 50% of the working middle-class population made less than \$50,000 per year; in 2009 this share was 60%, and that share is expected to increase in the future.
 - Food prices are expected to play an important role for consumers making less than \$50,000 per year.
 - The old-age dependency ratio in Japan is expected to increase from 36% in 2010 to 71% in 2040, representing a growing burden on the working population.¹²⁸

Implications and opportunities to 2040

- Price will play a major role in the types of food products Japanese consumers buy in the future.
 - Food safety is a major concern, as is acceptance of GM products. But over time, price will have a greater influence on the food purchasing decisions if most Japanese consumers become more cost-conscious. Major incidents involving food safety scares would override price-consciousness, however, and motivate consumers to spend more for safety and quality.



Food 2040

Emerging issue: Japan's shift from fish protein to meat and dairy proteins

Drivers

- Western-style commercial culture is accelerating in Japan as well as other parts of East Asia.
 - As East and Southeast Asian markets have opened to Western diets and food chains in the past 30 years, these companies have moved quickly to capture new consumers.
 - Western fast-food chains are now among the most popular restaurants in East Asia, with higher reputations for quality in China and Taiwan than they have in the West.¹²⁹
 - The advance of Western brands and companies is not restricted to larger, wealthier urban areas. Even in rural areas and third-tier cities, Western products such as Oreo cookies can be found.¹³⁰
- Fish consumption is currently concentrated in the older segment of Japan's population.
 - Fish consumption declines sharply with age. Currently, consumers aged 60 and over average about 17 kilos/year in per capita fresh fish purchases, while consumers under 50 average less than 6 kilos/year.
- The Japanese diet, along with other East Asian diets, is becoming more Westernized as younger people increase consumption of pizza, bread, hamburger, chicken products, and other foods that use more meat than fish.
- Younger people prefer meat over fish and tend to say they do not like fish or feel they can properly cook it.
 - Lower culinary skills favors use of meat instead of fish. Consumers view fish as a more difficult protein to cook.
- Wild-caught fish supplies are declining and this is unlikely to change in the future. Increased production will come from aquaculture, but only for limited number of species (i.e., more "commercial" and adaptable species); hence prices for high-end/wild caught species will rise, further limiting consumption.
- Japanese consumers who eat fish prefer wild-caught over aquaculture, due to taste preferences. However, this could change if the price is right.



Food 2040

Implications and opportunities to 2040

- Likely slower growth in fish consumption implies greater poultry, pork, cheese and beef imports, with the US as the favorite supplier.
- An opportunity exists for development of new, more cost-effective technologies for large-scale aquaculture for new species (i.e., other than salmon or tilapia), as well as for production of aquafeeds.
- Demand for aquafeeds will grow—mainly of high-protein vegetable meals to replace fishmeal. This provides an opportunity for US soybean complex and seed developers.
- Demand will rise for specialty vegetable oils with attributes similar to fish oil (especially omega-6 and omega-3 fatty acids)—representing another opportunity for US soybean growers and seed developers.

Emerging issue: The changing role of Asian women will change food consumption patterns

Drivers

- Women are reshaping their traditional gender roles in East Asian society.
 - Women in affluent East Asia (Japan, South Korea, Taiwan, and middle-class China) are marrying later or forgoing marriage altogether. The mean age of first marriage for women in these countries is now 29–30 (older than in the West).¹³¹
 - In East Asia, two-thirds of women are now employed, and in South Korea, there are more employed 20-something women than 20-something men, further shifting family eating patterns.¹³²
 - Female earnings are rising in East Asia, due to higher levels of female education and the decision by women to delay marriage and family for careers.¹³³

Food 2040

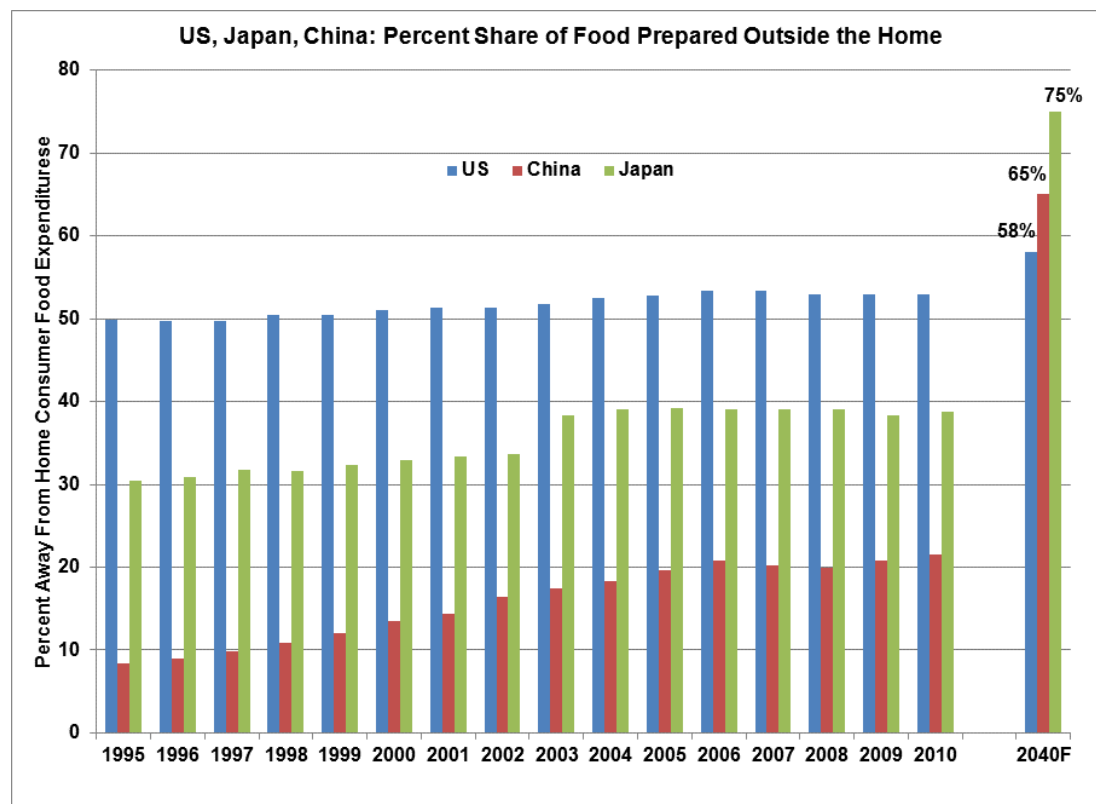
Implications and opportunities to 2040

- **Women's freedom.** Increasing social freedom will continue to alter women's roles in East Asian societies, transforming society in general as well as family dynamics. Single, middle-class women spend differently, shopping for themselves rather than for families.
- **Men as household shoppers.** As a result of women delaying or forgoing marriage, men are facing longer periods of single life. Where in the past certain products (household goods, non-bachelor food) were purchased either in conjunction with wives, or by women solo, increasingly this is no longer the case. Men as a shopping demographic will require new forms of marketing and even branding, and this will affect a wide range of products that male consumers traditionally have never purchased.

Emerging issue: Japan's away-from-home food industry is expanding rapidly

The share of Japanese food prepared away from home is expected to expand from 38% of consumer food expenditures in 2010 to 70–80% by 2040. This trend is expected to occur in the rest of Asia and is already evident in China. This projected shift is the result of expanded sales of prepared foods (primarily fresh) in supermarkets, delis, restaurants, and convenience stores (e.g., 7-Eleven) as well as of home delivery. This is not a shift to fast foods and/or frozen dinners, such as has occurred in the US—rather, it is primarily a shift to fresh, chilled pre-prepared meals that are viewed as healthy, and that are packaged in smaller portions so consumers can save money by buying only what they need. This trend will be driven by the need to reduce space taken up by the kitchen, the convenience of not having to cook, a growing aging population, and an increasing number of smaller households.

In the US, away-from-home food expenditures have increased only 3% in the last 15 years and may increase only 8% more over the next 30 years (see figure on next page).



Drivers

- This shift has been underway in Japan for decades, and is starting to gain traction in China.
 - Major supermarket chains are selling prepared meals.
 - Convenience stores (e.g., 7-Eleven) carry a wide array of fresh, ready-to-eat foods.
- More families are seeking convenience.
 - Two-income families, where both spouses work and do not have time to cook, are increasing rapidly.

Food 2040

- Younger generations, including new mothers, have reduced skills or desire to cook.
 - One foodservice director says “25% of new mothers do not own a knife.”¹³⁴
 - Younger people do not like to cook and prefer to do other activities before they eat, which is different from older generations which prefer to eat first.
- Lower incomes, and lower expectation of future income among younger Japanese, have created a more cost-conscious market segment that favors ready-to-eat and convenient food.
- Shrinking families and more solo eating mean a greater focus on smaller quantities of food.
- Aging population
- Need to reduce space taken up by kitchens because of smaller apartments

Implications and opportunities to 2040

- Competition will increase within the food prepared-away-from-home sector, for example, between the fresh-prepared cooked meals sold in supermarkets, delis, and convenience stores and those sold in fast-food restaurants such as McDonald’s and KFC.
- There is an opportunity to increase food processing and the ready-to-eat industry, but at the expense of domestic food processors that rely on bulk, rather than specialized, inputs.
- There is an opportunity to market or develop more advanced home food preparation technologies, e.g. smart microwaves instead of traditional stoves.
 - Microwaves that can cook a combination of foods simultaneously could be demanded.
- There is an opportunity to develop packaging materials for small portions adapted to the needs of shrinking households.
 - Emphasis on longer shelf life so the food can stay fresher longer.
 - Nanotechnology will enable packaging that keeps products fresher.
- Domestic distribution channels will need to shift to support more end markets.
- Discerning East Asian consumers eating more processed and pre-prepared foods will still want safety and quality, implying a need to include more information on packaging labels.

Food 2040

- Current regulations do not require labels in food service, but consumer groups and consumers in general will ask for this by 2040.
- The greater focus on processed foods, rather than ingredients, could change import mixes.
- Stores will likely need to be smaller as the focus on prepared foods increases.
- There will be an increased need for electronic transaction tracking system across the food supply chain, to accommodate a larger number of transactions as people replace home cooking with buying finished meals.
- Countries with cheaper labor, such as China, could become Japan's kitchen by exporting pre-prepared meals to Japan.
- More pre-processing will be needed: foods will need to be fully processed before sale with a variety of cutting, assembly, and cooking by processors and perhaps more likely by retailers.
- US agricultural and food companies will need to focus their marketing more on Japanese/Asian food processors/retailers, less on consumers.

Emerging issue: China's food service sector is where Japan's was 10–20 years ago, but will likely be bigger than Japan's by 2040

Drivers

- China's march to urbanization continues as people move from rural areas to urban areas for jobs.
 - China's urban population has grown from 20% of the nation's population in 1980 to 34% in 2010, and will potentially reach 70–80% by 2040.
 - Urbanization drives up meat consumption. In 2010, China's urban population accounted for over 60% of national meat consumption.
- Increased disposable incomes will be used to buy processed and foodservice meals.

Food 2040

- Urban food expenditures per capita have increased at rate of 9% to 10% per year for the past 20 years. During the same period urban food expenditures as a percent of total consumer expenditures declined from 55% to 35%.
- Urbanization also drives demand for convenience, due to increasingly fast-paced lifestyles.
- Chinese away-from-home food expenditures have increased more than 150% in the past 15 years, from 8% in 1995 to 21% in 2010. Rural away-from-home food expenditures remained stable at 7% over this period.
 - The Chinese food service sector is where Japan's was 30 years ago, but is growing 30–50% faster than Japan's (depending on how it is measured).
- Demand is growing for convenience and quick-service, fast-food, and related foodservice chains.
- US, Japanese, and other restaurants chains have already been rapidly growing in urban markets.
- China's foodservice sector has been growing more rapidly than Japan's, which is a benchmark for the development and Westernization of foodservice products.
- These drivers add to an increased demand for food safety and quality among the middle and affluent classes, and are driving demand for US and other Western food products.

Implications and opportunities to 2040

- There is an opportunity to continue to develop foodservice sectors and particularly quick-service, convenience-driven establishments.
 - Industry sources suggest that China's foodservice will grow similar to Japan's but at a much faster rate.
- There is an opportunity for US food products and companies to target the growing middle and upper classes, who are more concerned with food safety, quality, and branded products.
 - China's affluent class views US products as safer and of higher quality than products produced in China.
 - Increased US-style foodservice will lead to increased demand for US and global meat and grain products.
- Opportunities will grow to market or develop more advanced foodservice-related technologies, including:
 - Smart microwaves
 - Advanced packaging materials



Food 2040

- There may be a need, driven by consumers or regulators, to include more information about food products at the foodservice level, aimed at affluent segments.
- A shift from cooking at home to eating away from home also signals a trend to increase the value of food via further processing and marketing. Thus, by 2040 there is a great opportunity for processed products. A similar development trend was followed by Japan, the US, and other more developed food markets.

Research Theme 2. Competitive and Regulatory Landscape: Evolving Issues and Standards

Over the next three decades, a number of East and Southeast Asian economies are on track to evolve from emerging markets into mature economies. This transition will require institutional changes and regulatory reforms that bring the growing economies of East Asia into closer alignment with global standards and practices. Protection of intellectual property (IP) rights, adherence to the rule of law, and effectively controlling corruption will be critical to sustaining growth and prosperity in East Asia. Emerging issues regarding this theme are as follows:



Emerging issue: Asian companies are investing in offshore farmland to expand their dedicated agriculture supplies

Several Asian countries are expanding their agriculture production into other countries through bilateral deals or direct foreign investment. They are leasing or acquiring production rights to overseas farmland, and exporting both capital and workers to

Image: Foresight Alliance

Food 2040

improve the production of these resources. This offshore production is oriented toward consumption in home markets, not for international trade. For example, China is buying or leasing farmland in parts of Africa and Southeast Asia as well as in agriculture powerhouses such as Brazil, Argentina, and Australia. South Korea has leased or purchased farmland in Madagascar, Sudan, Mongolia, and Eastern Russia. Japan is investing in biofuel production in Indonesia as well as buying farmland in Brazil and China.

Drivers

- Limited land and water resources for domestic production expansion are driving these nations overseas in a quest for food security.
- Food and commodity price volatility are another motivation to secure production.
- The goal is to ensure long-term food security.

Implications and opportunities to 2040

- Domestic production patterns in East Asia can be an impediment to farm consolidation and efficiency, making foreign investment in high-output agriculture a path of least resistance.
- These overseas farmland acquisitions have the potential to disrupt international trade.
- Nations that host offshore farming are limiting their future domestic food supplies.
- Investment in foreign land can result in infrastructure improvements and jobs for local people.

Emerging issue: Asian consumer groups and consumers may demand more product labeling and stellar reputations for food safety

Drivers

- The influence of consumer groups and NGOs in formulating food legislation is growing.

Food 2040

- Ready information about food products is becoming easier through social media such as Facebook or Twitter or via smartphones.
 - Social networking can disseminate product information quickly, and bad news (e.g., food scares, disease, etc.) travels faster than good news.
- Japanese consumers place a very high cultural value on food safety and quality. While food safety is less important in other East Asian and Southeast Asian countries, concerns continue to grow due to food scares. Younger generations in China and Korea are placing a higher value on food safety than older generations.

Implications and opportunities to 2040

- The renewed focus on safety and quality is opening opportunities to develop niche markets in East Asia for brands established as safe and of high value, and to target higher-income consumers.
- US food is viewed as safe and high-quality, so US brands will continue to enjoy a competitive advantage. There is new opportunity for high-end US food products, including processed products.

Emerging issue: Food safety concerns limiting China's potential as a food exporter

Drivers

- In China, food contamination incidents make food quality assurance and inspection a necessity.
- China is sharply expanding its vegetable exports.
- China needs to expand the capacity of its cold storage chain.¹³⁵
- China is developing as a niche exporter.
 - China has already developed niche exports of many products, such as apples, apple juice, and honey.¹³⁶



Food 2040

Implications and opportunities to 2040

- China could develop as a quality niche food market. Despite food quality concerns, China is already exporting some processed foods¹³⁷ and could move up the food export value chain, potentially exporting ingredients for higher-value goods and products.¹³⁸
 - Japan upgraded quality perceptions in a generation, and Taiwan can also serve as a model of how to change perceptions of the national brand.¹³⁹
 - Traditional Chinese medicinal herbs and plants have export potential.¹⁴⁰
- China will have a burgeoning food processing industry. Foreign food processing companies are already beginning to operate in China, giving China a route to upgrade its domestic food-processing capabilities to global standards.¹⁴¹
- China's food processing industry has a poor reputation, but the availability of low-cost labor may increasingly attract foreign food processors to use China for basic processing of ingredients. Collaborations with foreign food companies would familiarize Chinese food processors with high-quality food processing standards, expertise that can gradually be developed and internalized by domestic Chinese companies. The Chinese food processing industry may ascend the quality production chain in much the same way that Chinese electronics manufacturing has matured over the last two decades. Foreign firms will work to ensure safety and quality, as some Japanese companies are already doing.¹⁴²

Emerging issue: High and volatile food and fuel prices will likely continue for the foreseeable future

Economic growth in emerging economies, primarily in Asia, will require increasing energy consumption and will generate rapid increases in carbon emissions. This growth will add pressure on global energy supplies and will exacerbate concerns around energy import dependency in individual countries.

Food 2040

Drivers

- Asia accounted for about one-third of the world's energy consumption in 2007 and could account for 47% in 2030. China accounted for 16% of the world's energy consumption in 2007 and could account for 22% in 2030.¹⁴³
- China accounted for 21% of the world's CO2 emissions in 2007 and could account for 29% in 2030. China is expected to be by far the world's largest CO2 emitter by 2030, with emissions more than double the US level that year.¹⁴⁴
- FAO's world food price index reached a record high in February 2011, and continues high relative to historical trends. In addition, food prices have grown more volatile as consumption has grown relative to traditional levels of carryover stocks—a trend likely to continue as global demand growth continues. Climate change could exacerbate these trends.
- Biofuel production is expanding in a number of developed countries and elsewhere, a trend that increases competition for scarce land and water resources.
- High fuel prices directly increase food transportation costs, and can constrain trade as a result.

Implications and opportunities to 2040

- Asia could become 90% dependent on imported oil by 2050.¹⁴⁵
- Asia, and particularly China, will face growing pressure to produce more pressure to produce more fuels from unconventional sources.
- Pressure to expand clean fuel supplies, along with increasing competition for carbohydrate crops, will increase incentives to produce biofuels from cellulosic and other non-food competitive sources biofuels to supplement imported petroleum.



Food 2040

Research Theme 3. Food Technology: Biotech and Agricultural Innovation

Technology innovations from multiple fields—biotechnology, genomics, and information technology—are poised to transform the agricultural sector. East and Southeast Asian countries are stepping up investment in R&D, and well before 2040 could become important global players in each of these areas of innovation. The extent to which East Asia applies these technologies and their use throughout the food supply chain will be crucial in shaping the future of the global food market. Emerging issues regarding this theme are as follows:

Emerging issue: Bioscience in East Asia

New developments in biotechnology and other bioscience will open a wealth of possibilities for crops and agriculture, especially in China. However, biotech development in China is currently at a crossroads: the government strongly supports biotech advances as a means to meet its production self-sufficiency goals, but consumer groups are stepping up their opposition to GMOs used in foods.

Drivers

- The Chinese government has highlighted biotechnology as one of its key areas of development, investing heavily based on the outline of its 12th Five-Year Plan.
- There is an increase in planting of GM crops with multiple bioengineered traits,¹⁴⁶ as well as new technology for creating such crops more quickly and economically.¹⁴⁷



Image: kaibara87 (Flickr)

Food 2040

- China excludes foreign companies from developing biotechnology in China, which protects Chinese companies to develop their own technology.
- Chinese and other Asian biotech firms are enjoying rapid growth and attracting significant new private and public investment.
- Intellectual property rights are a concern in Asian development of biotechnology.
- Improved cropping techniques and practices allow for improved utilization of biotechnology.
- Demand for meat in Asia expands demand for grains and oilseeds, as feed for livestock and poultry.
- Despite concerns regarding biotech crops, consumers in some Asian countries are increasingly accepting GMO foods and food products.
- A consumer study in Taiwan concluded that 80–90% of respondents already accept GM foods.¹⁴⁸

Implications and opportunities to 2040

- Biotech expansion will help meet growing food demand as the middle class grows in East/Southeast Asia.
- Genetic engineering will provide strong assistance in controlling disease in crops.¹⁴⁹
- Gene deletion technology may make it possible to create GM plants that produce GM-free seed or pollen, lowering the risk of genetic transfer to unmodified species.¹⁵⁰
- Biotech research sometimes runs into a disconnect between discovery and application, because commercialization requires major resources. Better follow-up of basic research could be game-changing.¹⁵¹
- Synthetic biology involves the creation of wholly new biological systems from genetic material. One vision is to create nitrogen-fixing bacteria that can communicate with the root systems of corn plants, potentially reducing the need for fertilizers.¹⁵² It may also be possible to use synthetic biology methods to create organisms that produce specific chemical compounds with good yield.
- The gains from insect-resistant traits allow farmers (including those in developing countries) to improve their productivity and economic returns, while also practicing more environmentally friendly farming.



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Emerging issue: East and Southeast Asia crop biotech advances could help deal with climate shifts and resource constraints

A principal focus of biotechnology could shift from increasing yield to improving resilience in the face of changing environmental conditions, such as drought or soil salinity. These issues will be of even greater concern, given the uncertainty regarding future climate conditions and the need to adapt crop production to new, less hospitable growing conditions as the demand for food increases. In addition to adapting to harsher growing conditions, researchers will also seek to improve the nutritional properties of foods. One example of this is the incorporation of traits in crops that can allow for the production of healthier oils.¹⁵³ Sixty-eight percent of Delphi panel respondents believe that genetic modification of output traits, such as nutritional content, will have major or moderate-to-major impact on global agriculture over the next three decades, compared to 49% who feel similarly about input traits such as herbicide resistance.¹⁵⁴

Drivers

- Climate change may alter growing conditions in much of East and Southeast Asia, leading to more precipitation in some regions and less precipitation in others.¹⁵⁵
- New, faster technologies for biotech development will become available, allowing genetic improvements to be made more rapidly than in the past.
- Global population growth will demand food supply growth, but this will require growth of crops in areas with less favorable growing conditions.
- Irrigation will contribute to problems of soil salinity, and crops that can grow and generate yields in those conditions will be needed.
- Consumers with higher incomes will have higher expectations for the healthfulness of food than they have in the past.



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Implications and opportunities to 2040

- Drought-resistant and salt-tolerant crops have been under development for some time, but have not yet been introduced commercially.¹⁵⁶ More than 75% of Delphi panel respondents believe these will have major or moderate-to-major impact on global agriculture over the next three decades.¹⁵⁷
- Biotech corn with a reduced requirement for nitrogen would allow for reductions in the cost of production, while phytase corn would help address environmental concerns by reducing the release of phosphorous.
- Traits like enhanced drought tolerance and nitrogen efficiency are generally multigenic traits in plants, and will require regulation of pathways rather than insertion of single genes.¹⁵⁸
- Changing the composition of food at the production level to be healthier will be one of many technologies in a toolkit of improving the healthfulness of some foods.

Emerging issue: Diverse technologies go beyond biotech in food system

In addition to bioscience, a large number of new technologies may have substantial impacts on food and agriculture in East and Southeast Asia. For example, precision agriculture applies sensors and infotech to optimize the application of agricultural inputs like water and fertilizer.¹⁵⁹ Nanotech can be used to develop new sensing systems, or to create new food ingredients by processing common ingredients in novel ways.¹⁶⁰

Drivers

- Electrification, mechanization, and modernization of agriculture in developing nations are increasing the opportunities to apply agricultural technology.¹⁶¹
- There is substantial waste in the global food production system—and therefore opportunities to deploy technology innovations to reduce waste and mitigate food shortages that are forecast for the future.¹⁶²
- Perennial grains would have important environmental and economic benefits. Researchers are working to develop perennial versions of wheat, sorghum, sunflowers, legumes, maize, and rice.¹⁶³



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- Precision agriculture applies sensors and infotech to optimize the application of agricultural inputs like water and fertilizer.¹⁶⁴ More than half of Delphi panel respondents believe that precision agriculture will have major or moderate-to-major impact on global agriculture over the next three decades.¹⁶⁵
- Sensors, information systems, and packaging technologies will enable more complete, accurate, and precise tracking of food ingredients and products, including their ambient environmental conditions and safety and quality parameters.¹⁶⁶
- “System of systems” approaches leverage information technology and sensors to optimize extended systems—for example, the entire energy system of a city—that were previously too complex to manage concurrently, and can now be applied to agricultural production and distribution systems.¹⁶⁷
- Gene deletion technology may make it possible to create GM plants that produce GM-free seed or pollen, lowering the risk of genetic transfer to unmodified species.¹⁶⁸
- Marker-assisted breeding technology tracks genes in order to speed the development of new traits via conventional breeding.¹⁶⁹ New technologies developed over the past decade have accelerated the process of discovering and applying genetic markers.¹⁷⁰
- As noted above, synthetic biology involves creating wholly new biological systems from genetic material. For example, nitrogen-fixing bacteria could be created which communicate with the root systems of corn plants, potentially reducing the need for fertilizers.¹⁷¹ Synthetic biology may also be used to create organisms that produce specific chemical compounds with good yield.
- More controversial but plausible technologies include artificial meat (meat grown via tissue culture rather than by raising whole animals) and animal cloning (for example, to create exact copies of animals with optimum traits, such as meat or milk production). Japan is a world leader in animal cloning research.
- Engineered zinc-finger nucleases can be used to insert and remove genes from specific sites in plant genomes, enabling highly precise genetic modifications.¹⁷²
- Nutrigenomics—the use of individual genetic information to tailor a diet optimized for that individual—will transform the notion of a healthy diet, but decades will be required to understand and apply information connecting genomics and diet.

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- Aeroponics and hydroponics are high-intensity forms of agriculture with the potential to be deployed in urban settings, either on a small scale in individual restaurants and houses or on a larger scale in multistory “vertical farms.” While capital and operating costs are high, crop yields can be extremely high due to the controlled environment.

Implications and opportunities to 2040

- **National goals.** Different nations will prioritize, support, and implement particular technologies differently in response to national needs and priorities.
- **Intellectual property rights.** The right to protect agricultural technology innovations will be key to the growth of agriculture in developed and developing nations. Granting of intellectual property rights for genetic material and organisms remains controversial.¹⁷³
- **Regulatory process.** Development and global harmonization of effective regulatory processes is essential to realizing the potential benefits of new agricultural technology.¹⁷⁴
- **Black and gray markets.** With some East Asian nations generally accepting GM foods and others resisting them, there is the potential for conflicts and illegal activity.¹⁷⁵

Emerging issue: GM foods are expected to become a non-issue for China and much of Asia, but products labeled “non-GMO” will maintain a market among upper-middle and affluent East Asians

Drivers

- Consumers already eat GM-derived products including vegetable oil (e.g., soybean oil made from GM soybeans), meat (e.g., feed is GMO), and dairy products (e.g., livestock fed GM soybean meal).¹⁷⁶
- Consumers are hesitant to consume GM foods that are labeled as such (GM wheat) or are consumed directly (GM rice or GM soybeans for tofu).
- Negative perception of GM is shifting, with younger generations more accepting than older generations.

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- Increased consumption of processed food products and through foodservice establishments (i.e., where labeling is less visible) will support increased use of GM foods.
- The expert consensus on China is that once it develops GM crops internally, its GM food production will rapidly increase.
 - Chinese and other Asian biotech firms are enjoying rapid growth and attracting new private and public investment.
- Current biotech pipelines shed light on what will arrive in the next 10–15 years. New GM seed varieties will target 3 specific trait characteristics: 1) agronomic, 2) yield and stress, and 3) value-added.
 - Agronomic seed varieties aim to promote resistance to disease and insects and tolerance to herbicides. The most common type of GM seeds, agronomic traits will be applied to 50 new seed varieties in the next 10 years, in canola, corn, soybeans, sugarcane, vegetables, wheat, and rice.
 - Yield and stress varieties aim to limit yield loss in adverse conditions. They are receiving new attention and effort in the research and development pipeline. A total of 20 new seed varieties for corn, canola, cotton, soybeans, and wheat will be released by seed companies over the next decade. Varieties within this genre aim to increase yields under both adverse and normal conditions. Companies like Monsanto, Pioneer, and Syngenta have made additional efforts to stabilize yields under water-stressed conditions.
 - Value-added seed varieties have expanded beyond traditional agricultural production risks associated with yield, and are working to provide seed varieties with added nutritional, health, or taste attributes. Currently, 11 new varieties with such attributes are working their way through the pipeline, targeting soybeans, corn, rice, and vegetables. The majority of these varieties aim to provide added nutritional and health attributes to foods, such as increased omega-3s or high oleic soybean oils with less fats.

Implications and opportunities to 2040

- Global adoption of GM foods will grow.
- New biotechnology companies are emerging in East Asia, particularly in (but not limited to) China.

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- New GM varieties will arise that target demographic trends—e.g., health attributes incorporated into food ingredients (e.g., wheat with probiotics, corn that helps the environment via lower GHG, or soybean oil high in omega-6 fatty acids)
- Agricultural biotechnology, which has been primarily focused on crop plants, will be extended to other areas—livestock, pests, beneficial insects, etc.
- GM foods will steadily develop a track record for safety. So far there have been no health incidents; by 2040, GM foods will have been in the market for 40–50 years.
- Japan is somewhat of an outlier in East Asia: it will remain a destination for non-GMO foods.
- Anticipated growth of food demand will support the need to increase productivity, and consequently will stimulate interest and need around biotech developments that can improve yield, adapt to climate change, and bring marginal land into cultivation.

Research Theme 4. Agriculture and Food Distribution and Packaging (Grain Transportation/Infrastructure)

Logistics and supply chain management for transporting agriculture and food has advanced with changes in technology, ocean vessel sizes and types (dry bulk and container), rising energy prices, and packaging and product labeling requirements. This section will focus on two sub-areas: (1) Agriculture Grain Transportation and Infrastructure, and (2) Food Distribution and Packaging. Emerging issues regarding this theme are as follows:

Emerging issue: Containerization will continue to grow as demand for processed products (cheese, yogurt, meals, specialty crops) and meat increases; commodity crops will remain in bulk

Containers are used to transport food products including dairy products, meat, processed products, fruits and vegetables, and others. However, until the past 10 years the use of containers for transporting feed and food grains and oilseeds has been more limited. Since then, container use for these goods has increased rapidly; for example, container grain exports accounted for up to 5% of US trade in 2010. The emerging issue is the increased containerization of crops, driven by (1) market demand for specialty/customized crops and supply chain assurance, (2) a potential switch from trading crops (e.g., feed or wheat) to trading processed products (e.g., meat or pasta); and (3) the changing economics of using bulk vs. container transport in supply chains. At the same time, undifferentiated/generic crops will remain in a bulk distribution system, and in even larger vessels. For instance, expansion of the Panama Canal will support

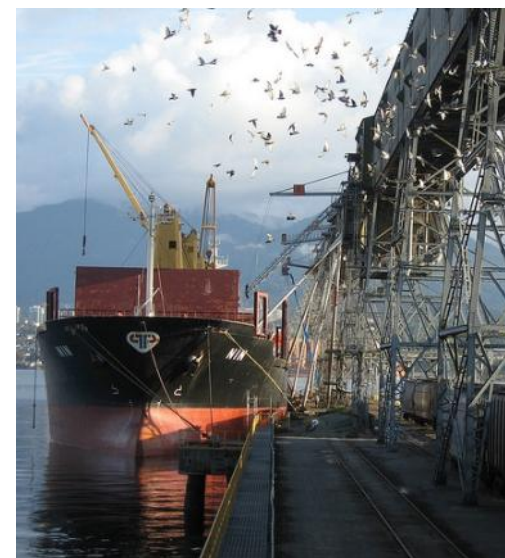


Image: AverageJoe (Flickr)



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construction of larger bulk and container vessels; five major ports in Japan are already being redesigned to accommodate larger “Panamax” vessels.

Drivers

- Rising incomes will drive “nichification” of consumer preferences in East Asia, in turn driving differentiation of grains and other agricultural products (e.g., high-protein varieties, non-GMO, and others).
 - Customers will want a large array of increasingly specific food attributes in the future. This consumer base will be drawn mainly from upper-middle and affluent classes in East Asia, with Japan as a leader; as income increases it will expand to affluent classes elsewhere.
 - This segment of consumers wants convenience, quality, consistency, health, and food safety.
 - Consumer demands are becoming very specific (e.g., non-GMO, high-fiber, organic or natural, lower fat).
- Demand for supply chain assurance is rising accordingly.
- Containers can be integral to quality assurance programs. The pipelines of seed technology companies already show a wide array of differentiated crops that, if traded, will need supply quality assurances.
- Through 2040 there is the potential for a large-scale switch from trading crops (e.g., feed or wheat) to trading processed products (e.g., meat or pasta).
 - As China and other East Asian developing economies quickly increase food consumption, they will need to import more meat and dairy products as feed for domestic livestock production. For example, China is not expected to be able to meet its own domestic meat demand via domestic production, due to water, land, demographics, and environmental issues.
 - Korea is expected to increase meat imports significantly in the future.
 - As energy and logistics costs rise it becomes more economical to import meat than feed ingredients.
- The economics of bulk vs. container transport in supply chains is shifting.
 - Containers are becoming increasingly available on freight markets.
 - New producers and consumers are leading to penetration of marginal markets that are better served by containers rather than bulk.

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- Bulk shipping rates are rising and fluctuating.
- Relative rate stability is increasing, making containerization more attractive as an option.
- Empty containers are being repositioned, particularly for trips to Asia where more containers are available for backhauls.

Implications and opportunities to 2040

- These trends in containerization will afford greater supply chain control and the potential to increase field-to-factory initiatives.
- Increased use of traceability and identity preservation systems will increase the cost-competitiveness of containers relative to bulk.
- The containerization of global shipping and logistics provides an extensive foundation upon which new sensors and methods of supply chain monitoring can be deployed.

Emerging issue: China's expected economic growth by 2040 will require expanded and improved transportation infrastructure, traceability, and identity preservation

Drivers

- China's government recently added logistics to its top 10 priority industries for revitalization.¹⁷⁷
- Significant capital investments are necessary to modernize and extend highway networks, railway systems, and air- and seaports.
- China has focused on infrastructure development over the last decade and now has more advanced port structures than Japan's, in some cases.
 - China needs to improve food quality and safety for both domestic consumption and exports, making infrastructure upgrades a competitive necessity.

Food 2040

- Liberalization of China’s logistics sector is allowing wholly owned foreign firms to become established in the market. The resulting influx of foreign investment will “be key to rapid development of a world-class logistics sector.”¹⁷⁸
- Cost-effective inland transport is important to helping China’s inland farms compete for consumer food dollars in China’s coastal cities and abroad. Given the government’s focus on strengthening its interior economy, this will further motivate it to create an effective nationwide intermodal transport system.
- Taiwan has a traceability program underway, with top-level government commitment.¹⁷⁹
- Japan is a leader in sensor miniaturization.
- Consumer demand for quality is strong, and rising incomes will allow them to pay for it.
- Traceability will be facilitated by technological innovation, such as edible RFID chips.¹⁸⁰

Implications and opportunities to 2040

- Effective modern distribution and logistics systems will become a crucial competitive differentiator for both nations and companies operating in East Asia.
 - China, out of necessity and opportunity, will develop a world-class internal distribution infrastructure.
 - Foreign and domestic firms in China will vie in a highly competitive distribution sector.
 - In the next decade China will likely finish upgrading its major infrastructure (ports, shipping channels, river navigation, highways, high-speed and freight rail, etc.) and will transition to concentrating on other issues such as sustainability of infrastructure and compliance with codes.
 - Foreign investment will speed deployment of traceability systems in Asia. In China, wholly owned foreign companies will deploy traceability systems and impel domestic competitors to do the same.¹⁸¹
- Elsewhere in East Asia, too, infrastructure will be modernized. Experts believe most of East Asia will achieve advanced distribution and logistics infrastructures during either the 2020s or the 2030s.¹⁸²
- Rising consumer demand for safety and quality, along with rising incomes, will drive investment in traceability and identity preservation.¹⁸³

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- Containerization (unitizing commodities into smaller parcels to preserve and protect perceived and realized value benefits and protection of those commodities) will facilitate traceability. “The containerization of global shipping and logistics provides an extensive foundation upon which new sensors and methods of supply chain monitoring can be deployed.”¹⁸⁴

Emerging issue: Japanese consumers want smaller-portioned food products and more information about these products

Drivers

- Older consumers eat less, so as Japan ages its population will want smaller portions.
- Ready-to-eat meals from convenience stores and home delivery services are growing strongly. The share of food prepared outside the home in Japan has been rising since the 1960s, from about 11% of Japanese consumer food expenditures in 1963 to nearly 40% in 2010.
- Japanese households are shrinking as fewer people marry or have children.
- Consumer demand for quality and safety are driving demand for better information about food products.

Implications and opportunities to 2040

- Japanese consumers will want smaller quantities of food.
 - Prepared meals and processed foods will increasingly be sold in different sizes so customers can buy only what they need to eat.
 - Price points can be disproportionately higher on smaller portions, opening an opportunity for greater profits.
- Aging will also provide opportunities to develop new product lines for food processors.
- Improving safety and transparency will need to go beyond the traditional “Sell by [date]” stamp, which neglects, for example, whether the product was inadvertently exposed to elevated temperatures during

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storage or transportation. The opportunity to develop more specialized packaging materials and products could be very large; for example, the emerging category of “smart packaging might include microbial growth and temperature-time visual indicators based on physical, chemical, or enzymatic activity in the food itself—giving an accurate and unambiguous indication of product quality, safety, and shelf-life condition.

○ Smart packaging features that could become common include:

- Real-time freshness indicators (e.g., for meat or milk)
- Time-temperature history
- Microbial growth indicators
- Leakage, microbial spoilage indicators

○ Smart packaging will be integral to many traceability systems as well.

- There will be logistics challenges to move individually packaged ready-to-eat meals in large urban areas, such as Tokyo.

Emerging issue: Japanese crop and livestock agriculture production will be flat at best, but more likely will decline by 2040

Drivers

- Japan’s farmers are aging. Over 60% of Japan’s commercial farmers were age 65 or older in 2009.
- Farming is viewed negatively: 70% of male farmers marry foreigners (mostly Chinese) because Japanese women won’t marry them.
- Japan has declining amounts of arable land available for any meaningful agricultural expansion. Agricultural area over the last 30 years has declined from 6.1 million hectares to 4.6 million hectares.

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- Most production is limited to small-scale (thus less competitive) farms, partly due to limited available flat land. However, in the future this could change, potentially reducing (though only partially) the decline in agricultural production.
 - One driver favoring increased production: the rise of industrial farming (i.e., US- and Brazil-style farms), which is expected to become common in Japan.
 - One driver against increased production: corporate farming enterprises are already focusing on high-value crops (e.g., vegetables, spices, fruits), since these can be globally competitive with or without government support.
- Japan currently has restrictions on selling land to bigger farmers, but as corporate farming ramps up, farm and population demographics will compel the government to support these alternative farming structures.
- In the future Japan may participate in more free-trade agreements (e.g., the Trans Pacific Partnership Agreement or TTP), driven by its need for a competitive export industry.
 - Japan is a major global exporter. As its domestic markets shrink for all industries, it could depend more and more on its exports for growth.
 - Agriculture (in Japan, a protected industry with high tariffs) represents 3% of national GDP, so farmers may not be able to block future free-trade agreements that favor GDP, including around food processing industries that want to export to Asia and the US.
 - If Japan joins the TPP, concerns are:
 - Livestock producers will not be able to compete since for meat (carcasses and half-carcasses) the import tariff is currently 38.5%.
 - Rice producers will also have a difficult time competing with imports because of high import tariffs.

Implications and opportunities to 2040

- Import volumes of meat, rice, wheat, and other commodity-like products will rise, with US meat and grains as favored suppliers.
- Production of processed products, targeting exports, will rise.

Food 2040

- Food processing and distribution centers will need to be shifted to port areas where raw materials (bulk and containers) are imported.
- Japan will become a more important player in the export of high-value products including vegetables, spices, regional fruits, dairy products (e.g., yogurt), and other processed products.
- Opportunities exist to invest in large farming operations in Japan.

Research Theme 5. Environment and Resources: Impacts of Global Growth

Over the next 30 years, East and Southeast Asia's environment and expanding agricultural industry are likely to impose increasing stresses upon each other. Demand for both quantity and quality of food will escalate in the face of limited environmental resources. The question of how to meet required production levels while also mitigating environmental degradation will be a key challenge, not just for emerging East Asian economies seeking their fair share, but also for developed economies working to maintain and increase production of the high-quality food their consumers have become accustomed to. Emerging issues regarding this theme are as follows:

Emerging issue: Global overfishing limits wild fish availability and fuels aquaculture growth

From 1974 to 2008, overexploited, depleted, or recovering fish stocks increased from 10% to 32% as a share of wild fish stocks. However, due to expansion of aquaculture production, global fish supplies have increased at a relatively steady rate of roughly 4% per year since 1950, offsetting wild catch production (which has been stable since the 1980s). Global fish production is expected to increase at a rate of 2.1% annually between 2005 and 2030, assuming no growth in wild catch production and implying a 3.9% annual growth rate in aquaculture through 2030.

Drivers

- World fish consumption increased 300% from 1961 to 2007.



Image: Harry Wagner (Flickr)

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- East Asian populations (Japan, China, and South Korea) are especially fond of fish, with their share of global fish consumption increasing from 11.7% in 1961 to 41.6% in 2007.
- From 1961 to 2007, China surpassed Japan as the largest consumer of fish in East Asia, increasing its share of world fish consumption from 11.8% to 32.2% during this period while Japan decreased its share from 16.9% to 7.1%.
- Global fisheries production (capture fisheries and aquaculture) has increased significantly in the last 30 years. Most of the increase is attributed to aquaculture development. A large share of this aquaculture production growth has come from China.

Implications and opportunities to 2040

- Total aquafeed demand can be expected to increase by roughly 45 million metric tons by 2040, due to increases in aquaculture production and an increased share of aquaculture species consuming compound feed.
- As world fishmeal production faces sustainability constraints, other protein sources will be required to meet growing aquaculture demand.
- Plant proteins could account for 16–25 million metric tons of aquafeed demand in 2040, based on average-to-maximum plant protein inclusion rates of 20–30%, respectively.

Emerging issue: Environmental impacts on agricultural production in East Asia

East and Southeast Asia are facing environmental constraints on agriculture in terms of land and water availability and quantity. In addition, agricultural practices in certain countries are greatly taxing both water resources and agricultural lands. At the same time, the region faces very limited available land for agricultural expansion, which means that future increases in production to feed growing populations will have to come from imports, yield gains, and cropping intensification. These could increase stress on Asia's natural resources even further, unless they are carefully managed and closely regulated.



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Drivers

- Chinese agriculture:
 - Given population density and the still-backward state of much Chinese agriculture, Chinese farming has much more room for efficiency improvements than for footprint expansion.¹⁸⁵
 - China's pork industry in particular has huge impacts on the environment, even though it is not yet in factory farming mode and thus not yet at maximum production capacity.¹⁸⁶
 - Consumers in densely populated areas of China are quick to perceive environmental impacts, and attitudes are shifting toward increased activism.¹⁸⁷
 - Educated elites and NGOs are active in raising awareness of environmental impacts.¹⁸⁸
 - China is responding to its environmental crises. Mitigation and adaptation efforts are underway. For instance, one government program focuses on increasing the use of methane digesters; another educates farmers in the use of pesticides; a third aims to recover soil fertility.¹⁸⁹
 - As Chinese farmers continue to age, experts foresee a consolidation of today's "patchwork of small farms,"¹⁹⁰ transforming the organization of agriculture toward improved efficiency.
 - Desertification problems and decline in pasture quality have led the government to subsidize herders to reduce the number of grazing livestock.¹⁹¹
- Water:
 - "Estimates suggest that exported foods account for between 16% and 26% of the total water used for food production worldwide, suggesting significant potential for more efficient global use of water via trade."¹⁹²
 - Population growth, urbanization, and industrialization will increase demand for water, especially in developing economies.
 - Global water demand is projected to rise 35–60% between 2000 and 2025, and could double by 2050.¹⁹³



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- Agriculture currently consumes 70% of freshwater withdrawal/use from rivers and aquifers, and agricultural demand for water could rise by more than 30% by 2030.¹⁹⁴
- In many arid places, rates of water extraction for irrigation are exceeding rates of replenishment. Major nonrenewable fossil aquifers being depleted are in India, Egypt, Libya, and Australia.¹⁹⁵
- The amounts of water and other inputs needed to produce a pound of food have dropped significantly in the past 30 years.
- Widespread use of monoculture has contributed to increased water use. Indigenous crops can demand less water, as they are adapted for the area. Agriforestry is another way to help crops get more access to water.¹⁹⁶
- Early experimentation in new “crop-for-the-drop” strategies include micro-irrigation, solar drip irrigation, and treadle pumps.¹⁹⁷
- Rapid urbanization is contributing to water tensions in many parts of the world (e.g., East Africa). There are signs of increased use of waste water and sewage for both moisture and nutrients in developing countries. A number of NGOs are working on educating farmers to use waste water safely to grow crops.¹⁹⁸
- Climate change:
 - By 2040, climate change is likely to shift where things can be grown. There will be loss and gain of arable land across geographies, with more instability in the system.
 - Water laws, property rights for water, water pollution, and “virtual water” are emerging as key issues.
 - In an expert panel survey, 79% of respondents either disagree (38%) or strongly disagree (41%) with the statement that “Climate change will have a negligible impact on the agricultural system.”¹⁹⁹

Implications and opportunities to 2040

- The future of Chinese agriculture is green. To increase output, China has to reduce the environmental impacts of its agricultural system. In a new “grand bargain,” interests of the government and of the population could converge in a campaign of environmental improvement over the next two decades.

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- Chinese agriculture has abundant leapfrogging opportunities in methods and technologies as it modernizes.
 - Chinese agriculture needs to modernize and industrialize without harming the environment. As a result, China is likely to be an ever larger market for greener agricultural technologies.
- There will be growth in green inputs to support the shift to green agriculture (safer pesticides, biotech seeds, etc).
- Chinese consumers' environmental awareness will continue to grow as incomes and educational levels rise.
- Intensifying competition for water will shape agriculture's future globally. Water scarcity will push food production in the direction of increased efficiency. Agricultural trade is water trade, making "local" water issues transnational.
- Climate change perceptions could alter the conditions under which agriculture is undertaken. Policy responses will likely have major impacts on agriculture.

Appendix 1. Methodology

Delphi survey

The Delphi survey method was used to flesh out the expected future by elaborating on the five core research themes and initial expert interviews, setting the stage for further expert panels and interviews and, ultimately, the six insights the comprise the heart of **Food 2040**. The Delphi was administered across a pool of 46 subject-matter experts identified by the US Grains Council, FAS Tokyo, Informa Economics, and Foresight Alliance.

Delphi background

- The Delphi survey method is a foresight consultation process invented by the RAND Corporation, engaging a wide group of participants in order to pool expert opinion on a specific forward-looking topic. The process begins with a set of predefined questions and is carried out in rounds. At the end of each round, replies are shared anonymously among all participants, and participants may then adjust their own answers in response.
- A Delphi survey is meant to investigate experts' opinions on the likelihood of events and issues occurring within a certain time horizon. Typically, the survey asks multiple-choice questions supplemented by open-ended questions to capture new insights and information on the research areas.
- Anonymity of panel members is one of the hallmarks of the Delphi approach. This feature worked especially well for **Food 2040**, where experts had the opportunity to share frank opinions in full anonymity while also being presented with options for open interaction during the expert panels that followed. Anonymity can allow participants to privately share their individual insights without the need to defer to the consensus wisdom of their organizational affiliations, or to general “conventional wisdom.”

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Applying Delphi to Food 2040

Foresight Alliance and Informa Economics worked to develop a well-defined set of key issues within each of the five core research themes. These were further refined during individual interviews with a subset of eight subject-matter experts. The key issues were used to frame the questions for the Delphi, as well as helping to frame the discussions in subsequent phases of the project.

The primary goal of the Delphi was to address key uncertainties and allow the analyst team to delineate the baseline, or expected, future for East Asian food and agriculture in 2040. Foresight Alliance enlisted a Delphi panel of 46 subject-matter experts. Together with Informa Economics, Foresight Alliance designed the questionnaire for the Delphi and worked to ensure all necessary conditions for its effective administration and execution. The Delphi study was conducted in two rounds:

- *Round 1:* A customized version of an online survey tool (Survey Monkey©) was used to administer the Delphi. Panelists could use the tool to respond to the questions asynchronously. Participant responses were completely anonymous, even to the Delphi administrator. At the end of Round 1, Foresight Alliance aggregated and analyzed the responses, focusing on capturing the distribution of the participants' opinions for each of the questions.
- *Round 2:* Foresight Alliance prepared a new version of the Delphi questionnaire, displaying the results of Round 1 for each question. The goal of Round 2 was to share the results from the previous round with all respondents and allow them to adjust their answers in view of the feedback. Experts were asked to respond a second time to the same questions, changing their responses as desired according to the new information.

The outputs of the Delphi were: aggregated results including the statistical distribution of answers, and supplemental free-form responses from each respondent. These results provided key input toward generating provocative hypotheses for each of the five core research themes. The Delphi enabled the research team to



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identify and validate significant drivers, uncertainties, and implications and use these factors to generate hypotheses regarding potential future outcomes.

Expert contributions

The next stage was designed to build on the insights gleaned from the Delphi survey, the first round of expert interviews, and desk research through further expert participation. To synthesize all of this content in ways that would provoke forward thinking, Foresight Alliance built a set of future hypotheses for each of the five core themes. These hypotheses were intended not as forecasts, but as plausible ways in which the future might unfold in each theme area. Because there is always more than one plausible future, hypotheses were not required to be mutually consistent.

Project research was streamlined into two topic areas:

- Food Markets (Agriculture and Food Distribution and Packaging, Competitive and Regulatory Landscape) and Food Consumers (Consumer Trends)
- Food Inputs (Food and Technology, Environment and Resources).

In order to work most effectively within the distinct cultural norms and expectations of the expert participants, different processes were used with Western and Asian experts.

- For Western experts, Foresight Alliance designed and facilitated two online panel sessions to allow participants to contribute ideas and respond to each other's contributions in a structured process.
- For experts in Asia, one-on-one interviews were deemed a more culturally appropriate way to gather input.

Process for Western experts

Online panels were supported by FacilitatePro©, a dedicated Internet collaboration tool for managing real-time virtual meetings. Panel A included six experts plus one additional expert providing online input

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asynchronously after the session; Panel B included four experts plus one additional expert providing asynchronous input. FacilitatePro© allowed participants to simultaneously post to an electronic flipchart, comment on items posted by other recipients, and prioritize the most important items. Results were then expanded and refined through verbal discussion.

In each panel, participants discussed the future hypotheses for the relevant theme areas. The panel process consisted of three steps:

- Rank the hypotheses according to their impact on the future of food, agriculture, and consumers through 2040.
- Beginning with the hypothesis with the greatest potential impact and proceeding down the list as time allowed:
 - Rate and discuss the plausibility of the hypothesis.
 - Assuming that the future unfolds according to the hypothesis, brainstorm potential consequences, opportunities, and challenges that would result.
- Brainstorm additional hypotheses about the way the future might unfold in the relevant theme areas.

Process for experts in Asia

As noted above, one-on-one interviews were deemed a more culturally appropriate way to gather input from the experts in Asia. Participants were offered the option of conducting the interview through a language interpreter or in English; in practice both options were employed. Interview questions were designed to:

- Provide additional background information and current trends relevant to the hypotheses.
- Directly or indirectly gather expert opinion on the plausibility and consequences of the hypotheses.

Interviews were conducted with six experts in Taiwan, one in China, one in Korea, one in Singapore, and one in South Africa. In addition, similar interviews were conducted with nearly 40 experts in Japan (as described in



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the following section); these interviews also included questions designed to test the hypotheses that had been formed and refined by this stage of the research.

Japan interviews

Foresight Alliance and Informa Economics sent a team of project researchers to Japan for a week to conduct in-person expert interviews. The Informa Economics and Foresight Alliance team was assisted by FAS Tokyo in identifying 37 Japanese food-industry experts, academics, and government officials and arranging a course of interviews. The team developed a pool of 52 formal research questions, with the interviewers using a subset of the pool questions depending on the subject-matter knowledge of the expert. Topics for the research questions included consumer life and consumer trends, views of food, changing demography, transportation and logistics, and food biotechnology.

Insight synthesis

- Informa Economics and Foresight Alliance summarized the most important research findings derived from the sum of the research performed to this point. Key research findings were developed for each of the five research themes and used as the foundation for further insight generation.
- Informa Economics performed a targeted outlook analysis to map out future changes in Asian food consumption. For each of the research themes, an econometric model was built to evaluate the potential change in demand (volume only, not value) for food products including meat, dairy products, vegetable oils, and others given the outlook for key economic and demographic trends such as rising incomes, rising average ages, and the expanding urban middle classes in East Asia's emerging economies.
- Foresight Alliance mapped out the key findings across all five research themes, and identified potential areas where trends and drivers interacted across multiple research areas, both converging and reinforcing each other. These trend clusters were refined into six relevant and impactful "insights" about the future of the Asian food system.



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- These six insights were then compared against each other in a cross-impact matrix, where each insight was provisionally paired with another insight to generate potential outcomes, as well as to highlight future outcomes that had been identified in the research foundation. Further implications and outcomes were then generated for the six insights.

Appendix 2. Food Demand Analysis—Approach

Food Demand Model Approach

- The model used in the “Projecting Food Demand to 2040” section uses historical data to describe world food trends to 2040.
- The model assumes that changes in food availability in less developed countries will tend to reflect the same historical process that occurred in today’s richer countries; that is, food consumption in less developed nations will tend toward that of richer nations with some minor variations due to differences in cultural preferences, demographic characteristics, and socioeconomic conditions.
 - Country-level data on food supply, as reported by FAO, was used as a proxy for food consumption, which is the dependent variable.
 - The FAO data, which is available for the period 1961–2007, was combined with World Bank country data on purchasing power parity (PPP) GDP per capita measured in international US dollars (available from 1980 to 2016; this was deflated to compute PPP GDP per capita in real terms) and UN country data on population trends from 1950–2100.
- Regression analysis was used to model food consumption by country over the period 1980–2007.
 - The drivers of the model are:
 - Age distribution of population,
 - Percentage of population that is female,
 - Population density,
 - Dependent ratio (ratio of population aged 0–19 or 65 and older over population aged 20–64),
 - Percentage of urban population living in urban areas, percentage of urban population living in slums,
 - Real PPP GDP per capita measure in 2005 US dollars, and
 - Country and region qualitative variables.

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- The food consumption items analyzed were:
 - ❑ Meat products, including beef, poultry, pork, and seafood,
 - ❑ Dairy,
 - ❑ Cereals,
 - ❑ Oilseeds,
 - ❑ Sugars and sweeteners,
 - ❑ Beer and wine,
 - ❑ Corn, soybeans, rice, wheat, and
 - ❑ Fruits, roots, and vegetables.
- The model's projections were based on projections of future population growth and predicted demographic trends regarding age, social class, and per capita income and included consumption estimates in kilograms per capita of the above food items.
- Using Informa's database of historical production and yields for food grains, feed, grains, and oilseed crops in different regions of the world, as well as livestock feed ration trends, estimates were made regarding the number of hectares required to produce cereals, feed grains, and oilseed crops to meet the demands indicated by the quantities listed above. Exhibit 12 below shows the yield estimates used in the baseline forecast for determining the land use requirements of forecast food consumption, while Exhibit 13 indicates our baseline forecast for claims against agricultural land for food consumption, given the parameters and forecasts of the model.

Exhibit 12: Baseline Yield Estimates: MTs/Hectare

	Food Grains	Feed Grains	Oilseeds
1980	1.79	2.51	1.15
1990	2.23	2.79	1.43
2007	2.79	3.75	1.94
2010	3.05	3.90	2.03
2020	3.31	4.26	2.30
2030	3.71	4.70	2.60
2040	4.13	5.20	2.90

Exhibit 13: Estimates of Land Needs to Support Food Consumption

Model Forecasts	Food Grains	Feed Grains	Oilseeds	Model Total Crop Area	Actual Total Crop Area
1980	480	219	112	812	822
1990	456	224	127	807	820
2000	456	189	173	818	827
2010	479	191	207	877	892
2020	482	205	238	925	
2030	447	236	247	930	
2040	389	291	249	929	

Endnotes

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- ¹ David Biello, "Can Algae Feed the World and Fuel the Planet? A Q&A with Craig Venter," Scientific American, November 15, 2011, www.scientificamerican.com/article.cfm?id=can-algae-feed-the-world-and-fuel-the-planet.
 - ² Interview with Japanese expert, September 2011.
 - ³ Interview with Japanese expert, September 2011.
 - ⁴ "China's 5-Year Biotech Investment Fires Clear Warning to US," Generics and Biosimilars Initiative, August 26, 2011, www.gabionline.net/Biosimilars/News/China-s-5-year-biotech-investment-fires-clear-warning-to-US.
 - ⁵ Matthew Strelau, "Go to China, Young Scientist," Washington Post, May 22, 2011, A19.
 - ⁶ Eliza Barclay, "China Turns to Biogas to Ease Impact of Factory Farms," Environment 360 website, November 11, 2010, http://e360.yale.edu/feature/china_turns_to_ecological_biogas_production_to_ease_impact_of_factory_livestock_farms/2338.
 - ⁷ Jonathan Watts, "China puts the eco back in economy," Guardian (UK), May 25, 2010, www.guardian.co.uk/environment/2010/may/25/china-ecological-values.
 - ⁸ Orville Schell, "How Wal-Mart is Changing China," Atlantic, December 2011, www.theatlantic.com/magazine/archive/2011/12/how-Wal-Mart-is-changing-china/8709/?single_page=true.
 - ⁹ Interview with Japanese expert, September 2011.
 - ¹⁰ "Pocket K No. 16: Global Status of Commercialized Biotech/GM Crops in 2010," ISAAA, April 2011, www.isaaa.org/resources/publications/pocketk/16/default.asp.
 - ¹¹ Interview with Asian scientist in biotechnology; "China Biotech on the Rise," Farm Chemicals International, July 2011, www.farmchemicalsinternational.com/seedbiotech/?storyid=3183.
 - ¹² Interviews with Japanese experts and food industry executives, September 2011.
 - ¹³ "Pocket K No. 16: Global Status of Commercialized Biotech/GM Crops in 2010," ISAAA, April 2011, www.isaaa.org/resources/publications/pocketk/16/default.asp.
 - ¹⁴ Delphi survey of experts, August 2011.
 - ¹⁵ Interview with American expert, July 2011.
 - ¹⁶ "Pocket K No. 16: Global Status of Commercialized Biotech/GM Crops in 2010," ISAAA, April 2011, www.isaaa.org/resources/publications/pocketk/16/default.asp.
 - ¹⁷ Delphi survey, August 2011.
 - ¹⁸ Interview with American expert on China, July 2011.
 - ¹⁹ Interview with American expert on Africa, July 2011.
 - ²⁰ Howard W. French, "In Africa, An Election Reveals Skepticism of Chinese Involvement," Atlantic, September 29, 2011, www.theatlantic.com/international/archive/2011/09/in-africa-an-election-rejects-chinese-involvement/245832/.



Food 2040

- ²¹ Delphi survey, August 2011.
- ²² Asian Development Bank, *Asia 2050: Realizing the Asian Century*, Manila, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ²³ “Outsourcing’s Third Wave,” *The Economist*, May 21, 2009, www.economist.com/node/13692889.
- ²⁴ Interview with American expert on Africa, July 2011.
- ²⁵ AmCham-China, *2010 White Paper*, Transportation and Logistics, www.amchamchina.org/download?path=/cmsfile/2010/04/19/6cd315b8b96e4f6532acbf29b4b2a895.pdf.
- ²⁶ Interview with Japanese food industry executives, September 2011.
- ²⁷ Expert panel, September 2011.
- ²⁸ Interview with Taiwanese expert, September 2011.
- ²⁹ Interview with American expert on China, July 2011.
- ³⁰ Interview with American expert on China, July 2011.
- ³¹ Charles Wolf, Jr., et al., *China and India, 2025: A Comparative Assessment*, RAND, 2011, www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG1009.pdf.
- ³² “Hands Slapped,” *The Economist*, July 7, 2011.
- ³³ Expert panel, September 2011.
- ³⁴ Expert panel, September 2011; interview with Taiwanese expert, September 2011.
- ³⁵ Expert panel, September 2011; interview with Asian expert, September 2011.
- ³⁶ Interviews with Asian experts, September 2011.
- ³⁷ Interviews with Japanese experts, September 2011.
- ³⁸ Interview with Taiwanese expert, September 2011; expert panel, September 2011.
- ³⁹ Delphi expert panel, August 2011.
- ⁴⁰ Expert panel, September 2011.
- ⁴¹ Delphi expert panel, August 2011; interviews with US and Asian experts, July and September 2011.
- ⁴² Interviews with Asian experts, September 2011.
- ⁴³ Expert panel, September 2011.
- ⁴⁴ Delphi expert panel, August 2011.
- ⁴⁵ Interviews with US and Asian experts, July and September 2011.
- ⁴⁶ Delphi expert panel, August 2011.
- ⁴⁷ Interview with Japanese expert, September 2011.
- ⁴⁸ Interviews with Asian experts, September 2011.
- ⁴⁹ Expert panel, September 2011; interviews with US and Asian experts, July and September 2011; “Of Cabbages and Kims,” *The Economist*, October 7, 2010, www.economist.com/node/17204655.



Food 2040

-
- ⁵⁰ Orville Schell, “How Wal-Mart Is Changing China,” Atlantic, December 2011, www.theatlantic.com/magazine/archive/2011/12/how-Wal-Mart-is-changing-china/8709/?single_page=true.
- ⁵¹ Orville Schell, “How Wal-Mart Is Changing China,” Atlantic, December 2011, www.theatlantic.com/magazine/archive/2011/12/how-Wal-Mart-is-changing-china/8709/?single_page=true.
- ⁵² Orville Schell, “How Wal-Mart Is Changing China,” Atlantic, December 2011, www.theatlantic.com/magazine/archive/2011/12/how-Wal-Mart-is-changing-china/8709/?single_page=true.
- ⁵³ Keith B. Richburg, “China Says It’s Cracking Down amid Anger over Tainted Food,” Washington Post, August 10, 2011, www.washingtonpost.com/world/asia-pacific/amid-anger-over-tainted-food-china-says-its-cracking-down/2011/08/08/gIQANPYC6I_story.html.
- ⁵⁴ Interviews with Asian experts, July and September 2011.
- ⁵⁵ Interview with Taiwanese expert, September 2011.
- ⁵⁶ Interview with Japanese food industry executives, September 2011.
- ⁵⁷ *Transportation and Logistics 2030—Volume 4: Securing the Supply Chain*, PricewaterhouseCoopers, 2011, www.pwc.com/en_GX/gx/transportation-logistics/pdf/TL2030_vol.4_web.pdf.
- ⁵⁸ Interview with Japanese expert, September 2011.
- ⁵⁹ Interviews with Asian experts, September 2011.
- ⁶⁰ Expert panel, September 2011; interview with Asian expert, September 2011.
- ⁶¹ Delphi expert panel, August 2011.
- ⁶² Interviews with Japanese experts, September 2011.
- ⁶³ Interview with US expert, July 2011.
- ⁶⁴ Interview with US expert, July 2011.
- ⁶⁵ Expert panels, September 2011; interview with Japanese expert, September 2011.
- ⁶⁶ Interview with Japanese expert, September 2011.
- ⁶⁷ Interview with Japanese expert, September 2011.
- ⁶⁸ Nathan Gray, “Nutrigenomics and Personalized Nutrition: What Does the Future Hold?” NutraIngredientsUSA.com, March 30, 2011, www.nutraingredients-usa.com/Research/Nutrigenomics-and-personalized-nutrition-What-does-the-future-hold.
- ⁶⁹ Interview with Japanese expert, September 2011.
- ⁷⁰ Expert panel, September 2011.
- ⁷¹ Rachel Wimberly, “China Food Show Expands Reach into Nutraceutical Market,” Trade Show News Network, March 3, 2011, www.tsnn.com/news-blogs/china-food-show-expands-reach-nutraceutical-market.
- ⁷² Interview with Taiwanese expert, September 2011.
- ⁷³ Alfred Romann, “Longer Lifespans Could Be a Blow for Asia,” China Daily, July 2, 2011, www.chinadaily.com.cn/world/2011-07/02/content_12822929.htm.
- ⁷⁴ Expert interview, July 2011.



Food 2040

- ⁷⁵ Expert panel, September 2011.
- ⁷⁶ Christopher Shay, "Hong Kong's Expanding Obesity Problem," Wall Street Journal, January 10, 2011, <http://blogs.wsj.com/hong-kong/2011/01/10/hong-kongs-expanding-obesity-problem>; "Six Die of Heart Disease Per Minute in China," China Daily, August 12, 2011, www.chinadaily.com.cn/china/2011-08/12/content_13104625.htm.
- ⁷⁷ Delphi expert panel, August 2011.
- ⁷⁸ Delphi expert panel, August 2011.
- ⁷⁹ "The Asian Promise: Key Trends and Alliances In Biotechnology in 2010," Grant Thornton, 2011, www.wcgt.in/html/assets/Whitepaper_BioAsia2011TheAsianPromise.pdf; "Asia Pacific Biotech Market Promises Immense Potential," Pubarticles.com, June 6, 2011, www.pubarticles.com/article-asia-pacific-biotech-market-promises-immense-future-potential-1307345199.html.
- ⁸⁰ Interview with Taiwanese expert, September 2011.
- ⁸¹ Interview with Japanese expert, September 2011.
- ⁸² Interviews with Japanese experts, September 2011.
- ⁸³ Interview with American expert, September 2011.
- ⁸⁴ Expert panel, September 2011; interview with Asian expert, September 2011.
- ⁸⁵ Laurie Segall, "This 3D Printer Makes Edible Food," CNN Money, January 24, 2011, http://money.cnn.com/2011/01/24/technology/3D_food_printer/index.htm.
- ⁸⁶ Interviews with Japanese food manufacturer and Japanese retailer, September 2011.
- ⁸⁷ Interviews with Japanese food manufacturer and Japanese retailer, September 2011.
- ⁸⁸ Interview with Japanese food service manager, September 2011.
- ⁸⁹ Interview with Japanese retailer, September 2011.
- ⁹⁰ Expert panel, September 2011.
- ⁹¹ *Asia 2050*, Asian Development Bank, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ⁹² Delphi expert panel, August 2011.
- ⁹³ Interview with Asian expert, September 2011.
- ⁹⁴ "The Flight from Marriage," The Economist, August 20, 2011, www.economist.com/node/21526329.
- ⁹⁵ "The Flight from Marriage," The Economist, August 20, 2011, www.economist.com/node/21526329.
- ⁹⁶ "The Flight from Marriage," The Economist, August 20, 2011, www.economist.com/node/21526329.
- ⁹⁷ "The Flight from Marriage," The Economist, August 20, 2011, www.economist.com/node/21526329.
- ⁹⁸ Interview with American expert, September 2011.
- ⁹⁹ Interview with Asian food expert, September 2011.
- ¹⁰⁰ Interview with American food industry expert, July 2011.
- ¹⁰¹ "China to Breed Large Seed Firms, Up Reservoir Spending," Reuters, February 23, 2011, www.reuters.com/article/2011/02/23/china-agriculture-idUSTOE71M04V20110223.

-
- ¹⁰² Suzanne Goldenberg, "GM Corn Being Developed for Fuel Instead of Food," Guardian (UK), August 15, 2011, www.guardian.co.uk/environment/2011/aug/15/gm-corn-development-food-fuel.
- ¹⁰³ Interview with Asian food expert, September 2011.
- ¹⁰⁴ Interview with Japanese food expert, September 2011.
- ¹⁰⁵ Interview with Japanese food expert, September 2011.
- ¹⁰⁶ Keith B. Richburg, "China Seeks to Address Food-Safety Crisis," Washington Post, August 11, 2011, A6; interviews with food experts, July–September 2011.
- ¹⁰⁷ Interview with American food expert, August 2011.
- ¹⁰⁸ Interview with American agricultural researcher, July 2011.
- ¹⁰⁹ Interview with expert on Chinese agriculture, July 2011.
- ¹¹⁰ Interview with Japanese food expert, September 2011.
- ¹¹¹ Interview with American food expert, August 2011.
- ¹¹² Jim Lane, "Chromatin's Yield Machine: Is Instant Gene-Stacking a Game-Changer for Energy Crops?" Biofuels Digest, January 19, 2011, <http://biofuelsdigest.com/bdigest/2011/01/19/chromatins-yield-machine-is-instant-gene-stacking-a-game-changer-for-energy-crops>.
- ¹¹³ Delphi expert panel, August 2011.
- ¹¹⁴ Interview with Asian food expert, September 2011.
- ¹¹⁵ Interview with American agricultural researcher, July 2011.
- ¹¹⁶ Expert panel, September 2011.
- ¹¹⁷ Interview with American food expert, August 2011.
- ¹¹⁸ *Asia 2050: Realizing the Asian Century*, Asian Development Bank, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ¹¹⁹ *Asia 2050: Realizing the Asian Century*, Asian Development Bank, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ¹²⁰ "Food Security Data and Definitions," Food and Agriculture Organization, viewed August 2011, www.fao.org/economic/ess/ess-fs/fs-data/ess-fadata/en/.
- ¹²¹ Christopher Shay, "Hong Kong's Expanding Obesity Problem," Wall Street Journal, January 10, 2011, <http://blogs.wsj.com/hong-kong/2011/01/10/hong-kongs-expanding-obesity-problem/>; "Six Die of Heart Disease per Minute in China," China Daily, August 12, 2011, www.chinadaily.com.cn/china/2011-08/12/content_13104625.htm.
- ¹²² "World and Selected Country/Region Population Aged 65+," UN Department of Economic and Social Affairs, viewed July 2011, http://esa.un.org/unpd/wpp/unpp/panel_indicators.htm.
- ¹²³ Alfred Romann, "Longer Lifespans Could Be a Blow for Asia," China Daily, July 2, 2011, www.chinadaily.com.cn/world/2011-07/02/content_12822929.htm.
- ¹²⁴ Interview with US expert, July 2011.

-
- ¹²⁵ Christopher Shay, “Hong Kong’s Expanding Obesity Problem,” Wall Street Journal, January 10, 2011, <http://blogs.wsj.com/hong-kong/2011/01/10/hong-kongs-expanding-obesity-problem/>; “Six Die of Heart Disease per Minute in China,” China Daily, August 12, 2011, www.chinadaily.com.cn/china/2011-08/12/content_13104625.htm.
- ¹²⁶ Lorraine Heller, “Asia Pacific Leads World in Nutraceutical Sales,” Nutraingredients-usa.com, May 5, 2008, www.nutraingredients-usa.com/Consumer-Trends/Asia-Pacific-leads-world-in-nutraceutical-sales.
- ¹²⁷ Rachel Wimberly, “China Food Show Expands Reach into Nutraceutical Market,” Trade Show News Network, March 3, 2011, www.tsnn.com/news-blogs/china-food-show-expands-reach-nutraceutical-market.
- ¹²⁸ US Census Bureau.
- ¹²⁹ Interview with Taiwanese expert, September 2011.
- ¹³⁰ Interview with Asian expert, September 2011.
- ¹³¹ “The Flight from Marriage,” The Economist, August 21, 2011, www.economist.com/node/21526329.
- ¹³² “The Flight from Marriage,” The Economist, August 21, 2011, www.economist.com/node/21526329.
- ¹³³ “The Flight from Marriage,” The Economist, August 21, 2011, www.economist.com/node/21526329.
- ¹³⁴ Interview with Japanese food service manager, September 2011.
- ¹³⁵ Interview with US food industry expert, July 2011.
- ¹³⁶ Interview with Japanese expert, September 2011.
- ¹³⁷ Interview with Japanese food expert, September 2011.
- ¹³⁸ Interview with Japanese food expert, September 2011.
- ¹³⁹ Interview with Taiwanese food expert, September 2011; Delphi expert panel, August 2011.
- ¹⁴⁰ Delphi expert panel, August 2011.
- ¹⁴¹ Interview with Japanese food expert, September 2011.
- ¹⁴² Interview with Japanese food expert, September 2011.
- ¹⁴³ *Asia 2050: Realizing the Asian Century*, Asian Development Bank, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ¹⁴⁴ OECD.
- ¹⁴⁵ *Asia 2050: Realizing the Asian Century*, Asian Development Bank, 2011, www.adb.org/documents/reports/asia-2050/asia-2050.pdf.
- ¹⁴⁶ Jacqui Fatka, “Biotech Adoption to Accelerate,” Feedstuffs FoodLink, February 27, 2009, www.feedstuffsfoodlink.com/ME2/dirmod.asp?sid=&nm=&type=news&mod=News&mid=9A02E3B96F2A415ABC72CB5F516B4C10&tier=3&nid=4A594E22D68748AD990ED0E2577205DA.
- ¹⁴⁷ Jim Lane, “Chromatin’s Yield Machine: Is Instant Gene-Stacking a Game-changer for Energy Crops?” BioFuels Digest, January 19, 2011, <http://biofuelsdigest.com/bdigest/2011/01/19/chromatins-yield-machine-is-instant-gene-stacking-a-game-changer-for-energy-crops>.
- ¹⁴⁸ Interview with Taiwanese expert, September 2011.



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- ¹⁴⁹ Interview with US expert, July 2011.
- ¹⁵⁰ Keming Luo et al., “GM-Gene-Deletor’: Fused loxP-FRT Recognition Sequences Dramatically Improve the Efficiency of FLP or CRE Recombinase on Transgene Excision from Pollen and Seed of Tobacco Plants,” Plant Biotechnology Journal, 2007, http://plantsciences.utk.edu/pdf/stewart_luo.pdf.
- ¹⁵¹ Interview with US expert, July 2011.
- ¹⁵² “Can Corn Be Taught to Fix Its Own Nitrogen?” Physorg.com, March 4, 2010, www.physorg.com/news186923765.html.
- ¹⁵³ Boris Gitlin, “The New Frontier: Genetically Modified Oil Wars,” GMO Journal, July 7, 2010, <http://gmo-journal.com/index.php/2010/07/07/the-new-frontier-genetically-modified-oil-wars/>; interview with US expert, July 2011.
- ¹⁵⁴ Delphi expert panel, August 2011.
- ¹⁵⁵ Justin Gillis, “A Warming Planet Struggles to Feed Itself,” New York Times, June 4, 2011, www.nytimes.com/2011/06/05/science/earth/05harvest.html?pagewanted=all; Gerald C. Nelson et al., “Climate Change: Impact on Agriculture and Costs of Adaptation,” IFPRI, October 2009, www.ifpri.org/sites/default/files/publications/pr21.pdf; interviews with Taiwanese and Chinese and Singaporean experts, September 2011.
- ¹⁵⁶ James Randerson, “Drought Resistant GM Crops Ready ‘In Four Years’,” Foundation for Biotechnology Awareness and Education, 2009, www.fbae.org/2009/FBAE/website/news_08_10_drought-resistant.html.
- ¹⁵⁷ Delphi expert panel, August 2011.
- ¹⁵⁸ Susan J. Martino-Catt and Eric S. Sachs, “Editor’s Choice Series: The Next Generation of Biotech Crops,” Plant Physiology, 2008, www.ncbi.nlm.nih.gov/pmc/articles/PMC2330289.
- ¹⁵⁹ Joshua M. McGrath, “Precision Agriculture and Nutrient Management in 2010,” University of Maryland, January 11, 2011, <http://midatlanticcropmanagementschool.pbworks.com/f/McGrath+NM.pdf>; interview with Taiwanese expert, September 2011.
- ¹⁶⁰ Interview with Taiwanese expert, September 2011.
- ¹⁶¹ Interview with US expert, July 2011.
- ¹⁶² Interview with US expert, July 2011.
- ¹⁶³ Jerry D. Glover and John P. Reganold, “Perennial Grains: Food Security for the Future,” Issues in Science and Technology, Winter 2010, www.landinstitute.org/pages/Glover-Reganold%20article.pdf.
- ¹⁶⁴ Joshua M. McGrath, “Precision Agriculture and Nutrient Management in 2010,” University of Maryland, January 11, 2011, <http://midatlanticcropmanagementschool.pbworks.com/f/McGrath+NM.pdf>; interview with Taiwanese expert, September 2011.
- ¹⁶⁵ Delphi expert panel, August 2011.
- ¹⁶⁶ Interview with Taiwanese expert, September 2011.
- ¹⁶⁷ Peter Korsten and Christian Seider, “The World’s 4 Trillion Dollar Challenge: Using a System-of-Systems Approach to Build a Smarter Planet,” IBM Corp., January 2010, <ftp://public.dhe.ibm.com/common/ssi/pm/xb/n/qbe03278usen/GBE03278USEN.PDF>.
- ¹⁶⁸ Keming Luo et al., “GM-Gene-Deletor’: Fused loxP-FRT Recognition Sequences Dramatically Improve the Efficiency of FLP or CRE Recombinase on Transgene Excision from Pollen and Seed of Tobacco Plants,” Plant Biotechnology Journal, 2007, http://plantsciences.utk.edu/pdf/stewart_luo.pdf.

-
- ¹⁶⁹ Interview with Taiwanese expert, September 2011.
- ¹⁷⁰ N. Appleby, D. Edwards, and J. Batley, “New Technologies for Ultra-High Throughput Genotyping in Plants,” *Methods in Molecular Biology*, 2009, www.ncbi.nlm.nih.gov/pubmed/19347650.
- ¹⁷¹ “Can Corn Be Taught to Fix Its Own Nitrogen?” *Physorg.com*, March 4, 2010, www.physorg.com/news186923765.html.
- ¹⁷² “The Science of Exzact™,” Exzact Precision Technology, viewed October 2011, www.exzactprecisiontechnology.com/science/.
- ¹⁷³ “Can Biotech Food Cure World Hunger?” *New York Times*, October 26, 2009, <http://roomfordebate.blogs.nytimes.com/2009/10/26/can-biotech-food-cure-world-hunger/?th&emc=th>; Beverly D. McIntyre, Hans R. Herren, Judi Wakhungu, Robert T. Watson, “Agriculture at a Crossroads,” IAASTD, 2009, [www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Synthesis%20Report%20\(English\).pdf](http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Synthesis%20Report%20(English).pdf); interview with US expert, July 2011.
- ¹⁷⁴ Interviews with US, Korean, and Singaporean experts, July and September, 2011.
- ¹⁷⁵ Interview with US expert, July 2011.
- ¹⁷⁶ Interviews with Taiwanese and Korean experts, September 2011.
- ¹⁷⁷ AmCham-China, *2010 White Paper*, Transportation and Logistics, www.amchamchina.org/download?path=/cmsfile/2010/04/19/6cd315b8b96e4f6532acbf29b4b2a895.pdf.
- ¹⁷⁸ AmCham-China, *2010 White Paper*, Transportation and Logistics, www.amchamchina.org/download?path=/cmsfile/2010/04/19/6cd315b8b96e4f6532acbf29b4b2a895.pdf.
- ¹⁷⁹ Interviews with Asian experts, September 2011; Delphi expert panel, August 2011.
- ¹⁸⁰ Jesse Emspak, “Chips for Dinner,” *New Scientist*, June 10, 2011, www.newscientist.com/blogs/onepercent/2011/06/chips-for-dinner-edible-rfid-t.html.
- ¹⁸¹ Delphi expert panel, August 2011.
- ¹⁸² Delphi expert panel, August 2011.
- ¹⁸³ Delphi expert panel, August 2011.
- ¹⁸⁴ Delphi expert panel, August 2011.
- ¹⁸⁵ Interview with US expert on China, July 2011.
- ¹⁸⁶ Interview with US expert on China, July 2011.
- ¹⁸⁷ Interview with US expert, July 2011.
- ¹⁸⁸ Interview with US expert, July 2011.
- ¹⁸⁹ Interview with US expert on China, July 2011.
- ¹⁹⁰ Interview with US expert, July 2011.
- ¹⁹¹ Interview with US expert on China, July 2011.
- ¹⁹² Foresight, *The Future of Food and Farming*, UK Government Office for Science, London, 2011, www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf.

-
- ¹⁹³ Foresight, *The Future of Food and Farming*, UK Government Office for Science, London, 2011, www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf.
- ¹⁹⁴ Foresight, *The Future of Food and Farming*, UK Government Office for Science, London, 2011, www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf.
- ¹⁹⁵ Foresight, *The Future of Food and Farming*, UK Government Office for Science, London, 2011, www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf.
- ¹⁹⁶ Interview with US expert, July 2011.
- ¹⁹⁷ Interview with US expert, July 2011.
- ¹⁹⁸ Interview with US expert, July 2011; Foresight, *The Future of Food and Farming*, UK Government Office for Science, London, 2011, www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf.
- ¹⁹⁹ Delphi expert panel, August 2011.