EXECUTIVE INSIGHTS

Climate Change and the Impact on the Agriculture and Food Ecosystem

The impact of increasingly frequent and intense extreme weather events often captures media attention; however, what's less reported is how climate shifts are impacting agricultural productivity in the U.S. and are likely to change the productivity of growing regions for key crops in the future. Indeed, climate shifts have already started to affect the cultivation map of numerous crops, and they are expected to continue to slowly alter underlying crop yields achievable in any given location. Some areas likely will see yields gradually trend downward, while other regions will see their productivity improve from shifts in climate.

While these changes will have clear implications for the future value of cropland, there are also implications for the agribusiness and food industries more broadly. For example, today's networks of grain elevators and milling facilities, which are optimally located proximate to key crop growing regions, may need to shift in order to adapt to changes in crop production over the next several decades. And food companies may need to rethink where and how they will be able to source the ingredients they need as climate shifts impact which crops are best grown where. Some forward-looking companies are already beginning to develop long-term climate-related risk assessments. L.E.K. Consulting expects this to become an increasingly important strategic issue for companies and investors in the agribusiness and food sectors.

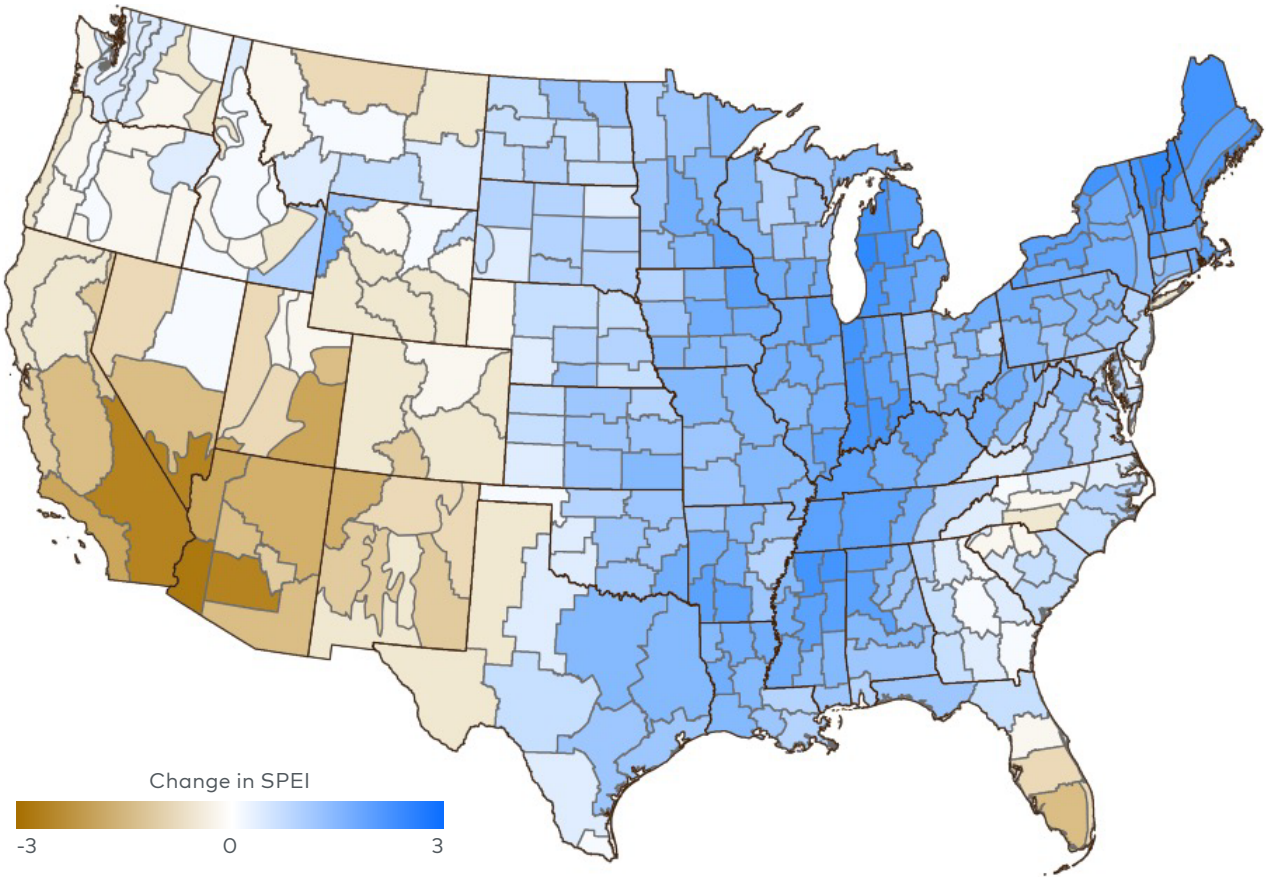
What climate shifts are expected in the U.S.?

The U.S. is getting warmer; since the late 1970s, the National Oceanic and Atmospheric Administration has observed that the average surface temperature across the contiguous 48 U.S. states has increased at an average rate of 0.32-0.55 F per decade. In fact, nine of

the top 10 warmest years on record in the U.S. have occurred since 1998. In addition to the temperature rise, climate shifts have driven and are expected to drive more frequent and extreme weather events.

Firstly, certain regions, in particular Southwestern states, have seen less precipitation over the last century, causing and prolonging drought conditions. At the end of 2022, around 85% of the land in California was under severe drought, marking a long-term trend in decreased moisture (see Figure 1).

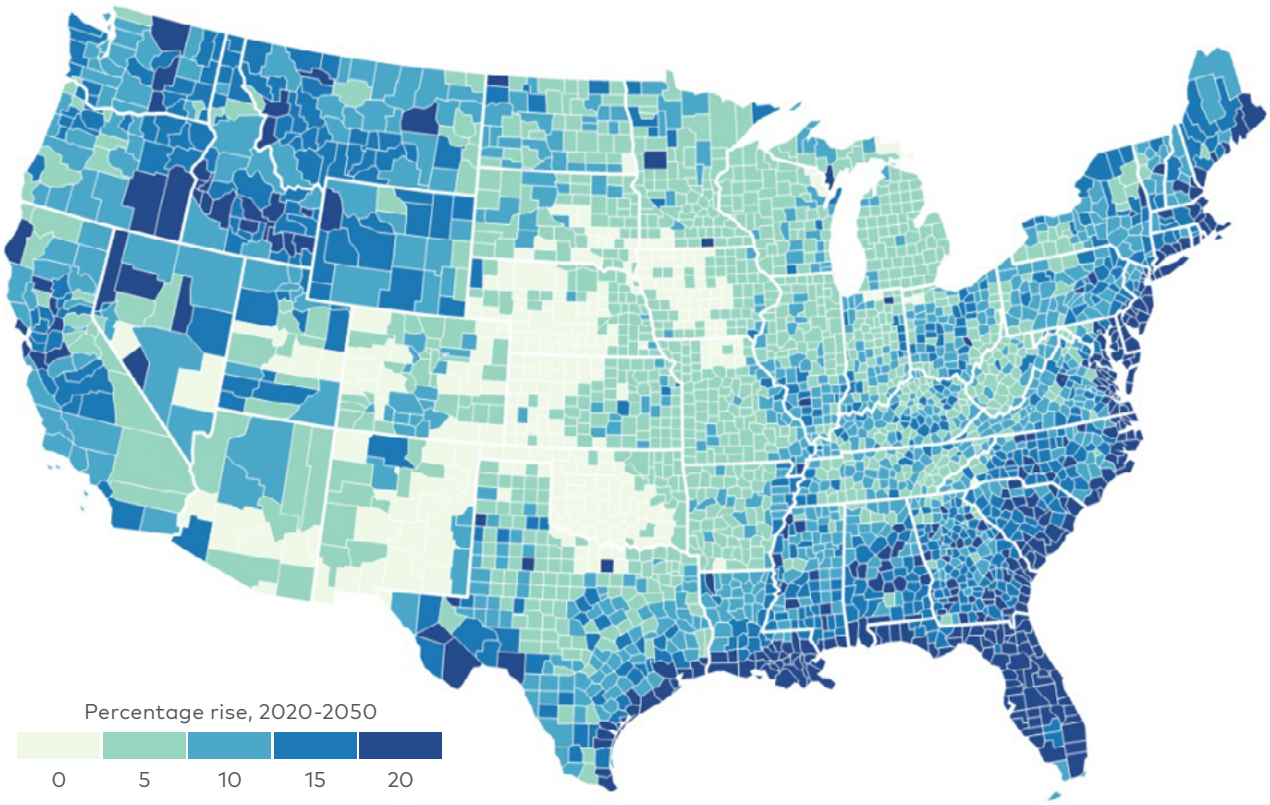
Figure 1
US average change in drought (five-year SPEI) (1900-2020)



Note: SPEI=Standardized Precipitation Evapotranspiration Index
Source: WestWide Drought Tracker, https://www.epa.gov/climate-indicators/climate-change-indicators-drought

Secondly, in the future, warmer sea surface temperatures are expected to lead to increased land-based precipitation as well as higher tropical storm intensity. Subsequent higher projected flood risk in coastal communities by 2050 could be compounded by rising sea levels as well as "stalling" storms causing higher total rainfall and longer periods of high winds (see Figure 2).

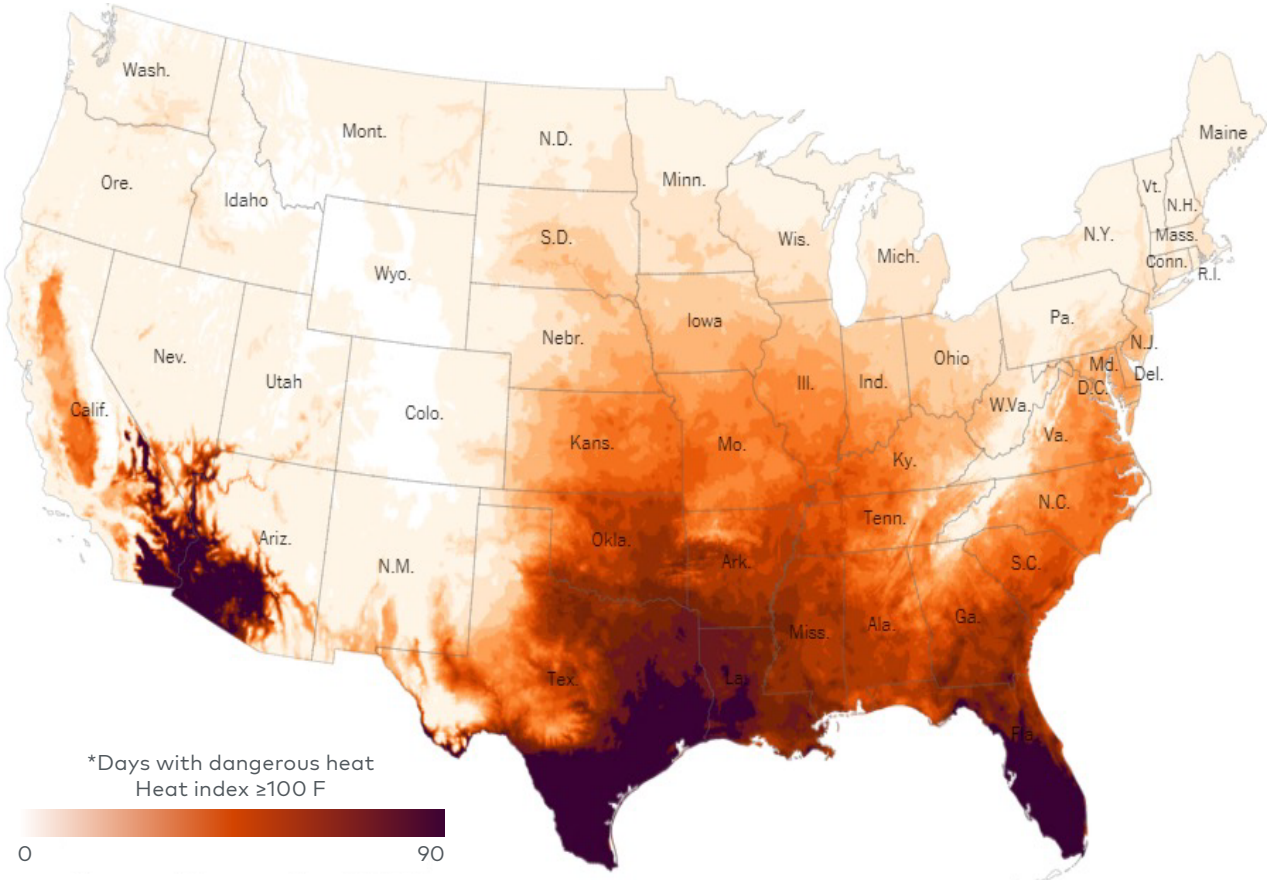
Figure 2
US projected flood risk by county (2020-2050)



Source: Wing et al., https://lailluminator.com/2022/02/01/new-flood-maps-show-stark-inequity-in-damages-which-are-expected-to-rise-over-next-30-years/

Finally, heatwaves are expected to further intensify in certain parts of the country, with certain states in the South, West and Southeast expected to have more than 90 days of dangerous heat (over 100 F) by the 2050s (see Figure 3).

Figure 3
US expected days with dangerous* heat (2053)

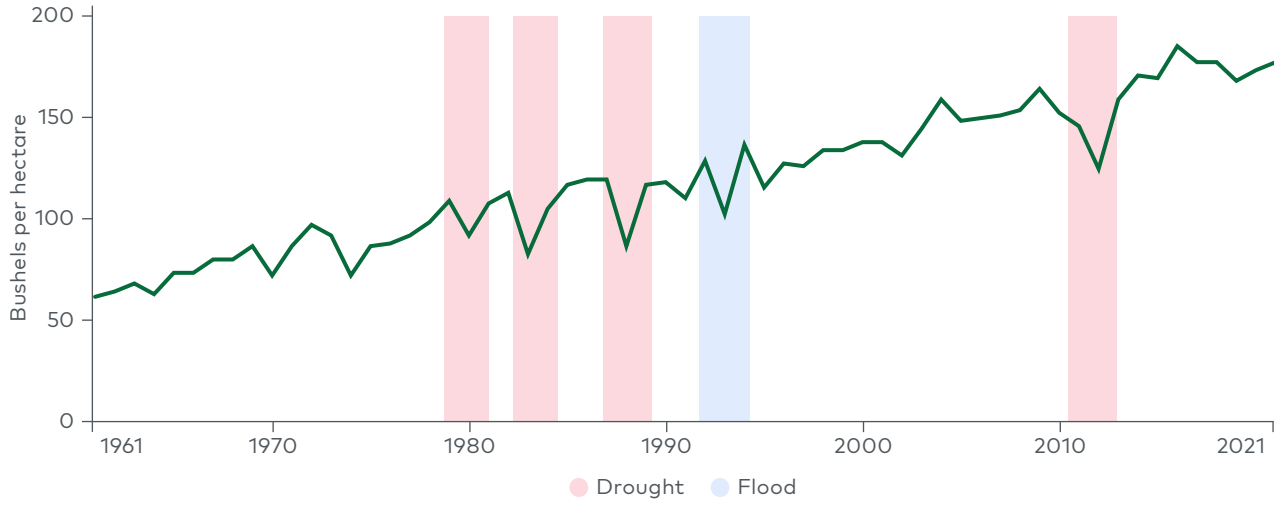


Source: First Street Foundation, https://www.washingtonpost.com/climate-environment/interactive/2022/extreme-heat-risk-map-us

What is the expected impact of climate shifts on the cultivation map?

Extreme weather events cause widespread damage to cropland and decimate harvests. The 1980s, 1990s and 2010s saw significant drops in corn yields caused by periods of drought and flooding (see Figure 4).

Figure 4
Average corn (maize) yields per hectare per year in the US (1961-2021)



Source: USGCRP and USDA

However, while extreme weather impacts often draw media scrutiny, the agronomic impact on crops from more gradual change in temperature and related trends are more subtle. For example, a wide range of fruit and nut trees require a minimum amount of cold night weather, known as "chilling hours," in order to blossom and produce fruit. In California's Central Valley, the U.S. Global Change Research Program estimates that chilling hours will decrease 30%-60% from 1950 levels by 2050 and 80% by 2100.

Below, we highlight the impact of climate shifts on the production of three significant U.S. crops:

1. Sorghum

Sorghum is a cereal grain, of which the U.S. is the world's largest producer. Increasing temperatures in Texas, the second-highest-producing state for sorghum, cause widespread heat stress and allow pests such as stink bugs and headworms, which feed on the head of the sorghum plant, to thrive. Thus, sorghum production has further consolidated in Kansas to the north in the past 10-15 years, increasing its leading share of U.S. sorghum production from about 41% to almost 55% (with the majority of flow away from Texas, whose share of national production declined from approximately 31% to roughly 21%).

2. Pecans

In 2018, Hurricane Michael caused significant damage to pecan production in Georgia, the largest producing state in the U.S., destroying about 17% of pecan tree acreage. Following this supply shock, the pecan industry replanted orchards using high-density techniques developed in New Mexico and Arizona. However, while these states have seen higher productivity due

to innovation and low humidity (reducing the likelihood of scab infections), they also face significant water availability issues, precluding a migration of the pecan industry to the Southwest and requiring producers in Georgia to adapt to climate shifts instead.

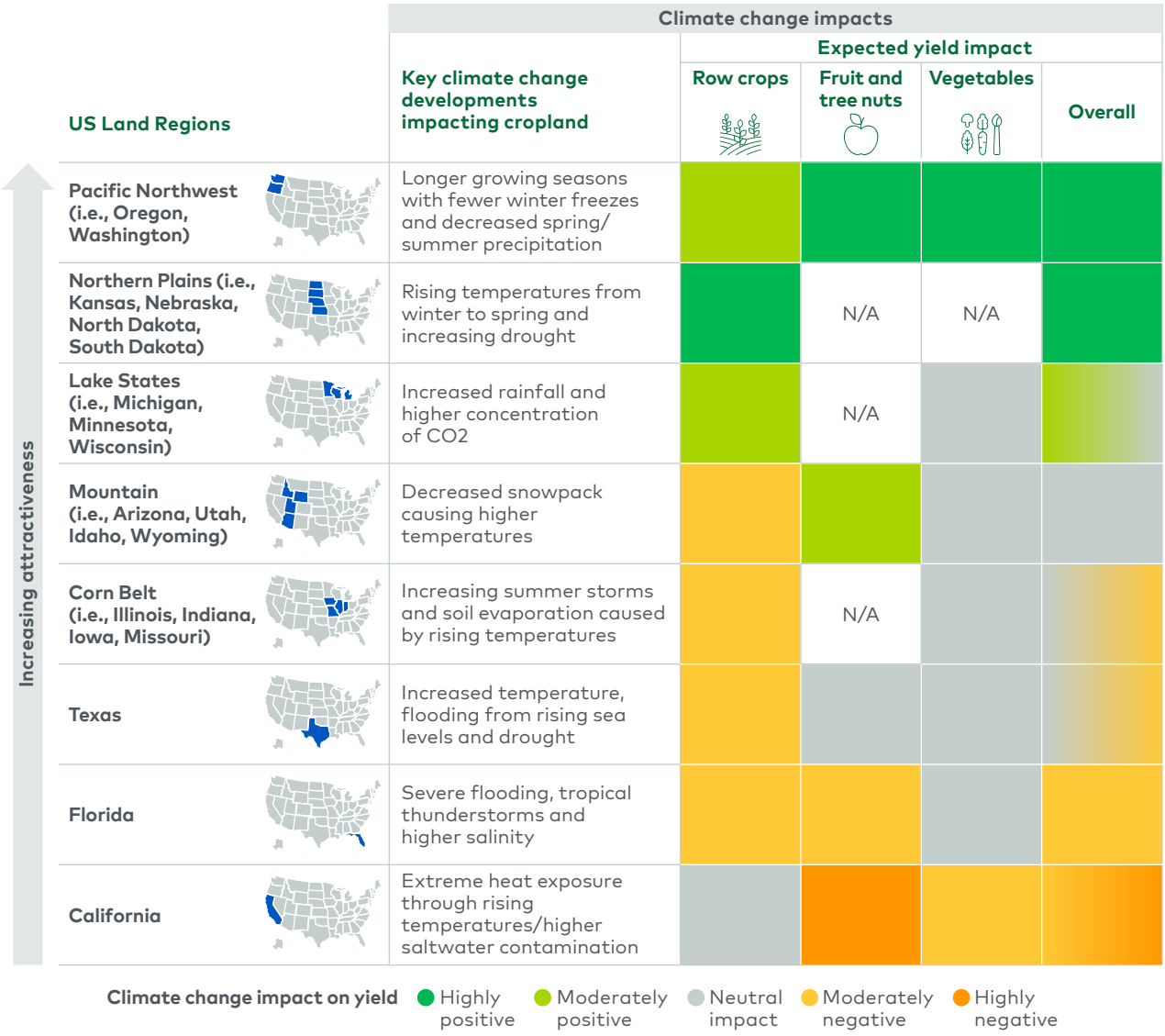
3. Wine grapes

Connoisseurs take note — suitable locales for growing premier grapes are gradually inching northward to higher-elevation land with relatively cooler climates such as Oregon. This is because the highest-quality wine grapes require warm temperatures, low risk of frost damage and no extreme heat. Long-term warming trends are expected to impact vintage quality and therefore which grape varieties can be grown in certain wine regions. In addition, wildfire smoke exposure to ripening grapes can potentially spoil their taste and aroma. This is particularly pertinent in major wine regions like Oregon and California where the annual risk and frequency of wildfires have been increasing.

Based on our research and analysis of state-level climate reports and expert interviews, we developed a perspective on the long-term outlook for yields across different crop types, based on key climate developments in important growing regions (see Figure 5). Trends in productivity vary by region.

- In the Pacific Northwest (i.e., Oregon, Washington), the lengthening of the growing season and decreased winter freezes (with a tendency toward wetter winters) will be beneficial to most crop types grown in the region, with a particularly positive impact on fruits such as apples for which the reduction in chilling hours is not enough to offset yield increases from warmer weather.
- In contrast, a region such as Florida faces future challenges from stronger and more frequent tropical storms, severe flooding and higher water salinity, lowering productivity for row crops as well as fruit and vegetable crops such as citrus and sugarcane.
- In the Corn Belt, a combination of temperature and moisture changes is expected to lower the productivity of land that has traditionally been focused on corn and soybeans, with research indicating more suitable conditions for row crops are likely to shift northward toward Minnesota and the Dakotas.

Figure 5
Expected yield impact by region and crop type in 2050 relative to 2023



Source: L.E.K. research and analysis

Implications for investors and players in the ecosystem

Shifts in crop growing conditions across the U.S. are already underway, albeit at a gradual pace over a multidecade time horizon; the Corn Belt will not stop growing corn anytime soon. However, climate shifts have already started to affect the cultivation map of numerous crops given where they are likely to be most productive in the future.

For participants in the agribusiness and food sectors (e.g., investors, producers, processors and food companies), regional climate risk must be integrated into strategic decisions across the value chain.

- Producers may find it necessary to adapt to changing conditions by diversifying crop types or reallocating some land toward other uses such as renewable energy or animal production; however, the switching costs involved may be significant
- Processors and supporting infrastructure, including mills, grain elevators, and fruit and vegetable packhouses, should consider future investments in facilities and logistics networks to ensure that they will be located in optimal future locations of higher productivity
- Food companies may need to evaluate the resilience of their ingredients supply chain to future potential climate shifts and take action to develop new supplier relationships or strengthen existing ones

Based on our deep expertise in produce, the growing controlled environment agriculture[1] industry and sustainability,[2] we believe agribusiness and food investors in particular should assess the impact of climate shifts through the following lenses and key questions:

- Investment-related:
    - How likely are key value drivers of a company/asset to be affected by potential future climate risk? And how might this affect future valuations?
    - What potential upside opportunities could emerge as a result of climate shifts, and where should companies and investors look for new assets and locations with positive future exposure?
    - How will availability and costs of financing from bank lending or capital markets change as climate risk increases?
- Operational:
    - In what ways will climate policy, technology and changing consumer preferences impact prices, costs and demand?
    - In light of this, what climate mitigation/response initiatives should be put in place to maintain or improve future margins?

In summary, the future impact of a shifting cultivation map will have significant implications for established companies and new investors in the agribusiness and food sectors. Companies and investors who put climate-related risk at the top of the corporate agenda as an increasingly important strategic issue will be much better prepared for potential future impacts. And those who think ahead are also more likely to uncover attractive areas of new opportunity resulting from climate-related changes.

For more information, please contact industrials@lek.com.

Endnotes

[1]Lek.com, "The Controlled Environment Agriculture Opportunity Is Ripe for Investment." https://www.lek.com/insights/ei/controlled-environment-agriculture-opportunity-ripe-investment

[2]Lek.com, "The State of Play in Sustainable Agriculture." https://www.lek.com/insights/ind/us/ei/state-play-sustainable-agriculture

About the Authors

Peter Walter
Peter Walter is a Managing Director and Partner in L.E.K. Consulting's New York office. Peter has more than 25 years of global consulting experience, with a focus on growth strategy development M&A and performance improvement for both corporate and investor clients. He leads L.E.K.'s Agribusiness practice in the Americas and the Environmental Services practice, and he works across selected industrials markets, such as specialty chemicals, packaging and industrial/business services.

Rob Wilson
Rob Wilson is a Managing Director in L.E.K. Consulting's Chicago office. Rob is a senior member of L.E.K.'s Retail and Consumer Products practice and heads the Food & Beverage practice in North America. He advises clients on a range of critical strategic business issues, including growth strategy, buy-side commercial due diligence, sell-side market studies, postmerger integration, price pack architecture strategy, trade spend optimization, profitability enhancement and organizational transformation.

Jen Wu
Jen Wu is a Managing Director and Partner in L.E.K. Consulting's New York office. Jen is a member of the firm's Retail and Consumer Products practice, where she has deep expertise in food and beverage growth strategies and M&A. With over eight years at L.E.K., she has advised corporate and private equity clients on strategic projects ranging from investment screens and buy- and sell-side due diligence to new market entry and corporate growth strategies.

Jonny Wong
Jonny Wong is a Senior Consultant in L.E.K. Consulting's New York office and is dedicated to the Consumer practice. Primarily working across food, beverage, and agribusiness sectors, Jonny advises clients on a range of critical issues, including growth strategy, project execution and M&A transaction support. He has also worked in the firm's London and Tokyo offices.

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