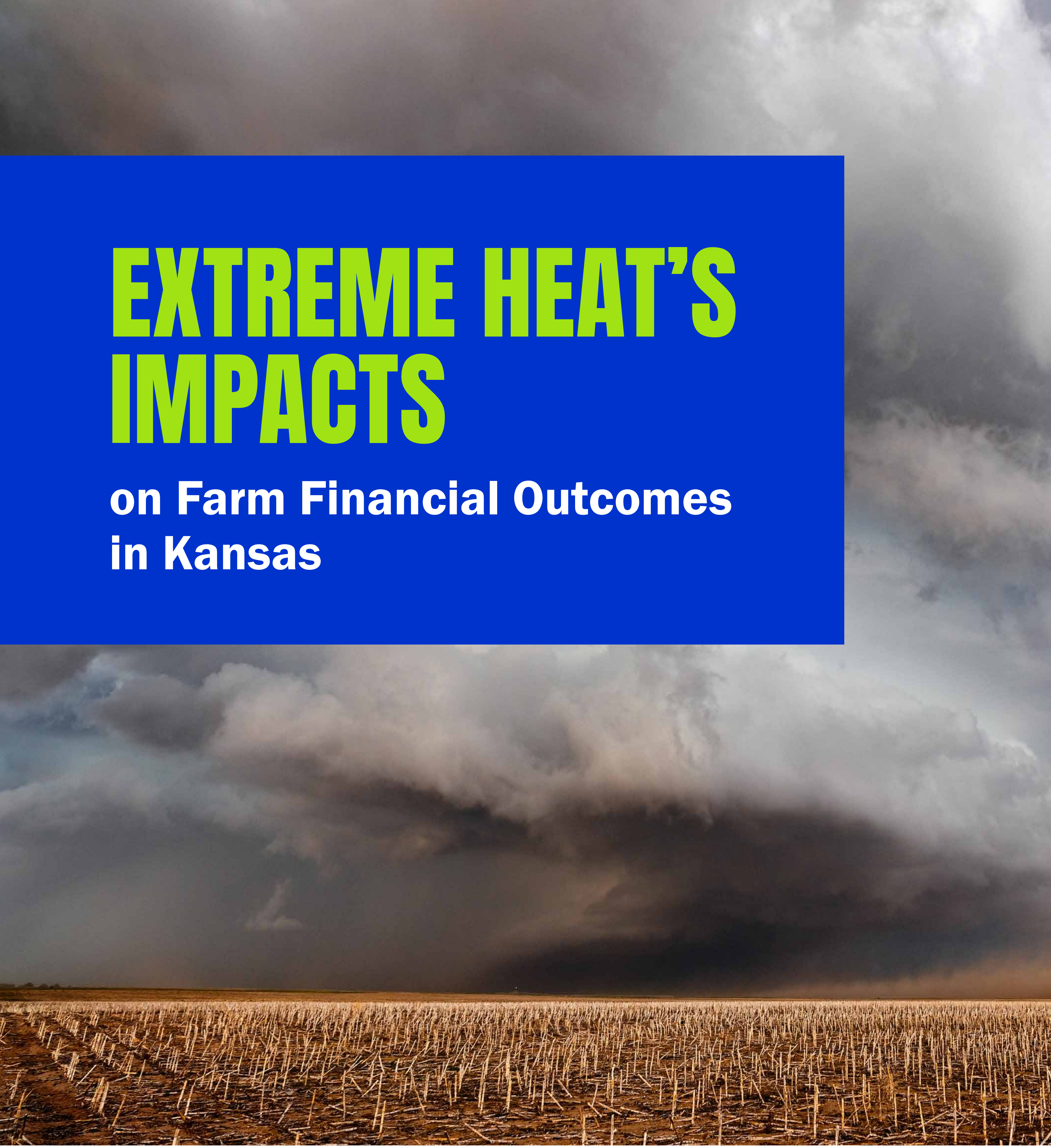


EXTREME HEAT'S IMPACTS

on Farm Financial Outcomes in Kansas

Environmental Defense Fund

Kansas State University

Cornell Atkinson Center for Sustainability

Understanding the impacts of extreme weather on Kansas farms can inform solutions that support farmers in adapting to climate change.

Environmental Defense Fund, Cornell University, and Kansas State University studied how severe weather financially impacts Kansas farms and how management choices and government programs mitigate the negative impacts. The study used a 40-year Kansas farm financial dataset and historic weather data to measure the impacts of extreme heat on gross and net farm income.

Extreme heat decreased farm income.

For every 1°C of warming:

Gross farm income decreased by **7%**

Net farm income decreased by **66%**

Extreme heat had negative long-term impacts on land value growth and farm equity.

Farmers' risk management tools helped reduce the impacts of extreme heat on net farm income.

51% of net income losses were recovered by crop insurance.

16% of net income losses were recovered by crop inventory adjustments.

37% less net income losses were experienced by farms with above-average irrigation access.

IT IS CRITICAL

to support farmers' adaptation to climate change.

See all solutions →

USDA, Land Grant Universities and the private sector can increase research, outreach and education on climate resilience solutions to support farmers' adaptation to climate change.

The Federal Crop Insurance Program can support farmers in implementing on-farm climate change-resilience measures while continuing to provide financial risk management.

Agricultural lending institutions can support their borrowers in making investments that mitigate climate change risks on the farm and manage risks to lenders' loan portfolios.

Climate change presents risks to agricultural production in Kansas.

Climate change is projected to significantly increase the frequency and severity of extreme weather across the U.S. in the coming decades. As weather extremes become more frequent, U.S. farmers are projected to face increasingly negative impacts on crop yields (Jägermeyr et al., 2021). The Midwest is already seeing major impacts. In 2012, a drought resulted in $30 billion in agricultural losses (Rippey et al., 2015), and floods in 2019 caused a $4.5 billion loss in agricultural sales (English et al., 2021). Such cases of extreme weather and crop production losses are becoming more frequent, and farmers can face financial losses that put their businesses in jeopardy.

The state of Kansas is a major crop-producing region spanning across irrigated and non-irrigated cropland. As a top producer of wheat, soybeans and corn in the U.S. (USDA 2017; USDA 2021), the state presents itself as an informative case study of climate risks to farms' financial health. Under a moderate greenhouse gas emissions scenario, Kansas corn yields are projected to decline by up to one-third and winter wheat yields are projected to decline by 17% by mid-century (Araya et al., 2017; Obembe et al., 2021). Even greater losses can be expected if GHGs are not reduced to the level of a moderate projection scenario.

The increasing frequency and severity of extreme heat is one outcome of climate change. In Kansas, extreme heat is a growing threat to agriculture. Climate models project a 58% increase in hot days (days above 82°F or 27.8°C) by 2030 and a 96% increase by 2050 (Environmental Defense Fund 2022).

The number of hot days (above 82°F) in Kansas are projected to increase by 58% by 2030.

Understanding farm financial impacts of extreme weather can inform climate adaptation solutions.

While severe weather conditions like extreme heat directly impact crop productivity, measuring the impacts on crop production solely does not accurately reflect the effects on farm financial health. Farmers make management decisions and have access to government programs that influence the severity of the negative impacts of extreme weather on their business income. It is critical to evaluate climate change impacts on gross and net farm income and the buffering effects of farm management decisions and government programs. Gaining insight into the historical financial impacts of severe weather on farms, along with the management decisions and government initiatives that alleviate these adverse effects, can help inform solutions that advance climate resilience in U.S. agriculture to face the growing threats from climate change.

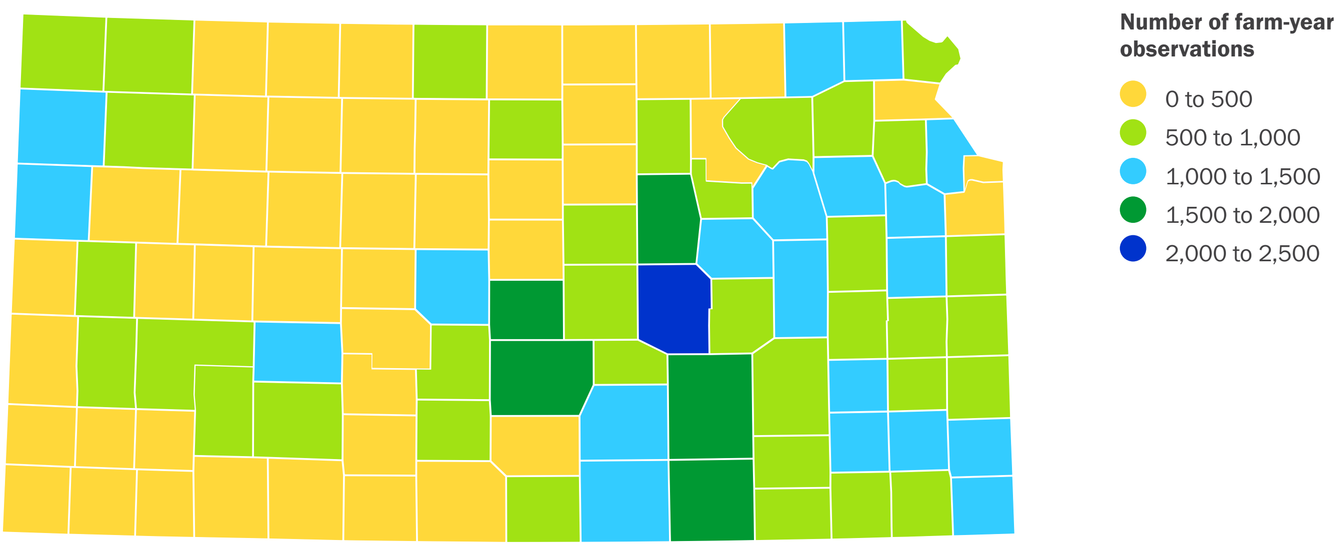
Farm finance and weather data can provide insights on financial outcomes of extreme heat.

In this study, we examined the impacts of extreme heat on the financial outcomes of Kansas farms to inform future adaptation solutions. This analysis required detailed farm-level data. We utilized a unique Kansas Farm Management Association, known as KFMA, dataset with detailed information on farm production and finances from 1981 to 2020 across 6,958 unique Kansas farms. The KFMA provides financial analysis and accounting services to Kansas producers and has a partnership with Kansas State University that allows research to be conducted with the data. Figure 1 shows the distribution of the KFMA sample across 105 counties in Kansas.

The dataset contains crop yield and detailed farm-level financial information. We relied on detailed financial and historical weather data to evaluate the impacts of extreme heat on two farm financial performance metrics: gross farm income and net farm income. Gross farm income represents the revenue generated by the farm business, and net farm income represents the profits of the farm business by subtracting direct and overhead costs from gross farm income.

We used farm financial data to measure the impacts of extreme heat on gross and net farm income.

FIGURE 1. Spatial distribution of the Kansas Farm Management Association dataset observations.

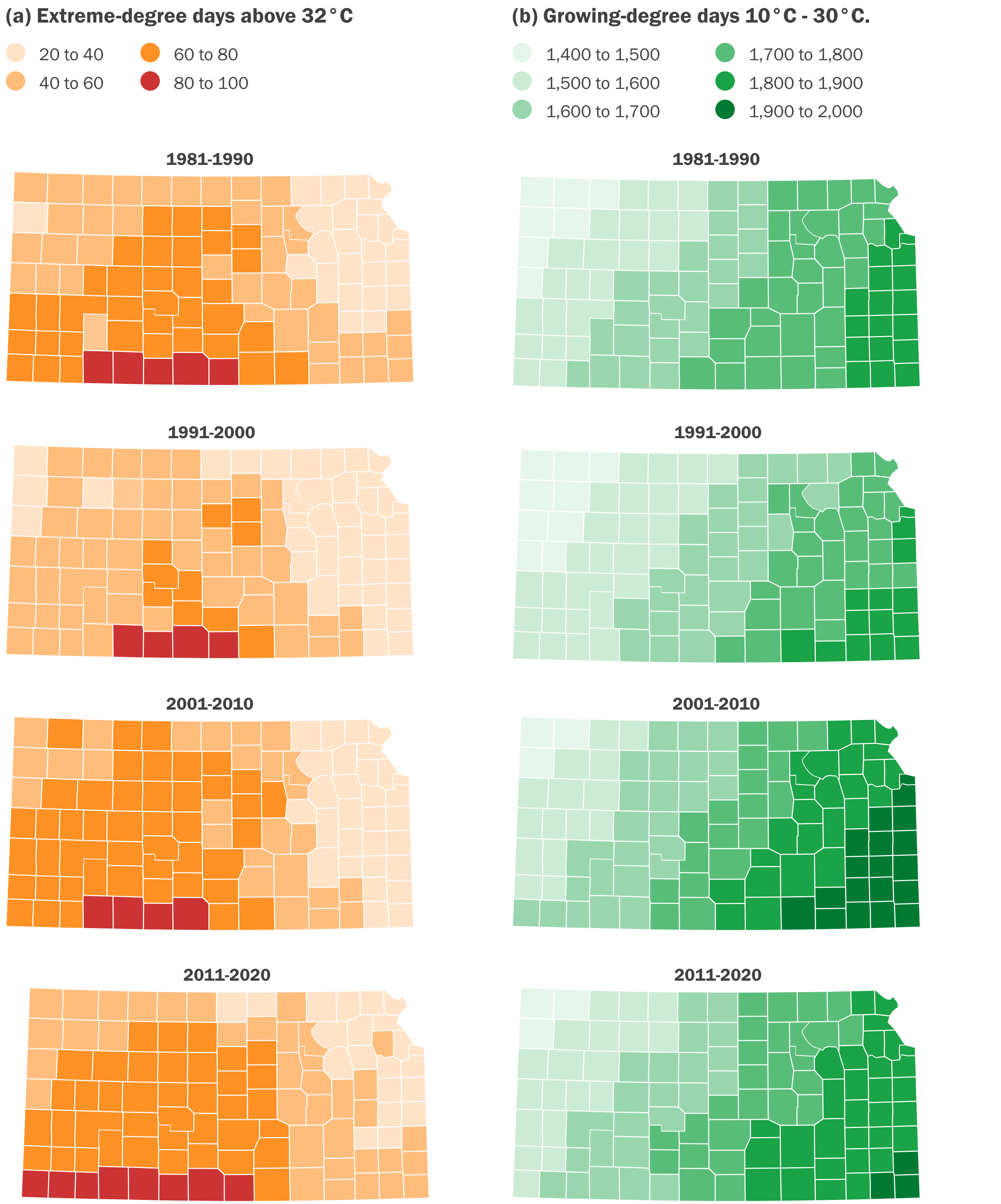


We also evaluated the effects of farm management decisions and risk management programs on reducing the severity of financial impacts caused by extreme heat. We specifically evaluated the role of crop insurance indemnities, government payments, changes in crop inventories and access to irrigation in buffering extreme heat impacts on farm financial outcomes. We also evaluated how long-term changes in extreme heat are related to changes in land values and farm equity over a 30-year period.

We measured farm exposure to extreme heat using a yearly measure of extreme-degree days, known as EDD. EDD is a multiplication of temperature (in 1°C increments above 32°C) and exposure (in days) at each temperature point. As a result, days with temperatures that are further above 32°C (or 89.6°F) are given more weight, reflecting their increased negative effect on crop yield. Thirty-two degrees Celsius is used as a threshold of exposure to extreme heat since the literature supports that crop yields start declining once temperatures reach that limit. Over the past four decades across Kansas, EDD has increased by three degree-days from 54 EDDs per year (during the growing seasons of 1981 to 1990) to 57 EDDs per year (during 2011 to2020).

Similarly, we calculated a yearly measure of growing-degree days, known as GDD, between 10°C and 30°C (or between 50°F and 86°F), which are ideal for crop-growing conditions. Figures 2a-2b show EDD and GDD for Kansas counties separately for four decades between 1981 and 2020. EDD grew by 0.3% per year at nearly double the growth rate of GDD (0.2% per year) over the past several decades. Over the past several decades, increasing temperatures appear to have had a greater negative impact on growing conditions because of extreme temperatures than a positive impact through extending growing season length.

FIGURE 2. Extreme-Degree Days (EDD) and Growing-Degree Days (GDD) in Kansas by county from 1981 to 2020.



Extreme heat had significant negative impacts on gross and net income.

Increased farm exposure to extreme heat negatively impacted crop yields across our study period. For ease of interpretation, we translated the impacts of EDDs into impacts associated with a 1°C uniform temperature increase during the 40-year dataset. **Our study finds that 1°C of warming reduces major crop (corn, soybean and wheat) yields by approximately 16-20%.**

Our analysis finds that extreme heat exposure negatively impacts gross and net farm income. **We find that a 1°C of warming is associated with a 7% reduction in gross income and a 66% reduction in net income.**

To provide context, we can apply this finding to the U.S. 2012 drought, one of the largest droughts in recent years, leading to a growing season about 1.6°C warmer than normal in Kansas. A similar temperature increase to the 2012 growing season would reduce gross and net farm income by 11% and 105% respectively, based on the association found in our research. Additional sources of income, like crop insurance, are all accounted for in these measures of gross and net income. These impacts show that even with such income support measures, high temperatures still have significant negative effects on farm income.

1°C OF WARMING

is associated with:

7% reduction in gross income

66% reduction in net income

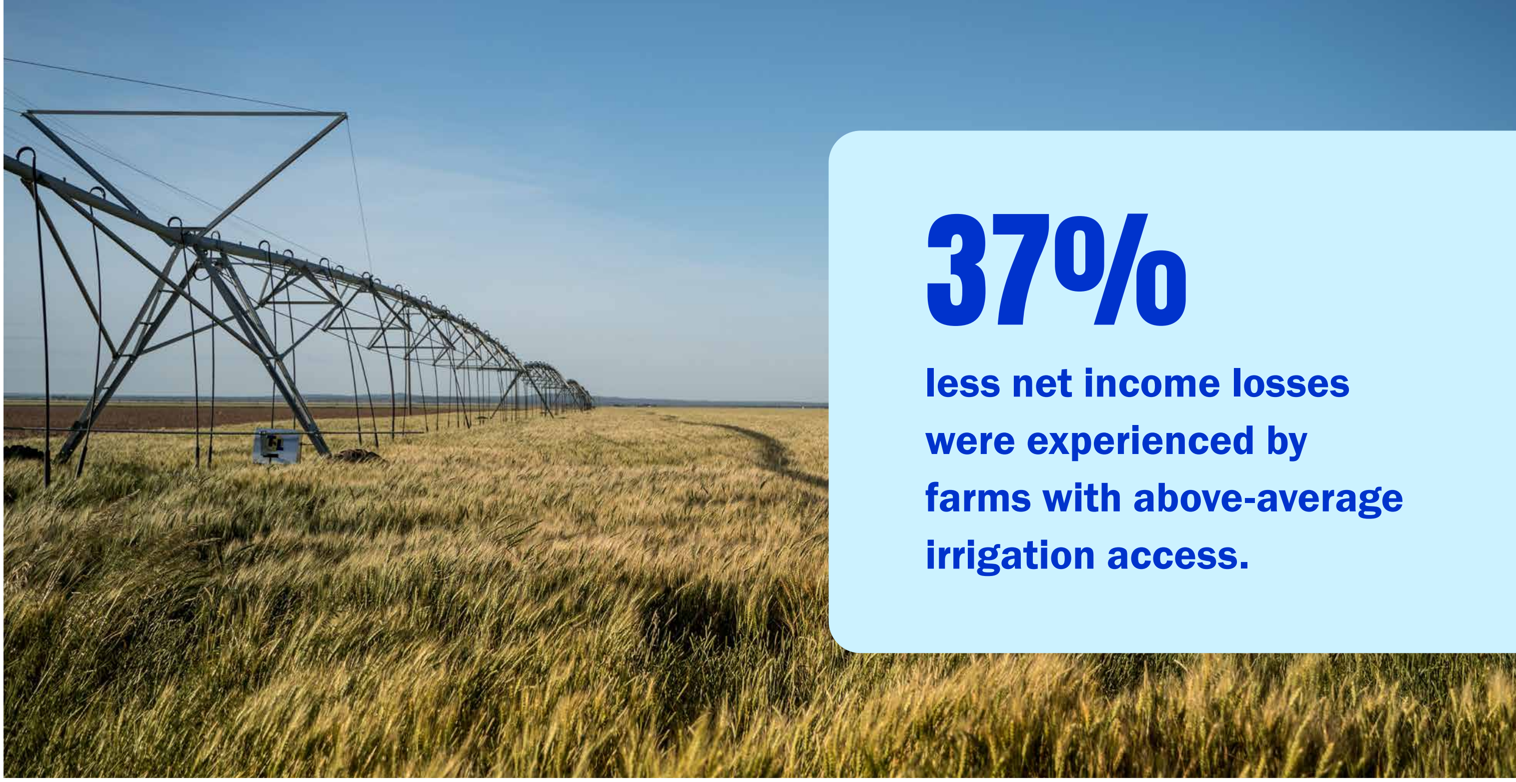
Crop insurance, inventory sales and irrigation buffer the farm financial impacts of extreme heat.

Our study finds that farmers' risk management tools reduce the impacts of extreme heat on net farm income. We find crop insurance payouts significantly reduce net farm income losses associated with extreme heat. In our dataset, **crop insurance helped recover 51% of the net income losses from extreme heat.** Farms in our sample received approximately $20,200 on average in crop insurance payments per year.

We also find that farmers' crop inventory stock (the crops not yet sold that they hold in storage) decreased significantly after farms experienced extreme heat. A typical farm in our sample holds $159,500 of crop inventory, which is more than twice the yearly net income. We find **adjustments in crop inventory recovered 16% of the net farm income losses from extreme heat**. This shows that farmers can effectively smooth out their income across good and bad weather years by holding crops in storage during good years and selling them off during bad weather years.

51% of net income losses were recovered by crop insurance. →

16% of net income losses were recovered by crop inventory adjustments. →



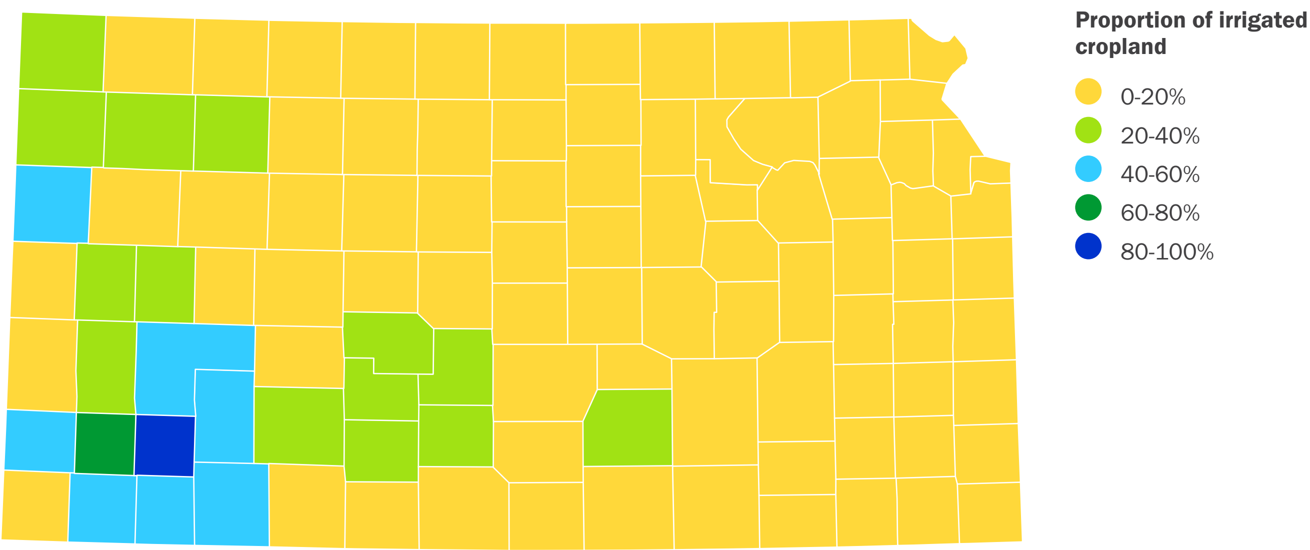
37%

less net income losses were experienced by farms with above-average irrigation access.

To understand the role of irrigation in buffering the impacts of extreme heat on farm finance, we calculated the share of irrigated cropland for each farm-year observation, as seen at the county level in Figure 3. While there is considerable irrigation in western Kansas, most of the cropland in the state is not irrigated. We classified farms as 'highly irrigated' if the irrigated area of their cropland is above-average, and we used this binary measure as the key indicator of irrigation use in our analysis.

Access to irrigation also appears to limit some income loss due to heat. **Farms with a greater than average proportion of irrigated crops experienced approximately 37% less net income loss compared to other farms.** While irrigation was found to serve as a buffer to the impacts of extreme heat in the short term, [recent legislation on water use in Kansas] indicates that future limits may be imposed, and investments in increased irrigation could cause stranded assets and discourage the adoption of long-term water conservation solutions, such as crop switching.

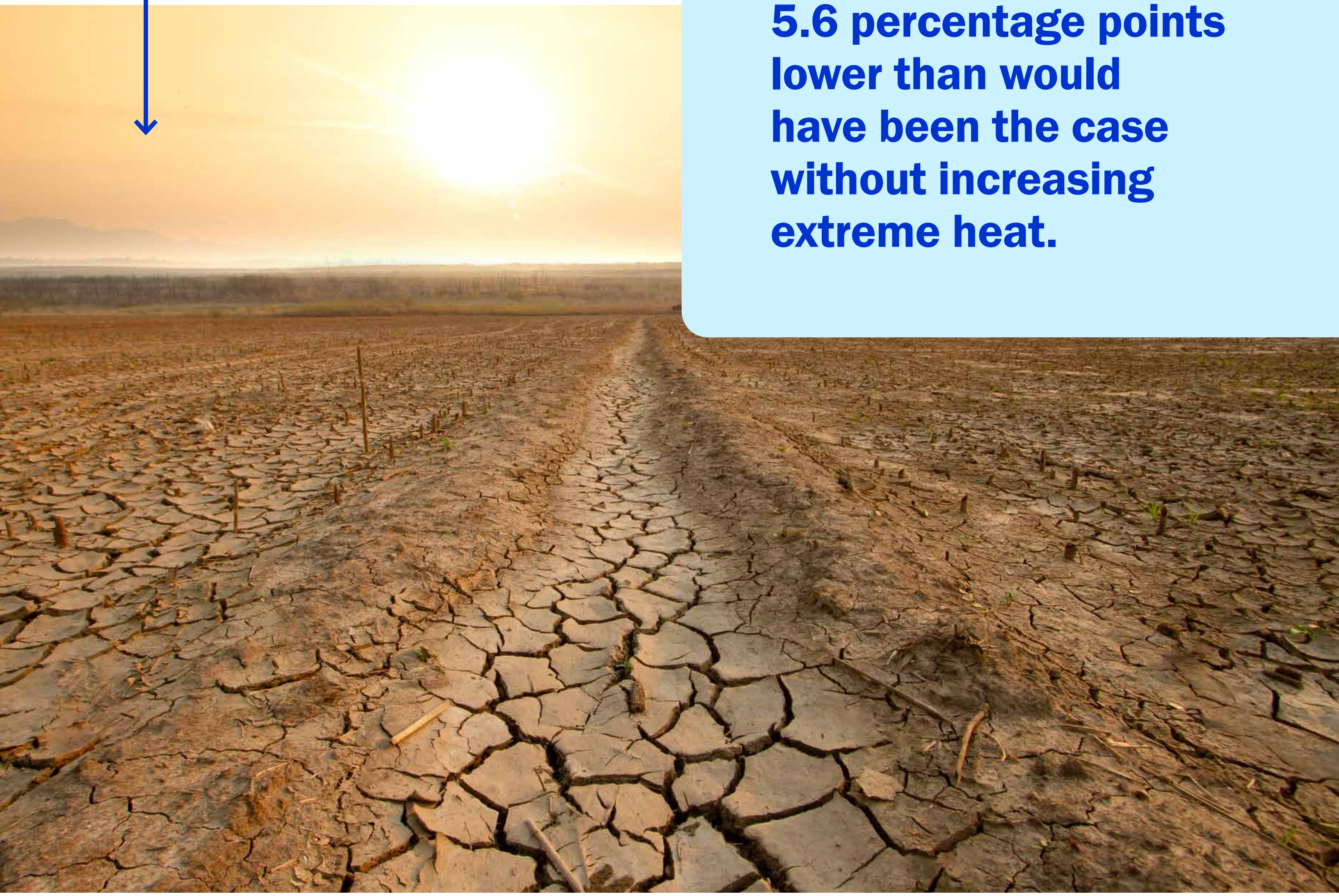
FIGURE 3. **Irrigated cropland for each farm-year in Kansas.**



Extreme heat had long-term impacts on land value.

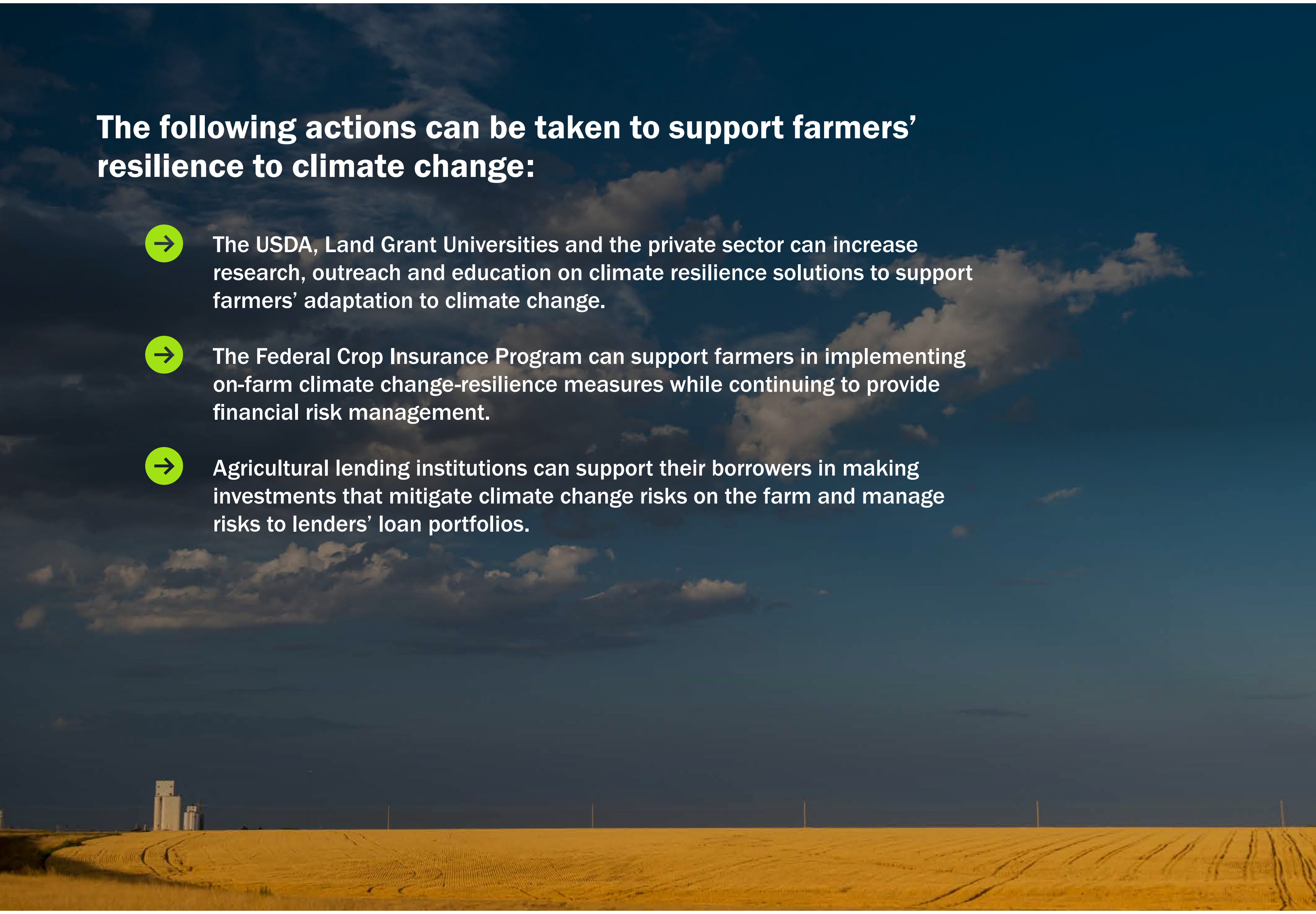
Over the long term, we find that extreme heat negatively correlates with growth rates of farmland value and farm equity. Over a 30-year period, land value and farm equity grew by 53% and 107%, respectively. The study estimated that **land value growth was 5 percentage points lower, and farm equity growth was 5.6 percentage points lower than would have been the case without increasing extreme heat.**

Over a 30-year period, land value growth was 5 percentage points lower, and farm equity growth was 5.6 percentage points lower than would have been the case without increasing extreme heat.



Supporting on-farm adaptation can help farmers build resilience to climate change.

Climate change is expected to increase the frequency and severity of extreme weather in Kansas. With extreme heat serving as a proxy, we find that extreme weather has had significant negative impacts on farm financial performance in Kansas. We also find that farm policy and risk management methods are critical in mitigating those impacts. Looking to the future with this in mind, it is critical to support farmers' adaptation to climate change.



The following actions can be taken to support farmers' resilience to climate change:

- The USDA, Land Grant Universities and the private sector can increase research, outreach and education on climate resilience solutions to support farmers' adaptation to climate change.
- The Federal Crop Insurance Program can support farmers in implementing on-farm climate change-resilience measures while continuing to provide financial risk management.
- Agricultural lending institutions can support their borrowers in making investments that mitigate climate change risks on the farm and manage risks to lenders' loan portfolios.

The USDA, Land Grant Universities and the private sector can increase research, outreach and education on climate resilience solutions to support farmers' adaptation to climate change.

The USDA should continue its progress to achieve the **USDA Action Plan for Climate Adaptation and Resilience** and increase support for research and development on climate adaptation practices and technologies. Land Grant University researchers can increase research on alternative cropping systems better adapted to future heat and drought to provide producers with adaptation alternatives. Agricultural economists can supplement that research with analysis of the financial costs, benefits and barriers to adoption of adaptation alternatives. One example of this is the Center for Farm Financial Management at the University of Minnesota's collaboration with EDF, Minnesota Farm Business Management and other partners to **gather and analyze cover crop financial data from 121 farms** across four crops and five cover crop types. Extension services, agricultural lenders and others with direct relationships with producers can expand outreach and education to share the insights of that research on climate change adaptation measures. The private sector can also play an important role in developing new adaptation solutions and supporting investments in resilience through their supply chain. Seed and crop genetics companies can continue investing in research and development to produce climate-adapted crops and technologies such as drought-tolerant crops. Continued investments in this area are crucial to help farmers and supply chains be more resilient to the physical impacts of climate change. Commodity traders and consumer goods companies can also manage climate-related supply risk by proactively supporting their suppliers in adaptation investments.

The Federal Crop Insurance Program can support farmers in implementing on-farm climate change-resilience measures while continuing to provide financial risk management.

The FCIP has played a critical role in reducing financial risks to farmers in the face of climate change. Still, as those risks continue to mount, additional options for on-farm risk mitigation may be necessary to support the role of crop insurance in providing financial stability to producers. This could come in the form of integrating farm characteristics proven to improve crop yield resilience to insurance pricing, parallel risk reduction programs designed to support farmers in building resilience and ultimately reducing crop insurance payments, or other similar changes. An immediate step that can be taken by the USDA is to make compatible datasets from the Risk Management Agency, the Farm Service Agency and the Natural Resources Conservation Service and to use those datasets to research the risk reduction impacts of climate-smart practices on crop insurance indemnities. The **Conservation and Crop Insurance Research Pilot** conducted by AGree and the University of Illinois at Urbana-Champaign demonstrated a reduction in the likelihood of prevent plant indemnities during the extremely wet 2019 spring for farms that used cover crops and no-till in the Upper Midwest. The Pilot also recommends improvements USDA agencies can make in their data infrastructure to assess the risk reduction impacts of climate-smart agriculture practices.

Agricultural lending institutions can support their borrowers in making investments that mitigate climate change risks on the farm and manage risks to lenders' loan portfolios.

While agricultural lenders cannot prescribe practices their borrowers must use to receive financing, lenders are important business partners to farmers and can help them identify investments that can help the farm be resilient to climate change and create the financing needed to make those investments. A **2022 survey of 167 agricultural finance institutions** conducted by EDF and Deloitte found that while 87% of respondents expect climate change to pose a material risk to their business, only 25% are significantly factoring climate change impacts into their decision-making. To address this gap, agricultural lending institutions can assess climate risks to their portfolio of agricultural loans, understand adaptation solutions on the farm that can mitigate climate risk and engage their borrower on those risk mitigation opportunities. They can provide their borrowers with education on climate resilience solutions, connect them with opportunities and provide financing to enhance their climate resilience. **A climate strategies guide for agricultural lending institutions** published by EDF and Deloitte in 2023 presents five strategies agricultural lending institutions can implement to address climate risks to their business and to their borrowers.

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