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ADDRESSING CLIMATE-RELATED FOOD SECURITY CHALLENGES

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INTRODUCTION

Corn
Phys.org, 2021

Climate change poses a serious threat to the economy, infrastructure, and general welfare. Agricultural production in the United States will be severely impacted by the effects of climate change, with increasingly warmer and volatile weather threatening crop yields. Furthermore, changes in weather patterns brought about by human-induced climate change can threaten water supplies and contribute to long-term drought, which makes it difficult for crops to receive the water necessary to grow.

This briefing explores how climate change may affect yields of the most important crops grown in the United States, along with what strategies effectively mitigate these effects. The security of the nation's agricultural system is essential to residents' food security and the economy at large, as agricultural exports from the United States totaled a value of $196 billion in 2022 (Kaufman, 2023). As the planet warms and weather patterns change, it is important that the country can produce enough food to feed its residents. Doing so requires careful planning based on an accurate understanding of how climate change affects crop yields. Therefore, this committee should propose solutions that expand our understanding of the threat climate change poses to national food security. Furthermore, this committee should also explore the best course of action to mitigate those threats.

EXPLANATION OF THE ISSUE

Scope of the Problem

Climate change poses a threat to the stability of agricultural systems in many ways. Namely, warmer temperatures, stronger **hydroclimatic events**, and recurrent fires can destroy crop yields. This briefing will discuss the changes in yield brought about by warming temperatures and by decreased water availability. Then, we will explore the uncertainty of how these variables will change, highlighting the essential need for more research to predict the effect of climate change on yields of specific crops.

Increased Temperature and Crop Yield

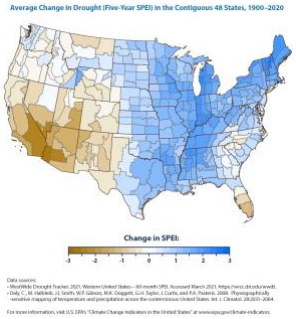
Killing degree days – days in which the temperature of a given cropland region exceeds a limit, above which crops are likely to die from

One way climate change will impact crop yields is through warmer average temperatures and extreme temperature swings during the growing season. Warmer temperatures can decrease crop yields by shortening the growing season and increasing evapotranspiration rates, which leads to water stress (Minoli et al., 2019). Increased temperatures shorten the time it takes for a crop to reach maturity. In doing so, climate change can decrease a crop's grain filling period, which leads to losses in mass harvested from fully mature plants. Furthermore, warmer temperatures can disrupt normal pollination patterns and increase the number of killing degree days (where plants experience extreme temperatures). These phenomena damage plant tissues and can even kill crops (Minoli et al., 2019). The response of yield to increases in temperature varies; some crops may even benefit from slight increases in temperature if they are currently grown in regions that are colder than their optimal growth temperature (Minoli et al., 2019). However, most staple crops grown in the United States today are well adapted to their current climate conditions, so future increases in temperature will generally lead to losses in yield without adaptation measures.

Predicting how increased temperatures will affect future yields is challenging. Current warming has had little effect on American agriculture thus far and, in some cases, has even boosted yields (Sharma et al., 2022). However, these effects may be attributed to the wide availability of some adaptation measures in the United States, such as intensifying irrigation, which may not be feasible to implement with even higher temperatures (Burrows, 2018). Furthermore, since many crop regions of the United States are colder than those in countries closer to the Equator, some mild warming may be beneficial to crop yields. However, these trends are not necessarily significant in a broader context. In one study, researchers at Penn State looked at eighteen different warming scenarios and found that corn production in the US Great Plains (the top corn producing region in the country) decreases under all

scenarios, though to differing extents. Though increased temperatures will impact major crops differently, this example of corn is important because it demonstrates how currently experienced crop yield trends may not be helpful for predicting future crop yields under heat stress (Mulhollem, 2022).

Water Stress and Crop Yield



Average Change in Drought (Five-Year SPEI) in the Contiguous 48 States, 1900–2020 United States Environmental Protection Agency, 2021

Another mechanism by which climate change can affect crop yield is through water stress. Higher temperatures increase evaporative demand, which means that plants need more water to remain healthy and maintain normal yields (Sadras et al., 2016). Crops grown in the United States can be grouped by being either rainfed or irrigated. Examples of major rainfed crops include corn, wheat, soybean, cotton, sorghum, and barley. Major irrigated crops include rice, almonds, grapes, and citrus trees, along with most leafy green vegetables. Some of these crops, such as rice and almonds, are known for their high demand for water. As temperatures increase in the coming decades, rainfed crops may not receive enough water to maintain their normal yields under higher average temperatures and more extreme temperatures. Therefore, some traditionally rainfed crops may need to be irrigated to preserve yields. Similarly, irrigated crops that face increased temperatures may also require more intensified irrigation methods. One paper published by Dr. Sara Minoli from the Potsdam Institute for Climate Impact Research found that increasing irrigation for maize, rice, soybean, and wheat can neutralize the negative effects of increased temperatures: up to 4°C for maize, 1.5°C for rice, 2.5°C for soybeans and around 5°C for wheat. However, the feasibility of irrigating major rainfed crops (soybean, maize, and wheat) across the United States is unknown and likely very costly.

The feasibility of expanding irrigation to counteract the negative effects of rising temperatures relies on existing water constraints. The figure to the left, from the Environmental Protection Agency, shows the change in drought in the last century across the continental United States. A negative SPEI (brown) indicates intensified droughts, experienced mostly in Southern Florida and most of Western United States. A positive SPEI (blue) indicates a relative decrease in drought intensity. This map highlights that water availability trends are region-specific (Climate Change Indicators: Drought.", 2021). Therefore, whether expanding irrigation to combat higher temperatures can succeed depends on where the crop is located. Crops such as almonds, grapes and citrus trees are highly water intensive and are mostly grown in Florida, California, Arizona, and parts of Texas. Many of these regions face growing water scarcity.

Uncertainty of Impacts on Crop Yield

It is important to note that the extent to which climate change affect crop yields is uncertain. More research is needed to understand the implications of rising temperatures and changes in water availability. This research must be specific for a particular crop in a given area. Different regions and different crops will respond differently to climate change. Furthermore, advanced irrigation and other adaptation mechanisms to maintain yields under higher temperatures also requires research. Finally, predictions about future warming are dependent on concentrations of greenhouse gasses in the atmosphere. Reduction of emissions and carbon sequestration are therefore deeply relevant to the conversation about mitigation of the impacts of climate change on US crop production.

Congressional Action

Congress has long been preoccupied with the stability and success of American agriculture. The twenty-first century has marked a significant shift in agricultural policy, with a pivot toward addressing the impacts of climate change. Most recently, the Inflation Reduction Act (IRA) appropriated funding to address the impacts of climate change on agriculture in Title (Title II: COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY). The IRA allocates funding for the United States Department of Agriculture (USDA) to implement agricultural conservation and carbon sequestration programs, such as the Environmental Quality Incentives Program (EQIP). EQIP provides specialized technical and financial assistance with farmers to create custom conservation plans for individual farms. These plans can help address droughts and weather volatility. Similarly, the Infrastructure Investment and Jobs Act of 2021 allocates extra funding for many infrastructure projects, including groundwater recharge and desalination projects, both of which help increase water availability for crop use. While crop resilience is not the primary focus of the IRA and the Infrastructure Investment and Jobs Act, these pieces of legislation represent substantial efforts to increase crop resilience nationwide.

In 2022, the House passed the Global Food Security Reauthorization Act of 2022, which reauthorizes the implementation of the Global Food Security Strategy and the Emergency Food Security Program. These programs run through the United States Agency for International Development (USAID) and help combat global food insecurity. While these programs are not run domestically, they represent past congressional action to preserve the stability of food systems in the face of climate change. This bill was then introduced to the Senate in 2022 and referred to the Senate Committee on Foreign Relations.

Other recent bills that were introduced concerning this topic include the Agricultural Resilience Act of 2023, the Agricultural Innovation Act of 2023, and the Sustainable Agriculture Research Act of 2021. The Agricultural Resilience Act of 2023 was introduced simultaneously to the House and the Senate. Its purpose was "to address the impact of climate change on agriculture, and for other purposes." The bill focuses extensively on research concerning the risks on agricultural stability associated with climate change. This bill also provides for programs that conduct technology transfer to rural areas, soil-health programs, and on-farm clean energy facilities. The research hubs proposed are region-specific and would exist under the Department of Agriculture. These hubs would focus on providing information and programming on region-specific climate change mitigation strategies. As of June 2023, the bill has remains in committee. In the Senate, the bill has been referred to the Senate Committee on Agriculture, Nutrition, and Forestry.

The Agricultural Innovation Act of 2023 would entail the USDA collecting and analyzing data from different croplands that would help researchers better understand the link between conservation practices and cropland yields. This data would be available to independent researchers and would be especially useful to address the current uncertainty surrounding the effects of climate change on crop yields and how different mitigation measures can dampen those negative effects. As of June 2023, this bill was introduced to the Senate and referred to the Senate Committee on Agriculture, Nutrition and Forestry.

The Sustainable Agriculture Research Act was introduced to the House in 2021 and referred to House Committee on Agriculture but has been stalled there ever since. This bill proposes a revision to the the Agriculture Advanced Research and Development Authority (AGARDA), which is run by the USDA. This revision includes developing agricultural resilience solutions to address the impacts of extreme weather on crop production, the potential for carbon storage through agriculture, and the adoption of on-farm clean energy generation.

Other Policy Action

Beyond Congress, the Department of Agriculture can also implement policies to address climate change in the context of crop yield. Secretary of Agriculture Thomas J. Vilsack has highlighted the importance of responding to climate change threats to United States agriculture ("Secretary of Agriculture Tom Vilsack", 2021). In addition, the United Nations Food and Agriculture Organization (FAO) also focuses on addressing food security threats. Farmers organizations such as the National Farmers Union and the American Farm Bureau Federation are also important stakeholders in this issue. These stakeholders have each proposed their own policies to

combat the impacts of climate change on crop yields, and each play a key role in ideating and implementing these policies across the nation.

IDEOLOGICAL VIEWPOINTS

Many of the discussions surrounding agricultural resilience in the face of climate change focus on the extent to which humans can mitigate the effects of climate. Representatives from districts with large agricultural economies, including, but not limited to: California, Nebraska, Iowa, Texas, and Illinois are likely to express more concern over the implications of climate change on agriculture.

Conservative View

While generally conservative representatives are hesitant to legislate climate action bills, there are many Republican representatives that support environmental stewardship and voluntary conservation initiatives, such as Rep. Brian Fitzpatrick (R-PA), Rep. Elise Stefanik (R-NY), and Rep. Garret Graves (R-LA). Generally speaking, conservatives want to minimize government mandated actions and prefer opt-in mitigation programs. Some conservatives may be hesitant about legislation that directly addresses the cause of global warming— the emission of greenhouse gasses. In general, Republicans oppose the expansion of government subsidies for clean energy generation on farms.

Environmental stewardship *– the sustainable management of natural resources and the natural environment at large; conservationism.*

Liberal View

Liberal representatives almost unilaterally recognize the reality of anthropogenic climate change, usually voting in favor of action to fight climate change. Some of the Democratic representatives most involved in the issue of agricultural climate change resilience are Rep. Chellie Pingree (D-ME), Rep. Abigail Spanberger (D-VA) and lieutenant governor of New York Antonio Delgado (D-NY), who previously served in the House of Representatives. Liberal policy is likely to favor larger government spending on mitigation strategies. The bills mentioned in the Congressional Action section of this briefing were all sponsored by Democratic members of Congress, though the Agricultural Innovation Act of 2023 was sponsored by Sen. Amy Klobuchar (D-MN) and cosponsored by Senator John Thune (R-SD). Therefore, there is room for a substantial bipartisan effort to address climate-related food security challenges.

AREAS OF DEBATE

Implementing In-Situ Adaptation Methods

In-situ adaptation methods refer to adaptation strategies that do not change the geographic location of where a given crop is grown. These adaptation methods include increasing irrigation or starting the irrigation of traditionally rainfed crops, switching **cultivars** to be more drought tolerant, and altering the planting date of crops. One promising adaptation method is expanding irrigation networks, as irrigation has the potential to almost entirely counteract the yield losses associated with increases in average temperature. However, this solution is also one of the most resource intensive. Cultivar switching is another solution. This strategy involves selecting cultivars that can maintain current yields even when exposed to more extreme temperatures and drought. A more extreme alternative to cultivar switching is switching the crops grown in an area to crops that are better adapted to higher temperatures and more extreme drought. Altering the planting date of crops can also be a useful in-situ adaptation method that allows farmers to avoid exposing crops to high temperatures by planting earlier in the year.

Cultivar *– short for cultivated variety, refers to different varieties of the same crop species that have a range of characteristics through selective breeding.*

Pursuing in-situ adaptation methods requires a deep understanding of how best to address regional climate change-driven threats to crop resilience. Not only must the predictions of how local climates will change in the coming years be precise and region-specific, but thorough economic analyses are needed to see if these interventions are cost-effective.

Political Perspectives on this Solution

The extent to which governments should be involved implementing the in-situ adaptation methods is a point of disagreement between conservatives and liberals. While Democrats are more likely to favor programs that provide funding to farmers who implement climate adaptation programs, Republicans support market-based solutions that leave implementation of initiatives largely up to the farmer.

Some of the adaptation methods mentioned may be more contentious than others. For example, promoting the intensification of irrigation is not likely to garner support in states that are already struggling with persistent droughts and wildfires, such as California.

Water Availability and Infrastructure

As previously discussed, intensifying irrigation is one of the best ways to maintain yields under increased heat-stress. Widespread increase of irrigation on croplands necessitates large scale

infrastructure investment to provide sustainable access to water and protect natural aquifers and other sources of water.

Some promising infrastructure projects include desalination plants and water diversion projects to recharge depleted aquifers. The Infrastructure Investment and Jobs Act discussed previously allocated $250 million to desalination projects, in accordance with the Water Desalination Act of 1996. However, these desalination projects were not necessarily intended for agricultural use. Another solution is to provide grants for farms that implement their own water conservation strategies. In this way, new water infrastructure is implemented by farmers and agricultural corporations with the government needing only to approve projects and provide funding.

***RCPs** – scenarios used in climate modeling that represent different trajectories of greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) and many other institutions use four main RCPs to model possible climate change scenarios.*

In addition to improving existing water infrastructure, it is important to have accurate and timely information on the availability of water. Regulations can limit the amount of water used in non-agricultural sectors to increase cropland water accessibility. Furthermore, policies can be implemented to encourage consumers to purchase water conscious crops in areas that have low water availability.

Political Perspectives on this Solution

Political discussion about increasing water availability for crops will likely center around the cost and level of government involvement in these projects. For example, desalination plants can be quite expensive, and where that money comes from in the budget is likely to be contentious. Likewise, implementing any regulations that determine how much water crops or other sectors can use is likely to be opposed by conservatives and supported by liberals.

Other important stakeholders in the conversation of water use are Native American groups, who have long advocated for the right to water for their use. Any water diversion program implemented should take these rights into consideration to not jeopardize water access on reservations.

Research and Public-Private Collaboration

One of the main goals of the United States House Committee on Science, Space, and Technology is to promote cutting edge research in a variety of applied STEM fields. Research into the impacts of climate change under different **Representative Concentration Pathways (RCPs)** is a key step in preparing our agricultural systems for the impacts of climate change. Secondly, the extent to which different mitigation strategies are effective at maintaining crop yields is also not completely understood. These two areas of research should be a priority for this committee.

Introducing funding for universities and other research institutions on topics related to climate change mitigation and agriculture is one way to achieve this goal. Projects such as **Free-Air**

CO2 Enrichment (FACE) studies and greenhouse simulations that imitate global warming are just two ways to explore this topic.

To ensure farmers have access to useful information about climate change mitigation strategies, the USDA can provide free online classes and workshops, as well as creating an online hub to access important tools at any time. Furthermore, the National FFA Organization could integrate climate change mitigation strategies into their curriculum and training to educate the next generation of agricultural experts.

Political Perspectives on this Solution

Education on the impacts of climate change in public education has recently been a contentious topic between Democrats and Republicans. As there is currently no nationwide mandate to teach about climate change in public schools, education about this topic has been largely left up to each state. The leaders of some states may not outwardly accept the scientific fact of anthropogenic climate change, making education on these topics in programs such as FFA difficult.

BUDGETARY CONSIDERATIONS

FACE facility in the Nevada desert
National Nuclear Security Administration Nevada Site Office Photo Library

For Fiscal Year 2023, the US federal budget appropriated $24 million to the USDA's hubs for climate research, as well as an additional $4 billion for USDA's research, education, and outreach programs ("Budget of the US Government", 2022). The budget also allocates $4 billion for drinking water infrastructure. The National Science Foundation (NSF) receives $2 billion for research infrastructure. The NSF provides grants for research in all STEM fields, not just climate science.

Though these numbers may seem large, a large portion of the budget is used to maintain existing infrastructure and programs, so the addition of new programs and initiatives should acknowledge an untapped source of funding. In theory, any appropriations made during our committee time would be sent to the House Appropriations Committee for approval.

CONCLUSION

Though great progress has been made in the past few years to tackle the climate crisis, national action thus far has still not been enough to limit carbon emissions and fully address the challenges of the future. Climate science is a relatively new field, and more must be done to understand the potential effects of warming on agricultural yields. Furthermore, decisive national action is

necessary to guarantee food security across the country and maintain the health of the agricultural industry, which accounts for around $200 billion in exports each year. This issue will affect different parts of the country in different ways. Therefore, a regional understanding of how climate change will affect particular crops in different states is essential for effective policymaking. As a representative in the House Committee on Science, Space and Technology, it is your job to guide the country to better understand the threat climate change poses to agriculture through meaningful research. In addition, you must also determine the best practices to solve this problem.

GUIDE TO FURTHER RESEARCH

The sources primarily used throughout this guide were the Congress.gov bill tracker, the USDA website, academic papers on different agricultural climate change mitigation strategies, and reports from international organizations (such as USAID, FAO, etc). One of the best ways to research this topic in the context of your assigned constituency is to understand (1) what major crops are grown in the area, (2) whether those crops are mostly grown by large corporations (such as Monsanto, etc) or by small scale farming, (3) what climate models predict will occur in the region in the coming decades, and (4) how farmers are currently trying to adapt to changing climates. Most of the policies and bills discussed in this briefing have been discussed across the nation, so it is important to also understand what each state is doing to prevent agricultural losses as temperatures rise and water-stress becomes more acute. Some questions to ask as you build your understanding of this topic are:

1. What programs to protect agricultural yields have been most successful in the past, and how scalable are these programs?

2. Who are the stakeholders in the agricultural sector in a given state/county?

3. What climate change mitigation strategies create the most jobs?

4. How costly is a proposed mitigation strategy, and who should bear that cost?

5. How can the consumption habits of American consumers change to promote the consumption of crops that are climate resilient?

6. To what degree should the federal government be responsible for guiding and executing agricultural mitigation strategies against climate change?

GLOSSARY

Cultivars– short for cultivated variety, refers to different varieties of the same crop species that have a range of characteristics through selective breeding.

Environmental stewardship– the sustainable management of natural resources and the natural environment at large; conservationism.

Free-Air CO_2 Enrichment (FACE) studies– a methodological approach to studying the effect of different CO_2 concentrations on various aspects of plant growth. Typically, crops are grown in a field with surrounding towers that release CO_2 at specific concentrations.

Grain filling period– the period in development of cereal crops where the plants accumulate most of their dry matter that is then harvested.

Hydroclimatic events – weather phenomena that influence the hydrological cycle (water cycle) in a region. These include droughts, floods, hurricanes, heatwaves and intense rainfall.

Killing degree days – days in which the temperature of a given cropland region exceeds a limit, above which crops are likely to die from heat-stress.

In-Situ adaptation– referring to agriculture, farming methods and techniques in response to stressors that take place directly in the region of growth, rather than moving crops to new regions.

Representative Concentration Pathways (RCPs) – scenarios used in climate modeling that represent different trajectories of greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) and many other institutions use four main RCPs to model possible climate change scenarios.

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