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Climate Adaptation in the Agricultural Sector

Lessons from Vermont

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Abstract

This white paper summarizes the challenges that climate change will pose to the agricultural sector and presents opportunities for promoting climate-resilient farming practices, with a focus on how state governments can play a proactive role in encouraging adaptation. Drawing on case studies from Vermont, the paper grounds its recommendations in practical examples.

The overview explains the basics of "climate-smart agriculture" and describes approaches that can increase the resilience of the agricultural sector and, in some cases, also reduce greenhouse gas emissions. The paper outlines ways that smart investments in data, education, and the adoption of new technology can protect food security and the continued economic viability of the farming industry. Adaptation solutions for the agricultural sector must be developed to acknowledge the specific context of the farming industry in different parts of the United States—an industry that is diverse, multi-faceted, and characterized by individual business decisions that are also influenced by state and federal policy.

The Vermont case study demonstrates ways the agricultural sector is working with state, local, and non-governmental organizations to apply climate-smart farming techniques. Each example shows how strategic investments, changes in policies, and technical assistance can contribute to resilience.

About the Author

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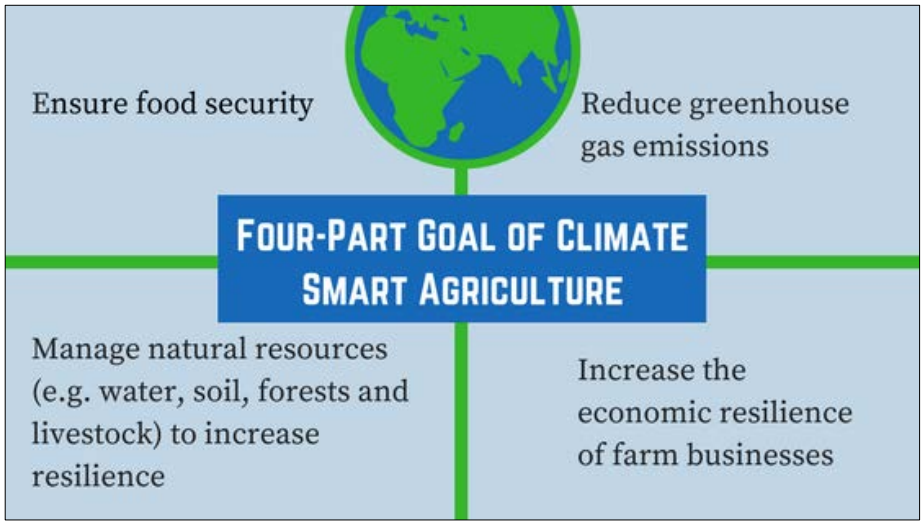
Climate Adaptation in the Agricultural Sector: Overview

Introduction

Farmers and others in the agriculture sector are inherently resilient as they must always adapt to changing conditions including shifting market demands, fluctuating weather, and the introduction of new technology. Still, farmers will need information, resources, and policy support as they work to protect the globe's food security and their own financial enterprises from climate change. This paper frames the challenges of adaptation in the agricultural sector, identifies lessons from Vermont's experience addressing climate risks to the state's agriculture and food systems, and recommends strategies aimed at state policymakers for responding to climate threats to the United States' food system.

"Climate-smart agricultural" practices will enable farm businesses to prepare for climate change impacts. The United Nation's Food and Agricultural Organization defines these practices as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes greenhouse gases (GHGs) (mitigation) where possible, and enhances achievement of national food security and development goals."[1]



While most farms are private businesses, state policymakers and others in the public sector can facilitate the adoption of climate-smart agricultural practices. States can provide financial and technical assistance to increase the capacity of farm businesses to fully understand climate risks and experiment with strategies to mitigate those risks. States can also address legal barriers and adopt new policies that promote action. Even more, states can support and drive needed research on climate-smart farming techniques.

The Challenge

Climate change poses significant risks to agriculture and food security because of the dependence of agriculture on the weather. Sea-level rise and saltwater intrusion, and the rising incidence of extreme weather, including heat waves, drought, and very heavy precipitation, will increasingly affect crop and livestock productivity. Climate change will also increase the spread of invasive species, insects, and diseases, and may play a role in the decline of pollinators. Climate-related changes in crop yields will increase food prices, and extreme weather can negatively affect food processing, storage, and distribution systems, which in turn can decrease food security.

In addition, agriculture was responsible for 9 percent of the nation's greenhouse gas emissions from 1990 to 2015.[2] In contrast to other sectors, most of these emissions come from biological processes rather than energy use. There is a growing body of research on methods farmers can use to reduce their GHG footprints. This includes land, soil, and crop management practices that sequester carbon, as well as adjusting livestock feeding, manure, and nutrient management practices. Some of these practices can also increase a farm's resilience to the impacts of climate change. For example, alternative energy sources can be used to reduce GHG emissions from farm operations while also providing a source of power during outages.

Finally, as the world population continues to grow, and as more of our population is clustered in urban areas, there will be increased pressure on farmers to manage their farms efficiently, to use higher yielding farm practices to increase production, and to improve distribution. These methods may create challenges of their own, including diverting limited water resources, draining wetlands, and increasing reliance on chemical fertilizers and pesticides that can exacerbate water pollution, pollinator die-offs, and risks to human health. Consequently, as production intensifies, it will be even more important to use climate-smart practices.

Finding Solutions

The adoption of climate-smart agriculture in the United States will require:[3]

- *Data –* Near- and medium-term climate projections that are "geographically specific" and "agriculturally relevant" will help farmers understand their risks and deploy solutions to reduce those risks.
- *Risk assessments and adaptation plans –* Support to conduct risk assessments and to develop adaptation plans that account for climate variability and extreme weather, as well as for other climate impacts, such as the introduction of new weeds, pests, and diseases from agricultural extension services and other experts can help farmers consider climate change in business continuity planning.
- *Research and development on solutions for enhancing farm resilience –* Research and the development of new technologies and strategies can help farmers address risks to crops and livestock production. This could include new crop varieties that are drought-, heat-, and/or disease-resistant, as well as management practices such as crop rotations, tillage, manure management, and harvest strategies.
- *Funding and financing –* Grants and loans allow farmers to invest in new farming practices and technologies to enhance their resilience or to diversify their income streams. For example, smart-irrigation systems can help farmers save on water and energy costs by using GPS-technology to adjust irrigation based on weather conditions. However, to adopt these types of technologies, farmers often need upfront capital.[4] Farm service providers (lenders and insurers) who understand the challenges facing agriculture from climate change, and emerging approaches to adapting to those changes, may be helpful in finding solutions.
- *Legal and policy changes –* In addition to these approaches, farm policy can provide incentives for climate-smart agriculture. For example, the federal Farm Bill[5] could be a means for promoting adaptation best practices. Additionally, state governments may be called on to play more active roles providing data and education, should the federal government withdraw support for climate-smart agricultural practices.

Creative Farming Practices

Successful adaptation in the agricultural sector will involve both straightforward and more creative solutions for:

- Managing soil, water, and waste;
- Diversifying income sources (e.g., allowing the use of conserved farmland for renewable energy projects, agrotourism, diverse livestock, and crops);
- Supporting infrastructure investments for new farming methods that build resilience (e.g., advanced irrigation systems, manure injection systems, no-till planters, on-farm energy production, and mechanical ventilation systems to cool livestock);
- Offering financing and insurance products that take into account climate risks;
- Introducing new crop varieties and land management practices (e.g., heat- or drought-resilient crops, no-till farming, crop rotation, pasture rotation for livestock);
- Supporting adoption of new and different farm enterprises (e.g., producing value-added products like jams, cheese, and sausage);
- Managing energy consumption and reliability;
- Developing and expanding local and regional markets; and
- Supporting disaster planning and preparation with a focus on unique risks to the agricultural sector.

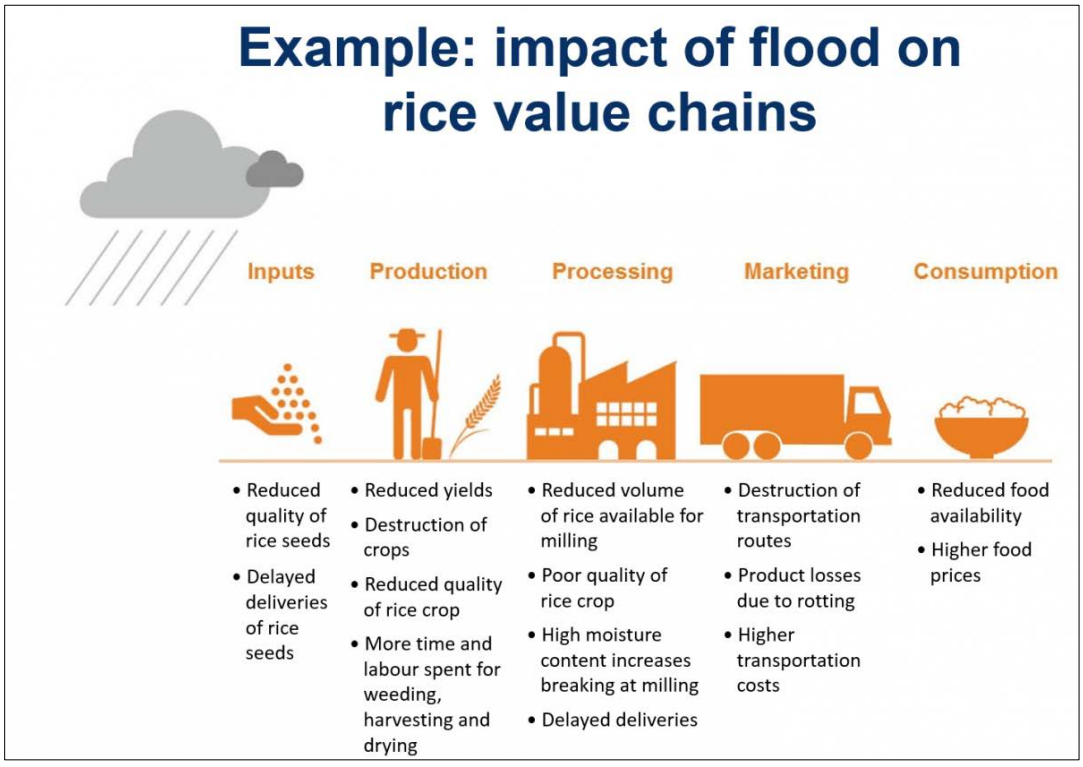
The Value Chain

Adaptation in the agricultural sector is not limited to considerations of on-farm practices. Vulnerabilities and opportunities for resilience can be addressed throughout the value chain to achieve food security as climate risks increase.

- *Inputs* – Seeds, fertilizers, and pesticides should be developed with the impacts of climate change in mind. Farm services, such as bank loans and crop insurance, should consider climate risk management.[6] Energy systems powering farming operations can be made more resilient to protect against outages that interrupt food production, processing, or storage.

- *Production –* On-farm practices should adapt to climate impacts. This includes climate-smart land and water management practices—such as no-till planting and cover cropping—that can increase organic matter in the soil and reduce erosion, thereby decreasing run-off. Changes might also include targeted irrigation and riparian buffers[7] that help conserve water and protect water quality; changing or diversifying crops and livestock production practices to integrate more climate-resilient varieties and breeds; and changing manure and nutrient management practices to prevent nutrient loss and water pollution.
- *Processing, storage, and transportation –* Food processing, distribution, and storage facilities can prepare for power outages that stop production and cause food to spoil. Additionally, anticipated climate impacts should inform infrastructure investments. For example, as droughts cause rivers to be unnavigable during certain times of the year, river barges may no longer be a feasible option for grain shipments. Instead, distributors may need to invest in warehouse facilities near railroads or trucking facilities.
- *Access and consumption –* Extreme weather, wildfires, pests, disease, and floods impact the availability and cost of food. A robust local food economy can provide a buffer against disruptions in the national and international food system. In addition, with as much as a quarter of all food in the United States ending up in landfills, efforts to limit waste can enhance food security and reduce the greenhouse gas emissions that result from organic waste in landfills.

Climate-resilient value chains start with assessing risks to a particular sector in a specific geographic location. The infographic below, taken from the International Institute for Sustainable Development's blog on Policy Solutions for Climate Resilient Agricultural Value Chains, illustrates the potential impact of extreme weather on rice production in Uganda.[8]



Source: International Institute for Sustainable Development. Retrieved July 27, 2017, from https://www.iisd.org/blog/policy-solutions-climate-resilient-agricultural-value-chains)

No Single Solution

Agricultural adaptation policies and approaches should acknowledge that farms are not monolithic. The climate risks and adaptation opportunities associated with each farm will vary depending upon geographic location, the size of the farm, the diversity and types of crops or livestock produced, as well as production methods.

A starting point for addressing adaptation in the agricultural sector is to understand this diversity. Every five years the United States Department of Agriculture (USDA) conducts a census of U.S. agriculture. The last one was completed in 2012.[9] It found:

- The U.S. has 2.1 million farms.
- There are 913 million acres of land in production.
- As of 2012, there were fewer farms and less land in production than in 2007.
- 97 percent of farms are operated by families or individuals.
- 88 percent of all farms are small, family-owned operations grossing less than $350,000.
- 80 percent of agricultural sales come from large- and medium-sized farms.
- Well over half of the country's net farm income came from the largest farms (larger than 3,000 acres.)
- 58 percent of direct-to-consumer sales (farmer's markets, farm stands, and community-supported agriculture) come from small family farms.
- 17 percent of all organic sales come from small family farms.
- Only 16 percent of small family farms depended on the farm for most of their household income.
- The largest farms represent one-half of one percent of all farms, but they produced nearly a third of the value of all agricultural products sold.
- New England and the Southeast have the greatest proportion of small farms. The Midwest, Texas, and California have the greatest concentration of large farms.

While there is a temptation to focus on small- and medium-sized farm, it is important to remember that much of the nation's food comes from the largest producers. They operate on an industrial scale and although they often have greater access to capital (financing), the challenges of changing their practices are complex because of the level of investment in the infrastructure that supports current farming methods.

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Farmers Adapt to New Challenges

The good news is that farmers are accustomed to managing for changing circumstances. The agricultural sector constantly responds to new research and tools designed to help farmers manage the risks associated with farming. These have included practices that help farmers use land and water more efficiently. Some of these practices, while effective in producing greater yields or in making a farming operation more economically viable, raise significant questions of their own. For example, tile drainage, a system that removes water from beneath the soil, extends the growing season by drying out wet fields and enables marginal land to be farmed. However, tile drainage can also exacerbate water pollution problems and wetland conversion. Genetically modified seeds, in combination with herbicides and certain pesticides, can ensure higher yields. However, there is growing evidence that some of these chemicals cause harm to people and pollinators. As new approaches to climate-smart farming are developed, it will be important to consider their greater overall impacts.

Farms are Part of the Solution

Between 1990 and 2015, farms contributed 9 percent of the nation's GHG emissions.[10] Most emissions come from biological processes, such as nitrous oxide emissions from nutrients and methane released from livestock, manure pits, overgrazing, and tilling the soil. Additionally, other emissions come from the use of diesel-powered farm equipment and the use of fossil fuel-based fertilizers, pesticides, and herbicides.

Over the past decade "Carbon Farming" has emerged as a new research area. The non-profit Carbon Cycle Institute defines carbon farming as "practices that are known to improve the rate at which carbon dioxide is removed from the atmosphere and converted to plant material and/or soil organic matter" with the goal of sequestering more carbon than is emitted through the farm operation.[11] Scientists who study carbon have found that there is almost twice as much carbon in soil (2500 billion tons) as there is in the atmosphere and plant and animal life combined (1360 billion tons).[12] This is because plants pull carbon out of the air and into the plant's roots where it can be taken up by soil organisms. Soil organic matter is made up of carbon, which helps it retain water, micro-organisms, and the nutrients necessary to encourage new plant life. When soil is exposed to or eroded by water, the soil carbon goes back into the atmosphere.

Carbon Farming

Some examples of Carbon Farming include:

- **No-till or direct seed farming,[13]**
- **the use of anaerobic digesters to produce heat and electricity,[14]**
- **nutrient management to reduce the need for chemical fertilizers[15], and**
- **riparian restoration to prevent soil loss and erosion.[16]**

Many Carbon Farming practices also have important co-benefits, such as protecting water quality, improving soil moisture, or creating additional income streams for the farmer.

Farm Policy Matters

A challenge for the agricultural sector is that farmers rely heavily on federal programs that have not yet fully integrated climate-resilience practices and do not always encourage climate-smart agriculture. For example, some USDA conservation easements require the productive use of land, making it impossible to amend the easement to allow larger riparian buffers necessary to protect against soil erosion, flood damage, and water pollution.[17] Crop insurance programs ensure farmers will make a profit even when their crops fail and thus serve as a disincentive to change farming practices. In fact, in some instances, farmers have lost crop insurance once they began to use more resilient land practices such as cover cropping, because of inconsistent and confusing policies.[18]

As the new Farm Bill moves through Congress, there will be an opportunity to inject considerations of climate resilience. Special attention should be given to:

- *Conservation programs* – Agricultural conservation programs administered by USDA should be fully funded and designed to encourage adoption of climate-smart agricultural practices. For example, the Regional Conservation Partnership Program (RCPP)[19] helps farmers implement conservation practices to improve water quality and soil health, and to conserve water. The Environmental Quality Incentives Program (EQUIP) [20] pays for farmers to implement farm practices that conserve natural resources and build resilience.

- *Crop Insurance –* The crop insurance program costs over $8 billion annually. Though crop insurance provides important liability coverage, it also masks farmers' exposure to climate impacts. In fact, the subsidies distort the market by encouraging farm consolidation and influencing what a farmer grows, which could ultimately increase exposure to risk. The Whole Farm Revenue Protection (WFRP)[21] insurance is a relatively new crop insurance program that provides insurance for all the crops grown on a farm, not just a single crop. The WFRP is designed to protect diversified agriculture and provides insurance options for organic and underserved farmers. This program should be protected and expanded.
- *Commodity subsidy payments –* To protect farmers from price fluctuations for agricultural products, the Farm Bill subsidizes certain commodities. The program has historically paid farmers based on the crop planted. This has created an incentive to plant whatever crop will receive the biggest payment that year, which discourages crop rotation, depletes soil nutrients, and can create weed, pest, and disease problems.[22] Subsidy reforms are needed to ensure that this program is not contributing to maladaptive farming practices.
- *Disaster recovery programs* – USDA provides assistance to farmers who suffer damage to their crops, livestock, farm buildings, and equipment. Additionally, the Federal Emergency Management Agency (FEMA) plays an important role. FEMA's flood hazard mapping rules about structures in floodplains and their hazard mitigation grant programs should consider the unique challenges of agriculture, as well as the role that farm fields play in stormwater management. The Small Business Administration (SBA) also provides low-interest disaster loans to help businesses of all sizes recover from disasters. These loans can be used in conjunction with USDA loans to help farms recover from a disaster. SBA also provides support to a community or region interested in developing particular economic sectors. This funding could be used to support climate-smart food systems.[23] The federal government and other partners should do more outreach to ensure that farmers are aware of these resources.

Accessible Climate Data and Adaptation Research

Climate-smart agriculture can only succeed if farmers and agricultural service providers have ready access to climate data and scientific research on agricultural adaptation. Farmers need good information and technical assistance to plan for climate change. The Obama Administration established regional Climate Hubs to provide adaptation and mitigation information to farmers.[24] These regional hubs bring together land grant universities and federal agencies to develop climate change outreach products and information for farmers and foresters.

USDA is not the only federal agency that produces climate science and data. The National Oceanic and Atmospheric Administration (NOAA) provides historical and current climate data, as well as climate projections, that farmers rely on as they plan for the future.[25] NOAA also provides grants and technical assistance to help communities develop agricultural adaptation plans.

These programs are all at risk from budget cuts. The Trump Administration has proposed steep budget cuts and rollbacks of climate programs, and with the expected cuts to USDA and NOAA, the future of these programs is unclear. Support for these programs would provide the data and technical assistance that farmers need to understand their risks and adapt their farming practices.

It will also be important for state agencies, agricultural service providers and colleges and universities—particularly the land grant institutions—to ensure that needed research continues and that existing climate adaptation and mitigation information are readily available. Groups like the North American Climate Smart Alliance and the National Sustainable Agriculture Coalition are already working to ensure farmers and farm service providers have the information they need to participate in the policy debate and advance progress on climate-smart agriculture.[26]

States Matter

State agriculture and environmental agencies can provide leadership to advance climate-smart agriculture. States can take proactive steps to:

- Assess climate vulnerabilities in the state's food system, looking at both the short-term and long-term risks across the value chain, and consider climate vulnerability in their state's FEMA-approved Hazard Mitigation Plan;
- Evaluate what information is available to farmers to help them make decisions that will enhance the resilience of the food system;
- Convene the agricultural sector, including farmers, farm service providers, researchers and technical service providers, to develop a strategic plan to address climate risks in the sector;
- Use state funding and grant programs, including economic development funds, to encourage innovative and climate-smart farming techniques;
- Work with public utility commissions to make it easier for farms to incorporate renewable energy and methane digesters;
- Engage in Farm Bill deliberations and other federal regulatory proposals, and encourage the incorporation of climate-resilience provisions;
- Review state technical assistance, grants, and regulatory programs to ensure that they are not continuing to provide incentives for maladaptive practices like wetland conversion or soil and nutrient management practices that increase vulnerability; and
- Support the efforts of local colleges and universities to engage in climate adaptation and mitigation research in the agricultural sector and provide farmers with this information.

Conclusion

Adaptation in the agricultural sector will require a complicated mix of changes in both the public and private sectors. Farm businesses need help understanding their risks and developing strategies to prepare for coming changes. To be resilient, farmers will need to diversify their crops and income streams and consider changes to their farming practices to incorporate climate-smart strategies. Assistance from the financial and insurance sectors can also provide the resources to purchase needed technologies and to recover in the event of impacts.

Although adaptation in the agricultural sector will primarily involve private-business decisions, the public sector also has a role to play. The following case study reviewing Vermont's initiatives demonstrates the different roles that states can play in supporting adaptation efforts in the private sector. States can provide technical support and financial resources to farm businesses to help them understand their risks and implement strategies to enhance farm resilience. Additionally, states can remove legal barriers to more easily allow farms to diversify their income streams (e.g., siting renewable energy on farms) or develop new farming and waste management technologies (e.g., anaerobic biodigesters).

Finally, federal policy will also affect the long-term resilience of the agricultural sector and food security. For example, the Farm Bill could require existing conservation programs to incorporate climate-smart practices. Farm-subsidy programs could support crop and livestock diversification. Crop-insurance programs could promote practices that reduce climate risk.

To enhance the resilience of the U.S. agricultural sector, all parties will need to work together to ensure that farms, big and small, are prepared to meet the challenges associated with climate change.

Case Study: Vermont's Approach to Agricultural Adaptation

Introduction

As in much of the country, the principal risks to agriculture in Vermont relate to heat and water. High temperatures and warming at the wrong time can reduce crop yields and livestock health. Access to water through rainfall and irrigation is essential for crop production and healthy animals. However, intense storms can bring floods, wind, and hail that can destroy crops and damage infrastructure. This case study illustrates the vulnerability of the agricultural sector in Vermont to extreme weather events and ways the state is starting to address climate resilience across the food system.

In August 2011, Tropical Storm Irene swept across Vermont, destroying roads, bridges, homes, and businesses in 225 of the state's 246 communities. The storm created erosive floods that destroyed hundreds of farms, in some cases washing away the topsoil and rendering the land worthless.

The impact of Irene was felt across the food system. According to the Vermont office of the USDA Farm Service Agency, more than 25,000 acres of crops and farmland were affected by Irene; the estimated value of crop losses and crop land damage exceeded $20 million statewide. A total of 476 Vermont farms reported damage to the USDA.[27]

Even farmers whose land was not directly flooded, or whose crops survived, were affected. The flood hit at a time when most crops were being harvested. Farmers who still had crops in the field found that these crops were rendered valueless because they were in contact with floodwater and potentially exposed to petrochemicals and other contaminants. Therefore, the USDA and the Food and Drug Administration (FDA) prohibited their sale. Farmers with food in storage suffered losses because of lengthy disruptions in electricity and the inability to access fuel for backup generators. Thousands of gallons of milk had to be dumped; freezers full of meat thawed and had to be eaten or discarded.

After Irene, many organizations and agencies began to focus on helping Vermont's farms become more resilient to climate impacts. This effort started with the creation of a farm recovery fund that was managed by the Vermont Community Foundation; they raised and distributed millions of dollars in private donations to help farmers get back on their feet.[28] The state then turned its attention to addressing the long-term impact of climate change on Vermont's food system. This case study includes examples of efforts that are underway in Vermont to enhance the resilience of the agricultural sector and a discussion of some initial outcomes.

Vermont's Approach

Supporting Climate Research and Technical Assistance

The Vermont Climate Assessment: In 2015, the University of Vermont Gund Institute of Ecological Economics conducted a comprehensive state-level assessment of climate impacts by combining state- and local- level data with downscaled global climate models and information from the National Climate Assessment.[29] The assessment reported on projected impacts to a variety of sectors and identified community-level vulnerabilities under future climate change scenarios. One of the sectors of focus was agriculture. The report found that climate change will create both challenges and opportunities in the agricultural sector, and its findings have been used by state, local, and nongovernmental organizations that are working toward climate-smart agriculture. The assessment identified changes that may affect the agricultural sector in Vermont, including the following:

- The warming climate in the Northeast means that the spring will come earlier, and the hard frost later, extending the growing season. This can potentially increase crop productivity and allow new kinds of crops to be grown. However, these conditions will also foster new hostile invasive species, disease outbreaks, and pest infestation. For example, shorter winters have led to an increase in disease-carrying ticks. For the first time, farmers need to take significant measures to protect their families and farm labor from being exposed to tick bites, and they need to be ready to recognize and respond to symptoms of Lyme disease.
- Unpredictable weather can wreak havoc with natural systems and productivity; for example, in 2016 some apple orchards had trees that budded two months early—in March—because of an extended warm spell. This was followed by a deep freeze in April, resulting in at least one orchard owner reporting a loss of 60 percent of his crop. Historic high temperatures across the Northeast and Midwest in February 2017 raised the same concern for thousands of orchardists across the region. In addition, in 2013, after the wettest May and June in Vermont's recorded history delayed the budding of trees, Vermont's pollinators had to compress their collection of early pollen into just a few weeks, possibly contributing to a bee die-off the following winter.

Farming and Climate Change Program at the University of Vermont: The University of Vermont Extension's Center for Sustainable Agriculture started a Farming and Climate Change Program to conduct research and to provide technical assistance to farmers and farm service providers on adaptation to climate change.[30]

Current research topics include:

- Reducing soil and nutrient loss during intense storms;
- Remote monitoring of soil moisture for improved irrigation management;
- Preventing and mitigating soil compaction on farms;
- Increasing soil infiltration and reducing runoff volumes in agricultural watersheds;
- Managing impacts on water quality using tile drainage management;
- Assessing how climate change will affect phosphorus movement through agricultural lands and implications for water quality; and
- Evaluating the economics of climate change adaptation practices on farms.

Research on adaptation to climate change: Vermont's Experimental Program to Stimulate Competitive Research (EPSCoR) won two successive National Science Foundation grants (in 2011 and 2016) of $20 million each to support research on climate change adaptation focused on the Lake Champlain basin. This project integrates scientific research (e.g., modeling hydrological processes in subwatersheds) and social science (e.g., public policy) on mitigating the impact of climate change on the long-term health of the watershed.[31] In addition, "Vermont Agricultural Resilience in a Changing Climate" is a long-term, collaborative effort that works with farmers, agricultural service providers, researchers, and community organizations to address the impacts of climate change on agriculture in Vermont.

Addressing Flood Risk

Managing land in the floodplain: Irene provided a stark example of the role farm fields play in providing a place for flood water to go—saving built areas downstream from destruction. Consequently, the Vermont Department of Environmental Conservation (DEC) and the Agency of Agriculture began to discuss how to better protect and manage land in the floodplain to maximize flood storage, and how to compensate farmers for providing these ecological services. State agency staff focused on educating state legislators, farmers, and community leaders about the importance of reconnecting rivers with their floodplains, and the value of vegetative buffers between field and stream. As a result, a new state law was passed and local regulations were adopted in some communities to limit development in the floodplain.[32] The state also collaborated with USDA and other land conservation and watershed organizations to purchase easements on farmland to re-establish vegetative buffers along the waterways. DEC's Rivers Program developed its own easement program, using money from the agency's ecosystem restoration fund. The program targets farmers in areas where the rivers needed room to move so they could get back into equilibrium. It also pays farmers for a buffer easement that moves with the river channel.

During Irene, two merging rivers about 1000 feet behind where this photo was taken, wreaked havoc on crops and parking lots in Chester, VT. Image source: Gange, L. (2011, September 12). Retrieved September 1, 2017 from: http://www.mansfieldheliflight.com/flood/index2.html

Flood resilience and land conservation: Following Irene, the Agency of Natural Resources (ANR) convened the land conservation community to determine how it might contribute to making Vermont more resilient to flooding. This inspired many of the conservation organizations that work with Vermont's farming community to integrate flood resilience into their policies, and a computer modeling tool was developed to help land conservation organizations identify and prioritize conservation investments that provided the most flood protection benefits.[33] One such project resulted in the purchase of conservation easements on farm fields that were identified as extremely vulnerable to erosive floods. This enabled farmers to move their operations to less vulnerable locations. The U.S. Environmental Protection Agency (EPA) highlighted the importance of using land conservation easements on agricultural land to help address the threat of flooding in its report entitled "Smart Growth Approaches for Disaster-Resilient Communities."[34]

Addressing Threats from Pest and Invasive Species

Invasive species control: State officials discovered that the flood waters during Irene served as a superhighway to spread invasive plants like buckthorn, japanese knotweed, and garlic mustard. In the months following the storm, Vermont's Agency of Natural Resources deployed volunteers from watershed groups across the state to work with farmers and landowners to eradicate these plants before they could get fully established and wreck stream banks or impact hayfields. ANR established a website to help develop a coordinated approach to addressing these threats and created a permanent position to focus on invasives.[35]

Public health announcements: State officials also engaged the Department of Health to include information about associated risks to human health in its public health announcements. This year, the health department issued multiple warnings about tick and mosquito-borne illnesses as well as some invasive plants that can create burn-like symptoms. This is particularly important to protect farmworkers who have a higher risk of exposure because they are working outside.

Reducing Water Pollution

With climate scientists predicting increased precipitation and more frequent extreme weather events, climate-smart agriculture in Vermont must address water pollution. Indeed, because of the erosive power of Irene's floodwaters, many tons of nitrogen and phosphorus were washed into Vermont's waterways, exacerbating existing nutrient pollution problems.

New regulations and technical assistance programs: Vermont's lake cleanup plans, under the federal Clean Water Act, consider the increased frequency and intensity of precipitation due to climate change. New regulatory requirements, grants, and technical assistance programs have been designed to help, and in some cases to require, livestock and land-management practices that prevent erosion and soil loss that contribute to water pollution. New rules require vegetative buffers and improved grazing land management systems to prevent livestock from damaging sensitive terrain. A $16 million USDA grant was awarded to the state and Vermont's Conservation Districts[36] to work with farmers to change their manure-management practices and to convert to cover crops and no-till farming to prevent erosion and pollution.[37] In addition, new tools have been developed to identify the farm fields within a sub-watershed that contribute the most pollution. This research allows technical assistance and grants to be directed where they will have the most impact.[38]

Integrating water quality into farmland conservation programs: The Vermont Housing Conservation Board (VHCB) was given new authorities to consider water quality in its programs. VHCB is a quasi-governmental agency that is funded by a surcharge on all property transfers in Vermont, along with EPA, USDA, and Department of Housing and Urban Development (HUD) grants. It has a broad mission: to create affordable housing and to conserve agricultural lands, forest land, natural areas, and historic properties. The statute that created VHCB was updated after Irene to require that the program prioritize agricultural and forestland conservation investments that improve water quality, make communities more flood resilient, and help meet Vermont's climate and energy goals. Consequently, farmland easements now include water-quality protections for surface waters and riparian areas. Additionally, a new grant program helps farmers implement water-protection practices. For example, the Dairy Improvement grant program allowed one farmer to purchase a no-till planter that maintains crop residue from previous crops and minimizes disturbances to the soil. This can reduce the carbon dioxide released into the atmosphere, improve soil quality, and reduce erosion. In another case, VHCB helped to buy out a dairy farm located on a parcel of land that, because of its proximity to Lake Champlain and its low elevation, could not be effectively managed to prevent pollution. This enabled the family to relocate their dairy farm to a more suitable location.

Promoting Renewable Energy Production

Following Irene, there was a flurry of activity with respect to on-farm renewable energy. The goal was threefold: to prevent energy disruption in the next storm, to provide a new revenue stream for farms, and to reduce the greenhouse gas emissions associated with farm operations. For example, EPA estimates that digesting manure and capturing the gas to generate electricity means that over 1,000 pounds of greenhouse gases per cow per year are not emitted (CO_2 equivalent).

Removing state law barriers to siting of renewables: Vermont's Agency of Agriculture Food and Markets (AAFM) created an agriculture and energy position to identify and address policy and legal barriers to the deployment of renewable energy on the state's farms, and to educate farmers about opportunities to benefit from the renewable energy market. This ensured that the agricultural sector was represented in policy conversations to advance the deployment of renewable energy. As a result, the regulatory process for on-farm biodigesters was streamlined, and concerns about wind and solar installations on conserved land and prime agricultural soils are being addressed so that farmers will be able to make use of these technologies. AAFM is also promoting research into biofuels generated from harvesting grass and oil crops to offset on-farm fuel needs and to heat greenhouses or other farm buildings. Additionally, AAFM provides technical assistance to farmers that seek to integrate renewable energy into their operations.[39]

"Big Bertha" is an anaerobic digester that uses a combination of manure and organic matter to generate electricity. Image source: Vermont Technical College.

Cow Power: In 2008, Vermont's largest electric utility, Green Mountain Power (GMP), established a program to support on-farm generation of energy using cow manure. Methane digesters use microorganisms in oxygen-free tanks to transform biomass, like cow manure, into biogas that can be used to generate electricity or to generate heat. One digester produces enough methane to generate electricity for about 200 homes. It also captures and uses the methane gas, reducing the GHG footprint of the farm. There are currently 12 farms enrolled in the Cow Power program. Participating farmers have not only benefitted from the revenue provided by selling electricity to GMP, they have also used the waste heat to heat their farm buildings and diversify their operations by adding greenhouses that can be heated year-round.[40]

Vermont Technical College was inspired by the success of the Cow Power program to build a larger anaerobic digester to take farm and food waste. "Big Bertha,"[41] as it is called, uses a combination of cow manure and organic matter from Vermont farms and brewery waste, about 16,000 gallons a day combined, to generate 8,800 kilowatt-hours of electricity a day.[42]

Pollinator solar pilot: With the stresses of climate change, loss of habitat, and the increased use of pesticides in agriculture, there has been a significant decline in the number of pollinators in Vermont and across the country. To increase pollinator habitat, the University of Vermont Agricultural Extension, the Energy Action Network, and the Vermont Audubon Society partnered in a project that encouraged developers of solar arrays to manage their land for pollinators.[43]

Tawnya and Mike Kiernan, showing off bees at their solar farm. For more information see beethechangeproject.org. Image credit: Bee the Change.

This project, based on the "Fresh Energy" campaign of the Minnesota Audubon Society,[44] provides information to developers about vegetative management plans that include a mix of low-growing and shade-tolerant, pollinator-friendly plants that can be used with small- and large-scale solar projects. Sixteen sites across Vermont are already participating in this effort. The Vermont partners have developed several resources designed to make it easy for new sites to join, including a Solar Site Pollinator Habitat Planning and Assessment form[45] that helps with site and seed mix planning and design, as well as an assessment tool to determine the success of the project. Conversations are underway with regulators to possibly incorporate pollinator friendly management requirements for medium- and large-scale projects.[46]

Vermont's Farm to Plate Food System seeks to increase economic development and improve access to healthy food. It also supports climate-smart agriculture. Image source: Farm to Plate Vermont. Retrieved August 14, 2017, from: http://www.vtfarmtoplate.com/about-farm-to-plate

Building Resilience Across the Food System

The geographic specialization in food production, the concentration of agricultural production, and the consolidation of food distribution in the United States increases the vulnerability of food systems to climate change. Accordingly, it takes a whole-systems approach to ensure access and affordability of food. One way to do this is to build a strong local food system.

Farm to Plate legislation: In 2009, Vermont's legislature initiated a "Farm to Plate" program and directed the analysis of Vermont's food system and the development of a ten-year strategic plan to meet four goals: 1) to increase jobs and economic activity in Vermont's food system; 2) to improve access to healthy, local food for all Vermonters (especially low-income Vermonters); 3) to improve the quality of the environment (e.g., soil, water, energy); and 4) to improve the ability of the local food system to support the health of Vermonters. Now, five years into implementation of the plan, there are many examples of climate-smart agriculture that have emerged from this effort.

Vermont Goat Collaborative:[47] Climate-smart agriculture seeks to limit the need to import food over long distances, to eliminate waste in existing systems, and to meet the needs of communities for culturally appropriate food. An example of this is the Vermont Goat Collaborative. The Collaborative was created to respond to growing consumer demand for goat meat from a community of new Americans from Africa and Asia. Prior to this project, these families either went without goat meat or paid high prices for goat imported from as far away as Australia and New Zealand.

The Farm to Plate initiative helped connect all the pieces to make this project work. The Vermont Land Trust made available conserved land to develop into a farm, goat dairies contributed bucklings (male kids) that they would have otherwise euthanized, the new American community found people willing to serve as goat herders, and the Agency of Agriculture addressed the need to have on-farm butchering available. Over time, this project has grown into the Pine Island Community Farm, a collective for new Americans who wish to raise goats, chickens, or vegetables. It also sells pasture-grown animals to families who wish to slaughter their own goats and chickens for meat.

Food recovery programs: Climate-smart agriculture considers ways to protect vulnerable populations from the impacts of climate change by addressing the price and availability of food. One way to help is to minimize waste in the system.

Volunteer gleaners working with the Vermont Food Bank. Image credit: Vermont Food Bank.

Every year, approximately a quarter of all edible food ends up in the waste stream. Vermont's Farm to Plate Initiative spurred the creation of the Vermont Foodbank's Gleaning Program. The program works with over 600 volunteers to harvest and gather produce that may otherwise go to waste. Over 465,000 pounds of fresh, local produce are distributed to Vermonters through food shelves, meal sites, senior centers, housing sites, schools, and hospitals throughout the state.[48]

With the additional impetus of new regulations banning food waste from landfills from large- and medium-sized producers, food donations grew by nearly 40 percent from 2015 to 2016.[49] Grocers, food processors, restaurants, and institutions like hospitals and universities are donating food that otherwise would have gone to waste.[50] This not only helps needy Vermonters, but it also reduces GHG emissions by keeping organic material out of the landfill and avoiding waste from food production and transport in the first place.

Funding Climate-Resilient Agricultural Practices

In 2012, the Legislature created the Vermont Working Lands Enterprise Fund to provide small grants to farmers, foresters, and food processors with the goal of advancing innovation, entrepreneurialism, market value, and business development in these sectors. To date, this program has funded 148 agriculture and forestry projects, distributing over $4.4 million and leveraging $8.6 million in matching funds.

Not all of the projects relate to climate resilience, but many do. In the recent grant cycles:

- $20,000 was provided to upgrade the aeration equipment at a composting facility;
- $7,100 was granted to a farmer to purchase a compost tea-brewing set and a skid-based pickup truck transportable sprayer to increase soil biological activity and retain carbon;
- $20,000 was provided to a farm to upgrade its water- and manure-management systems to achieve USDA's Good Agricultural Practices (GAP) certification;[51] and
- $7,700 was provided to a berry farm to modernize its irrigation system.

A Community-Planning Approach to Disaster Preparedness

Vermont Economic Resilience Initiative: In the years following Tropical Storm Irene, Vermont's Agency of Commerce and Community Development started the Vermont Economic Resilience Initiative (VERI).[52] VERI chose five towns to conduct a community process designed to build local flood resilience. State, regional, and local partners came together to help the targeted communities identify and then implement changes and investments needed to protect the towns' businesses and families from the long-term impacts of disasters, including costs to taxpayers for repetitive repair to infrastructure.

The project involved multiple public forums in which the partners helped identify the particular risks to the community and engaged stakeholders to identify and prioritize local actions. The agricultural sector was included, both because of the ecological services that farm fields provide for flood attenuation, and because they are businesses that are particularly vulnerable to climate risk.

Technical Assistance Worksheets on Disaster Preparedness: The VERI project inspired a series of technical-assistance worksheets that help local governments and business sectors, including agriculture, prepare for the next disaster. The worksheet was drawn from Pennsylvania State University and USDA's ReadyAG project. Their disaster-preparedness manual is designed to help farmers identify their vulnerabilities to disaster and develop an action plan.[53]

The Vermont worksheet[54] includes suggestions for:

- Crop-related preparations (e.g., elevating the sides of hoop houses in the floodway to allow for the movement of floodwater);
- Energy/food/water preparations (e.g., ensuring that backup generators are in good working order and have sufficient fuel, keeping a 36-hour reserve of drinking water for animals and farm workers);
- Livestock preparations (e.g., moving animals, feed, hay bales, etc., to higher ground);
- Equipment preparation (e.g., securing hazardous substances like propane tanks and chemical fertilizers and pesticides in areas safe from flooding); and
- Development of a farm-operation disaster plan (e.g., a list of important phone numbers, review of insurance coverage, and training of farm workers).

Conclusion

Vermont's experience shows that a climate-resilient food system requires adaptation across the agricultural value chain and the involvement of a broad cross-section of public and private partners. This includes farmers, consumers, farm-service providers, food processors and distributors, universities, and local, regional, state, and federal agencies. As more is learned about the impacts of climate change on agriculture, it will be vital to continuously seek out new ways to adapt and strengthen food security.

ENDNOTES

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[5] As stated by the Congressional Research Service, the Farm Bill "is an omnibus, multi-year law that governs an array of agricultural and food programs" (3). While Farm Bills have traditionally focused on commodity program support for staple crops including corn, wheat, and dairy, the Farm Bill has much wider consequences. It also includes programs on nutrition, conservation, and research. The most recent Farm Bill was enacted in 2014 and will expire in 2018. See: Johnson, R., & Monke, J. (2017). *What is the Farm Bill?* Congressional Research Service. Retrieved July 26, 2017 from: https://fas.org/sgp/crs/misc/RS22131.pdf

[6] Federal crop insurance is a program that began in the 1930s to help producers protect against the loss of crops due to natural disasters, declines in prices, and other risks. In a 2016 paper, Marzen and Ballard point out that one of the current conditions for buying insurance is utilizing "good farming practices." They argue that the definition of "good farming practices" could be amended to include "sustainable, resilient, and soil-building agricultural practices" in line with climate-smart farming. *See* Marzen, C., & Ballard, J. (2016, May 31). *Climate change and federal crop insurance.* 43 B.C. Envtl. Aff. L. Rev. 387. Retrieved August 15, 2017, from: http://lawdigitalcommons.bc.edu/cgi/viewcontent.cgi?article=2196&context=ealr

[7] Riparian buffers are vegetated areas near a water resource such as a stream. Riparian buffers protect water sources from pollution, stabilize stream banks and prevent erosion, provide habitat for wildlife, and can decrease the intensity of flooding. *See* Klapproth, J. and Johnson, J. (2009). *Understanding the Science Behind Riparian Forest Buffers: Effects on Plant and Animal Communities.* Blacksburg, VA: Virginia Polytechnic Institute and State University. Retrieved August 14, 2017, from https://pubs.ext.vt.edu/420/420-151/420-151.html

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[13] Direct seed farming is where seeding is done without prior soil disturbance to improve soil health and resilience. This process reduces the need for fertilizer and reverses soil organic carbon depletion. See: *Developing Direct Seed Organic Farming Systems for the Pacific Northwest (PNW)*. (n.d.). Retrieved July 28, 2017, from Oregon State University:

Columbia Basin Agricultural Research Center website: http://cbarc.aes.oregonstate.edu/sites/default/files/Working_folder/Direct_Seed_Organic_Farming.pdf

[14] "An anaerobic digester is an enclosed tank that excludes oxygen through which manure is passed and broken down by naturally occurring bacteria." The biogas released from the manure can be captured to produce electricity that can either be used directly on the farm or sold to a local utility. See: Pillars, R. (n.d.). *Farm-Based Anaerobic Digesters*. Retrieved July 28, 2017, from Michigan State University Extension website: http://www.agmrc.org/media/cms/FinalAnearobicDigestionFactsheet_2E11FAB524961.pdf

[15] Excess chemical fertilizers can cause soil microbes to release high levels of nitrous oxide, a gas that traps heat at 300 times the rate of carbon dioxide. See: Mole, B. (2014, June 9). Fertilizer produces far more greenhouse gas than expected. Retrieved July 28, 2017, from https://www.sciencenews.org/article/fertilizer-produces-far-more-greenhouse-gas-expected

[16] To maximize cropland, many forests and natural ecosystems along streams have been removed or reduced to maximize cropland. Restoring these buffer zones can prevent soil erosion and decrease pollution. Additionally, mature forests can increase natural carbon storage. See: Rheinhardt, R. D., Brinson, M. M., Meyer, G. F., & Miller, K. H. (2012). *Carbon storage of headwater riparian zones in an agricultural landscape*. CARBON BALANCE AND MANAGEMENT, *7*, 4. http://doi.org/10.1186/1750-0680-7-4

[17] For example, agricultural use easements limit the size of buffers and do not provide enough flexibility to address the need for larger buffers along some river systems to build flood resilience.

[18] How cover cropping works: After insured crops, like corn or soybeans, are harvested, a quick growing crop, like winter rye, is planted. This cover crop protects the soil from erosion over the winter months. In the spring, the cover crop is killed and the insured crop is planted. The cover crop is climate-smart because it adds organic matter to the soil, helps with moisture retention and sequesters carbon. See: *Cover Crops - Keeping Soil in Place While Providing Other Benefits*. (n.d.). Retrieved July 28, 2017, from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ny/technical/?cid=nrcs144p2_027252; Dobberstein, J. (2017, January 11). *More Changes to Cover Crop Guidelines*. Retrieved July 28, 2017, from https://www.no-tillfarmer.com/blogs/1-covering-no-till/post/6383-more-changes-to-cover-crop-guidelines

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[20] The Environmental Quality Incentives Programs (EQUIP) is also a USDA program the provides financial and technical assistance to farmers to help them implement conservation practices to improve soil health, water quality, wildlife habitat, and air quality on agricultural lands and private forestlands. Examples of EQUIP conservation practices include vegetative and structural changes such as terraces, manure waste lagoons, efficient irrigation, pasture restoration, vegetative buffers, hedge rows and wildlife habitat enhancements. EQUIP also pays farmers to change their management practices including adopting conservation crop rotation, implementing new nutrient management, drainage management, and integrated pest management approaches. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

[21] The Whole-Farm Revenue Protection Pilot Program is a pilot program administered by USDA. https://www.rma.usda.gov/Policies/WFRP.html

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[50] Vermont's Good Samaritan law extends to good faith donations of food and farm products, reasonably believed to be safe for human consumption, protecting donors from liability. 12 V.S.A. § 5762.

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