MERIDIAN INSTITUTE

Finance for Resilience

An Overview of Risk Mitigation in Agricultural Systems for Farms, Lenders, and Governments

A Synthesis of Existing Literature and Research

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Contents

Acknowledgments

This report was commissioned by Meridian Institute. The purpose of this paper is to provide farmers, lenders, and policymakers with options to consider and is intended to inform and foster dialogue. Learn more about Meridian's work at merid.org

This report was authored by Anna Aspenson, Sharlene Brown, Christi Electris, and Jaime Silverstein of Croatan Institute. Croatan Institute is an independent, nonprofit research and action institute whose mission is to build social equity and ecological resilience by leveraging finance to create pathways to a just economy. Croatan Institute's Soil Wealth Program is centered around financing farms, forestry, food, and fiber to create the constellation of benefits that result when we build healthy soil and community wealth through regenerative and organic agriculture. Learn more at croataninstitute.org

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Introduction

Investments to build resilience in agriculture have not kept pace with the risks associated with climate change, biodiversity loss, and other global disruptions. Farmers are facing increasing climate threats related to drought, floods, wildfires, unpredictable weather patterns, pests, and disease.[1] Furthermore, essential resources and native habitats that farmers rely on for productivity are degrading at an unprecedented rate.[2] Agricultural systems and these environmental challenges extend beyond the farms themselves, interacting with social, political, cultural, and economic systems—including through markets, social equity, and demographic change.[3]

Disasters such as floods, drought, wildfires, and hurricanes could cost the U.S. federal budget approximately $2 trillion each year, according to an assessment from the White House.[4] These risks are trending upward. From 2014 to 2019, the U.S. experienced, on average, 12.6 major extreme weather events, compared to 6.3 per year from 1980 to 2018.[5] These events impact all U.S. residents but disproportionately impact vulnerable farms and communities, such as small and midsize farms, the rural poor, and communities that are predominately Black, Indigenous, and people of color (BIPOC).[6] These disproportionate risks are related to systemic disinvestment in these communities, demonstrating that there are opportunities to reverse this trend with new financial investment mechanisms.[7]

Climate shocks and global disruptions, such as COVID-19 and geopolitical trade conflicts, have laid bare the lack of resilience in today's supply chains. At the height of COVID-19, shutdowns meant that farmers had few means to bring their products to markets, while grocery stores and food pantries struggled with food shortages.[8] In 2019, United States-China trade disruptions led to record debt levels and the highest number of farm bankruptcies since 2011.[9] Extreme weather has caused crop loss and unplanted acres, which reduces farm revenue, supply chain revenue, and threatens the U.S. food supply.[10,11]

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Farms are facing not only these global shocks, but also ongoing shifts in farm policy and markets that are threatening farm income. Farm debt and loan delinquencies are rising, while half of all farmers have lost money every year since 2013.[12] Communities, agricultural lenders, and governments rely on the profitability and financial viability of farms for food access, economic activity, rural livelihoods, and land stewardship.[13]

Therefore, agriculture demonstrates a key opportunity to build resilience to these global risks. On-farm practices can restore soil health, water resources, land-based carbon sinks, and biodiverse habitats—in turn building profitability and long-term financial viability. Practices for farm resilience are often referred to as conservation and regenerative practices, which may include no-till, cover crops, crop diversity, integrated pest management, perennials, integrated livestock, riparian buffers, alley cropping, and many others (see below, "**Resilient agriculture principles and practices**"). The United

Nations Environment Programme (UNEP) has estimated that agriculture and land-based solutions will require $8.1 trillion in investment between now and 2050 ($536 billion annually) to successfully tackle the interlinked climate, biodiversity, and land degradation crises.[14] Opportunities exist for capital decision-makers to mobilize resources that not only meet these systemic ecosystem challenges, but that also support resilience in distressed rural communities, which have been historically underserved. **This report provides insights into the risk-reducing potential of agricultural transitions that farmers, lenders, and governments can use to create new financial mechanisms for resilience**.

Policy and capital incentives drive the U.S. agricultural landscape. Farmers and ranchers experience significant barriers to transition to these practices because they lack capital and markets that value these risk-reducing farming practices. Most public and private financial mechanisms available today do not adequately incentivize farms to implement practices for crop diversity, soil health, and water management.[15] For example, the distribution of public farm support payments does not currently reflect a systemic push for crop diversity. Of the three largest public farm support programs in the U. S., which are federal crop insurance and the income support programs, Agricultural Risk Coverage (ARC) and Price Loss Coverage (PLC), an estimated 70 percent of payments go to farmers of just three commodity crops: corn, soybeans, and wheat.[16] Capital is also disproportionately distributed to larger farms, which disadvantages farm populations with predominantly smaller operations, such as historically underserved producers (new and beginning farmers, veteran, limited resource, and socially disadvantaged farmers and ranchers). The USDA defines Socially Disadvantaged Farmers and Ranchers as, "those belonging to groups that have been subject to racial or ethnic prejudice", which include farmers who are American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, and Hispanic.[17]

As discussed later in this paper, federal programs such as crop insurance, income support, agricultural lending, and loan guarantees play a significant role in shaping a farm's financial risk management strategy. Additionally, government conservation and resilience programs, such as the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP), provide cost-share and incentive payments for farms to implement or expand conservation on their farms. However, farmers with diversified small and midsize operations describe frustrations about not qualifying for federal assistance, cumbersome application processes, and discrimination.[18]

Private lending, on the other hand, poses unique challenges such as collateral and income requirements, misaligned loan terms, and high interest rates.[19]

Farms are part of interconnected systems of supply chain enterprises, consumers, and public and private lenders. Therefore, shifts in farm production practices have the potential to benefit farms' financial partners, rural livelihoods and food access, human and animal health, and to reduce government expenditures in disaster mitigation and other related social and environmental programs in these communities and across the country.[20]

The risks and potential benefits of agricultural transitions have distinct cost considerations for farms, communities, and financial, national, and global systems. In this report, we refer to these unique risk-bearers within three dimensions of risk: on-farm, off-farm, and systemic. This report provides an overview of risk considerations and the mitigation potential of agricultural transitions for resilience across three risk types (environmental, financial, and social). The report will also highlight evidence gaps and provide recommendations to inform future research and the development of financial mechanisms.

Investment from a range of actors can reduce barriers and risks for farm transitions to resilient agriculture, as well as finance the markets and infrastructure that can ensure profitability and viability in the long-term. These diverse and widespread investments can create interconnected systems that operate to address environmental, financial, and social risks across these on-farm, off-farm, and systemic dimensions. Scaled investments with these updated risk frameworks can support far more resilient agricultural systems that are also profitable.

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About this report

The authors reviewed scientific literature, publicly available research, news articles, and policy reports across a range of databases and sources, filtering for relevant information between January 2007 and February 2023. The authors reviewed over 450 articles and reports and found 223 relevant sources. In-depth interviews and focus groups with 14 farmers, advocates, and other stakeholders helped

guide the research, development of risk frameworks, and recommendations. Throughout the report, the authors include quotes from focus group and interview participants from conversations hosted by Croatan Institute and Meridian Institute in July 2022.

The audience for this report includes producers (farmers and ranchers), supply chain enterprises, policymakers, financial capital providers, and regulators. The aim is to provide up-to-date evidence regarding risks to agriculture, mitigation strategies, and the risk-reducing potential of resilient conservation agricultural systems, for various risk types and risk bearers. Policymakers can incorporate the on-farm, off-farm, and systemic risk-reducing benefits of conservation and regenerative practices into agricultural policies to incentivize and support adoption. Capital providers and regulators can include these risk analyses into their decision-making processes around capital deployment, as well as expand their existing definitions of risk to include environmental and social risk factors. Widespread investments across each risk dimension will encourage more capital deployment in resilient agricultural systems.

Risk framework

This report provides a synthesis of current research regarding the environmental, financial, and social risk-reducing benefits of resilient agricultural practices across three dimensions of risk: on-farm, off-farm, and systemic. Within these dimensions, there are distinct risk bearers and cost considerations (See Figure 1). For example, producers conduct their own on-farm risk evaluations based on their costs, revenue, markets, debt, and availability of labor and integrate those analyses into their decision making. Furthermore, the interconnections (and shared risks) between farms and their supply chains, communities, ecosystems, and regions fall within the off-farm dimension. National and global risks to agricultural industries, governments, and financial systems fall within the systemic risk dimension.

In this report, risk refers to the chance of harmful impacts of a future event, change, or activity, particularly those impacts that influence environmental, financial, and social conditions. Resilience refers to the capacity to reduce potential harms, to recover after a shock or disruption, and to make transformational changes to farms and agricultural systems to enhance response and recovery capacity now and into the future.[21] Therefore, resilience refers to adaptation and mitigation capacity in the face of environmental, financial, and social risks that are specific to the risk dimension or risk bearer. In agriculture, advocates

Figure 1

Risk Dimensions and Risk Bearers

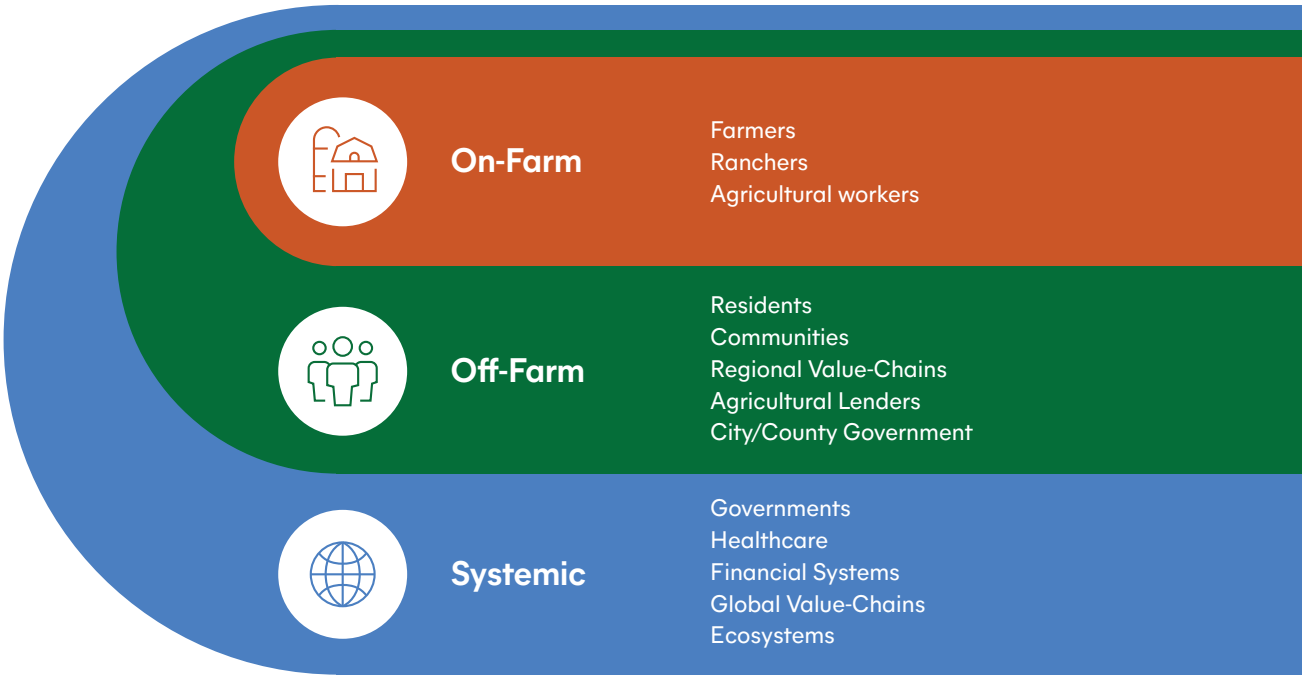
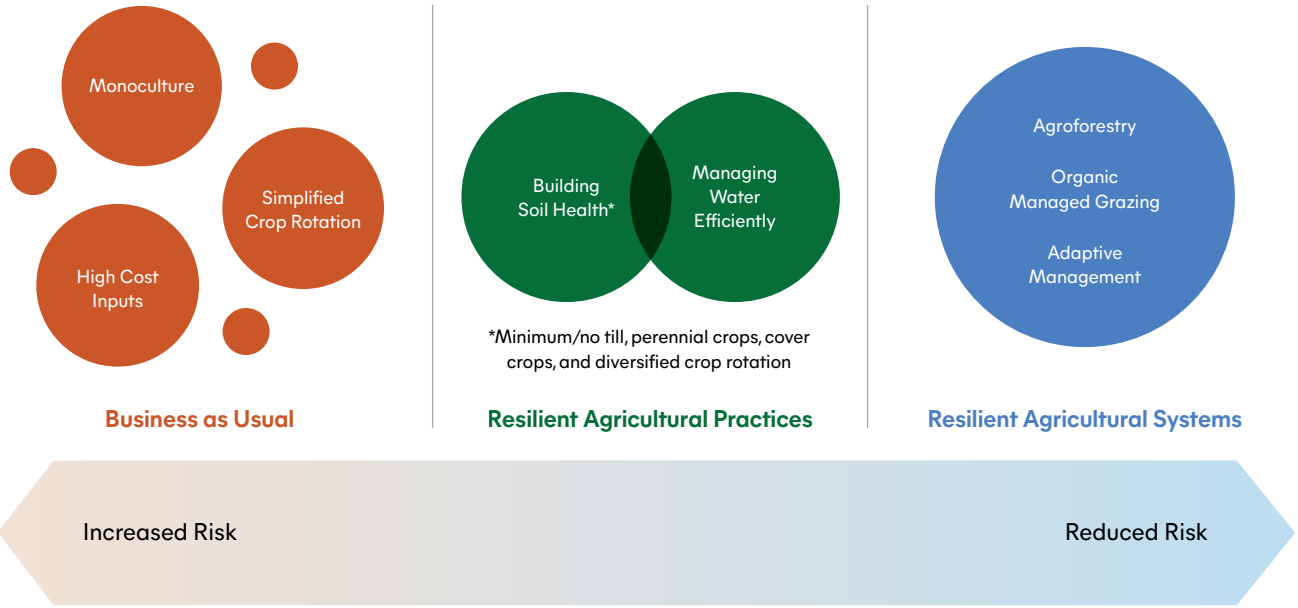


Figure 2

Environmental, Financial, and Social Risk Spectrum of Agricultural Practices

Agricultural practices have different financial, environmental, and social risks



sometimes use the term "climate resilience." This report uses "resilience" to encompass not only climate resilience but also wider environmental, financial, and social resilience.

For this report, we define resilient agricultural systems as systems of farms, businesses, industries, governments, and lenders that operate to withstand, recover, and prevent harm from acute disruptions and shocks—as well as the ongoing crises related to climate change, biodiversity loss, environmental degradation, and social inequity. These resilient agricultural systems inherently work to provide quality and accessible food and farm products for all (both now and in the future). In this report, a "resilient agricultural system" is a scenario of interconnected farms producing with regenerative and conservation practices (see "Resilient agriculture principles and practices"), which are connected to supply chain enterprises, governments, and financial partners that account for their environmental, financial, and social risk-reducing benefits.

This risk framework calls attention to the shared risks across farms, regions, and supply chains. Given these shared risks and benefits, farms do not hold the sole responsibility for the transformation to more resilient systems. **To accomplish this transformation, decision-makers can work to develop new frameworks for resilience in financial ratings, loan terms, and federal farm support programs.** As governments, lenders, and supply chain enterprises scale investments and implement new risk frameworks, this will contribute to the evolution of ecologically, financially, and socially resilient farming systems in the long run (See Figure 2).

Resilient agriculture principles and practices

This report uses "practices for resilience" to describe agricultural practices that steward climate, soil, water, biodiversity, and both ecosystem and human health, primarily through conservation and regenerative practices (see Box 1). Though a variety of terms can describe these production strategies (climate-smart, climate-resilient, nature-based practices, agroecology, among others), this report will use the term "resilient agricultural practices" to describe the range of potential approaches (which encompasses overarching concepts of regenerative and conservation).[22,23,24]

While practices and definitions can vary, the term "regenerative agriculture" used in this report refers to "a system of land stewardship, rooted in centuries old Indigenous wisdom, that provides healthy, nutrient-rich food for all people, while continuously restoring and nourishing the ecological, social, and cultural systems unique to every place".[25] In addition to the environmental and economic on-farm considerations, regenerative agriculture and agroecology also incorporate principles of political and sociocultural dimensions. This includes resource sovereignty in the hands of communities (seeds,

inputs, land, etc.), knowledge sharing, improved livelihoods, human and animal health, and relational values (which refers to the reciprocal relationships between humans and nature, such as heritage, sense of place, culture, spirituality, justice, and conviviality).[26] "Conservation agriculture" typically refers to cover crops, crop rotation, and minimal tilling to produce annual crops to protect soil, avoid emissions, and sequester carbon.

Farmers determine the best practices based on their production and landscape.

Farmers determine the best practices based on their production and landscape. It is beyond the scope of this report to determine which practices may be most suitable for any specific farm. This report refers to the available research that corresponds to practices referenced in Box 1, though this list is not exhaustive.

Background: Updating risk frameworks at scale

Some financial decision-makers have started to assess the potential returns and risk benefits of resilient agricultural systems, yet more work is needed to update risk frameworks to reflect present-day challenges.[27] In 2020, Environmental Defense Fund and AGree: Transforming Food & Ag Policy, an initiative of Meridian Institute, conducted interviews with agricultural lending institutions. The authors found that U.S. agricultural lenders do not currently collect financial data specific to regenerative practices or integrate the risk-reducing potential of these farm practices into their risk ratings, despite evidence of the long-term profitability and resilience benefits these practices have for farms and farming systems.[28]

Box 1

Resilient Agricultural Practices

Resilient agriculture is based on several on-farm principles and practices. Conservation and regenerative production systems include agroforestry, organic farming, managed grazing, and integrated crop and livestock production:[29,30]

Regenerative production principles include:[31,32,33]

- Minimizing tillage and soil disturbance
- Continuous soil cover
- Integrating livestock and cropping operations on the land
- Maintaining animal health
- Decreasing the inputs needed for production
- Preserving biological diversity in agroecosystems

Resilient Practices (regenerative and conservation) include:

- Integrated livestock
- No-till and reduced tillage
- Cover crops
- Crop rotation and diversity
- Composting and organic soil amendments
- Integrated pest management
- Native species and perennials

Practices within agroforestry systems include:

- Alley cropping
- Forest farming
- Silvopasture
- Riparian forest buffers
- Windbreaks

Practices within integrated crop and livestock production systems include:

- Rotational grazing or adaptive management
- Multi-species grazing
- Runoff management
- Inclusion of trees and fodder shrubs
- Increased permanent soil cover
- Natural reseeding enclosures

Figure 3

Risk Type by Dimension (On-Farm, Off-Farm, and Systemic)

	Risk Dimensions		
Risk Types	**On-Farm**	**Off-Farm**	**Systemic**
Environmental Water Weather Soil Biodiversity Energy Air	Water use Extreme weather events Soil loss Pollinator loss Erosion	Water and air pollution Biodiversity loss	Climate change Extreme weather events
Financial Revenue Assets	Crop yield Cost reductions Soil Loss	Agricultural lending	Systemic crop loss Financial systems Government costs
Social Health Political Equity	Human health and safety Labor practices Wages Animal health Job satisfaction	Community health Supply chain resilience Rural communities	Social and racial equity Climate migration Food security National security

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Global organizations are developing strategies for holistic risk assessments and action potential. In 2019, Natural Capital Finance Alliance and UN Environment Programme Finance Initiative developed a risk assessment framework for bank lenders to assess environmental risks in their lending decisions.[34] The framework posits that environmental risks (and opportunities) in risk analyses would improve allocation of capital for enterprises with enhanced resilience practices, thereby also improving outcomes for the lender and society.[35] Additionally, the World Business Council for Sustainable Development (WBCSD) recommends that companies conduct materiality assessments with soil health risks along their supply chain and to establish processes to invest in soil health and ensure long-term viability of the company.[36] The Global Alliance for the Future of Food, Rockefeller Foundation, and the United Nations have also advocated for incorporating these material risks into food system assessments and policymaking, a practice known as True Cost Accounting.[37,38] These frameworks demonstrate processes financial decision-makers can use to incorporate resilience into financial risk assessments of public and private investors.

State and federal government agencies can also update their risk frameworks to include resilience benefits. The conservation title in the 2018 Farm Bill provides $60 billion in 10-year mandatory funding.[39] Despite increasing attention to the benefits of resilient agriculture practices, the overall land base of these practices funded by farm bill programs is low compared to total cropland.[40] Only 34 percent and 5.5 percent of cropland was used for no-till and cover cropping, respectively, in the 2017 crop year.[41] To help address this need, the 2022 Inflation Reduction Act (IRA) provides approximately $19.5 billion for agricultural conservation efforts.[42] This scaled investment to build a resilient U.S. agricultural system serves to greatly benefit farmers and ranchers, as well as address risks to communities and wider systems, such as climate and health (See Figure 3). The IRA investments show that public investors can address current barriers and benefits available to build resilient agriculture systems and supply chains across the U.S.

On-Farm Risks

Producers can steward long-term farm resilience and reduce risks by investing in soil health, crop and species diversity, and water management solutions.[43] This section summarizes current research regarding the influence of these practices on environmental, financial, and social risk factors. In the on-farm risk dimension, farmers and agricultural workers are the primary risk bearers. In this context, resilient practices and their environmental benefits can work to build both financial and social resilience on farms.

On-Farm Environmental Risks

Resilient agricultural practices help an operation generate greater ecosystem services and have been shown to reduce environmental risks from drought, flood, temperature fluctuations, pests, and disease. Farmers with on-farm resilience practices are typically "seeking not to maximize yield in an optimum year, but to maximize yield over many years by decreasing the chance of crop failure in a bad year."[44] However, many risk assessments and loan instruments focus on the short term. Consequently, many U.S. producers rely on annual short-term debt to pay for operating costs such as seeds, fertilizer, livestock, and machinery. Producers repay these loans after harvest, creating a year-to-year debt cycle. Federal crop insurance also works year-to-year. This means that policies calculate the yield or revenue to determine coverage and indemnity payments annually. For example, crop insurance coverage for perennial trees is for a single crop year, not the full life span of the tree.[45] Furthermore, USDA requires farmers to follow guidance on good farm management practices for insured crops to reduce the risk of operator-caused crop losses.[46] Good farming practices are the production methods likely "to make normal progress toward maturity and produce yields on par with average historical yields for the farm operation".[47] This can create a barrier for adopting resilience in a year-to-year timeframe. On-farm environmental transitions often do not fit into the annual balance sheet of cost considerations and may even lower yields in the short-term.[48] However, on-farm transitions can prevent crop loss and improve farm productivity in the long-term, in addition to maintaining the soil health and thus viability of the land for future generations. This section discusses the on-farm environmental risk-reducing benefits related to soil, water management, biodiversity, disease, and pest risks.

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Soil health and water use risks

Soil health is a critical factor for farm resilience and viability. At the current rate of soil degradation, U.S. farmers could lose two inches of topsoil by 2035 as flooding and droughts worsen.[49] Higher temperatures and extreme precipitation patterns are expected to significantly affect crop production.[50]

Soil quality and protective living cover help to conserve soil resources. Indicators of soil quality include physical and biological properties, organic matter, infiltration, water holding capacities, biological activity, and microbial diversity.[51] Higher infiltration improves soil moisture levels over time. Soil moisture levels also benefit the organic matter and living conditions for organisms to maximize soil functions like soil structure formation and nutrient cycling.[52]

Resilience practices build structural stability, permeability during heavy rainfall, and enhanced water storage during drought.[53] Soils with a low base infiltration rate (related to depleted and/or bare soils) absorb less water during rainfall, leading to surface ponding, evaporation, runoff, and erosion.[54] On the other hand, soils with higher infiltration more efficiently use water from rainfall or irrigation. Higher infiltration means more water passes through the groundwater to maintain soil moisture levels, sustain river base flows, and recharge aquifers.[55,56] Farms with higher soil infiltration and readily available soil moisture levels require fewer irrigation doses.[57] This means irrigation scheduling can be more forgiving, which is critical with irregular temperatures and precipitation.[58]

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Incorporating perennial crops or grasses, cover crops, trees, and grazing animals can contribute to higher soil infiltration.[59] A meta-analysis of 89 studies estimated various soil health practices and their association with soil infiltration and found that use of perennial crops and cover crops showed statistically significant improvements (59 percent and 35 percent increase in infiltration respectively).[60] Soil scientists at the Natural Resources Defense Council (NRDC) find that every one percent increase in soil organic matter leads to increased water holding capacity by 20,000 pounds of water per acre.[61] In 2018, DeLonge and Basche conducted a meta-analysis of 37 studies of soil infiltration in grazing operations, showing that plot rest periods, reduced stocking rates, rotational grazing, and adaptive management significantly improved soil infiltration.[62] An analysis of 126 field experiments found that by shifting the most erodible regions of Iowa to fields using perennial and cover crops, farmers could reduce rainfall runoff by up to 20 percent in flood events and make up to 16 percent more water available to crops during drought through retained soil moisture.[63] A Union of Concerned Scientists (UCS) report analyzed experiments evaluating techniques to influence water infiltration (such as no-till, cover crops, alternative grazing systems, crop systems integrating livestock grazing, and perennial crops).[64] Seventy percent of experiments showed an increase in water infiltration when using these practices and that continuous living cover of soil was the most effective strategy to achieve these benefits.[65] The analysis estimated that continuous living cover on farms can make on average 9 percent more

water available than annual cropping systems.[66] These are promising results that demonstrate that resilient agricultural practices can lead to improved water usage on the farm.

Practices that build soil organic matter contribute to soil stability, structure, and infiltration rate, which reduces soil erosion and improves water usage.[67] This is crucial as agricultural regions continue to lose topsoil. A report from the Intergovernmental Panel on Climate Change (IPCC) found that soils cultivated without conservation practices are eroding up to 100 times quicker than soil is forming.[68] A report by the World Resources Institute (WRI) found that the costs of soil erosion prevention are much lower than land restoration and rehabilitation after soils have been degraded—about $202/acre for prevention, compared to $607–$802/acre for restoration.[69] In addition, on-farm water use, water availability, and drought are significant risks to farmers. According to a 2022 study by the American Farm Bureau Federation, producers expected average crop yields to be down 44 percent due to drought conditions.[70]

In sum, on-farm soil and water use risks include soil erosion, flooding, and drought. These risks can lead to productivity loss for farmers and increased costs to restore degraded soils. The research also shows that agricultural practices that contribute to soil health include perennial crops or grasses, cover crops, no-till, incorporating trees, and grazing animals, and that continuous living cover is an effective way to build soil health. Practices for soil resilience build structural stability, permeability during heavy rainfall, and enhanced water storage during drought, which has benefits for water use and reduced soil erosion.

Disease, weed, and pest risks

Changes in temperature and precipitation patterns, as well as other climatic changes, are likely to advance the incidence, severity, and migration of weeds, pests, and disease.[71] A 2021 scientific review by the FAO found that climate change has already expanded the range and geographic distribution of some pests, which increases the risk of pest introduction to new areas.[72] These shifts may cause farmers to change management practices to maintain crop and livestock yields and quality, which is likely to become more difficult and costly as climate change advances.[73] Unfortunately, the increased use of pesticides and herbicides to stem pests and weed growth, coupled with an increasingly favorable environment for their reproduction, leads to the development of pesticide and herbicide resistance.[74] According to the University of Illinois, pesticide costs should be expected to increase due to the incidence of herbicide and pesticide resistance.[75]

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Soil organisms and microbial diversity support the decomposition of litter, the cycling of nutrients, and the conversion of atmospheric nitrogen into organic nitrogen, which contributes to the suppression of soil-borne pathogens.[76,77] Researchers have found positive disease suppression results from practices such as minimum tillage, cover crops, crop rotation, crop residue retention, mulch amendments, and organic farming.[78,79] A study of tomato plots found that a healthy soil microbiome was highly associated with disease suppression and healthier plants.[80] USDA has discovered a soil bacteria strain that can act as a nonchemical herbicide for invasive grasses, like cheat grass.[81] Invasive grasses have killed various native grass species, reduced cereal crop yields, and increased wildfire risks.[82] Researchers observed that the soil bacteria strain was able to nearly eliminate the invasive grass within five years.[83] EPA has even registered one soil bacteria as a natural herbicide.[84]

Healthy soils rich in biodiversity require fewer chemical inputs because of the critical functions performed by microorganisms such as fungi and bacteria, along with animals such as earthworms.[85] However, use of synthetic fertilizer and chemical inputs like herbicides and insecticides negatively impact these microorganisms and soil functions, limiting the soil resilience benefits.[86] A 2022 field study by Kim et al. found that the application of nitrogen fertilizers significantly disrupted nitrogen cycling communities of microbes to the point that it could take more than two years of cover cropping to restore microbial communities after 36 years of continuous fertilizer application in corn production.[87]

On-farm crop and landscape diversity provide habitat for beneficial organisms like pollinators, earthworms, and ladybugs.[88] Rich pollinator communities contribute to crop yields, yield stability, crop quality, and market value.[89] For instance, honeybee populations serve as essential pollinators for $10 billion worth of agricultural crops in the U.S.[90]

On the other hand, pesticides may interfere with the feeding behavior, nervous system activity, crop visitation, colony populations of pollinators, with important implications for other arthropod populations and ecosystem health.[91,92,93]

The application of insecticides can lead to subsequent pest outbreaks, due to the loss of insect diversity, reduction of food resources and the population of natural enemies for crop pests.[94]

A decline in biodiversity therefore may lead to a "pesticide treadmill". The "pesticide treadmill"[95] is a cyclical phenomenon where vulnerability to pests leads farmers to use more pesticides, creating pest mutation and pesticide resistance, increasing the farmers' reliance on pesticides.[96] These inputs also harm fungi in the soil and the plants themselves, which increases risk of pest infestations, leading to further dependence on pesticides, threatening on-farm productivity and sustainability of crop yields over time.[97]

Some producers are concerned that transitioning to lower pesticide use could decrease productivity.[98] However, a 2017 analysis of data from 946 non-organic arable commercial farms showing contrasting levels of pesticide use and productivity or profitability found low pesticide use rarely decreased the profitability of farms.[99] Another study found that pests were 10-fold more abundant in insecticide-treated corn fields compared to insecticide-free regenerative farms (mixed multispecies cover crops, no-till, no insecticides, and grazed livestock on cropland).[100] The authors LaCanne and Lundgren suggest that proactively designed pest-resilient systems outperform farms that treat pests chemically.[101]

Furthermore, herbicide resistant weeds are a growing concern for farmers.[102] In some cases, entire crop fields have been abandoned due to weeds, particularly in the South.[103] According to the SARE 2017 National Cover Crop Survey, cover crops are proving to be an effective tool for controlling these weeds.[104] Crop diversification, crop rotation, and intercropping have also been shown to suppress weeds that pose yield risks.[105]

Planting hedgerows, prairie strips, and alley cropping build essential pollinator habitats while also preventing soil erosion.[106,107] A 2022 study of prairie strips and lower land use intensity on six experiment plots in Michigan found that even in the first two years, treatments with prairie strips and reduced chemical inputs had higher soil organic carbon, butterfly and spider abundance, and pollinator services.[108] The authors found that crop yield was also equal to that of the highest intensity management, even while including the area taken out of production.[109] A 2020 Iowa field study found that native prairie strips enhanced bee abundance, species richness, and diversity of both common and uncommon bee species.[110] Another study found that prairie strips led to greater insect taxa richness and pollinator and bird species abundance, compared to crop-only catchments.[111]

Furthermore, pastures with managed grazing leave sufficient grasses and habitat for wildlife, including pollinator insects, birds, and bats.[112] Using multiple strategies synergistically, such as cover cropping, crop diversity, and animal integrations, further enables farmers and ranchers to reduce chemical inputs, reduce monetary costs, and support biodiversity and crop yield.[113]

Regenerative and conservation practices have been shown to address on-farm environmental risks such as drought, floods, temperature extremes, pests, disease, and biodiversity loss. In turn, environmental benefits help to build soil health, enhance biodiversity, and promote efficient water management. These ecosystem services often have significant financial benefits, which the next section outlines.

On-Farm Financial Risks

Farms face several financial risks, such as variability in yields and prices, supply chain disruption, rising interest rates, and increasing costs of production.[114,115] Resilient agricultural practices can reduce farm costs, minimize revenue and yield risks, and diversify farm income streams, generating financial risk-reducing benefits for farms and their financial partners.[116]

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However, agricultural lending often does not identify these risk-reducing benefits as part of the financial risk assessments. According to one focus group participant in the virtual focus group hosted by Croatan Institute and

Meridian Institute in July 2022, implementing resilience practices "introduces risk from an agricultural lending perspective because the majority of loans operate from year to year, including yield expectations and other concrete factors [that don't easily apply to resilient agricultural practices]."[117] Another participant stated, "If a farmer is implementing a [new] practice, and the lender determines there is no market for it, that farmer can be penalized, and may not even be eligible for credit."[118] Agricultural lenders have an opportunity to adapt to financially support these resilient outcomes by incorporating considerations of regenerative and conservation practices into their financial products.[119] This section discusses the research regarding on-farm financial benefits of resilient agricultural practices for farmers and lenders to consider, including risks related to revenue, labor and input costs, and transition to resilient agriculture practices.

Revenue risks

Current agricultural incentives and fluctuating crop prices encourage farmers to produce more and increase yields, yet research is beginning to demonstrate that increased yields do not necessarily correlate with farm financial resilience. A 2020 study found that croplands in the U.S. expanded by over one million acres a year between 2008-2016.[120] However, 69.5 percent of the new cropland areas produced yields below the national average (a nearly 7 percent yield deficit) and infringed upon essential habitats for Monarch butterflies and other native species.[121] According to the authors, the timeline of this initial cropland expansion (around 2007–2012) coincided with periods of high commodity prices, rapid buildout of the biofuels industry, and reductions in federal conservation programs.[122] These conditions have subsided, yet the landscape impacts have remained.[123] A 2013 study found a net loss of 1.3 million acres of grassland from crop expansion to corn and soybeans in five Corn Belt states between 2006 and 2011.[124] There is consistent evidence that the doubling of commodity prices during that time led to widespread loss of grassland habitat and the expansion of row crops in land previously considered marginal for crop production.[125] The cropland expanded mainly to lands with "high erosion potential, shallow soils, poor drainage, and less suitable climates for corn/soy production."[126] Therefore, the financial conditions during that time not only did not improve yields or farming conditions, but led to loss of ecosystems and habitat that benefit farms and communities.

Current agricultural incentives and fluctuating crop prices encourage farmers to produce more and increase yields, yet research is beginning to demonstrate that increased yields do not necessarily correlate with farm financial resilience.

Resilient agricultural practices have resulted in positive revenue potential.[127] American Farmland Trust conducted ten case studies of farms across five states and over 9,000 acres. The case studies examine outcomes from implementing soil health practices such as no-till, cover crops, nutrient management, conservation cover, mulching, and compost application. Across the case studies, farmers reported a range in net income improvement from $22 to $56 per acre, representing a 176 percent average return on investment.[128]

A growing body of research shows that adopting resilient agricultural practices contribute to yield stability and reduced crop loss.[129] For example, research shows that practices such as no-till and cover crops can reduce crop loss and build revenue resilience.[130] A Tennessee study analyzed 29 years of cotton yield and soil data under 32 management practices and found that "long-term no-tillage enhanced agroecosystem resilience and yield stability under climate extremes."[131] The authors also found that no-till maximized yield under favorable climates and enhanced the effectiveness of legume cover crops.[132] In 2021, the Soil Health Institute analyzed 100 corn and soybean farms in nine states that adopted cover crops and no-till. The researchers observed an average $52/acre increase in net farm income for corn and $45/acre for soybeans.[133] They also found that 97 percent of participants reported crop resilience to extreme weather.[134] This indicates that resilient agricultural practices have the potential to benefit on-farm income in circumstances of both normal and extreme climates.

Cover crops work to maintain soil cover and manage soil nutrients, which contributes to the depositing of soil organic matter, providing organic material and soil fertility for enhanced yield resilience.[135] The 2020 National Crop Cover Survey by USDA Sustainable Agriculture Research and Education (SARE) of over 1,000 producers across all 50 states found that farmers saw modest yield boosts from cover crops on a per acre basis: 5 percent for soybeans, 2 percent for corn, and 2.6 percent for wheat.[136] The survey found that farmers valued cover crops for additional risk-reducing benefits such as weed control, soil health, erosion control, livestock grazing, and more.[137]

LaCanne and Lundgren compared the effects of regenerative production systems on pest management services, soil conservation, farm profitability and productivity to conventional production systems and found that regenerative farming systems (no-till, no insecticides, and grazed livestock on their cropland) were associated with greater ecosystem services and profitability for corn producers in the Northern Plains of the U.S. Of the observed farms, regenerative fields had 29 percent lower grain yields but 78 percent higher profits.[138] In addition, fields with higher soil organic matter showed a strong association with greater profits.[139] LaCanne and Lundgren did not observe a positive relationship between greater crop yields and higher farm profits. This demonstrates that soil health (not crop yield) is a promising indicator for increased farm profits.[140] This research also helps address the unfortunate misconception that increasing yield (which can be more land intensive and environmentally risky) will improve a farm's profitability.

A meta-analysis of 610 studies of no-till and conventional tillage across 48 crops and 63 countries found that no-till practices along with sound crop rotation and residue retention helped bolster yield results, compared to no-till only.[141] Another study observed that, compared with other soil health indicators (such as water management and organic matter), yield and biomass are less directly linked to farmers' welfare.[142] Yield is also more closely linked to year-to-year income, instead of economic benefit in the long-term. As a farmer stated, "I look at trying to keep profitability in my operation…It's not making the biggest yield, but it's making the most economic yield, is what I've been trying to focus on."[143]

Labor and input cost risks

Farms implementing resilient agricultural practices for financial resilience must balance shifts in the costs of labor and inputs (such as fertilizer and pesticides).

Resilience practices may reduce external risks related to input prices. USDA has reported that global fertilizer prices reached a near record high in 2022 and are likely to remain elevated in 2023.[144] For conventional corn and wheat production, fertilizer prices account for 35-36 percent of a farmer's operating costs.[145] Recent years have also seen unprecedented price spikes and shortages for pesticides. From 2021 to 2022, prices for glyphosate and glufosinate jumped more than 50 percent.[146]

A 2020 farmer survey also found that cover crops helped respondents improve revenue by reducing fertilizer and herbicide costs.[147] For example, 49 percent of corn producers reported reduced fertilizer costs, as well as 41 percent of soybean producers, 43 percent of wheat farmers, and 53 percent of cotton producers.[148] Additionally, about 45 percent of producers with cover crops (soybeans, corn, wheat, and cotton) reported reduced herbicide use and 35 percent reported a 5 percent or greater increase in net profits (only 3.8 percent said their profits were reduced with cover crops).[149]

A 2008 report by the USDA Agricultural Research Service (ARS) states that no-till farming requires 50-80 percent less fuel and 30-50 percent less labor than conventional tillage.[150] By reducing labor, input, and fuel costs, no-till production can contribute to farm profitability and lower financial risks.

In resilient livestock systems, managed grazing reduces feed costs by maximizing high quality feed and pasture forage for beef or dairy cows.

In resilient livestock systems, managed grazing reduces feed costs by maximizing high quality feed and pasture forage for beef or dairy cows.[151] Continuous grazing results in "the lowest possible pasture yields since the forage is not allowed to recuperate between grazing"—meaning farmers are more reluctant and less able to rely on pastures as a forage source to feed their livestock.[152]

Managed grazing also restores the productivity of degraded or overgrazed grasslands and native grassland species which has led to reduced costs, increased productivity, and reduced financial risk over the long-term.[153] Financial benefits include improved plant and animal health and forage production, as well as lower costs for fuel, machinery, fertilizer, and pesticides.[154]

One case study by the Mid-American Agroforestry Working Group (MAAWG) of a 200-acre grass-fed lamb and beef operation in Minnesota observed that the shaded pastures provided by silvopasture reduce heat stress for livestock and create higher feed value.[155] One rancher in Virginia with a herd of 350 beef cattle described how an economic analysis of his budget showed he couldn't afford fertilizer or hay equipment: "I saw that [buying fertilizer and making hay] would not make a profit, so I got rid of them." The rancher now buys hay just "to cover the 40-65 days during the year when he needs it. For the remainder of the year, the cattle graze fresh and stockpiled pasture", which demonstrates a strategy for cost savings.[156]

By managing costs and savings from external inputs, time, and labor, the synergies between various resilience practices in production systems help improve a farm's balance sheet. A 2016 report by Doane et al. estimated the annual net cost reduction benefits of combined conservation practices (reduced tillage, cover cropping, and crop rotations) for corn growers in the U.S compared to conventional farming practices.[157] The authors found that cost for seed increased with cover crops, while time and labor costs decreased under conservation tillage, and fertilizer costs decreased under crop rotation.[158] The net annual cost reductions of these practices combined was about $41 to $124/acre for corn in the Midwest in a 3 to 5-year time horizon.[159]

Revenue gains from resilient agricultural practices often take several years to materialize. Agricultural lenders can adopt these time frame considerations into their loan products to farmers who practice resilient production. A 2021 study found that farmers generally see increases in soil organic matter from cover crops in the first three to five years, and that these changes are likely to improve with time.[160] Another study found that the time horizon, along with change in producer knowledge and experience over time play a role in maximizing benefits of these practices. For example, a study by EDF found that Midwestern corn and soybean growers with more than five years of cover crop experience had higher net returns and lower per acre costs than those with less or no experience.[161] The learning curve for growers to identify the best "recipe for success" also plays into time frame considerations, with experienced cover croppers saving more on seed, fertilizer, and equipment costs.[162]

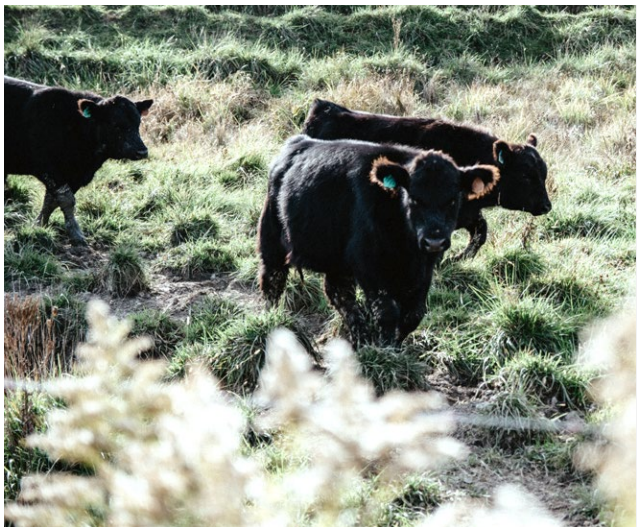
Financial transition risks

Farmers and experts interviewed in the focus group hosted by Croatan Institute and Meridian Institute in July 2022 described the unknown financial factors of transitioning to on-farm resilience practices as a significant challenge.[163] For example, farms may struggle to leverage new market channels for diverse crops, predict cost savings and future resilience, and to capture price premiums for their products. From a lending perspective, operations that employ resilient agricultural practices are often seen as riskier than conventional due to these unknowns. Agricultural lending tends to focus on concrete impacts, such as year-to-year data, that do not account for wider benefits of resilience practices.[164] Terms that do not take the extended time horizons of practice transitions into account, such as short-term leases and market rate operating loans, also increase a producer's transition risk.[165] Other financial offerings may be barriers for farms to transition, by focusing on factors like yield without incorporating the risk-reducing benefits into the financial risk calculations (see Box 2).

Agricultural lending tends to focus on concrete impacts, such as year-to-year data, that do not account for wider benefits of resilience practices.

Furthermore, farmers interviewed in the July 2022 focus group state that agricultural lenders are unfamiliar with the benefits of on-farm resilience, and perceive these practices as riskier, sometimes resulting in higher loan rates. This can mean that the farmer bears the cost burden more so than conventional farms that have readier access to financial support. One farmer interview participant explained,

> *"Regenerative agriculture is expensive if lenders don't understand the premise—that we're trying to heal the earth and feed people, and yet also [dealing with challenges like finding] supplies and seeds, and other things we need to maintain the health of soil, grow healthy crops, and not use chemicals…So, asking the banks to change their viewpoints on how they have interacted with farms, especially farms looking to transition to organic or regenerative, is a big step."*[166]



These transition risks are often especially burdensome for historically underserved and BIPOC farmers, who disproportionately experience barriers to accessing capital. A 2022 report by the Washington State Department of Agriculture explains,

> *"Limited intergenerational wealth, inadequate access to credit, and assistance to access and utilize grant funding were reported as major hurdles [for underserved producers]. The history of discrimination in credit lending, lack of support resources to know where to look for funding opportunities, and limitations to funding based on land ownership, citizenship status, types of crops grown, and language barriers compounded the difficulties in accessing capital to purchase land or equipment."*[167]

Further, the Union of Concerned Scientists (UCS) states, the history of "colonization, racist laws and policies, state-sanctioned land grabs, and other actions have eroded or directly prevented land security and access for many BIPOC."[168] Even though one-quarter of the US population are BIPOC, they operate less than 5 percent of the nation's farms, and cultivate less than 1 percent of U.S. farmland.[169] Additionally, a majority of the estimated 2.4 million farmworkers in the U.S. are people of color who do not own or operate farms of their own, and face unique challenges to access capital, such as immigration status.[170] Therefore, UCS argues, "Removing discriminatory barriers to BIPOC farmers and their networks, and supporting their leadership in sustainable and community-driven farming, will advance the equity and resilience of the nation's food systems."[171] In 2022, First Peoples Worldwide interviewed and surveyed 87 Native food producers and entrepreneurs and found that "many of the barriers limiting the current supply of Native-produced foods can be addressed through creating sustained and equitable access to capital."[172]

A farmer participant in the July 2022 focus group adds,

> *"Banks need to try to find more creative ways of structuring loans [that fit with the growing season, and conventional, organic, and regenerative production]. But young farmers need grants—they'll be over their heads with loans. There should be grant opportunities for beginning farmers, even for just $10k or $20k, so, they can have some sort of safety net… that's in the bank ahead of time, so a beginning farmer who has a hard time can dig into that reserve. Be creative in setting up the payment structure. We started with [crowdfunding] and did a lot of networking. No bankers were going to give us money. There's so much debt with beginning farmers, student loan debt—how can you be creative with student loan debt, or veterans, or people who have been incarcerated? [We need to structure loans] for people with different backgrounds, for people with no credit or poor credit…If you're going to create a system for the next generation of farmers, be creative."*[173]

Current financial offerings have not been updated to consider the unique risks, innovations, and production timelines for transitioning to resilient farm practices. Though the cost of future disruptions (e.g., from natural disasters, crop loss, input price shocks) are difficult to predict, research demonstrates that the cost of future losses and disasters are likely much higher than the costs of transitioning. Long-term resilience benefits may not show up in year-to-year balance sheets. So, financial decision-makers can integrate new, long-term criteria into their risk analyses to include resilience benefits. With the financial benefits of regenerative and conservation production, financial decision-makers can then create alternative financial mechanisms that lower the risk of farm transitions while reducing the loan default risk in the long-term.

Box 2

Crop insurance

Crop insurance helps to address year-to-year risk for farmers and lenders by protecting against the financial losses from weather-induced crop yield and quality loss. Although crop insurance is an essential risk management tool, many policy advocates argue that federal crop insurance is not sufficient to protect farmers and lenders from increasing climate risk.[174,175] As Monast states in the 2020 report *Financing Resilient Agriculture*, "crop insurance is not designed to make farmers 'whole' after a disaster".[176] The maximum crop insurance coverage is 85 percent of farm losses, which can negatively impact farmers who experience increased loss in the face of climate change shocks.[177]

Crop insurance is closely linked to a farm's capital, as loans backed by crop insurance are considered lower risk for lenders and can carry lower interest rates. Many lenders require borrowers to hold insurance (or significant collateral in its place), which can disadvantage smaller farms or farms with diversified crops.[178] The majority of crop insurance goes to corn, soybeans, and wheat.[179] In 2018, the three crops made up roughly 63 percent of all acres enrolled in crop insurance.[180] Furthermore, a greater proportion of large farms participate in crop insurance, 75 percent, compared to just 15 percent of all U.S. farms.[181] Without an adequate safety net for more diversified, non-commodity production systems, there are greater challenges in adopting those systems. Therefore, the USDA Risk Management Agency (RMA) — which manages the Federal Crop Insurance Program — should continue to incorporate new strategies to expand access for regenerative farms. For example, in 2015 the RMA adopted the Whole-Farm Revenue Protection program, which allows diversified growers to insure their entire farm, rather than individual field crops.[182] Advocates also successfully managed the inclusion of cover crops into the insurance program's Good Farming Practices (GFP) handbook so producers interested in that practice would not have to jeopardize their insurance coverage.[183] Advocates are also working for the recognition of other risk-reducing conservation and regenerative practices to be added to the Good Farming Practices in order to increase access and coverage for diverse growers.[184]

On-Farm Social Risks

On-farm social risks include health and safety risks for farmers, agricultural workers, and animals, as well as wider social considerations, such as on-farm wages, livelihood, and job satisfaction for both farmers and farmworkers. This section provides an overview of on-farm social risk factors, transition risks, and risk reducing benefits of the transition to resilient agricultural systems.

Livelihood and mental health risks

Farm livelihoods and wages are a critical factor for farm viability and encouraging the next generation of farmers.[185] The average age of farm producers and the hired farm workforce is growing older, due to the growing challenges of agricultural work.[186,187] A 2022 study by Burchfield et al. reviewed farm operator livelihood data in the U.S. and found that rising input costs, volatile production values, and rising land rental costs have left farmers with unprecedented levels of farm debt, low on-farm income, and high reliance on federal programs.[188] Furthermore, these livelihood challenges compounded with racial and gender disparities in access to farmland, capital, and federal support limits the diversity of U.S. farm owners and operators.[189]

The average age of farm producers and the hired farm workforce is growing older, due to the growing challenges of agricultural work.

The mental health of farmers related to these risks also poses a growing challenge.[190] A 2019 systematic review of 167 articles found that the four most-cited influences on farmers' mental health were financial difficulties, pesticide exposure, climate variabilities/drought, and poor physical health/past injuries.[191] The financial and mental health stressors may lead to more farmers leaving the profession and fewer young people starting to farm.

Currently, fewer young farmers are taking up farming than farmers reaching retirement age.[192] Farmers under the age of 35 account for only 9 percent of the total population, and the average size of farms has increased as farms consolidate.[193] Therefore, job satisfaction and the financial viability of farming is a social risk for growers and future generations of growers. Though the mental health benefits from resilient farming are understudied, one farmer survey found that farmers and ranchers practicing regenerative agriculture report greater optimism and job satisfaction than those without regenerative practices.[194]

The state of workplace standards and on-farm livelihoods poses a threat to farmworkers, which also affects the workforce population overall.[195] Many farm operators have expressed concerns around worker shortages. Labor is especially a risk for specialty crop farms (fruits, vegetables, and nursery crops), which have the highest share of labor costs—three times higher than the average for all farms.[196] Agricultural workers are deemed "essential workers", as shown in the height of the COVID-19 pandemic, yet their wages are disproportionately low compared to other workers–about 59 percent of nonfarm wages ($14.62 compared to $24.68).[197,198]

Climate change events are already impacting farmworkers' income and livelihoods.[199] Extreme weather, such as heat and drought lead to fewer jobs, more unworkable days, and income loss.[200] In the California Central Valley, one study found that the water shortage caused the loss of more than 8,000 jobs.[201] Farmworkers in California also reported $1,000-$3,000 of lost income in one month due to flooding.[202] These climate risks significantly impact the migrant and immigrant agricultural communities in those areas.[203]

Many regenerative agricultural businesses include labor standards and fair wages as part of their missions.[204] However, more research is needed to show how farms are addressing this social risk. Additionally, more work is needed to build on-farm wages and revenue potential for resilient agriculture practices and systems. Building markets for regenerative products is one strategy to enhance the dollar and value back to the farm.[205] Expanded retail markets and revenue streams are essential to reduce the social risk of labor wages and conditions.

Health and safety risks

Agricultural work poses significant safety risks and hazards related to equipment accidents and injuries, heat, and chemical exposures.[206] The 2019 Census of Fatal Occupational Injuries (CFOI) found that workers in the agriculture, forestry, and fishing (AFF) industry have a fatal work injury rate of 23.1 per 100,000 full-time equivalent workers, which indicates that these workers are seven times more likely to die on the job than non-AFF workers.[207] These incidents include heat stress-related deaths, an increasing risk as climate change progresses.[208,209] Health and safety on farms pose an urgent risk as extreme weather becomes more common. At the same time, farmworkers are excluded from many labor and safety standards in the U.S.[210,211]

Resilience practices can help address these health and safety risks. For one, practices that lower pesticide use reduce on-farm exposure and health hazards for farmers and farmworkers. The EPA estimates that farmworkers suffer up to 300,000 acute illnesses and injuries from pesticide exposure each year.[212] Prolonged exposure to pesticides can lead to higher risk for certain cancers, neurological, metabolic and thyroid disorders, DNA damage, lowered fertility, and hormone disruption.[213,214,215] Therefore, practices that reduce the need for chemical inputs can lower these health risks on farms.

Animal health risks

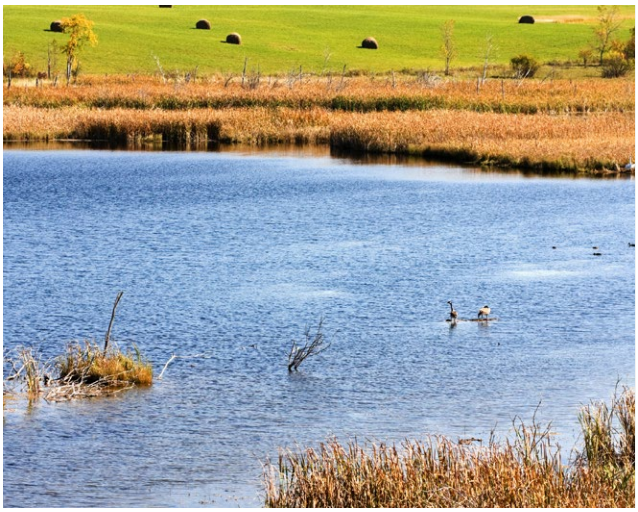
Resilient agricultural practices have also shown reduced risks for animal health, which can create wider benefits related to yield, reputation, and operational risk mitigation.[216] Animal welfare is a required component of regenerative certification for livestock operations, such as Regenerative Organic Certified™, Certified Regenerative by AGW, and Real Organic Project.[217] A Greener World (AGW) states, "The premise of the Certified Regenerative standards is that animals must be allowed to behave naturally and can play an important role in the nutrient cycle.[218]

Resilient agricultural practices have shown reduced risks for animal health, which can create wider benefits related to yield, reputation, and operational risk mitigation.

Additionally, diverse pastures produce significant nutritional benefits for animals by providing essential nutrients and bioactive compounds.[219,220] Some plants and trees used for grazing ruminants have shown to produce metabolites that reduce parasite burdens for animals.[221] Diverse pastures are also associated with improved finishing weights, fertility, and lower neonatal mortality.[222] Furthermore, as noted above, the shade, shelter, and lower temperatures from silvopasture trees can contribute to lower body temperatures and higher rumination rates for cattle and sheep compared to open pasture.[223]

Social transition risks

Farmers interviewed in the July 2022 focus group explained that there are social and community risks associated with transitioning to regenerative and conservation practices.[224] Farmers have experienced skepticism from neighbors, especially for practices with preventative and long-term



resilience benefits.[225] However, farmers in the focus groups for this report described how neighborhood and community risks decrease as their neighbors notice farm improvements. Participants mentioned that mentorship, shared learning, and "safe to fail" trials (small-scale experiments on smaller numbers of acres) can help mitigate these risks.[226]

Furthermore, improving farm resilience in the long-term works to protect community agricultural knowledge, expertise, and experience. As farms are lost due to financial or environmental decline, or as more farmers retire, the knowledge generated on that land base is also lost. The FAO specifies "[c]o-creation and sharing of knowledge" as a core tenet of agroecological and resilient agriculture systems, as "[p]roducer knowledge of agricultural biodiversity and management experience for specific contexts as well as their knowledge related to markets and institutions are absolutely central."

Moreover, resilient agricultural practices are rooted in Indigenous agricultural systems and knowledge from across the globe, as well as Black farmers and researchers in the U.S.[227] Therefore, investments in agricultural knowledge sharing and preservation can support diverse worldviews, innovations, historical knowledge, and relational values in the transition to resilient agricultural systems.

Both public and private financial decision-makers have a key role in addressing these on-farm social risk factors by deploying investments in farmer livelihoods, supporting markets and price premiums for products from regenerative and conservation operations, and investing in farm systems with optimized farmworker wages and on-farm safety standards. Investing in the social benefits of resilient agriculture also requires creating resources that meet the unique needs of new and beginning and socially disadvantaged farmers.

Off-Farm Risks

The risk-reducing benefits of adopting on-farm conservation and regenerative agricultural practices extends far beyond the farmgate and can improve the resiliency of local ecosystems, agricultural lending, supply chains, regional economies, food access, and rural communities.

As one focus group participant noted,

> *"Farm regions and [supply] chains have shared firm-level risks that also apply to off-farm entities. Changes in crops, products, markets, and ecosystem services, everyone involved at each stage of the supply chain [has] some version of their own firm level risk from that change. Therefore, we need to figure out how to handle everyone's risk in concert, dispel unfounded definitions of risk, and handle the real risks at present."*[228]

Farms that share ecosystems and supply chains share interconnected risks. Likewise, farm-adjacent communities are directly impacted by agricultural practices and production systems. Farmers and communities alike rely on productive and unpolluted ecosystems for food, water, and cultural services (recreational, spiritual, aesthetic, and educational uses).[229]

Given these shared risks and benefits, policymakers, private investors, and supply chain actors should take these off-farm environmental and financial risk factors into the risk calculations to determine investments and incentives for agricultural transitions to resilient systems.

This section will describe research regarding off-farm and regional environmental, financial, and social risks associated with agriculture, as well as the risk-reducing benefits of resilient production systems that are shared across communities, regions, and supply chains. The off-farm risk bearers include neighboring farms and residents, consumers, ecosystems, supply chain enterprises, lenders, and local governments.

Off-Farm Environmental Risks

Agricultural management impacts not only croplands, but the broader farm ecosystem, bioregion, climate, and downstream waterways. This contributes to shared environmental risks at the community and regional level.

This section provides an overview of these risks, such as water availability and competition, aquifer depletion, water pollution, and available land to provide societal value. Access to clean water and sound ecosystems has immeasurable health, recreational, and spiritual value that cannot be fully captured on the financial balance sheet. These resources are often not accounted for until they are already lost or depleted. Given the irreplaceability of complex ecosystems and habitats, investments in resilient agriculture offers distinct opportunities to create regional-level impact while supporting interconnected farms.

Water availability risks

Water availability is a growing risk and concern for both farmers and communities. Increased competition for water, water shortage and oversupply, climate variability, aging infrastructure, and pollution from agricultural runoff all pose significant risks to agricultural regions.[230] Groundwater is replenished through recharge and infiltration, yet some river basins must tap into deep aquifers containing nonrenewable groundwater, which replenishes over very long timescales.[231] Nonrenewable groundwater extraction from deep aquifers has trended upward in the U.S.[232] The proportion of groundwater withdrawals compared to surface water withdrawals increased from 25 percent to 30 percent between 2010 to 2015—of which irrigated agriculture accounted for more than half.[233]

Increased competition for water, water shortage and oversupply, climate variability, aging infrastructure, and pollution from agricultural runoff all pose significant risks to agricultural regions.

To address environmental risks associated with nonrenewable groundwater extraction from aquifers, local and federal governments are beginning to invest in sustainable water use for agriculture.[234] For example, the USDA NRCS funded the Ogallala Aquifer Initiative between 2011-2018 to invest in soil health, irrigation efficiency, nutrient cycling, plant and animal health, and other services for water conservation in the region.[235,236,237] The Ogallala Aquifer beneath the Great Plains, one of the largest aquifers of the United States, provides drinking water for two million Americans and irrigation water for $20 billion worth of food and fiber a year.[238] After decades of overuse, the aquifer is shrinking, losing up to 150 feet in some areas.[239] Investment in agricultural resilience can build long-term replenishment of aquifers to ensure enduring water availability for both agricultural and resident use.

Water quality risks

Water quality and pollution also impact farmers and downstream communities, with nutrient runoff proving a particular risk to waterways.[240] Excess nutrients in waterways may result in harmful algal blooms, low oxygen or hypoxic zones, and compromised water quality for human use and aquatic life.[241,242]

The Mississippi River Basin that drains into the Gulf of Mexico is a region of high concern. This region includes the Northern Plains, North Central, and Midwest Regions, which contain 55 percent of the United States' cultivated cropland, and represent the greatest expansion of cultivated acres from 2003–2016.[243] Where the Mississippi River meets the Gulf of Mexico, a dead zone covers about 4,800 square miles.[244] The National Research Council estimates the cost of excess nutrient runoff is $2.5 billion per year.[245] Federal agencies are supporting efforts to build resilience by reducing excess nutrient runoff. For example, the USDA's Mississippi River Basin Healthy Watersheds Initiative made $17.5 million available in 2020 to support conservation investments by agriculture producers.[246]

Resilience practices for soil health optimize water infiltration and retention, which can reduce flooding risks and risks of contamination from sediment, nutrients, and chemicals that are carried with agricultural runoff and flood waters.[247,248,249] An analysis of 119 studies reviewed the watershed impacts of resilient land practices such as conservation tillage, cover crops, buffers, irrigation water management, and environmentally sensitive land enrolled in the Conservation Reserve Program (CRP), where farmers have planted for conservation rather than agricultural production.[250] The authors found promising results such as reduced sediment and nutrient loss in runoff, improved soil quality, and improved conditions for processes that mitigate contaminant impacts on the environment.[251] A study measuring the use of wildlife buffers to minimize runoff and nutrient losses in a Lower Mississippi River Basin watershed demonstrated improvements in lake water quality.[252] In the Upper Wichita Basin in Oklahoma, 15 years of research demonstrated that resilient agricultural practices improved soil and water resources at a watershed scale (for instance, grassland conservation, riparian and buffer strips, and conversion of cropped area to Bermuda grass).[253]

Agricultural land risks

Just as farms benefit from regional water conservation and water availability, they also benefit from habitat and ecosystem service protection and land conservation programs. One study explored the services wetlands provide in the Des Moines Lobe ecoregion, "now a predominantly agricultural landscape where over 99 percent of the tall-grass prairies that once dominated the ecoregion have been converted".[254] In this region, "90 percent of the wetlands have been lost to filling and drainage".[255] Wetland conservation easements help to maintain the ability of these areas to support wildlife populations, regional biodiversity, nation-wide pollination services, and global atmospheric conditions. The conservation easements in this region provide nearly 70,000 additional acres of land with quality floral resources to support bee colonies in protected wetlands and grasslands, providing key pollinator services for farms.

Just as farms benefit from regional water conservation and water availability, they also benefit from habitat and ecosystem service protection and land conservation programs.

Local, state, and federal government policies that aim to preserve agricultural land are crucial for sustaining regional agricultural resilience. A report by American Farmland Trust found that between 2001-2016, 11 million acres of the nation's irreplaceable agricultural land was lost or fragmented, with about 2,000 acres being lost daily.[256] This area equals the total acreage used to produce fruits, vegetables, and nuts in the U.S. in 2017.[257] Another 18.4 million acres (the size of South Carolina) could be lost from 2016-2040, with most of the land converted for urban land use, commercial buildings, industrial sites, and residential development. As one farmer stated in a 2020 study, "If [badly eroded land is] cheap enough [I would buy it] because we're dealing with urban growth." In addition, available farmland is growing to record high prices, both to buy and rent, pricing out many small, midsized, and underserved producers. Nationally, 2022 farmland prices averaged $3,800 per acre, up 12.4 percent from 2021.[258] In states like Iowa, farmland rental prices reached a ten-year high.[259] Therefore, agricultural land loss, land competition, and land prices represent significant risks to farming communities.

Both farms and communities benefit from productive ecosystems, native habitats, and unpolluted, safe water. Environmental degradation leads to irreplaceable loss of land for food, clean water, and cultural services. Given the regional costs to maintain soil, water, and land conservation for safe public use, local governments have a key role to play in investing in agricultural resilience. As discussed in this section, practices such as conservation tillage, cover crops, wildlife buffers, water management, and conservation set asides have environmental value that extends beyond farms and contributes to real financial benefits.

Off-Farm Financial Risks

Increasingly, the impacts of climate change, whether extreme heat, drought, or flooding, affect farmers' ability to bring products to market, which can have financial implications for agricultural lenders.[260] If a climate-induced farm crisis or agricultural depression occurs, farmers who cannot repay loans and declare bankruptcy will pose a significant financial hazard to agricultural banks.[261] Financial risks in this section include public, private, and supply chain risks. Regional climate and ecosystem risks are shared across localities and supply chains, highlighting the need for well-connected and resilient agri-food regions.

Private financial risks

Farm lenders are less likely than other financial institutions to incorporate climate change in their risk assessments.[262] Current lending practices are also unlikely to include a comprehensive risk assessment that encompasses the numerous environmental, financial, and social considerations affecting agricultural risk.[263] Yet, agricultural lenders are also significantly exposed to climate risks.[264] For example, half of all agricultural loans are held at "highly concentrated agricultural banks," which have at least 25 percent of their portfolio concentrated in agricultural production or farmland.[265] This exposure to agricultural risks is also highly geographically concentrated in the Midwest.[266] In the event of an extreme climate event or farm crisis, community banks in farm country could be forced to fold.[267] This would leave rural communities without easily accessible banking or credit.[268] Agricultural lenders are concerned with farms' profitability and farmers' ability to repay loans. A 2019 survey found that more than 82 percent of farm bankers are seeing their customers' profits decline—with the most significant economic concerns among dairy, grain and livestock producers in Midwest and Southern states.[269] In 2023, the Farm Bureau estimates that 2023 net farm income will decrease $30.5 billion (18.2 percent), and

that production expenses will increase by $18.2 billion (4.1 percent) from 2022.[270] The Farm Bureau states that revenue declines expected in 2023 would more than erase the gains made in 2022, calling for producers to "have access to comprehensive risk management options and for producers to be given a resounding voice during formulation of vital legislation such as the farm bill."[271]

Public financial risks

Every year, excessive moisture, flooding, and drought cause widespread crop loss.[272] This leads to price and supply chain disruptions, and higher costs to government programs, such as crop insurance.[273] Between 2011 and 2016, flood and drought-related claims resulted in $38.5 billion in federal crop insurance payouts.[274] In the same period, flooding was the most frequent reason for "prevented planting" insurance claims.[275] In 2019, prevented planting insurance claims in Wisconsin were filed for 594,204 acres of corn, soy, and wheat, which would have been valued at $269 million.[276] However, the prevented planting indemnities for the state only totaled $131 million, leaving $138 million in uncompensated financial losses for farmers.[277] Furthermore, based on agricultural income estimations, these uncompensated farm losses caused $486 million in losses to the state economy.[278]

These risks in crop insurance and farm lending reflect a common theme reflected in other sections of this report recovery is more costly (and oftentimes insufficient) to recoup losses than to mitigate against losses in the first place.

Agricultural asset risks

Biodiversity loss and decreased ecosystem health could have profound consequences on the value of agricultural assets. Climate crises and environmental degradation may drive down the productivity, distribution, and value of U.S. crops and farmland, which could impact sector-wide risks for banks with loans in farmland.[279] A 2018 analysis used seasonal county-level climate data in the Southeast U.S. with long-term climate change projections to predict aggregate farmland value losses of 2.5–5 percent, ranging from large losses in Florida to significant gains in Virginia.[280] A 2020 modeling study found that profits for six major crops (barley, corn, cotton, soybeans, rice, and wheat) would drop by 31 percent if croplands are not reallocated based on climatic changes.[281] For example, the authors found that soybeans would gradually move north, replacing spring wheat and barley, and cotton would become southern California's dominant crop.[282] They also found that unprofitable croplands in the southern U.S. would expand, accounting for 5 percent of the six crops' cultivated land area by 2070.[283] According to a report by American Progress, if farmland becomes unproductive, it could significantly impact on agriculture collateral and agricultural loans, banks, and financial firms in these regions.[284]

Changes in geographic conditions driven by climate change can lead to impaired or "stranded" assets—assets that have lost some or all their value.[285] These assets may lose their value due to unexpected or premature write-offs, downward revaluations, or may be converted to liabilities, all stemming from environmental risks.[286]

From a business standpoint, stranded assets pose a significant challenge, as they often represent investments with low liquidity and a high susceptibility to sudden and substantial depreciation.[287] If farmland and physical infrastructure, concentrated in specific areas, become stranded assets, the impact transcends the business to the broader community.[288]

Climate change and a decline in soil health and productivity on agricultural lands could also lead to stranded assets for real estate loans and other sectors. USDA ERS forecasts that total farm sector debt (both real estate and non-real estate debt) will increase in 2023 relative to 2022.[289] USDA ERS also estimates that farm sector solvency, or the ability of a farm or ranch operation to satisfy its debt obligations, will be weaker in 2023, as debts will likely grow at a faster rate than the assets.[290] The projection for farm working capital in 2023 suggests a decrease of 11.2 percent compared to 2022, also signaling a reduction in available liquidity.[291]

If farm sector debt continues to increase and financial solvency continues to decrease, the risk of default becomes higher, especially if unexpected, damaging climate-related events that are not included in USDA farm financial predictions occur. Given current climate and soil health trends, farm sector real estate debt is increasingly at risk of weakened solvency and, more significantly, market failure. Farm sector stranded assets thus pose an unmitigated risk to the financial sector and agriculture real estate borrowers. Furthermore, the costs of stranded assets are significantly born by the state, in the form of temporary nationalization of firms (such as bank bailouts), the imposition of trade restrictions, direct farm support costs, and other social programs such as unemployment and health benefits.[292]

Supply chain risks

Environmental risks, such as flooding or drought, can also lead to stranded assets throughout the agricultural supply chain. For example, flooding or drought that leads to regional crop failure can have an upstream impact on businesses in the supply chain that rely on those crops for revenue. Understanding these risks and how to mitigate them can help investors, businesses, and policymakers develop effective strategies to improve and incentivize resilience-building practices in agriculture.[293]

Diversification of infrastructure for agricultural production is key to supporting local farming systems, especially mid-sized producers. In general, diverse and interconnected supply chains can provide mutually beneficial resilience opportunities for farms and supply chain enterprises through new markets, value-added goods and services, and added efficiencies. For example, regional assets such as storage and processing facilities for farm products create added efficiency or demand that farms can take to the bank, leading to investments in on-farm production or diversification.[294,295] Furthermore, having diverse products with multiple distribution and sales channels can help a farm to pivot in the case of disruptions, and ensure a stable and resilient food supply.[296,297] Processing and packaging infrastructure for both wholesale and retail markets, and online direct-to-consumer sales help to build financial resilience for farm enterprises and shared supply chains.[298,299]

One July 2022 focus group participant explained,

> *"There are financial ways to make "stuff" available to Americans, think about mortgage markets and car loans. Why isn't there a capital supply for long-term oriented investors, including CPG companies, to invest in the supply chains they want to see? The natural diversity of soil, crops, geographies, can allow you to diversify investment risks. We could use that to think differently about financing many different smallholder businesses instead of investing in one big farm. That could be better for food security. We need financial innovations around that [diversity]."*[300]

Whether diversified farms can survive and work optimally without off-farm diversified production and processing systems remains a question. Shared regional risk exposures demonstrate the need for financial actors to operate within a community, ecosystem, and diversified supply chain. Stranded asset risks in the supply chain can affect multiple assets from the farm enterprises to the processing, transport, and sale of agricultural goods.[301] Furthermore, collapse in one area of financial exposure—whether that is from a collection of farms defaulting on loans due to the same climate event or

a piece of the supply chain failing—can create a stranded asset. These concentrations of financial risks also impact rural communities. The collapse of farms and banks alike results in fewer rural resources, ultimately impacting the financial security of rural communities. The next section will outline these off-farm social risks.

Off-Farm Social Risks

Off-farm social risks include food availability and affordability, as well as the environmental health risks that impact rural communities. This section provides an overview of these off-farm social risks and the risk-reducing potential of regenerative and conservation practices on farm and food systems. Rural and BIPOC communities, as well as poor households, are disproportionately impacted by food insecurity, climate disasters, and environmental pollution.[302] A report from the EPA shows that underserved communities, particularly racial and ethnic minority communities, are the most vulnerable to the most severe risks of climate change.[303] Given these elevated social risks, agricultural investments could build resilience in the communities most impacted.

Supply chain risks

Off-farm supply chain disruptions can create local, regional, and even national social risks related to food availability and affordability. The early months of the COVID-19 pandemic showed the effect of these shocks, such as food shortages, a spike in emergency food demand, and dumping of crops and culling of animals. Supply chain disruptions cut off market access for farmers, leading to revenue loss and food waste. Agri-food system resiliency is becoming increasingly important to address supply chain risks from climate change shocks and extreme weather events. As one researcher stated,

> *"The biggest single issue is the systemic infrastructure we've built in most of the country around large-scale agriculture... More and more folks find themselves trapped in a 'treadmill of production' growing more and more of a very few crops for a very massive and undifferentiated global market that doesn't care much for or pay much for different production systems."*[304]

The COVID-19 pandemic illustrated the resiliency of decentralized, diverse regional food systems that are flexible enough to pivot when there is a sudden change in demand and needs.[305,306] Small to midsize farms and food businesses focusing on regional markets, which had struggled to compete with their larger counterparts, were quickly able to pivot during the pandemic to serve direct to consumer markets.[307] In July 2021, the federal government announced $500 million for expanded meat and poultry processing capacity as part of their efforts to "increase competition, level the playing field for family farmers and ranchers, and build a better food system".[308] A helpful policy change, this highlights the need for greater investment in diversified processing, storage, distribution, marketing, and retail channels to form resilient supply chain systems.[309] Investment on a regional basis will help to bolster markets for diversified products and contribute to food affordability and accessibility by making healthy products available across a range of markets.[310] Farmer and cooperative ownership of these infrastructure enterprises can work to improve farm incomes, as more farmers have greater say over the price they receive for their products.[311]

The COVID-19 pandemic illustrated the resiliency of decentralized, diverse regional food systems that are flexible enough to pivot when there is a sudden change in demand and needs.

In 2021, Gomez et al. developed a model to link food shock risk to supply chain diversity. Their empirical-statistical model explains a city's resistance to food shocks, based on annual food inflow observations from all metropolitan areas of the U.S. between 2012–2015, a time of moderate to severe drought across the country. The model shows that boosting a city's food supply chain diversity increases resistance to food shocks by up to 15 percent.[312] The authors state, "[a]nalogous to biodiversity buffering ecosystems against external shocks, ecological theory suggests that food supply chain diversity is crucial for managing the risk of food shock to human populations."[313] Their research shows that risk models can help to identify supply chain vulnerabilities and develop mechanisms to invest in diverse enterprises, food security, and emergency recovery assets. For example, increased food supply resilience may prevent food price spikes and variability.[314] Furthermore, insurers can price in shock risk to incentivize diversity and resilience, and the business sector could diversify their supply chains.[315]

Products grown with resilience practices and corresponding certifications (like Regenerative Organic (ROC)[316] and Certified Organic[317] often require specialized infrastructure, such as processing and marketing.[318] Specialized marketing infrastructure also helps farmers to capture the price premiums for products and bolster their revenue. For example, local meat processing cooperatives and distribution channels can aggregate products from regional farms and educate consumers about the ecological and social benefits. However, the market concentration of supply chains has threatened smaller, independent processors.[319] Therefore, resilient systems require further investment in infrastructure that works with farmers and diverse products. Anthony Chang, director of Kitchen Table Advisors, noted in a 2020 report,

> *"We need investment in the kind of regional food and farm infrastructure that has been under-resourced for a long time, infrastructure owned and controlled by farmers and especially communities of color. Basic nuts and bolts like cold storage, processing facilities, vehicles for distribution. Unfortunately, these aren't the sexy, high-return investments venture capitalists typically seek. The challenge is that these projects usually require a shift in how we think of 'return on investment,' prioritizing people and planet over profit. And historically this just hasn't been the norm".*[320]

Although infrastructure businesses oftentimes have smaller profit margins than other businesses, they provide essential connections within regional supply chains.[321] Thus investors looking for social impact may consider directing capital toward building resilient agriculture infrastructure. For example, a report by Native American Agriculture Fund (NAAF) proposed a regional model of food infrastructure for Tribal communities, including hub zones to support the aggregating and processing, distributing, and marketing of food and agriculture within the region.[322] This would require about $528 million in investment and generate $9.4 billion in returns, while supporting Indigenous farms and businesses.[323]

Health risks

Farming practices can impact the health of communities off-farm. Pesticide usage in the U.S. has fluctuated based on factors related to pest pressure, crop acreage, and the cost-effectiveness of alternative practices to protect crop yield and quality.[324] Agricultural communities are exposed to health risks from agricultural production such as pesticide drift, water and airborne pathogens from animal operations, and agricultural field burning.[325,326,327,328]

While pesticide health hazards disproportionately impact farmworkers, the negative effects of pesticide exposure can extend to workers' families and communities off-farm.[329,330] The U.S. spends about $12 billion every year on the environmental and health costs of pesticide use.[331] Children are especially vulnerable to these community exposures, which can cause long-term health issues such as asthma.[332] For example, a review of epidemiological studies found links between exposure to pesticides and agricultural burning with adverse respiratory health in children.[333]

While pesticide health hazards disproportionately impact farmworkers, the negative effects of pesticide exposure can extend to workers' families and communities off-farm.

Agricultural runoff containing chemical inputs can lead to health risks for communities located downstream from farms.[334,335] The nitrates in drinking water can cause "blue baby syndrome" in infants and are also associated with higher risks of miscarriage and some cancers, including cancers of the bladder, ovaries, and non-Hodgkin's lymphoma.[336,337]

These water supply health risks and costs are shared with municipalities, who are responsible for providing clean water to residents. For example, the City of Des Moines built a nitrate removal facility for $4.1 million, which treats 10 million gallons of water a day and costs $1.7 million a year.[338] In 2017, the city planned to spend $15 million to expand the facility.[339] The costs of unsafe nitrate levels in drinking water disproportionately fall on rural residents. In Iowa, The Union of Concerned Scientists (UCS) found that all the violations of the EPA's nitrate limit occurred in small, usually rural, water systems serving fewer than 3,300 people.[340] Additionally, rural Iowans pay up to $1,200 per person each year for nitrate treatment of drinking water, while urban residents only pay about $2 per person per year.[341] UCS also found that if farmers in the Corn Belt planted 10 percent of their acres with strips of prairie grasses, they could cut polluted runoff in half and save taxpayers $840 million a year in water cleanup costs.[342]

Federal and local governments have successfully partnered with farms to mitigate these community health risks. For example, a small town in Pennsylvania struggling with near maximum nitrate levels in their drinking water partnered with USDA NRCS and 20 farmers to install resilience practices and improve the town's water quality.[343] NRCS invested more than $2 million in targeted assistance for the area's farmers.[344] After just two years, conservation efforts had cut nitrate levels in half and the town's water treatment plant was running at minimum capacity, significantly reducing local costs.[345] A 12-year study by The Nature Conservancy found that constructed wetlands are another cost-efficient, highly effective tool to reduce nutrient runoff from fields and protect waterways.[346] A relatively small wetland, around 6 percent of the tile-drained agricultural area, can reduce nitrogen by nearly 50 percent.[347]

Climate risks

On-farm climate mitigation can provide key disaster risk reduction for vulnerable communities. Disaster relief for underserved communities and farmers is also essential for maintaining resilient, rural towns. Climate events are most devastating to small municipalities, businesses, and residents, as they are less likely to access relief funding allocated to major disaster events.[348] For example, decades of lending and housing discrimination have relegated BIPOC renters and homeowners to floodplains.[349] As community members use recovery dollars to relocate instead of rebuild, the viability of the small towns is threatened.[350] Known as "community collapse," individuals and businesses that have faced repeated flooding in small municipalities decide that it is no longer worth investing in that location and leave for higher ground.[351] In small, rural towns, small businesses and residents may invest their life savings to recover from one flooding event, only to see those savings lost in subsequent extreme weather events. Investment in on-farm conservation, such as wetlands and riparian buffers, can absorb and direct water away from homes.[352] This can help mitigate or prevent the effects of community collapse.

On-farm conservation interventions can also improve the resilience of farms and farming systems, supporting the overall health of rural communities in the long-term. Resilient farming systems bolster rural communities by providing viable farm jobs, purchasing goods and services from other agricultural businesses, and retaining farmland and housing to support families remaining in rural farm communities.[353] Furthermore, farms support regional input suppliers, fencing contractors, veterinarians, distributors, food processors, butchers, grocers, and restaurants.[354] Farm families participate in the local economy by attending schools, patronizing local grocery stores, populating first responder units, and participating in other community services.[355]

Climate events are most devastating to small municipalities, businesses, and residents, as they are less likely to access relief funding allocated to major disaster events.

A study in Missouri found that a shift to resilient production would create more than 165 additional farm households per county and more than 300 additional farms and non-farm households in total.[356] Regarding the hollowing out of his rural town, a California rancher stated, "the social aspects of regenerative agriculture are key—they're not spoken of very much...we're killing the communities where our food comes from".[357] One July 2022 focus group participant also noted, "90 percent of U.S. farm operations depend on off-farm jobs. Because rural communities in which those jobs exist are depopulating [there is significant farm income risk with rural collapse]."[358]

In sum, climate resilient farms, strengthened through on-farm conservation practices, provide multiple, essential community functions, including food availability and access, diverse supply chains, rural livelihoods, and community health. Historically, the risks and costs of climate change and environmental degradation have disproportionately impacted poor, rural, and BIPOC communities. However, decision-makers in policy and finance can contribute to mitigating these historical impacts promoting financial resilience by prioritizing regional investments in supply chains and interconnected farms.

Systemic Risks

Our world is interconnected through the global climate, shared resources, global trade, and global politics. Consequently, economic, social, and environmental risks are also intertwined with shared risks for governments, financial systems, industries, and the global population. Humans depend on agriculture and the ecosystems and biodiversity that support food production and other basic needs.

Globally, about 38 percent of land is used for feed, fiber, timber, and energy.[359,360] Land provides the principal basis for human livelihoods and well-being and provides essential carbon sinks.[361] As the human population grows and income growth affects consumption patterns, the UN Food and Agricultural Organization (FAO) projects that food and feed production will need to increase by 70 percent by 2050 to meet global food needs.[362,363] Meeting this need sustainably will require systemic changes in the global economy, ecosystems, and the geopolitical landscape.

In the U.S. alone, agriculture is a significant contributor to the US economy, contributing over $1 trillion to GDP in 2020.[364] As climate change intensifies, the U.S. will see increased risks of farmer financial decline, natural capital depletion, and food insecurity without significant investments in more resilient food and agricultural systems. The combined impact of these risks leads to greater incidences of global economic downturn and global shocks, such as food price inflation and loss of productivity in the world economy, threatening political and national security.[365,366] This section reviews the research identifying the systemic benefits that conservation and regenerative agricultural practices can provide, including risk reduction in natural resource conservation, national and economic security, and food security.

Systemic Environmental Risks

A vibrant and resilient agriculture depends on soil health, water availability, biodiversity, and broader ecosystem services. According to the IPCC, global agricultural systems have contributed to: (1) loss of natural ecosystems (wetlands, grasslands, savannah, and forests); (2) soil erosion caused by tilling, use of chemical fertilizers, and other land degrading practices; and (3) stress of global freshwater resources.[367] U.S. agricultural policy and investments have historically valued yield and production over ecological resilience. Retooled investments and new policies are needed to support a transition to agricultural systems that address societal threats, build soil health, reduce greenhouse gas emissions, and restore biodiversity.[368,369]

Policies to support resilient land transitions can lead to healthy soils and ecosystems, contributing to farm resilience and long-term agricultural viability.

Policies to support resilient land transitions can lead to healthy soils and ecosystems, contributing to farm resilience and long-term agricultural viability.[370] A report by UCS concludes that public funds provided by taxpayer dollars finance necessary farm support and risk management programs, while simultaneously providing allocations for the externalities associated with the environmental impacts tied to pollution cleanup and conservation programs.[371] Programs such as Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), and Conservation Reserve Program (CRP) provide a way for the public to share in the cost of getting basic conservation practices on the land and preserving key cropland and habitats.[372] Such programs , could be enhanced to more efficiently fund agricultural systems by prioritizing public benefit in the long-term.[373]

Although the adoption of resilient farming practices like cover cropping and conservation tillage has grown, large gaps remain. Federal and state agencies have a key role to play in expanding the total acreage of cropland under resilient agricultural practices by improving accessibility. For example, in Iowa, cover crops were implemented on 4 percent of harvested cropland, no-till on 34 percent, and crop rotations on 4 percent.[374] According to data from the USDA, from 2010-2020, 31 percent of farmers who applied for EQIP were awarded contracts and 42 percent who applied for CSP were awarded.[375] However, only 3.7 percent of CSP contracts and 6.4 percent of EQIP contracts are awarded to farmers of color.[376] According to a report by the Institute for Agriculture and Trade Policy (IATP), USDA does not seem to have data on how many farmers of color apply for these conservation programs.[377] However, "when only 1 percent of [BIPOC] farmers are enrolled in the largest conservation programs in the country, more needs to be done," because in many cases, BIPOC farmers are the most susceptible to climate risks.[378] Given the rapidly changing climate context for the agricultural sector, there is an urgent need to expand the numbers of farmers participating in these programs, while simultaneously making them more inclusive.

Federal and state agencies have a key role to play in expanding the total acreage of cropland under resilient agricultural practices by improving accessibility.

Federal policy can enhance the widespread risk-reducing benefits of resilient agricultural systems by redirecting funds to these programs, increasing investments for historically underserved farmers, especially BIPOC farmers, and improving technical assistance to improve and demystify applications and access to conservation programs.[379] As one July 2022 focus group participant stated,

> *"[Agencies and extension officers] need to work with BIPOC farmers. Quite often small farmers are not eligible for many of these [disaster relief] programs or are not told they have access to them."*[380]

Systemic land use in the U.S. also influences the availability of land-based carbon sinks. According to the USDA,

> *"Agriculture could play a prominent role in U.S. efforts to address climate change if farms and ranches undertake activities that reduce greenhouse gas (GHG) emissions or take greenhouse gas out of the atmosphere. These activities may include shifting to conservation tillage, reducing the amount of nitrogen fertilizer applied to crops, changing livestock and manure management practices, and planting trees or grass. The Federal Government is considering offering carbon offsets and incentive payments to encourage rural landowners to pursue these climate-friendly activities as part of a broader effort to combat climate change."*[381]

The USDA analyzed the carbon sink potential of agricultural activities and found that preventing cropland expansion with forestland remaining as forests and conservation settlements remaining as settlements had the greatest potential.[382] As mentioned above, conservation lands near farms lower land use intensity, and wildlife buffers help to improve production and biodiversity, oftentimes more so than increasing crop acreage.[383] The Conservation Reserve Program has nearly 21 million acres currently enrolled in contracts to remove environmentally sensitive land from production and plant species that will improve environmental health and quality. This prevents the equivalent of more than 12 million tons of carbon dioxide from entering the atmosphere.[384,385] These practices not only contribute to farm and regional resilience but contribute to climate adaptation for the agriculture industry. A 2021 meta-review by CGIAR, a global research partnership for food, land, and water systems, concluded that regenerative agriculture practices can generate additional critical ecosystem services by maintaining biodiversity in agricultural lands, with the potential to globally sequester 4.3-6.9 Gt CO_2e/year and create 12-17 million square kilometers of habitat for biodiversity.[386]

Public and private investments are necessary to expand accessibility and impact through intentional, systemic shifts to resilient agricultural systems. These investments would provide other benefits, including saving essential tax dollars while conserving our shared natural resources.

Systemic Financial Risks

Systemic financial risks include risks to national and global economies, as well as risks to financial systems, such as public and private agricultural finance systems. The number of disaster events causing losses over $1 billion are increasing.[387] This section will provide an overview of systemic risks for governments and financial systems, such as economic productivity, and widespread lending risk exposures in agriculture. Private and public lenders are exposed to climate and land risks, with the potential for systemic collapse without mitigation.[388]

Economic risks

Every economy around the world is dependent on natural resources and ecosystems. The World Economic Forum (WEF) estimated that half the world's economic output—$44 trillion—is moderately or highly dependent on nature.[389] The WEF 2020 Global Risks Report (GRR), a risk perception survey, ranked biodiversity loss as one of the top five risks to the global economy in terms of likelihood and impact in the coming 10 years.[390] A widespread loss of such resources could impact supply and demand across and within nations affecting supply chains and making some business models inoperable.[391] A study by Barclay's highlighting water scarcity risks warns that the consumer staple sector, which includes food and beverage companies, could face a $200 billion loss if such risks are not mitigated.[392]

Furthermore, the agriculture industry is closely linked to global geopolitical and commodity price risks. The Russia-Ukraine conflict has led to increased price volatility for agricultural commodities.[393,394] It has also exacerbated fertilizer shortages, highlighted through the immense price increase for chemical fertilizers around the world.[395,396] Federal policies that support resilient farm transitions can reduce the country's reliance on chemical fertilizers, help to improve land conservation, and mitigate economic and political risks.

Public-private financial risks

The U.S. agricultural sector relies on public and private loan services for general operations, disaster relief, and resilience investments. The Farm Credit System (FCS), a government-sponsored enterprise, and commercial banks hold the vast majority of farm debt.[397] The agricultural credit system includes extensive government involvement in order to facilitate credit access, mitigate farming risks, and to provide direct government loans and loan guarantees, income support, and crop insurance.[398] Given the shared risk and the public stake in the agricultural banking system, farm lenders and financial actors have a responsibility to introduce new measures to mitigate climate risk to ensure long-term viability and serve rural communities.[399]

The burden of agricultural transitions should not fall solely to farmers. Agricultural lenders and community banks that serve farmers and their communities are especially vulnerable to climate risks, "yet they are not the principal contributors to the carbon footprint of the financial system."[400] Agriculture bears much of the financial risk of climate change, but farmers are not primarily responsible for the root causes of climate crisis or the majority of greenhouse gas production. Since 2016, commercial banks have lent about $2.7 trillion to fossil fuel producers globally.[401] As a report by American Progress states, "[t]he responsibility for reducing the systemic risk and the impacts on community banks and agricultural lenders that arise from climate change should fall first and foremost on the largest GHG emitters and the major banks that finance them."[402] A wide range of financial decision-makers must invest in these systemic transition costs, especially those with the highest concentration of GHG emitters in their portfolios.

Agriculture bears much of the financial risk of climate change, but farmers are not primarily responsible for the root causes of the climate crisis or the majority of greenhouse gas production.

In addition to protecting key resources and farm viability, investments in farm resilience will likely save federal dollars in the short and long-term. Farm income in 2020 was heavily reliant on record government payments.[403] The World Resources Institute found that governments provide on average $600 billion per year for agricultural support globally.[404] Income support for farmers accounts for 70 percent of this funding, yet only 5 percent goes to any kind of conservation objective.[405]

USDA Economic Research Service (ERS) estimates that the cost of the Federal Crop Insurance Program (FCIP) will increase without farmer adaptation to climate change, due to variability of prices and yields, and higher crop prices driven by lower supply.[406] Although insurance coverage is high for major field crops, only about 25 percent of the U.S. total agricultural production value is covered under crop insurance.[407] This means that a significant amount of agricultural value in the U.S. is unprotected from the impacts of weather shocks on agricultural production.[408] As one participant in the virtual focus group hosted by Croatan Institute and Meridian Institute in July 2022 noted,

> *"In New Mexico, farmers are talking about lack of assistance to address flooding, contamination in soils, and fires that have cut off grazing lands. Agricultural solutions need to invert how we support farmers at the forefront of this transition and part of that is providing different types of crop insurance and addressing disaster relief so that small farms can recover from these crises."*[409]

Financial decision-makers can address fossil fuel emission contributions in their portfolios by providing direct investments to the communities most impacted by climate change. Public investments also work to establish new mechanisms to expand the reach, accessibility, and recipients of funds.

Systemic Social Risks

Systemic social risks include national security risks, such as population shifts and migration, as well as food security risks that impact all U.S. residents, with increased vulnerability for poor and underserved communities.

National security risks

As climate change advances, shifting weather patterns, ecosystem collapse, increased pests and diseases, heatwaves, and drought, will drive unprecedented food insecurity and migration, according to a systemic risk assessment by Chatham House.[410] The 2021 White House Report on the Impact of Climate Change Migration reaffirms this assessment, "When combined with physical, social, economic, and/or environmental vulnerabilities, climate change can undermine food, water, and economic security.[411] Secondary effects of climate change can include displacement, loss of livelihoods, weakened governments, and in some cases political instability and conflict."[412]

For example, agricultural expansion on the Great Plains and increasing droughts have led to nearly double the amount of wind-blown dust over the past 20 years.[413,414] According to researcher Gannet Haller, "Our results suggest a tipping point is approaching, where the conditions of the 1930s could return."[415] Today, in the Midwest and the Great Plains, regions that represent the top producers of corn, wheat, soybeans, and livestock, the soy and corn yield could decline by 40 percent and wheat yields could drop by 30 percent if a Dust Bowl type event occurred again.[416] This would have widespread repercussions for crops, food price spikes, and migration.[417] Indeed, climate impacts are already leading to significant crop loss. For example, droughts and heatwaves in 2012 affected 66 percent of the U.S. by July of that year and ultimately led to an estimated $30 billion in agricultural losses.[418]

The population in the West is likely to increase by 10 percent in the next 50 years, with new migrants arriving from the South and Midwest due to worsening climate conditions.[419] Climate change also leads to global migration changes.[420] A 2020 study by Feng et al. quantitatively examines the linkages between variations in climate, agricultural yields, and people's migration responses.[421] The authors estimate that climate change could force 1.4-6.7 million people to emigrate from Mexico to the U.S. as a result of declines in agricultural productivity alone.[422] Policies that encourage investment in climate resilient agricultural practices and secure land tenure have broad potential to increase rural food security and decrease the need for migration.[423,424]

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Food security risks

Finally, the U.S. Department of Defense has written extensively about the risks associated with climate change that strain the nation's resources to respond to natural disasters, impact food security, and affect strategic assets in key geographic areas. Yet, little consideration has been given to the interplay between a projected change in the U.S. demographics, wealth and incomes disparities, and the risk of increased food insecurity.[425] Food insecurity along with economic stressors across major sectors of the U.S. economy has the potential to increase domestic internal pressures. Climate change is likely to exacerbate such internal pressures as higher temperatures, changing precipitation patterns, and frequency of extreme weather events directly affect yields and crop quality, threatening food supplies and food insecurity.[426]

Resilient agricultural practices can also help address social equity issues by supporting smaller producers, providing food access in underserved communities, and improving long-term health outcomes. For example, resilient agricultural systems have been found to address challenges related to local emergency food demands, as well as bolstering regional infrastructure enterprises, diverse crop production, and dietary diversity.[427,428,429,430,431] Yet more investment is needed to address these systemic food security risks at scale. Therefore, public and private capital can invest in farm resilience, as well as broader systems for infrastructure that strengthens regional markets, farm revenue, and food access.[432]

Migration, food insecurity, and economic downturn are severe systemic risks to agricultural systems. Public and private investors should expand the scope of their investments to include these social risk considerations. Current investments in regenerative and conservation agriculture have not yet reached the scale necessary to create global resilience impacts. Coordinated, global efforts are an essential strategy to address threats to our shared climate and land. Just as with farms, communities, ecosystems, and supply chains, a weakness in one area creates risk for all. Therefore, investments in social equity are critical to strengthen entire systems and build resilience across communities. Capital from public and private sources has the capacity to address regional and global food security needs, from farms to healthy food infrastructure, emergency food assistance, equitable land access, and other social risks.

Recommendations

Recommendation #1

Create broader risk frameworks that incorporate environmental, financial, and social resilience potential.

Resilient agricultural practices have clear benefits for farm balance sheets and long-term financial resilience. Therefore, policy and financial decision-makers should implement strategies to integrate the economic value of these resilience benefits into their risk assessments and decision-making processes. For example, as discussed in this report, resilience benefits typically do not operate in year-to-year timeframes or one-outcome-specific scope (such as yield or labor costs). Additionally, the research has shown that environmental and social risks, though typically not reflected on balance sheets, create financial risks in the long run. Therefore, financial decision-makers must update their risk assessments and balance sheets to match the current reality of ongoing environmental, financial, and social challenges.

Risks have also historically been offloaded onto vulnerable, poor, rural, and BIPOC communities and laborers. Given that these are, in fact, systemic financial risks, public and private accounting systems need to expand to include off-farm and systemic risks in these frameworks to ensure thorough risk assessments.

Recommendation #2

Deploy capital for high-risk populations to build systemic resilience in vulnerable markets.

Public and private capital has historically distributed a smaller proportion of dollars to regenerative and conservation farms, small and midsize, BIPOC, underserved, socially disadvantaged, and beginning farmers. However, as described in this report, those populations are typically bearing the highest environmental, financial, and social risks. As financial actors update risk frameworks and deploy innovative finance per the above recommendations, these populations would see an increased flow of capital.

Financial decision-makers also can track data regarding social and racial equity of their capital deployment for greater transparency.

This report posits that the overarching pool of capital for resilient agricultural system transitions needs to be expanded, increasing resources for transitions across all farms and landscapes, encouraging system-wide action. However, the system-wide costs may indeed decrease because of the environmental, financial, and social risk-reducing benefits described throughout this report. Keeping in mind the reality of shared, company-level, and supply chain risks, the highest risk areas will need the most urgent and expansive investments to build whole-system resilience for all.

Recommendation #3

Conduct further research to track the long-term resilience benefits of regenerative and conservation practices across environmental, financial, and social risk types to encourage scaled investments.

This report has provided an overview of diverse risk considerations and the potential risk-reducing benefits of resilient agriculture. However, more research is needed to track long-term outcomes for farms and farming systems. For example, research could compare farms with and without resilience practices and their capacity to recover from shocks in specific regions. Other research could examine regional hotspots of regenerative and conservation farms with regional resilience criteria such as supply chain disaster preparedness, food access, and rural economic development. Additionally, further research could evaluate and compare using whole-farm and whole-ecosystem assessments to help determine what synergies work best in specific landscapes. This includes the environmental, financial, and social outcomes of resilient farms across diverse settings and farm types. New research and knowledge will continue to inform governments, producers, and financial institutions.

Though the evidence shows promising environmental and financial benefits of resilience practices, the research for various social outcomes needs further data. This report highlights potential areas where social benefits are possible in resilient systems using on-farm, off-farm, and systemic risk dimensions. A lack of evidence is due, in part, to a lack of targeted investments to address social risks. For example, possible research includes the relationship between farms implementing practices for resilience with food access and affordability, improved farm wages, rural revitalization, and health outcomes.

Furthermore, little evidence exists regarding the accessibility of implementing resilient agricultural practices for new and beginning farmers, especially BIPOC farmers and farmers in historically disinvested geographies, compared to multi-generational, larger farms. Regenerative practices may incur higher short-term risk due to higher costs and knowledge requirements, tentative regenerative markets and infrastructure, and social norms. Yet, the long-term risk-reducing benefits will support farm revenue by enhancing climate resilience and building key soil nutrients, biodiversity, and productivity.

Research could also track the financial mechanisms that best support farmers and supply chain transitions that achieve long-term profitability. As more investments flow to these farming systems, gathering data about the impacts will help to encourage and incentivize further transitions and investments, creating a positive feedback loop.

Recommendation #4

Implement innovative financial mechanisms that address barriers to farm transitions and account for the financial value of resilience.

Not only can financial decision-makers update their risk frameworks to reflect more holistic and long-term risk types, but their financial mechanisms can also work to reflect the realities of farm and landscape transitions to improve capital accessibility and success. As mentioned in this report, regenerative and conservation farms face unique challenges from the lack of alignment with the predominant capital options. Financial mechanisms such as patient and long-term payment structures, forgivable and low or no-interest loans, revenue-based payments, and other innovative mechanisms can work to address the barriers to capital and

reduce transition risks. Public and private capital providers can work with farms and supply chains' unique needs, and (as stated earlier) "get creative".

One critical need is a financial safety net for farms implementing resilience practices, especially those growing fruits, vegetables, and other food crops. As mentioned above, policy experts are advocating for improvements to the Federal Crop Insurance Program, including expanding the resilience practices included in the insurance program's Good Farming Practices (GFP) handbook. Advocates also recommend expanding resources for the Whole-Farm Revenue Protection program, to insure more whole farms, rather than individual field crops. Without an adequate, systemic safety net for more diversified farms, there are greater challenges in incentivizing transition to resilient systems.

Agencies at the USDA can expand the scope of federal programs to enhance the range and accessibility of federal funds for diversified and resilient farms. This is especially important to reach populations that have had disproportionately limited access to federal funds, technical assistance, and other resources, as described in this report.

Conclusion

The research summarized in this report provides evidence that resilient agricultural practices contribute to on-farm, off-farm, and systemic resilience and that investments across diverse geographies and production systems can expand these risk-reducing benefits at scale.

While the research shows that many producers see positive financial on-farm outcomes, many resilience benefits are not reflected in current balance sheets and risk assessments. For example, resilience practices can improve revenue and farm productivity in the long-term, enhance farm capacity to respond to acute shocks and help to reverse the trend of environmental degradation and biodiversity loss.

Resilience practices can improve revenue and farm productivity in the long-term, enhance farm capacity to respond to acute shocks and help to reverse the trend of environmental degradation and biodiversity loss.

An examination of the evidence also points to positive impacts off-farm, where communities and ecosystems benefit from reduced runoff, cleaner water, enhanced biodiversity, and habitat conservation to mitigate risks associated with climate change and environmental degradation.

Furthermore, national, and global systems have the potential to mitigate risks associated with migration, food security, and economic stability. While the scale and reach of current investments are not yet sufficient to realize the benefits associated with widespread and interconnected farms implementing resilient agriculture practices, comprehensive risk assessments modeling such transformations across geographies and supply chains will ultimately make resilient agricultural systems predominant in the future. This farm to system transition should safeguard food systems and positively support local economies.

Given the scale of the agricultural system and our understanding that farm transitions require upfront investments and some experimentation for the specific context of each farm and geography, financial partners are important stakeholders who can lead the process by updating update their risk assessments and providing innovative financial mechanisms for farms and supply chain enterprises. As discussed in this report, many resilience impacts and benefits of resilient agricultural production tend to accrue after several years.[433] The regeneration of land and biodiversity will take time. Therefore, more long-term capital commitments and research are essential.[434] Policymakers can expand scaled resources, such as the Inflation Reduction Act (IRA), to help build whole systems of resilient farms and food chains that address the environmental, financial, and social risks in their communities.

Like all business owners, farmers and ranchers are striving to operate resilient enterprises that support their families, workers, and communities. Increasingly, there is recognition that the strategies employed have ripple effects beyond the farm to communities, and cascade to impact broad geographic areas, and even national governmental and financial systems. The risk-reducing impacts across environmental, financial, and social dimensions are interconnected and mutually reinforcing, building the resilience of food systems, public health, and national security. New mechanisms to expand our conceptions of risk beyond isolated farms, lenders, years, or crops will work to imagine entirely new systems built to honor our mutual interdependence.

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