



SUMMARY OF FINDINGS

Transformative Investment in Climate-Smart Agriculture

Unlocking the potential of our soils to help
the U.S. achieve a net-zero economy

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Report Production



This report examines four key areas and recommends action steps to leverage technology and finance innovation to accelerate and scale the adoption of climate-smart agriculture. Findings are summarized in this briefing paper, and the full detail behind each analysis is provided in the full-length report.

- Soil-health Practices, Potential Benefits & Barriers to Adoption
- State of Soil-Health Technology
- Agricultural Capital Flows
- Financial Mechanisms & Enabling Infrastructure



Executive Summary

U.S. Agriculture is a key enabling sector in the transition to a net zero economy as well as a critical portfolio investment opportunity for those seeking an economic return that also benefits the environment and communities.

By 2025, widespread adoption of climate-smart agriculture practices could reduce U.S. agriculture's contribution to total U.S. GHG emissions by more than half, from 9.9% to 3.8%.¹ These practices—which span nutrient application, manure management, and cultivation and grazing—are “sufficiently mature, both scientifically and in practice, to materially increase carbon storage if widely deployed in the U.S. and globally.”² By 2035, with increased investments and partnerships across the food and agriculture value chain and the integration of promising frontier technologies, U.S. agriculture has the potential to be a carbon sink, at -4% of total U.S. GHG emissions.

This report focuses on six established practices: 1) no-till/reduced tillage with retained residues, 2) cover crops, 3) crop rotation, 4) compost application 5) managed grazing, and 6) integrated crop and livestock systems—all of which improve soil health, sequester carbon and produce numerous co-benefits such as reduced erosion, increased water infiltration, and economic and environmental resiliency. With technology and financial innovation targeted at specific practice adoption barriers, these benefits will accrue on the farm, throughout rural America and the agriculture value chain, and the nation as a whole.

Climate-Smart Soil Technology Findings

- *More than 150 companies support digital data collection, analysis and sharing for climate-smart soil agriculture. These digital solutions can accelerate farmer and rancher practice-specific knowledge, aid in business planning, and simplify reporting to value chain, funders or other partners.*
 - *Key barriers to technology adoption include the lack of standardized data collection methods and soil health metrics, data interoperability and rural broadband connectivity.*

Transformative Finance Findings

- *Approximately \$972 billion flows annually from institutional, retail and government investors across asset classes into the agricultural value chain.*
 - *Agricultural capital and outside investments can be better aligned to scale adoption of climate-smart practices, and blended capital is a key enabler.*
- *A range of asset classes, financial mechanisms and enabling infrastructures offer promising avenues to move capital in ways that ultimately help farmers and ranchers scale the adoption of climate-smart practices.*

¹ U.S. Environmental Protection Agency. (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2016, National Academies of Sciences, Engineering, and Medicine. (2019). Negative Emissions Technologies and Reliable Sequestration: A Research Agenda <https://doi.org/10.17226/25259>

² Ibid. 1.

The climate-smart agriculture sector is growing, has current deployable technologies and emerging innovations, and capable farmer ingenuity, but needs investment now and throughout the next decade to deliver on the potential of soils to be a key carbon sequestration solution and support resiliency for farmers and ranchers. The report details specific leverage points where stakeholders within the U.S. agriculture value chain and the technology and finance industries can focus innovation, investment, and collaboration to rapidly transition agriculture to the first carbon-negative sector in the economy.

Action steps to leverage technology and finance innovation to accelerate and scale the adoption of climate-smart agriculture in the U.S.

1. Raise investor awareness of climate-smart agriculture as a key enabling sector in the transitional net zero economy and connect investors to specific agriculture needs and opportunities.

- *While investments in climate-smart agriculture offer positive social, environmental, and financial returns, many climate-specific investment tools (including green bonds) have not identified agriculture as an opportunity.*
- *More fund managers would be inclined to invest in agriculture if they had greater familiarity with the potential for climate-smart agriculture practices for carbon mitigation and sequestration and other positive social and environmental outcomes.*
- *Identify metrics, frameworks, reporting standards, and criteria that companies can use to promote their ESG credentials as it relates to climate smart agriculture.*

2. Stimulate catalytic capital to flow into the agriculture sector through mechanisms that reflect the risk and return goals of ESG investors and climate smart agriculture finance innovation.

- *Catalytic capital from foundations, government, and through emerging ecosystem service and carbon markets can help to de-risk transactions and increase the flow of capital.*
- *Specifically engage philanthropy through both their grant-making and investment strategies to help grow climate smart agriculture.*

3. Encourage preferential lending programs, when possible, from existing agriculture lending institutions.

- *Connect the existing agriculture lending market to climate-smart incentive structures that reward producers for indicators of soil-health progress.*

4. Connect more sources of capital with producer ecosystems ready to transition to climate-smart agriculture to identify mutually beneficial solutions.

- *With a goal of “test and learn,” enhance the matchmaking between willing producer ecosystems and willing funders using online platforms and making sure producers are providing funders with digital reporting data to increase their comfort in supporting a producer ecosystem.*
- *Help funders gain comfort in providing compensation based on indicators of progress.*
- *Create blueprints for sustainability-linked loans that will reduce the time and transaction costs of leveraging this capital to advance climate smart agriculture.*

5. Promote the further use of digital tools amongst farmers and ranchers to exchange best practice know-how and data (soil health, yield, profitability, etc.).

- *Help to overcome the barriers to adoption of existing climate-smart soil technology tools. This includes ramping up the use of MRV (monitoring & estimation, reporting and verification) and other FMS (farm management systems) that can share information.*

6. Support the development of tools that collect on-farm data; connect on-farm data to larger databases and platforms to accelerate local and practice-specific knowledge and provide funders with indications of progress to reward farmers and ranchers for climate-smart efforts.

- *Develop a national repository of soil carbon reference data.*
- *Standardize laboratory methods, sensor measurements, and soil data exchange.*

7. Support emerging revenue enhancement mechanisms for farmers and ranchers.

- *Nascent efforts are underway (by actors such as technology start-ups and consumer packaged goods brands) to economically reward producers for implementing climate-smart practices. Private ecosystem services markets are emerging for direct payments to farmers through market-based incentives and vendor direct payments.*
- *These sources of capital can be blended with other sources to further de-risk the transaction by farmers and ranchers and their value chain partners.*

8. Demonstrate clear risk/reward profiles of successful climate-smart financial support for today's investors and farmers and ranchers.

- *Continue to share success stories of how different financial tools are being applied successfully to specific climate-smart agriculture opportunities to get a broader base of farmers and ranchers and funders aware of and comfortable with the opportunities to transition to climate-smart agriculture at scale.*



Soil-Health Practices, Potential Benefits & Barriers to Adoption

The practices examined in this report are in-field practices (as opposed to edge-of-field or off-field practices) and maintain productive use of the land. Figure 2 outlines these climate-smart practices, key principles, and potential environmental and on-farm benefits.

Figure 2

Climate-Smart Practices - Benefits

Practice	Principles	Potential Benefits
No till/reduced till with retained residues	Limited soil disturbance, soil cover	<ul style="list-style-type: none"> • Reduce sheet, rill and wind erosion • Reduce tillage-induced particulate emissions • Maintain or increase soil quality and organic matter content • Reduce energy use • Increase plant-available moisture • Provide food and escape cover for wildlife
Cover crops	Soil cover, living roots	<ul style="list-style-type: none"> • Reduce erosion from wind and water • Maintain or increase soil health and organic matter content • Reduce water quality degradation by utilizing excessive soil nutrients • Suppress excessive weed pressures and break pest cycles • Improve soil moisture use efficiency • Minimize soil compaction
Crop rotation	Crop diversity, living roots	<ul style="list-style-type: none"> • Reduce sheet, rill and wind erosion • Maintain or increase soil health and organic matter content • Reduce water quality degradation due to excess nutrients • Improve soil moisture efficiency • Reduce the concentration of salts and other chemicals from saline seeps • Reduce plant pest pressures • Provide feed and forage for domestic livestock • Provide food and cover habitat for wildlife, including pollinator forage, and nesting

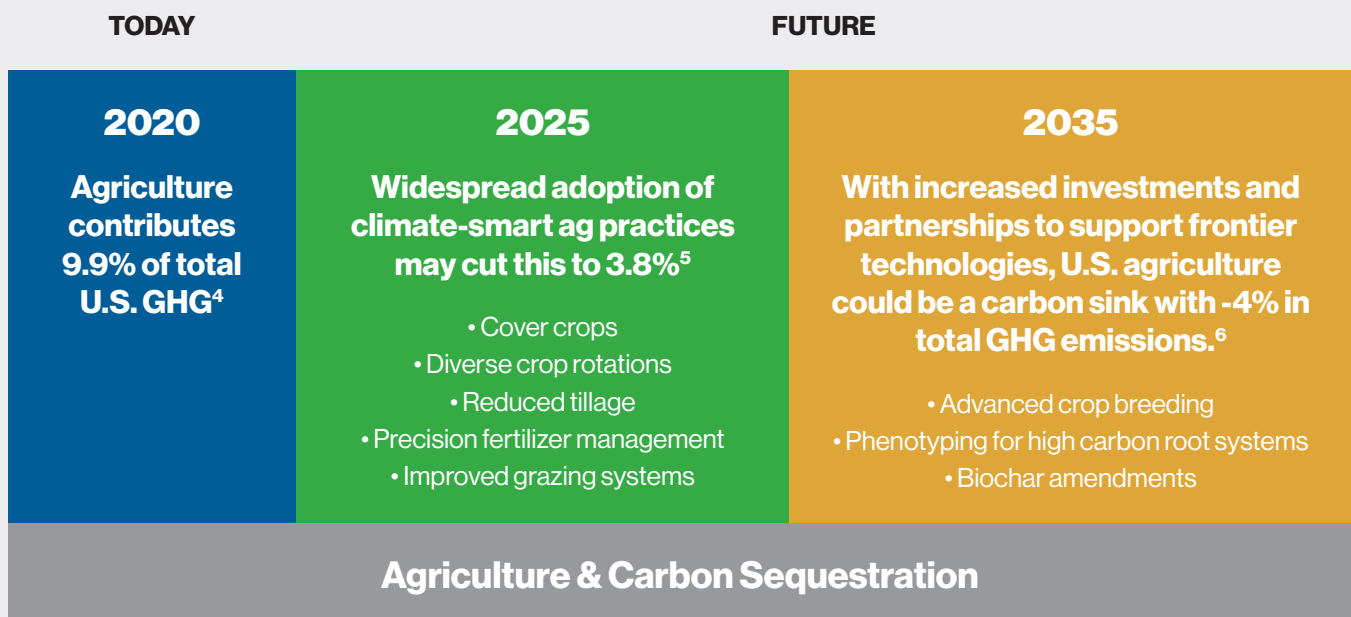
Compost application	Soil/carbon building	<ul style="list-style-type: none"> • Enhances water-holding capacity, • Provides stable, slow-release nutrients, • Enhances soil carbon sequestration • Increases forage production without harming native plant communities. • Mitigates emissions from other sources • Enhances the land’s resilience to extreme weather³
Managed grazing	Soil cover, living roots, crop diversity, limited disturbance	<ul style="list-style-type: none"> • Improve or maintain desired species composition and vigor of plant communities • Improve or maintain quantity and quality of forage for grazing and browsing animals’ health and productivity • Improve or maintain surface and/or subsurface water quality and quantity • Improve or maintain riparian and watershed function • Reduce accelerated soil erosion, and maintain or improve soil condition • Improve or maintain the quantity and quality of food and/or cover available for wildlife • Manage fine fuel loads to achieve desired conditions
Integrated crop and livestock systems	Soil cover, living roots, crop diversity, limited disturbance	<ul style="list-style-type: none"> • Improve or maintain desired species composition and vigor of plant communities • Improve or maintain quantity and quality of forage for grazing and browsing animals’ health and productivity • Improve or maintain surface and/or subsurface water quality and quantity • Improve or maintain riparian and watershed function • Reduce accelerated soil erosion, and maintain or improve soil condition • Improve or maintain the quantity and quality of food and/or cover available for wildlife • Manage fine fuel loads to achieve desired conditions

³ Retrieved from Marin Carbon Project <https://www.marincarbonproject.org/compost>

It's important to note that applicability and implementation specifics and outcomes depend on prior management history and vary across regions, sectors, crops and soil types, to the farm and field level.

Figure 3

U.S. Farmers & Ranchers Need Investment to Reach Full GHG Emissions Net Negative Potential



4 EPA (2020). Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2018. Retrieved from <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018>

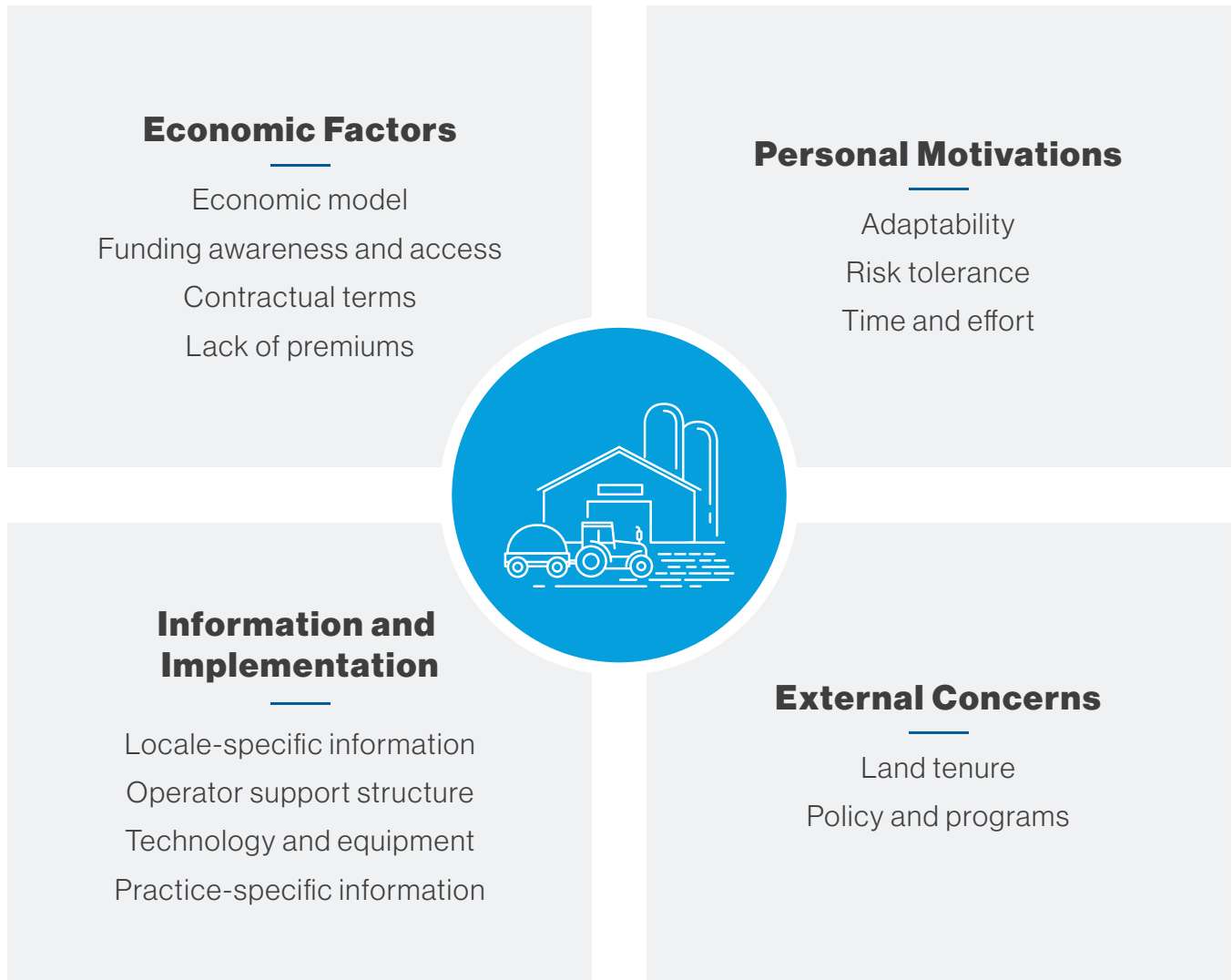
5 NAS, Engineering and Medicine. (2019). Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Retrieved from <https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda>

6 Ibid.

Figure 5 summarizes the key barriers farmers and ranchers face, based on dozens of interviews.

Figure 5

Barriers to Climate-Smart Agriculture Adoption

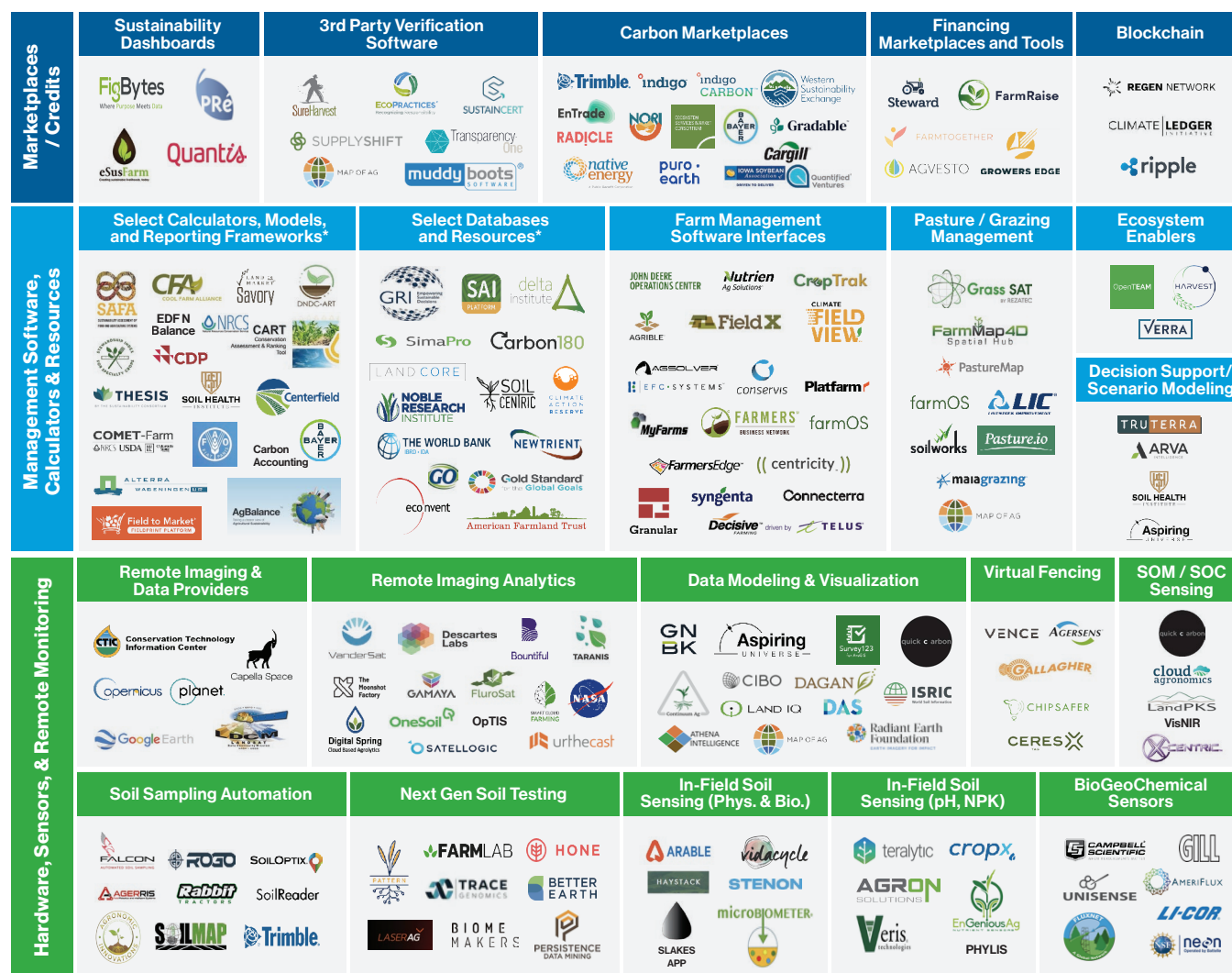


State of Soil Health Technology

Figure 11 shows the current landscape of soil technology relevant to soil-based climate-smart agriculture. The landscape is generally oriented around market-based models, Measurement & Estimation, Reporting & Verification (MRV) activities, and data collection technologies that can aid in planning, adoption, and business modeling, and three layers of solutions (from bottom to top in graphic):

1. Hardware, Sensors, and Remote Monitoring
2. Management Software, Calculators/Assessments, Databases and Resources
3. Marketplaces and Credits

Figure 11
Climate-Smart Soil Tech Landscape 2020

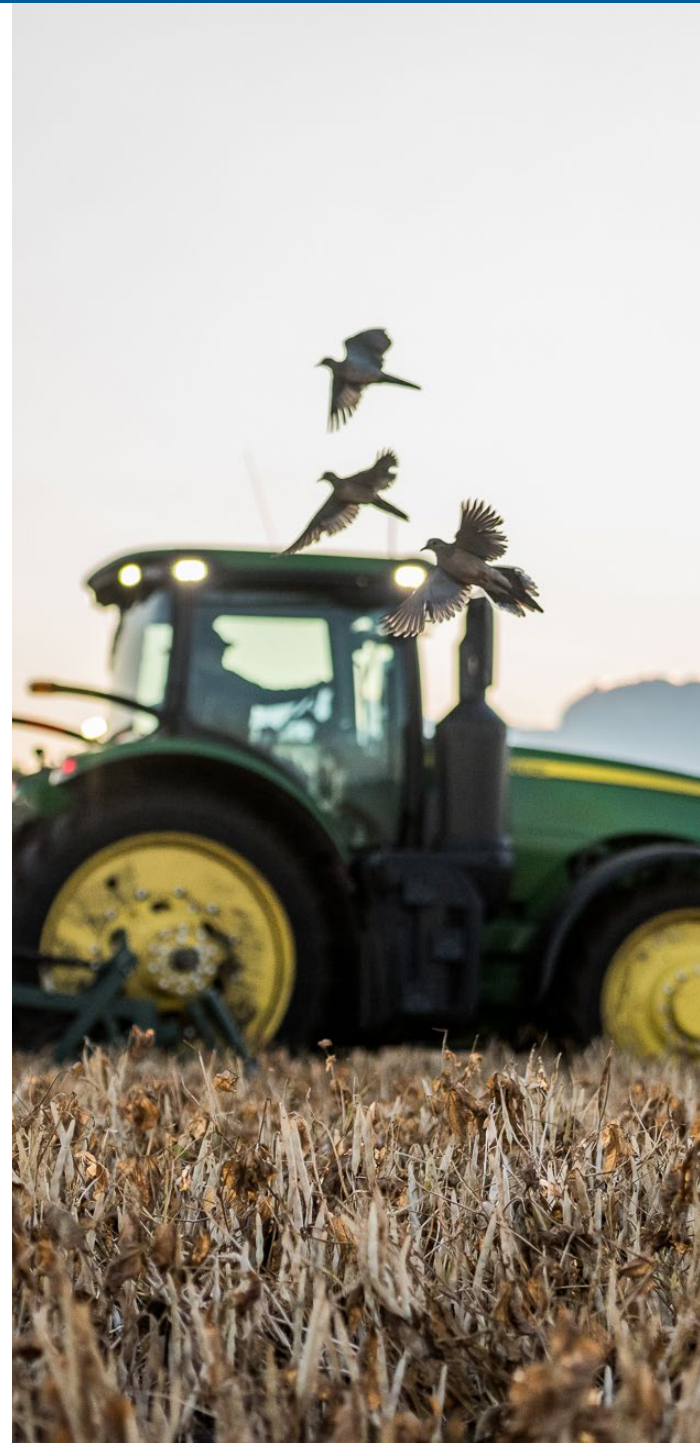


Investment Recommendations to Scale Climate-Smart Practices with Digital Agriculture

- 1. Invest in market-based solutions measuring soil health indicators versus outcomes**
- 2. Invest in a national repository of soil carbon reference data**
- 3. Fund the development of leadership beyond data standards**
- 4. Invest in the accelerated adoption of practice, indicator, and Farm Management Software (FMS) translation tables**
- 5. Invest in solutions to leverage enterprise know-how and speed collaboration at scale**

Additional Recommendations

- 1. Promote online locale & practice-specific information sharing for greater confidence**
- 2. Decrease barriers to calibrated producer digital soil health testing**
- 3. Integrate digital soil health test data into digital farm management solutions**
- 4. Improve usability**

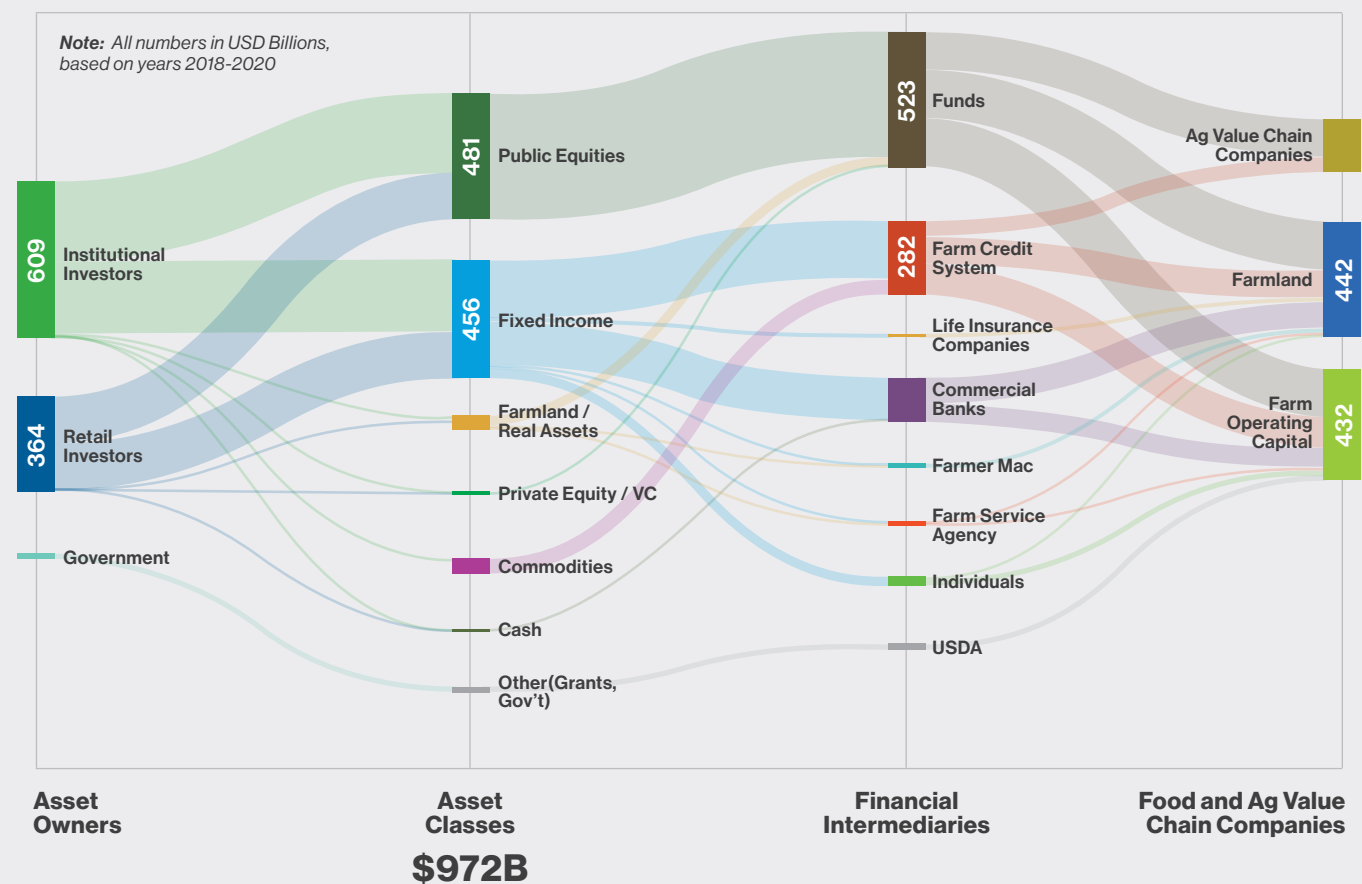


Agricultural Capital Flows

To provide informed context for an exploration of economic solutions, an Agricultural Capital Flows analysis was conducted which maps the flows of capital from asset owners through asset classes and financial intermediaries to participants in the U.S. agricultural value chain.

Figure 17

Annual Agricultural Capital Flows in the United States



This visualization is in the format of a Sankey diagram, in which the width of the linkage is proportional to the size of the economic relevance. Here, the nodes represent asset holders, asset classes, and financial entities. The analysis confirms previous hypotheses of how funds currently move through food and agriculture – for example, the established nature of fixed income financing in this space – but it also highlights opportunities around existing structures that might be leveraged to specifically target climate-smart systems on farms.

Stacking Capital Investment and Farm-level Revenue Streams

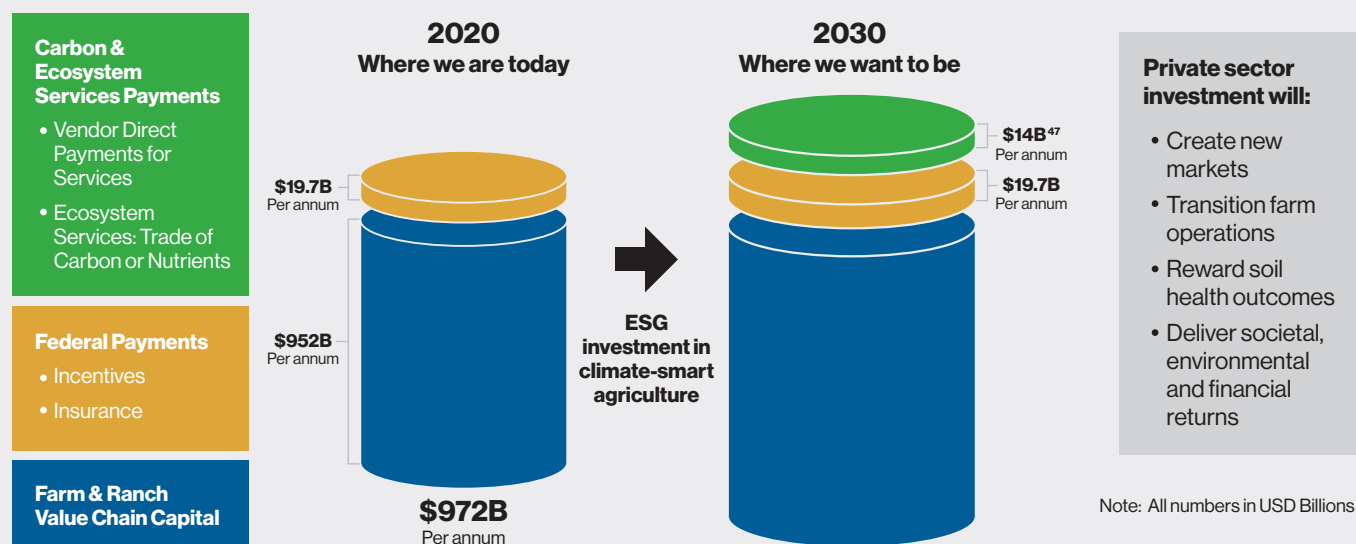
Scaled adoption of climate-smart practices will take not only the realignment of existing flows of capital toward climate-smart outcomes, but also the ability to draw in new sources and forms of capital. The report details a variety of pathways in which this capital might flow and calls out the importance of collaborative and blended approaches to capital deployment to rebalance the risk equation in the farm owner’s favor.

Figure 18 is intended to visualize the three main pools of capital that farm owners can tap into, over the next 10 years, to facilitate the transition to a more climate-smart agriculture – private sector capital (which is broken down by the Sankey diagram (Figure 17, p 55 of report), government subsidies (which we’re calling “payments”), and the carbon and nutrient trading markets (known as Ecosystem Services Markets).

Figure 18

The Path to Scaling Up Climate-Smart Agriculture

Scaled adoption of climate-smart practices by farmers and ranchers requires **the realignment of existing flows of capital toward climate-smart outcomes** as well as **new sources and forms of capital**.



Financial Mechanisms & Enabling Infrastructure

A range of asset classes, financial mechanisms and enabling infrastructures offer promising avenues to move capital in ways that ultimately help farmers and ranchers scale the adoption of climate-smart practices. The most promising financial mechanisms are compiled below in figure 19 and are examined in detail in the report, along with corollary and additional enabling infrastructures.

Figure 19

Six Asset Classes, Financial Mechanisms, and Target Entities

Asset Class	Mechanism	Target Entity
Cash & Equivalents	Thematic Certificates of Deposits (CDs) & Money Market Funds Targeted Institutional and Bank Lending Climate Risk Assessment at Banks & Lending Institutions Voluntary Standards and Certifications	Farm Operating Capital Value Chain Companies Farmland
Fixed Income: Public Bonds	Land-Secured Assessment Financing Climate Bonds/ Green bonds Blended Capital Facilities Credit Enhancements for Climate Bonds	Farm Operating Capital Value Chain Companies Farmland
Fixed Income: Private Debt	On-Bill Financing Environmental Impact Bonds (EIBs) Sustainability-Linked Loan Facilities Tailored Lending Programs CDFI Loan Funds Loan Guarantees	Farm Operating Capital Value Chain Companies Farmland
Public Equity	Initial Public Offering Exchange Traded Funds (ETFs) & Mutual Funds	A variety of assets that could include value-chain entities with a relationship to climate- smart agriculture
Private Equity & Venture Capital	Bridge Capital Funds Small Business Investment Company / Rural Business Investment Company Community Dev Venture Capital (CDVC) Venture Capital Fund Corporate Venture Capital Funds	Farmland Farm Operating Capital Agriculture Value Chain Companies
Farmland & Real Assets	Opportunity Zone Funds Real Estate Investment Trust (REIT)	Farmland Farm operating capital Agriculture Value Chain Companies
Additional Enabling Infrastructure	Credit Risk and Other Frameworks	Technology and equipment Funding awareness and access Locale-specific information

Investment Recommendations to Scale Climate-Smart Practices with Digital Agriculture

- 1. Educate those deploying capital on the proven practices and outcomes of climate-smart agriculture**
- 2. Raise awareness of new financial innovations amongst those in agri-finance**
- 3. Align the producer's ecosystem and value chain partners to finance transition**
- 4. Leverage information technology to identify and follow opportunities to financially support farmers and ranchers**
- 5. Blend capital to scale collective impact on targeted opportunities**
- 6. Test new financial mechanisms that activate financial and agricultural value chains**



Conclusion

Increased investment in climate-smart practices and partnerships can enable U.S. agriculture to become the first carbon-negative sector in the economy. A range of technological and financial innovations are poised to fuel the adoption of climate-smart practices at scale, at the same time a growing number of investors seek to decrease their risk exposure and increase their impact.

The next ten years will require significant emissions reductions, mitigation strategies and transformative capital in all sectors to meet the monumental challenges of climate change. Active investment in the agriculture sector is needed to increase adoption of climate-smart practices that rebuild soil health to promote sustainable food production, the economic and environmental resilience of American farms and ranches, and the carbon mitigation and drawdown needs of the nation -- and the planet. Climate-smart agriculture investments provide financial, community and environmental returns over both short-term and long-term horizons and deliver long-term positive impact.

The science is clear and the essential technological and financial elements to implement climate-smart practices at scale are present; they just need to be woven together.

According to the climate-smart soil technology landscape analysis, many new companies have brought technologies to market, but adoption rates remain low. Climate-smart soil technology faces similar barriers to general agriculture technology adoption, such as limited broadband connectivity and data interoperability. Additionally, practical technology for collecting, evaluating and tracking soil health is still nascent; so too are Measurement and Estimation, Reporting and Verification (MRV) platform adoption and privacy protocols to connect farm-level data to other data sets and analytical tools.

There are a myriad of opportunities for investors to fund innovations that enable farmers and ranchers to scale up climate-smart practices. Venture investment, for instance, in the sector is growing but too often funds are deployed into technologies not aligned with the critical needs of farmers and ranchers. Tools need to enable farmers and ranchers to increasingly do more with less, optimize inputs, restore soil carbon and soil health, and provide information that helps them run profitable, agile and resilient businesses.

We have identified a number of financial vehicles to fund the transition to climate-smart soil agriculture, leveraging the approximately \$972 billion flowing from institutional, retail and government investors into the agricultural value chain. The vehicles connect the existing lending market to indicators of progress and outcomes related to climate-smart practices, and directly support farmers, ranchers and close value chain actors through two key asset classes: fixed income and public equity instruments. Ecosystem services markets and federal and state government policy have a role to play in these transitions but given the magnitude of private capital moving in this space, the grand challenge will be to align those flows of capital with climate-smart outcomes. Even a relatively small percentage shift in this massive market would have a large impact.

There is also an opportunity to increase total investment in agriculture with the growing pool of environmental, social and governance (ESG) capital looking for impacts related to sustainability, socially responsible, or mission-aligned investment opportunities. Cumulatively, these investors can make a big impact by investing in agriculture that enables and targets climate-smart practice adoption and soil health outcomes.

Enabling farmers and ranchers to meet the challenges of the next decade will require innovative thinking, technologies and financial mechanisms, but with increased collaboration and focus in this space, it can be done. More directly, for the sake of rural America, the nation's food security, and the necessary responses in the face of climate change, it must be done.

We hope that this report will serve as a useful resource to all who are motivated to drive further action to realize agriculture's potential as a solution to climate change, and the many co-benefits that this work will generate.



[Click here to view the full-length report.](#)