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How promising are large-scale measures to reduce greenhouse gas emissions from agriculture by 2050?

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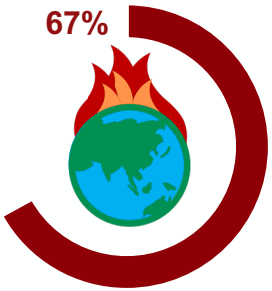
Executive summary

- The agriculture sector is a significant contributor to climate change due to its substantial greenhouse gas (GHG) emissions beyond carbon dioxide.
- Land degradation, livestock and on-farm energy and fertilizer use are the major contributors to GHG emissions. They can be tackled through an “avoid → reduce → reverse” approach.
- Livestock is the largest contributor of methane GHG emission from agriculture. Emission reduction in livestock can be effectively done through improved health monitoring and manure biogas production provides an additional future revenue stream but with high capital cost
- Alternative dairy and meat are promising avenues to reduce livestock emissions. At market share of 8% of alternative proteins can reduce 1.5% of global GHG emissions in 2030 and achievable with key actions to foster growth and build market share
- Precision farming using modern approaches including as AI, IoT and robotics can cut GHG reductions by up to 22% with existing technologies.
- Adopting sustainable agricultural practices can cut up to 30% of emissions from agriculture by 2035 but the transition must overcome financial and technical challenges
- Carbon credits are a market-based approach to incentivize GHG emission reductions by offering financial compensation for verified emission reductions. Monitoring, reporting and verification approaches are challenging and must be established for successful adoption.
- Collaboration between stakeholders across the food supply chain and governments is essential for the widespread implementation and success of GHG mitigation measures in agriculture to achieve their full potential by 2050.

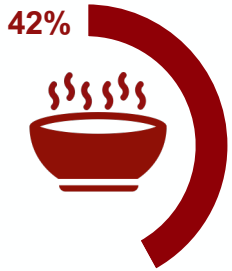
Agriculture is a growing climate-polluting industry but is critical for global food security

Ranking of major global concerns according to respondents (%)



Top ranking global concern:

Climate change & loss of biodiversity



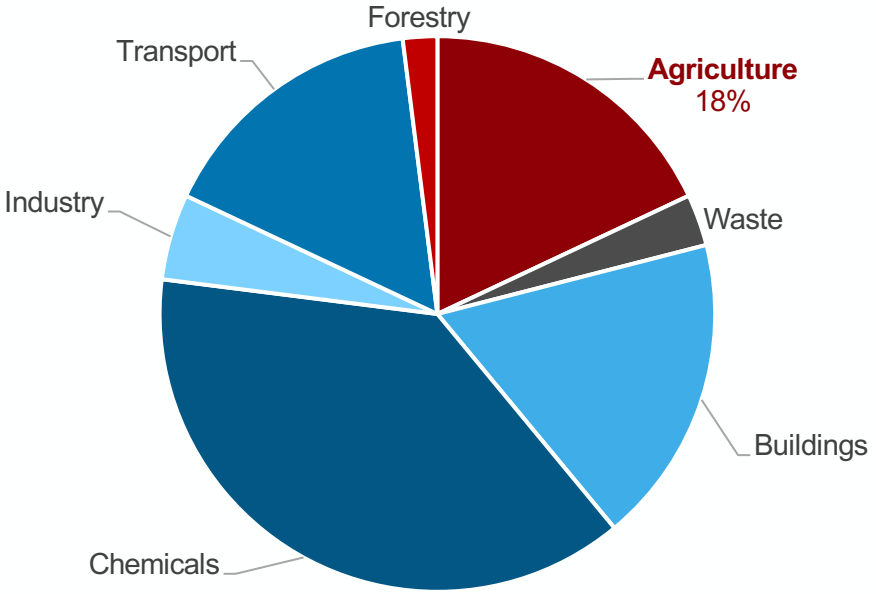
Ranking 4th out of 11

Lack of food, water & housing

" … limiting human-induced global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions. Strong, rapid and sustained reductions in CH_4 emissions would also limit the warming effect …"

Intergovernmental Panel on Climate Change (IPCC)
6th Assessment Report, 2021

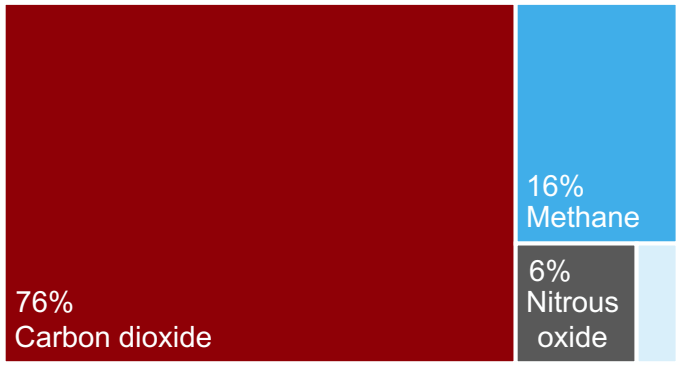
Global Emissions of GHG[1] by sector

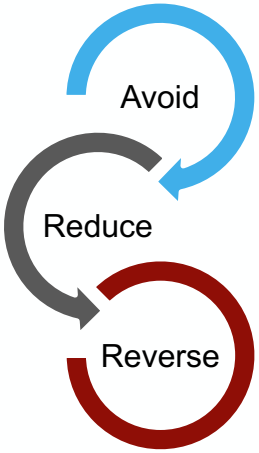


1. Greenhouse gas
Source: UNESCO survey: "The world in 2030", IPCC (2019)

Land use, livestock, fertilizer and energy use are leading GHG sources and important areas for GHG reduction in agriculture

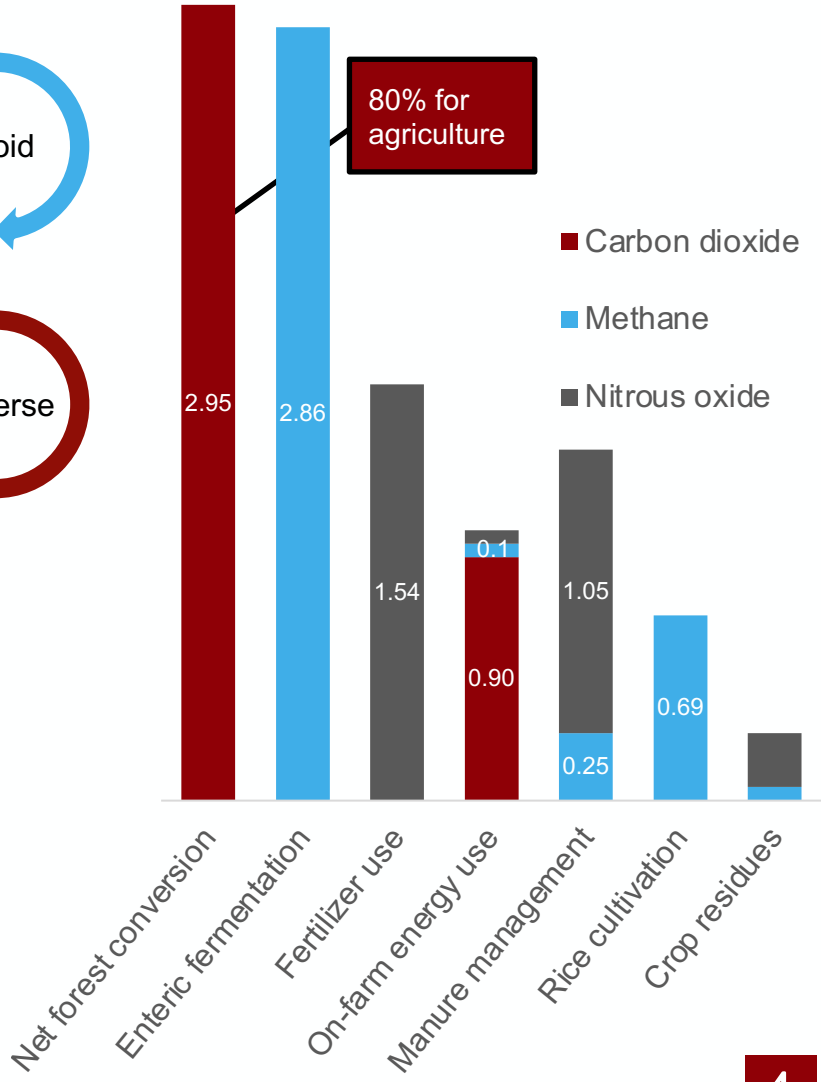
Global production of GHGs





- Emission reduction (ER)
  - Livestock Emissions
    - Feed additive and breeding
      - Lower methane
    - Alternative protein and dairy
  - Inefficient farming practices
    - Precision farming
      - Energy use
      - Fertilizer use
      - Better yields
      - Soil health monitoring
- Carbon dioxide removal (CDR)
  - Maintaining natural carbon sinks
  - Land degradation
    - Regenerative farming
      - Sustainable practices
      - Soil health management

GHG emission by area within the agriculture sector (Gt CO_2 equivalent)[1]



1. Gigatonnes of CO_2 equivalents – a standardized measure for climate pollution

Source: IPCC AR5, Food and agricultural organization of the United Nations, IPCC SRCCL

Emission reduction in livestock effective through improved health monitoring and manure biogas production provides an additional future revenue stream but with high capital cost

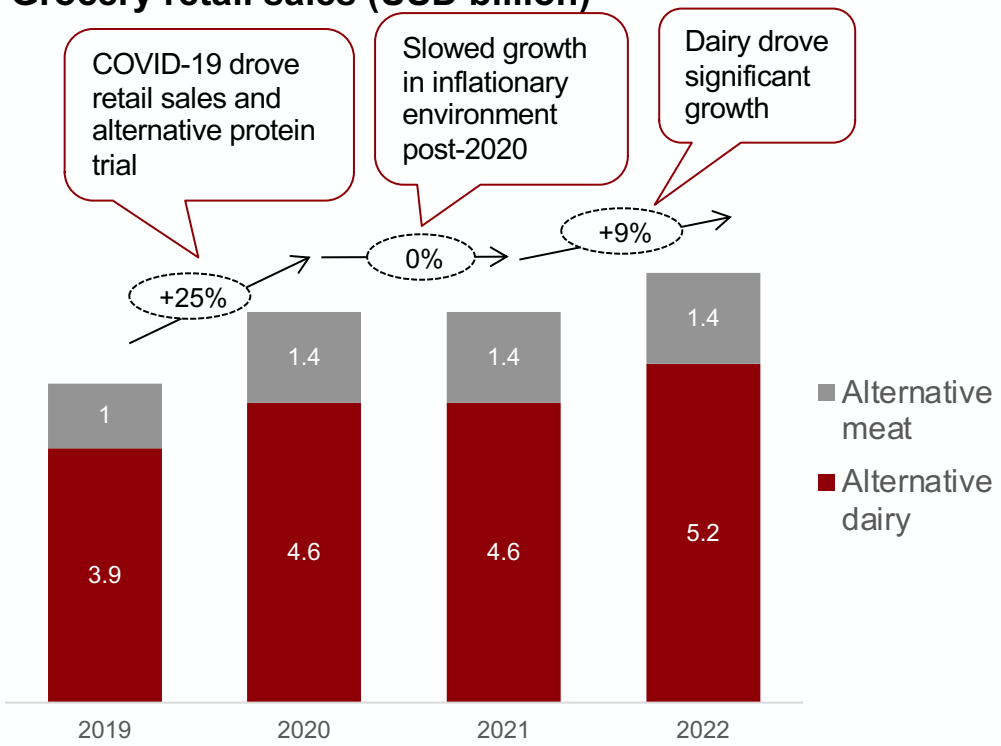
	Livestock feed additives	Anaerobic digester	Improved health monitoring
Cost	**Low** 99 $/tCO$_2$e	**High** 311 $/tCO$_2$e	**Savings** –5 – 0 $/tCO$_2$e
Technology	25% Not yet commercial	40 % Ready to scale	30 % Scalable depending on local infrastructure
GHG emission	77% Efficiency **High** ~350M tCO$_2$e (Enteric digestion)	85% Efficiency **Low-Medium** ~80M tCO$_2$e (Manure management)	8% Efficiency **Medium** ~112M tCO$_2$e (Enteric digestion, Manure management, Manure on pastures)
Challenges	⚠ No *financial incentive* Not conducive to *field grazing* Novel additives in development	⚠ High *capital* *Long-term* pay off Inaccessible for *small farms*	⚠ Lack of veterinary infrastructure Capacity-building needed for farmers
Opportunities	• Monitoring, reporting and verification (MRV) approaches for carbon-offsetting Bovaer® DSM • Recently (2022) 3-NOP was approved for dairy cows in Europe	• Biogas from methane is an *alternative to natural gas* • Future additional *revenue stream* for farmers Dominion Energy Powering Your Every Day. Smithfield Good food Responsibly • $500 million joint venture (2018-2028) • 26 family farms • 107k tCO$_2$e emission reduction	• Improved public health (e.g., swine flu) and animal *disease prevention*, limiting losses (vaccination → Emission decrease by 12 to 277 kt CO2-eq) • Regular deworming can cut emissions by ~33% in sheep • Fewer but healthier animals that are more *productive (8% - USA)*

tCO$_2$e – Metric tonnes for carbon dioxide equivalent, Gt (Giga tonnes)

Source: Our World in Data, Batten report (2019), Almaraz *et al* (2023), EDF (2022), McKinsey (2023), Fox et al (2018)

At a market share of 8% alternative proteins can reduce 1.5% of global GHG emissions in 2030 and achievable with key actions to foster growth and build market share

Grocery retail sales (USD billion)



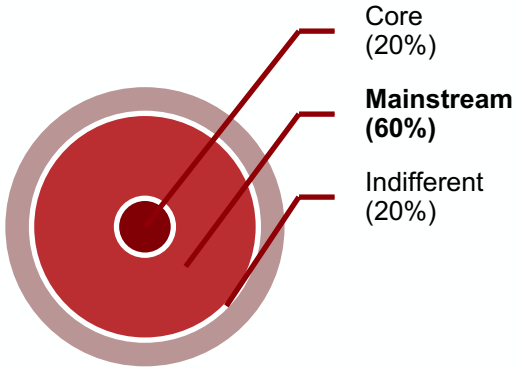
Growth rate

	2019-2020	2020-2021	2021-2022
Alternative meat	46%	**-1%**	**-0.4%**
Alternative dairy	20%	1%	12%

- **14% drop in volume** of refrigerated alternative meat
- Frozen alternative meat, has **lower price premium**
- **6% gain in revenue** upon compensation for decrease in volume by **price increase**

Customer base for alternative meat market

- No repeat purchases
- Unmotivated by sustainability alone
- Tolerate price premium at low cost, high quality and health benefits



Short and long-term actions for growth

Immediate action

- Limit *vegan* and *vegetarian* labels
- Clearly display the source of protein

Achieve parity

- Invest and innovate to optimize taste, texture, cost
- Highlight health benefits (or) sensory appeal

Source: BCG Analysis (2022), BCG Analysis (2021), FAIRR (2023), Good food institute (2024)

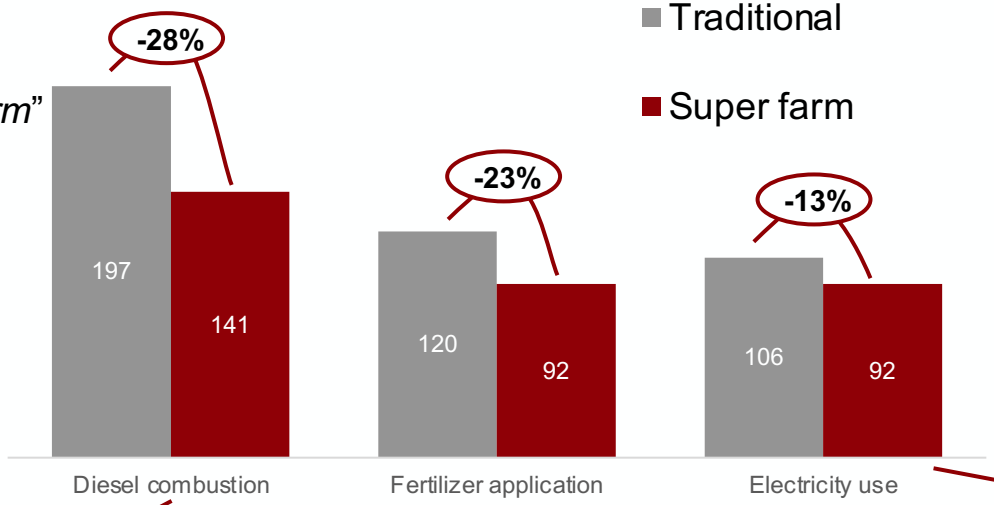
Incorporating modern technologies such as robotics, IoT and AI can cut GHG emissions from farming by 22% with reduced labor cost and similar yields

Case Study:

XAG

"*Super cotton farm*" project in China (2021)

GHG emission across activities (tCO_2e)



Challenges

- Unfavourable regulations
- Lack of standardization and infrastructure
- Farmer awareness and expertise
- Unattractively high costs

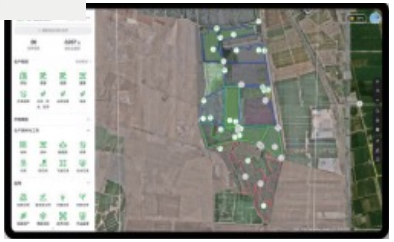
Opportunities

- Create a healthy regulatory environment
- Invest in infrastructure
- Improve awareness and customer education
- Customer-centric R&D
- Value-based pricing model

Drones and robots for application of pesticides and fertilizers instead of diesel vehicles

Automated steering system for tractors to take shortest paths and minimize fuel consumption

IoT systems (smart pumps, values) for irrigation and fertilization to save energy and avoid overdoses



Using AI to analyze high-resolution farm images to monitor key indicators for plants and direct drones to spray precisely

Monitor and improve the performance of current devices and adopt rewable energy sources on-farm

Source: XAG analysis report by BCG (2022)

Adopting sustainable agricultural practices can cut up to 30% of emissions from agriculture by 2035 but the transition must overcome financial and technical challenges

Key principles of regenerative agriculture

- Minimize soil disruption
- Keep soil covered with plants
- Plant diverse crops
- Avoid / reduce synthetic chemical use

Farmers' concerns

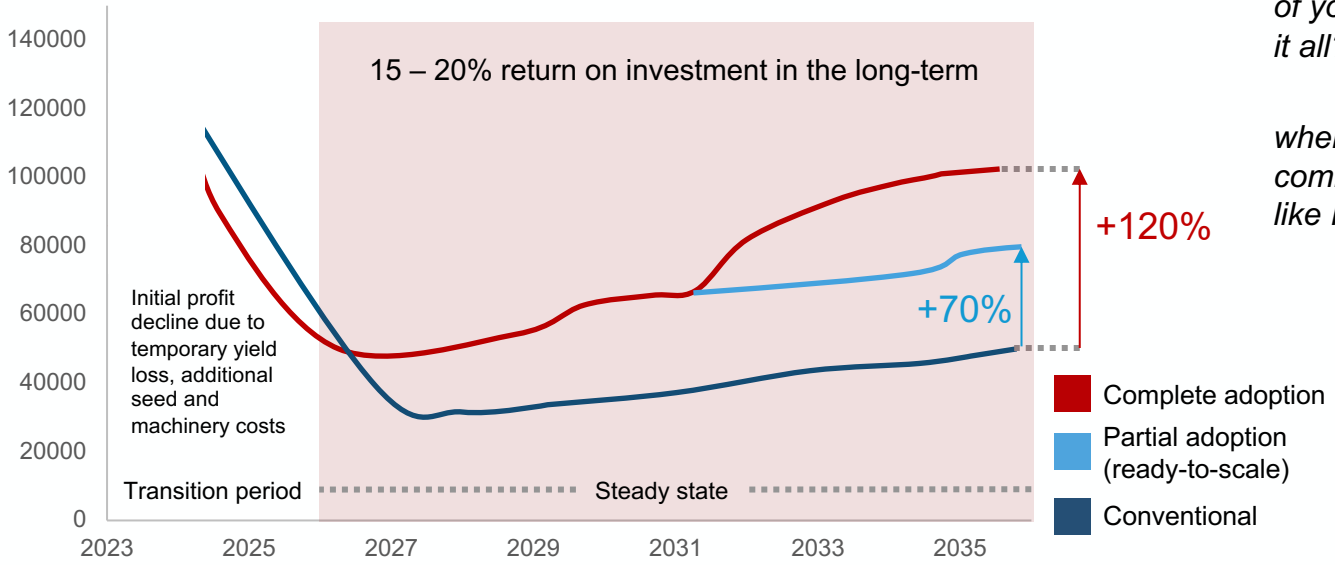
Costs due to equipment and input purchases

Risks of yield loss not covered by insurance schemes and subsidies

Technical Assistance to make the transition

Peer pressure to maintain conventional practices

Modelled[1] profit by farming system for average 780-acre Kansas wheat farm ($/year)



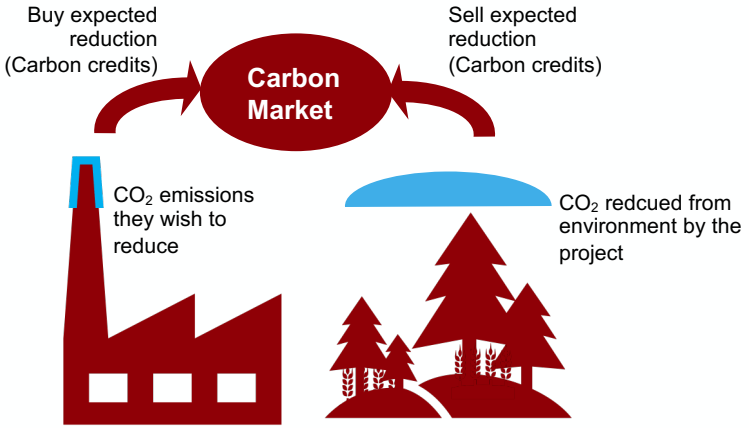
" On a multi-generational farm, the question that always lingers in the back of your mind is, 'Will I be the one to lose it all?'"

when I saw those first few earthworms coming up across my field, I finally felt like I was [farming] the right way"

US Farmers

Sources: 1-BCG Analysis (2023), BCG Report (2023), Science.org (2023), BCG Publication (2024)

Opportunities for agriculture technology (AgTech) startups are promising and can provide solutions for various technological and financial challenges in the agriculture industry



Main challenges

- Lack of Governance
- Lack of trust, Greenwashing
- Offset quality needs to be High
- Complexity in Accounting

Need of the hour

- Improved MRV practices

Monitoring, reporting and verification (**MRV**) methods lack transparency and detailed data which makes it hard to appropriately credit farmers for these practices.

The AgTech Environment (2023 Q3/Q2)

CAGR (expected from 2023 – 2030)

16.5%

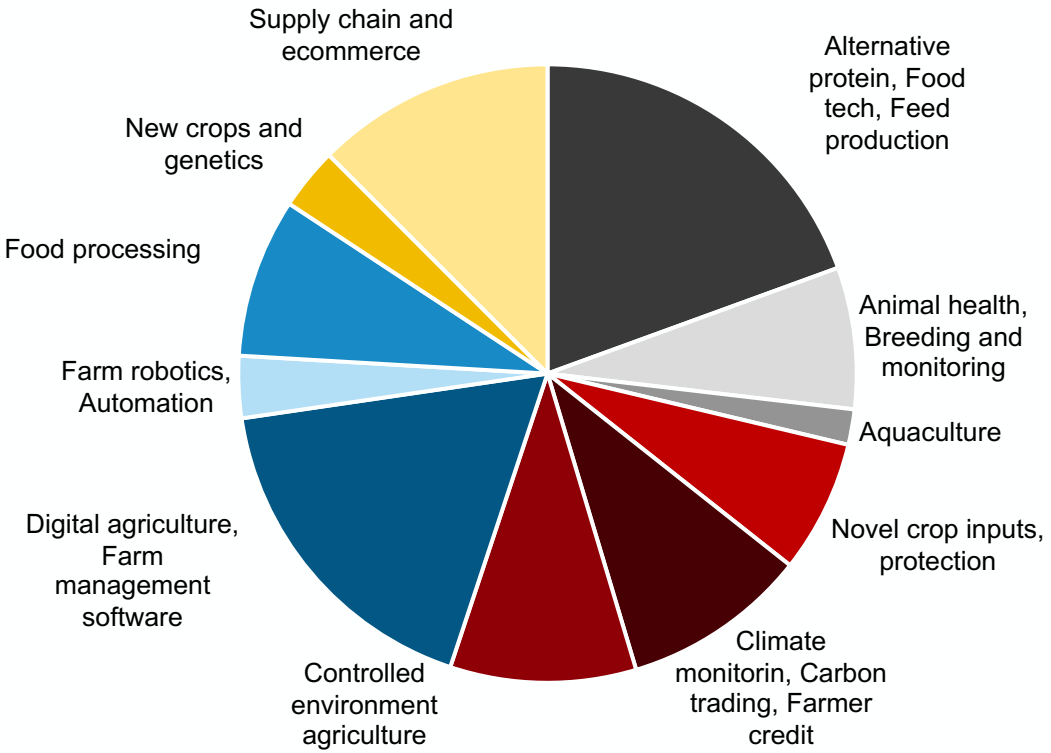
Total venture capital raised

$2 B

Percentage increase in deal values

19.1%

Number of AgTech Investments by area (2023 Q1)



Source: Broekhoff *et al* (2019), Pitchbook report and article (2023), Forward fooding blog (2024), Market analysis (2023)

Conclusion

Main Outcome

Various approaches to avoid, reduce and reverse greenhouse gas (GHG) emissions are promising and can be effective in the next ten years.

Key Factors

- Among the various contributors to methane GHG, livestock stands out as a significant source. However, the potential of alternative dairy and meat production to significantly reduce these emissions is a promising avenue that warrants further exploration.
- The adoption of precision farming, bolstered by modern approaches like AI, IoT, and robotics, along with the implementation of sustainable agricultural practices, is a crucial step towards reducing emissions from agriculture. Providing financial and technological support to farmers is not just a necessity for widespread adoption, but also a strategic investment for future returns.
- Carbon credits can incentivize reductions, but monitoring, reporting and verification (MRV) approaches are challenging and must be established for successful adoption.
- Modern technology can both improve MRV and cut emissions significantly.

Future perspectives

- Investment in various sectors of agriculture is growing despite global challenges, which can enable the transition toward net zero in the industry.
- Stakeholders must collaborate and coordinate to offer educational, technical, cultural, and financial support, and they must strive to deliver incentive programs through relationships that the customers and farmers trust.

Full link to sources by slide number

3 - UNESCO survey: “The world in 2030”
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