DISCUSSION STARTER

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Domain-specific actions to unlock private sector innovation for climate and food

Key actions in plant nutrition, sustainable livestock, and next-generation crops

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Introduction

The transformation of food systems in response to climate change necessitates innovative approaches that address both adaptation and mitigation gaps. As global populations surge and climate impacts intensify, the demand for sustainable, resilient agricultural practices has never been more urgent. The private sector, with its significant resources and capacity for innovation, has a crucial role to play in this transformation. Yet, despite its potential, significant barriers—or *lock-ins*—prevent the alignment of private sector innovation with climate action.

The Discussion Starter '*Picking Locks for Potential: Mobilizing Private Sector Innovation for Climate Action*' identifies these lock-ins and proposes strategic lockpicks to overcome them. Lock-ins such as market dominance by a few large players, traditional profitability models, and inadequate accountability measures stifle climate-oriented innovations. Unlocking these barriers requires targeted actions and collaborative efforts across various domains of the food system.

This paper builds on the Discussion Starter by applying its insights to three critical domains: plant nutrition, sustainable livestock, and next-generation crops (see Table 1). This report is not exhaustive of all areas of innovation; other areas, such as alternative protein and food loss and waste will also be essential in the transition to more sustainable food systems. However, each of these domains presents unique challenges and opportunities, making them key areas for intervention. They are all characterized by a rich landscape of innovations, both in the short and long-term, and are important in addressing both adaptation and mitigation challenges.[1] By focusing on these areas, we aim to illustrate how specific lockpicks can be employed to drive innovation and foster sustainable innovation by the private sector.

Table 1: Overview of the three domains

Plant nutrition	Sustainable livestock	Next-generation crops
Technology readiness: **0-10 year**	Technology readiness: **5-10 years**	Technology readiness: **10-25 years**
A sector heavily reliant on synthetic fertilizers, plant nutrition is plagued by high greenhouse gas emissions and market concentration. Innovations in fertilizer production and nutrient use efficiency could revolutionize this domain, but existing lock-ins prevent widespread adoption.	Methane emissions from livestock are a major climate concern. Despite promising technologies for emission reduction, the sector's market structure and diverse local contexts pose significant challenges.	These crops hold the promise of enhanced resilience and mitigation. However, market dominance by a few large entities, stringent IP rights, and regulatory hurdles impede their development and deployment

[1] FoodSystems.Tech provides an overview of some of the long-term innovations that could have a significant climate benefit.

In this paper, we first explore the lock-ins discussed in the original Discussion Starter, delving into the specific barriers that impede progress within each domain. We use the table below to structure our analysis and highlight the critical challenges in plant nutrition, sustainable livestock, and next-generation crops (Table 2). Following this, we propose concrete actions inspired by the lockpicks, imagining practical steps that stakeholders can take to break free from these constraints and promote climate-friendly innovation. While some of these developments may seem far into the future, our goal is to start to introduce clarity and direction to the conversation, offering tangible steps to begin addressing these complex issues: concretizing these concepts is what eventually holds the key to unlocking private sector innovation for climate action.

Table 2: Summary of the lock-ins and lockpicks from Clim-Eat Discussion Starter 7

LOCK-INS	LOCKPICKS	
Profitability trap	• **Increase profitability** by securing markets or return on investments • **Incentivize investments in climate action** by financial incentives or investment matching	• **Develop MRV tools** that balance granularity with practical feasibility • **Explore creative collaboration configurations** to build on the strengths of the diversity of actors
Competition & accountability	• **Strengthen the policy push** through legislation and strong metrics • **Convene pre-competitive networks** to enhance knowledge sharing and raise ambition	
Limited leverage of climate agenda	• **Build C-level leadership** on climate action beyond CSOs • **Consolidate best practices to increase climate leverage** in innovation pipelines, priorities, and processes	

Plant nutrition

A sector heavily reliant on synthetic fertilizers, plant nutrition is plagued by high greenhouse gas emissions and market concentration. Innovations in fertilizer production and nutrient use efficiency could revolutionize this domain, but existing lock-ins prevent widespread adoption.

Technology readiness: 0-10 year

Challenges and trade-offs

A major climate challenge in this domain is the emission caused by fertilizer production and use. Currently, nitrogen (N) fertilizer production accounts for approximately 2% of both all anthropogenic GHG emissions, and global energy consumption. Of these, 40% are emitted during production, and 60% during utilisation. Decarbonising N production could have substantial climate benefits through reduction of GHG emissions, as well as greatly increasing accessibility of N fertilizer to small-scale farmers in rural locations in lower-income countries. Improving the efficiency of N uptake and use would similarly have considerable climate benefits via reduced GHG emissions from reduced loss and waste, and other environmental benefits from reduction in volatilisation, runoff and leaching of N beyond the root zone. Similar (if smaller) benefits would apply to phosphorus (P) fertilizer as well.

There are a lot of ongoing innovation efforts in the plant nutrition space that are directly linked to these challenges. Broadly, these fall into one of two broad fronts. Firstly, novel ways of producing plant nutrients (N, P) are being explored. These include second-generation N production methods that can move the process towards fewer GHG emissions, such as green hydrogen-based ammonia synthesis and scaling down the Haber-Bosch process, and third-generation N production that decarbonizes the process more-or-less entirely, through, for example, plasma-assisted, photochemical, electrochemical ammonia synthesis. The development of microbial-based fertilisers and recovering and recycling nutrients from waste also fall on this front. The second front explores increasing the efficiency of uptake and use of plant nutrients by crops by, for example, better matching plant nutrient demand with supply and genetic modification and/or enhancement of the microbial environment and synergistic effects in the plant root system.

These innovations do have the potential to produce both co-benefits and trade-offs. These may include:

- Making considerable increases in the efficiency of N use may decrease the demand for N fertiliser, but its decarbonisation may reduce the price substantially and lead to increased (over-)use. At scale, the impacts on GHG emissions would need to be assessed carefully.
- Widespread off-grid N production in small plants would greatly increase the accessibility of fertilisers, especially in sub-Saharan Africa and particularly benefitting smaller scale farmers. However, this would require investments in new infrastructure and cause substantial potential negative impacts on the centralised business models of the large N production and distribution companies.
- Take up at scale of any of the innovations in this domain could be expected to have significant co-benefits on human nutrition and health via increased productivity and resilience in local small-scale farming systems in LMICs and potentially via reduced environmental pollution from inappropriate use of N fertiliser.

Lock-ins

The plant nutrition sector is hindered by significant market concentration, with a few large corporations dominating production and access to advanced technologies and intellectual property (IP) rights. This oligopoly limits competition and innovation, creating high entry barriers for startups and smaller entities. The geographic concentration of fertilizer production in developed countries exacerbates this issue, as lower-income regions often rely on imports, which restricts access to affordable, locally produced fertilizers. The limited sharing of resources and information due to inadequate international regulation further impedes collaborative efforts and the dissemination of innovative solutions.

Traditional business models in the fertilizer industry focus on high-volume sales and intensive input use, driven by centralized production and economies of scale. This emphasis on volume over efficiency is reinforced by input subsidies that incentivize increased fertilizer use, rather than improvements in nutrient use efficiency. Governments often favor large producers to reduce transaction costs, entrenching the dominance of established players. Furthermore, the integration of plant nutrition innovations with digital agriculture solutions tends to benefit large-scale operations, marginalizing smaller, more diverse agricultural practices that might benefit from tailored nutrient management strategies. Another critical factor is the sunk cost of existing fertilizer production facilities, which often have lifespans of 25-50 years. This long-term investment in infrastructure is a brake on transformative innovations.

A significant lack of accountability regarding environmental and climate costs also present a lock-in. Financial accountability is minimal, with environmental impacts not adequately measured or regulated. The absence of standardized Monitoring, reporting, and verification (MRV) tools further undermines efforts to track and manage these impacts. Without rigorous MRV systems, it is challenging to implement true cost pricing or capture the value of climate action. Moreover, the high costs of research and safeguarding new innovations fall on first movers, discouraging companies from pursuing sustainable practices. This regulatory lag and insufficient accountability create an environment where innovative and new practices struggle to gain traction. The geopolitical significance of fertilizers, which are critical for national food security, further complicates efforts to reform the sector, as governments are often wary of disrupting supply chains that are vital to their agricultural outputs.

"Significant lack of accountability regarding environmental and climate costs also present a lock-in. Financial accountability is minimal, with environmental impacts not adequately measured or regulated."

Table 3: Lock-ins in plant nutrition

LOCK-IN	MAIN CHALLENGE	BOTTLENECKS
Competition	The current concentrated market structure, geographical concentration of production and start-up costs hinder change.	• The current fertilizer sector is made up of relatively few large corporate players and competition is limited. • There is considerable geographic dominance in the fertilizer sector, with most production taking place in middle- and higher-income countries. Lower-income countries often have to import fertilizer. • It is highly risky for start-ups to open new, local markets with fertilizers produced in novel ways and move these to scale.
Profitability through business cases	Common company business cases are focused on volume and intensifying input use.	• Centralized production and economies of scale prioritize volume • Input subsidies also incentivize growing volume. Governments dealing with subsidies also tend to favour large producers to reduce transaction costs. • The bundling of plant nutrition innovations and digitalization in agriculture tends to favour large-scale, and volume agriculture.
Investments into alternatives to existing products	There are few incentives currently for large companies to explore different modes and profitability models of fertilizer production.	• Given the lack of public policy to incentive alternative business models, the high risks of change are carried by incumbents. • The role of fertilizer in securing food security heightens the sensitivity of disruptive innovations, not least in the context of wider geopolitical forces.
Accountability	There is very limited accountability in terms climate costs and impacts.	• There is a lack of financial accountability, as environmental and climate costs are not measured. • There is a regulatory lag to enforce accountability. Corporate responsibility regulations are generic and there is no domain-specific accountability mechanism. • Research and safeguarding costs fall on first movers, disincentivizing innovation.
Monitoring, reporting and verification (MRV)	There is a lack of standardized MRV tools that can provide reasonably accurate and timely information on the metrics of importance.	• Absence of standardized and rigorous MRV undermines accountability and regulation initiatives. • Awareness and evidence generation are hindered by the lack of MRV tools. • Absence of credible MRV undermines true costs pricing and value capture ("green premium") for climate action.
Collaboration	Market concentration and competition limits incentives for collaboration with competitors.	• Competition for market share and a "green premium" limits knowledge sharing between private entities. • Fundamental research is done in collaboration with public agricultural research institutes, but this limits the open-access availability of the findings.
Leadership	Existing platforms are predominantly linked to incumbent actors, and if addressing climate change, it is a part of a much broader agenda.	• More scientifically oriented platforms lack a working relationship with the private sector. • There is a lack of consensus on the need for climate action by private-sector decision-makers. • In sectoral coalitions, climate action and related innovations compete with other issues and concerns of the incumbent actors.

Sustainable livestock

Methane emissions from livestock are a major climate concern. Despite promising technologies for emission reduction, the sector's market structure and diverse local contexts pose significant challenges to scaling these innovations.

Technology readiness: 5-10 years

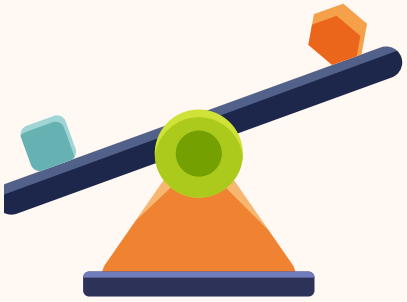
Challenges and trade-offs

A major climate challenge in the sustainable livestock domain is methane emissions from enteric fermentation in ruminants such as cows. Methane is a potent greenhouse gas, and livestock production contributes significantly to global methane emissions. Reducing these emissions can have substantial climate benefits, slowing global warming and contributing to net-zero goals. Despite promising technologies for methane reduction, such as feed additives, vaccines and oral treatments, the sector's market structure and diverse local contexts pose significant challenges to scaling these innovations.

There are numerous ongoing innovation efforts directly addressing these challenges. Broadly, these fall into two categories. Firstly, there are novel technologies aimed at directly reducing methane emissions. These include feed additives that inhibit methane producing enzymes in the rumen, and animal drugs designed to alter rumen fermentation patterns. Secondly, there are systemic approaches such as selective breeding programs aimed at producing livestock that naturally emit less methane. Innovations also include improving livestock diets to enhance digestion and reduce methane output.

These innovations have the potential to produce both co-benefits and trade-offs. These may include:

- Innovations focussing on improved digestion could improve animal health and productivity, and potentially reduce feed costs due to increased feed efficiency. However, especially in the short term, these innovations will be high-cost, disproportionally burdening small-scale farmers.
- Widespread adoption of feed additives and drugs could significantly reduce methane emissions, contributing to climate change mitigation. However, this may lead to increased dependency on external suppliers for these additives and drugs, impacting the autonomy of farmers.
- Selective breeding and dietary improvements may yield long-term benefits by creating more resilient livestock, but these approaches require significant initial investment and may disrupt traditional farming practices and undermine livestock's critical role in providing resilience to small-scale farmers.



All innovations have the potential to produce both co-benefits and trade-offs.

Lock-ins

The sustainable livestock sector faces significant lock-ins that hinder the development and scaling of methane reduction technologies by private sector companies. The market is dominated by a few large corporate players who control high-tech solutions for methane reduction, creating high barriers to entry for startups and smaller entities. This concentration limits competition and innovation, making it difficult for new technologies to gain traction. The geographic concentration of innovation in developed countries further restricts access for lower-income regions, exacerbating disparities in technology adoption and implementation.

Similar to plant nutrition, profitability models in the livestock industry are traditionally focused on volume rather than efficiency. The growing demand for livestock products is primarily met through scaling and increasing production volumes, not through improving productivity or efficiency. The long lifecycle of livestock farming, compared to other agricultural sectors, implies longer breeding and innovation timelines, as well as high costs associated with transitioning to new technologies. The complex and lengthy supply chains increase the required coordination and costs associated with innovation, limiting the scaling of new, climate-oriented innovations. Moreover, the resilience and cultural value of livestock in many regions raise fundamental questions about the desirability and feasibility of implementing disruptive innovations. Lastly, standardized MRV tools also hinder accountability and opportunities for true pricing, similarly to the plant nutrition domain.

Table 4: Lock-ins in sustainable livestock

LOCK-IN	MAIN CHALLENGE	BOTTLENECKS
Competition	The current concentrated market structure, geographical concentration, local contexts of production and start-up costs hinder change.	• The livestock sector is characterized by a few large corporate players in high-tech solutions for methane reduction, making it difficult for start-ups to enter the market. • Geographical dominance exists, with developed countries leading in innovation, potentially limiting access for lower-income countries. • The diversity of local contexts of production in the livestock sector presents a strong bottleneck for scaling innovations
Profitability through business cases	Common company business cases are focused on volume.	• The growing demand for livestock products has mainly been met through scaling and increasing volume of production, not increased productivity/ efficiency. • Livestock farming has a long lifecycle compared to other agricultural products, implying longer breeding and innovation timelines, as well as high costs associated with transitioning to new technologies.
Investments into alternatives to existing products	Alternative business models have not been explored widely in the sector.	• Cultural sensitivity and contextual diversity complicate change, not least due to the resilience and cultural value of livestock in many regions. • There is a lack of viable innovations that could significantly affect the existing business model. • The particularly complex and lengthy supply chain increases the required coordination and costs associated with innovation, limiting scaling of innovations.

Accountability	There is very limited accountability in terms of climate costs and impacts.	• There is a lack of financial accountability, as environmental and climate costs are not measured. • There is a regulatory lag to enforce accountability. Corporate responsibility regulations are generic and there is no domain specific accountability mechanism. • Research and safeguarding costs fall on first movers, disincentivizing innovation.
Monitoring, reporting and verification (MRV)	There is a lack of standardized MRV tools that can provide reasonably accurate and timely information on the metrics of importance.	• The sector's focus on living animals complicates already challenging MRV development. • Absence of standardized and rigorous MRV undermines accountability and regulation initiatives. • Awareness and evidence generation are hindered by the lack of MRV tools. • Absence of credible MRV undermines true costs pricing and value capture ("green premium") for climate action.
Collaboration	Leading companies have little to gain in terms of productivity when it comes to the climate-related innovations in this domain.	• There are few win-win innovations in this domain; most climate-related innovations solely target emission reduction or measurement, not providing an incentive (e.g. resource efficiency) for the companies themselves to implement these. • Progress on climate-related innovations are dominated by new actors outside of the value chain, due to the low incentive and high-risk for companies embedded in the status-quo. • The sector's focus on living animals implies a long-term horizon and accompanied collaboration requires more risk and costs.
Leadership	Existing platforms are predominantly linked to incumbent actors, and if addressing climate change, it is as part of a much broader agenda.	• More scientifically oriented platforms lack a working relationship with the private sector. • There is a lack of consensus on the need for climate action by private-sector decision-makers. • In sectoral coalitions, climate action and related innovations compete with other issues and concerns of the incumbent actors.

Next-generation crops

These crops hold the promise of enhanced resilience and mitigation. However, market dominance by a few large entities, stringent IP rights, and regulatory hurdles impede their development and deployment.

Technology readiness: 10-25 years

Challenges and trade-offs

Next-generation crops offer significant potential for climate resilience and climate change mitigation, including carbon sequestration These crops can be designed to withstand extreme weather conditions and contribute to environmental sustainability. However, several significant lock-ins impede their development and deployment. The market for these crops is dominated by a few large entities that control advanced technologies and IP rights, creating high barriers for new entrants. Regulatory hurdles and social acceptance of genetically modified organisms (GMOs) further complicate the development and adoption of these crops.

Innovations in the next-generation crop domain are focused on two broad fronts. Firstly, there are advancements in genetic engineering to create crops with enhanced traits such as drought tolerance, pest resistance, and improved nutritional content. Examples include crops developed through targeted breeding programmes, CRISPR technology and various other genetic modification techniques. Secondly, there are efforts to improve the synergy between crops and their environment. This includes developing crops with enhanced shade tolerance and using signalling molecules to optimize plant-microbe interactions, thereby improving nutrient uptake and resilience.

These innovations have the potential to produce both co-benefits and trade-offs. These may include:

- Genetic engineering to enhance crop resilience can reduce crop failure risks and improve food security. However, the high costs of development and regulatory compliance may disproportionately affect small-scale farmers and limit their access to these technologies.
- Innovations that improve plant-microbe interactions can increase yields and reduce the need for chemical inputs, benefiting both the environment and farmers. However, social resistance to GMOs may hinder market acceptance and widespread adoption of these crops.
- Developing next-generation crops that are climate-resilient, have enhanced nutritional value, and can assist in carbon sequestration can contribute to better societal and public health outcomes. However, dependence on a few large companies for seeds and (digital) technologies could limit farmer autonomy and increase costs, posing a significant trade-off.

Lock-ins

Innovations in next-generation crops face significant lock-ins that impede their development and deployment. The market is dominated by a few large entities that control advanced technologies and IP rights, creating high barriers for new entrants and limiting competition and innovation. The limited sharing of genetic resources and information, partly due to inadequate international regulation, further hinders collaborative efforts and the broad dissemination of innovative crop varieties. In addition, the dependency on a few large companies for seeds and technologies could limit farmer autonomy and increase costs, posing significant trade-offs in the adoption of next-generation crops innovations.

The traditional business models in the crop industry focus on high-volume, high-demand crops, often overlooking those with significant climate resilience or environmental benefits. This focus is driven by profitability models that prioritize high-demand crops and lack push or pull incentives to explore the diversity of alternative crops that also exists. Similar to the other two domains, a lack of rigorous MRV systems is an important limiting factor for accountability and the development of business cases that incorporate climate considerations. Additionally, there is a lack of public policy to incentivize alternative business models, leaving incumbents to bear the high risks of change without adequate support. Regulatory hurdles and social acceptance of GMOs further complicate the development and adoption of next-generation crops, limiting the potential for transformative change in the sector.

Monitoring, reporting and verification (MRV) is a key bottleneck for innovations in next-generation crops, as well as for the other two domains.

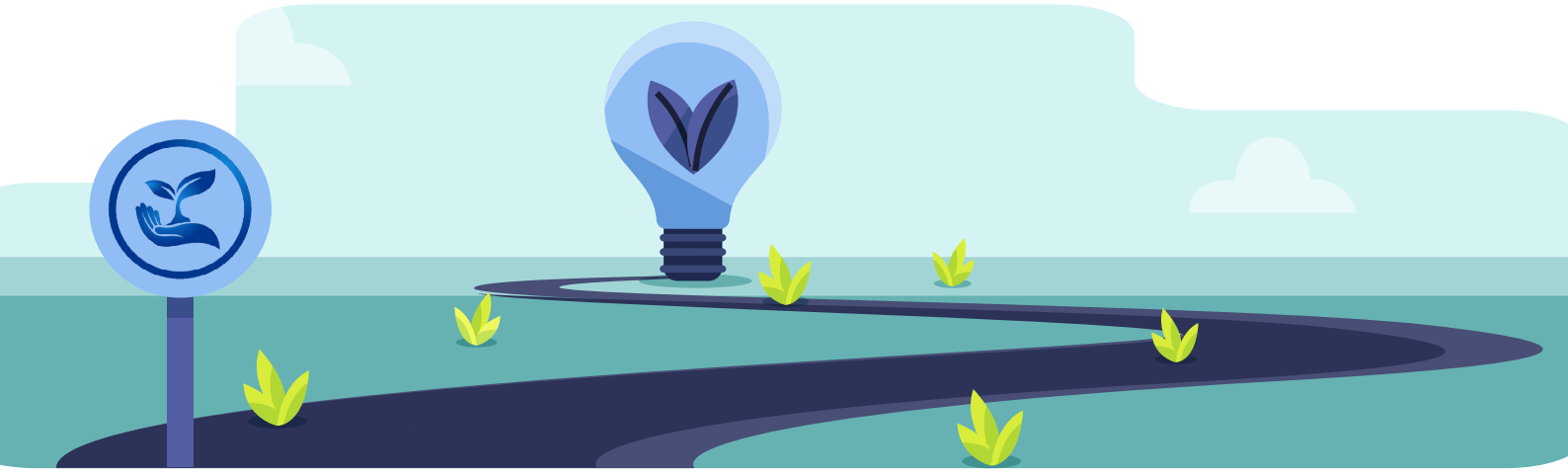


Table 5: Lock-ins in next-generation crops

LOCK-IN	MAIN CHALLENGE	BOTTLENECKS
Competition	The market is dominated by a few large actors controlling access to advanced technologies and intellectual property (IP) rights. In addition, social license to operate, and regulations limit innovation and scaling opportunities for start-ups.	• There is limited sharing of genetic resources and information, partly because of a lack of international regulation on this topic.
Profitability through business cases	Common company business cases are primarily focused on high-volume, high-demand crops.	• The focus on high-demand crops potentially overlooks crops with significant climate resilience or environmental benefits. • There are no push or pull incentives to deviate high-demand crops; there is little demand and no enabling policy landscape.
Investments into alternatives to existing products	There are few incentives currently for large companies to explore different modes and profitability models of next-generation crops.	• Given the lack of public policy to incentivize alternative business models, the high risks of change are carried by incumbents. • The regulatory and social limitations of innovations in terms of crops make exploring new business models unlikely.
Accountability	There is very limited accountability in terms of climate costs and impacts.	• There is a lack of financial accountability, as environmental and climate costs are not measured. • There is a regulatory lag to enforce accountability. Corporate responsibility regulations are generic and there is no domain-specific accountability mechanism. • Research and safeguarding costs fall on first movers, disincentivizing innovation.
Monitoring, reporting and verification (MRV)	There is a lack of MRV tools that can provide reasonably accurate and timely information on the metrics of importance.	• Absence of standardized and rigorous MRV undermines accountability and regulation initiatives. • Awareness and evidence generation are hindered by the lack of MRV tools. • Absence of credible MRV undermines true costs pricing and value capture ("green premium") for climate action.
Collaboration	Market concentration and competition limits incentives for collaboration with competitors.	• Competition for market share and a "green premium" limits knowledge sharing between private entities. • Fundamental research is done in collaboration with public agricultural research institutes, but this limits the open-access availability of the findings.
Leadership	There is no specific platform for leadership engagement on climate action	• More scientifically oriented platforms lack a working relationship with the private sector. • There is a lack of consensus on the need for climate action by private-sector decision-makers. • In sectoral coalitions, climate action and related innovations compete with other issues and concerns of the incumbent actors.

Actions per domain

The lock-ins discussed for each domain highlight the significant barriers to aligning private sector innovation with climate action. To overcome these challenges, strategic "lockpicks" must be employed. The actions outlined here translate these lockpicks into practical steps for various stakeholders, ensuring that the innovation potential of the private sector is fully harnessed. These actions involve governments, private companies, public research organizations, and NGOs working together to unlock an enabling environment for sustainable innovations for climate action in the three domains.

Profitability

Increasing the profitability of climate action is an essential step to incentivize more climate action through innovation. A true cost accounting approach would be an important strategy for internalizing the environmental and social costs of agricultural practices, significantly improving the profitability of climate action while penalizing the continuation of unsustainable activities by the private sector. This approach, however, would require a longer time horizon of 5-15 years due to the complexity and scale of implementation, and it necessitates extensive advocacy and comprehensive research by public research organizations and NGOs. Hence, in the short term, reorienting subsidies can play a pivotal role in enhancing profitability and fostering climate action. For plant nutrition, short-term green energy subsidies for production can significantly reduce greenhouse gas emissions and lower costs, making sustainable practices more viable within a 2-3 year timeframe. Similarly, repurposing livestock subsidies to support climate-smart practices can provide immediate financial incentives for adopting methane reduction technologies. However, specifically for livestock subsidies, it will be essential that multilateral organizations and philanthropics support a repurposing agenda by realigning their own portfolios to this as well. For next-generation crops, the introduction of premium pricing strategies and eco-labeling for crops with enhanced resilience and carbon sequestration capabilities is essential. However, the longer time horizon of 10-15 years reflects the current absence of fundamental alternatives and the need for developing robust market demand and consumer awareness to support these innovations.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Increase profitability of climate action	**Plant nutrition**	Short-term green energy subsidies for production.	Government	2-3 years
		Adopt true cost accounting for the food system.	Government, public research organizations, NGOs	5-15 years
	Sustainable livestock	Repurposing livestock subsidies to support climate-smart practices.	Government, multilateral organisations, philanthropy	2-3 years
		Adopt true cost accounting for the food system.	Government, public research organizations, NGOs	5-15 years
	Next-generation crops	Premium pricing strategies for crops with enhanced resilience and carbon sequestration capabilities. Encouragement of eco-labelling for consumer awareness.	Private companies	10-15 years

Actions for unlocking innovations in plant nutrition, sustainable livestock and next-generation crops

Incentivize investments

Incentivizing investments in climate innovation is critical to driving the development and adoption of sustainable technologies by private sector companies. Here, de-risking investments for private sector companies is an essential key to crowding in more investment. Advanced market commitments and supply-push/demand-pull mechanisms can be effective strategies for this. These mechanisms, supported by public and philanthropic funders, can provide the necessary financial assurance to encourage private sector engagement within a 3-5 year timeframe. Developing workable technology bundles that add value, such as integrating renewable energy provision for plant nutrition or soil health improvements for livestock, can strengthen business cases and attract diverse investments from public, private, and philanthropic sources within a shorter 1-3 year horizon.

Facilitating public-private partnerships is another crucial strategy, particularly for sustainable livestock technologies. These partnerships can leverage investment matching and the sequencing of public research with private development to drive innovation. Public and private tech developers, along with funding from public, private, and philanthropic sources, can support these efforts, ensuring that research and development are adequately funded and aligned with market needs. The time horizon for these initiatives is typically 3-5 years, reflecting the complexity and required coordination. For next-generation crops, targeted funding for fundamental research in resilient and climate-oriented crop varieties is essential. This funding should be prioritized as soon as possible to bridge the gap between research and commercial application and to enable further progress on other lock-ins. Creative financial incentives, like competitions and benevolent patent extension, can further enhance private sector investment, ensuring that innovative crop varieties are developed and scaled to meet the challenges of climate change.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Incentivize investments in climate innovation	**Plant nutrition**	Advance market commitments and other supply-push / demand-pull mechanisms that can help to de-risk investment in the sector.	Public & philanthropic funders	3-5 years
		Develop workable technology bundles that add value, such as renewable energy provision, to strengthen business cases and crowd in investment.	Public & private tech developers, then public, private and philanthropic funders	1-3 years
	Sustainable livestock	Facilitate public-private partnerships to fund research and development in sustainable livestock technologies, for example, through investment matching and sequencing of public research and private development.	Public & private tech developers, then public, private and philanthropic funders	3-5 years
		Advance market commitments and other supply-push / demand-pull mechanisms that can help to de-risk investment in the sector.	Public & private tech developers, then public, private and philanthropic funders	3-5 years
		Develop workable technology bundles that add value, for example, related to soil health to strengthen business cases and crowd in investment.	Public & private tech developers, then public, private and philanthropic funders	1-3 years
	Next-generation crops	Targeted funding for fundamental research in resilient and climate-oriented crop varieties. Creative financial incentives to enhance investment by private sector into further development.	Governments, venture capital, philanthropy	As soon as possible

Policy push

Strengthening the policy push for climate action by the private sector will be an essential driver for innovation. For plant nutrition, retargeting subsidies while moving towards true cost accounting for the food system can help internalize environmental costs and promote sustainable practices within a 1-5 year timeframe. Temporary tax exemptions for green investments can further incentivize immediate adoption of sustainable technologies. In the livestock sector, revising agricultural policies to support sustainable and ethical practices and aligning metrics across ministries and countries will enhance transparency and accountability, driving consistent implementation within a 1-5 year horizon. Promoting social dialogue for next-generation crops is crucial for enhancing public acceptability and support, which needs to start as soon as possible. Revising and aligning international legal frameworks to incentivize new crops and intellectual property models will require a longer timeframe of 5-15 years, reflecting the complexity and scale of these regulatory changes

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Strengthen policy push for climate action	Plant nutrition	Retarget subsidies while moving towards true cost accounting for the food system.	Government and development banks	1-5 years
		Temporary tax exemptions for green investments.	Government	1-3 years
	Sustainable livestock	Revise agricultural policies and legislation to support sustainable and ethical livestock practices and reduce greenhouse gas emissions.	Government	1-5 years
		Align metrics across ministries and countries for transparency and accountability.	Governments with support from public research organizations	3-5 years
	Next-generation crops	Promoting social dialogue to enhance public acceptability and support.	NGOs, governments, media	As soon as possible
		Revise and align (international) legal frameworks to incentivize the introduction of new crops and new models of intellectual property rights.	Governments	5-15 years

Convene pre-competitively

Convening pre-competitive networks is vital for fostering collaboration and accelerating innovation across different domains. Establishing platforms for relationship building, knowledge brokering, and trust building, led by NGOs and INGOs, can enhance collaboration in plant nutrition and livestock sectors within a 1-3 year timeframe. For next-generation crops, establishing platforms for sharing genetic resources and technological innovations and collaborative R&D projects across industries and academia will have a longer timeframe.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Convene pre-competitive networks	Plant nutrition	Establish platforms and processes for relationship building, knowledge brokering, and build trust.	Led by NGOs and INGOs, in consultation with all other stakeholders	1-3 years
	Sustainable livestock	Establish platforms and processes for relationship building, knowledge brokering, and build trust.	Led by NGOs and INGOs, in consultation with all other stakeholders	1-3 years
	Next-generation crops	Establish platforms for sharing genetic resources and technological innovations. Collaborative R&D projects across industries and academia.	Research institutions, private sector R&D	5-15 years

Best practices for managing innovation

In the plant nutrition sector and livestock sector, participating in pre-competitive collaboration between private and public research entities can pool resources and accelerate innovation within a 3-5 year timeframe. For next-generation crops, applying new international frameworks to incentivize the introduction of new systems for intellectual property rights management and the sharing of genetic resources will be a first priority to enhance innovation over a longer timeframe of 5-15 years, ensuring that new crop varieties reach the market efficiently.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Consolidate best practices in innovation management for climate	**Plant nutrition**	Take part in pre-competitive collaboration in plant nutrient R&D between private and public research entities, and between multiple private research entities via resource and results pooling	Private and public research organizations	3-5 years
	Sustainable livestock	Take part in pre-competitive collaboration in livestock R&D between private and public research entities, and between multiple private research entities via resource and results pooling	Private and public research organizations	3-5 years
	Next-generation crops	Apply new (international) frameworks to incentivize the introduction of new systems for intellectual property rights management and the sharing of genetic resources.	Private companies and government	5-15 years

C-level leadership

Building C-level leadership is crucial for embedding sustainability into corporate strategies and driving organizational change. Leveraging recent ESG legislation in important markets (EU/US) to develop ambitious domain-specific targets as part of executive performance reviews can ensure that sustainability is prioritized at the highest levels of corporate decision-making within a 1-3 year timeframe. For next-generation crops, this timeline is more extended, given the absence of clear innovation opportunities and metrics. Therefore, recognition programs for leaders could be a way to showcase leadership in this domain while other leverage points are addressed.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Building C-level leadership	**Plant nutrition**	Building on recent ESG legislation in important markets (EU/US) to develop ambitious domain-specific targets, that are part of executive performance reviews.	Private sector and industry bodies	1-3 years
	Sustainable livestock	Building on ESG legislation in important markets (EU/US/Latin America) to develop ambitious domain-specific targets, that are part of executive performance reviews.	Private sector and industry bodies	1-3 years
	Next-generation crops	Sustainability metrics in executive performance reviews. Recognition programs for leaders in crop development.	Private sector and industry bodies	5-15 years

Creative collaboration

Identifying and implementing creative collaboration models is fundamental to mobilizing private sector innovation and navigating some of the inherent bottlenecks to working on public goods with for-profit companies. For plant nutrition and livestock, making an inventory of different collaboration models and establishing concrete partnerships to trial these models can facilitate effective collaboration within a short timeframe of 1-3 years. This approach ensures that the most effective models are identified and implemented quickly. For next-generation crops, developing such an inventory would also be a priority, although establishing concrete partnerships with private sector companies will only become feasible once there are more developed business cases for the innovations in this domain.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Identify creative collaboration models	**Plant nutrition**	Make an inventory of different collaboration models, their characteristics and use cases	Public research organizations, in consultation with private companies and governments	As soon as possible
		Establish concrete partnerships and modes of interaction to trial and implement different collaboration models	NGOs and private sector companies to initialize collaboration formats	1-3 years
	Sustainable livestock	Make an inventory of different collaboration models, their characteristics and use cases	Public research organizations, in consultation with private companies and governments	As soon as possible
		Establish concrete partnerships and modes of interaction to trial and implement different collaboration models	NGOs and private sector companies to initialize collaboration formats	1-3 years
	Next-generation crops	Make an inventory of different collaboration models, their characteristics and use cases	Public research organizations, in consultation with private companies and governments	As soon as possible

Monitoring, reporting and verification (MRV) tools

Developing robust MRV tools is essential for tracking and verifying the impact of climate innovations across all domains. These tools provide timely and credible information on environmental, social, and economic impacts, acting as critical enablers for other leverage points, including true-cost accounting and accountability efforts, as well as the assessment of policies. It is crucial that the development and application of these MRV tools are led by public research organizations and NGOs, in consultation with the private sector, to ensure a well-balanced MRV system. This approach prevents the hijacking of the process by powerful corporate actors, maintaining the integrity and objectivity of the MRV system. Implementing these tools as soon as possible ensures that the impact of innovations is accurately measured and communicated, which in turn could crowd in significant additional investments across all domains.

LOCKPICK	DOMAIN	POSSIBLE LEVERAGE POINTS	ACTORS INVOLVED	TIME HORIZON
Monitoring, reporting and verification (MRV) tools on climate indicators	**Plant nutrition**	Develop and apply novel MRV tools that can provide timely and credible information on environmental, social and economic impacts of innovations.	Public research organizations and NGOs in consultation with private sector	As soon as possible
	Sustainable livestock	Develop and apply novel MRV tools that can provide timely and credible information on environmental, social and economic impacts of innovations.	Public research organizations and NGOs in consultation with private sector	As soon as possible
	Next-generation crops	Develop and apply novel MRV tools that can provide timely and credible information on environmental, social and economic impacts of innovations.	Public research organizations and NGOs in consultation with private sector	As soon as possible

Conclusion

Each domain is unique in terms of the readiness of technologies and specific lock-ins. Market concentration is a significant barrier in all domains, though the nature of control varies. In next-generation crops, the concentration of IP rights and genetic resources is a major hurdle, while in livestock, access to high-tech solutions is the primary bottleneck. Similarly, industrial farming practices dominate all three sectors. However, while plant nutrition and next-generation crops have benefited from innovations in sustainable intensification, livestock production has largely scaled through increased volume rather than efficiency improvements. These particularities of each domain have influenced the action tables and will undoubtedly present other unique challenges that will shape the lockpicks that are needed.

Still, there are bottlenecks that are similar across the domains. For example, accountability is a critical issue, with all sectors showing significant gaps in measuring and regulating environmental and climate impacts. Platforms that work on climate leadership are also driven by established companies in all three sectors, while scientific platforms lack productive working relationships with the private sector, which limits their effectiveness and influence on private sector innovation efforts. Lastly, measurement, reporting, and verification systems are fundamental across all domains for supporting business cases, ensuring profitability, and maintaining accountability.

That is why developing and applying novel MRV tools to provide timely and credible information on the impacts of innovations as soon as possible is essential. Additionally, making an inventory of different collaboration models and their use cases, especially beyond the food and agriculture sector, could contribute to developing novel partnership models. Further, critical opportunities to accelerate action include conducting more in-depth analyses of the practical implications of these innovations in specific contexts and geographies. Socio-economic analyses that explore logistical and infrastructure challenges will help develop robust business cases, attracting private sector investment. Second, relationship and trust-building among private sector companies and the broader landscape is fundamental. Effective convening and knowledge brokering by bridging organizations can ensure that the key to unlocking private sector innovation for climate action is turned successfully.

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Citation

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