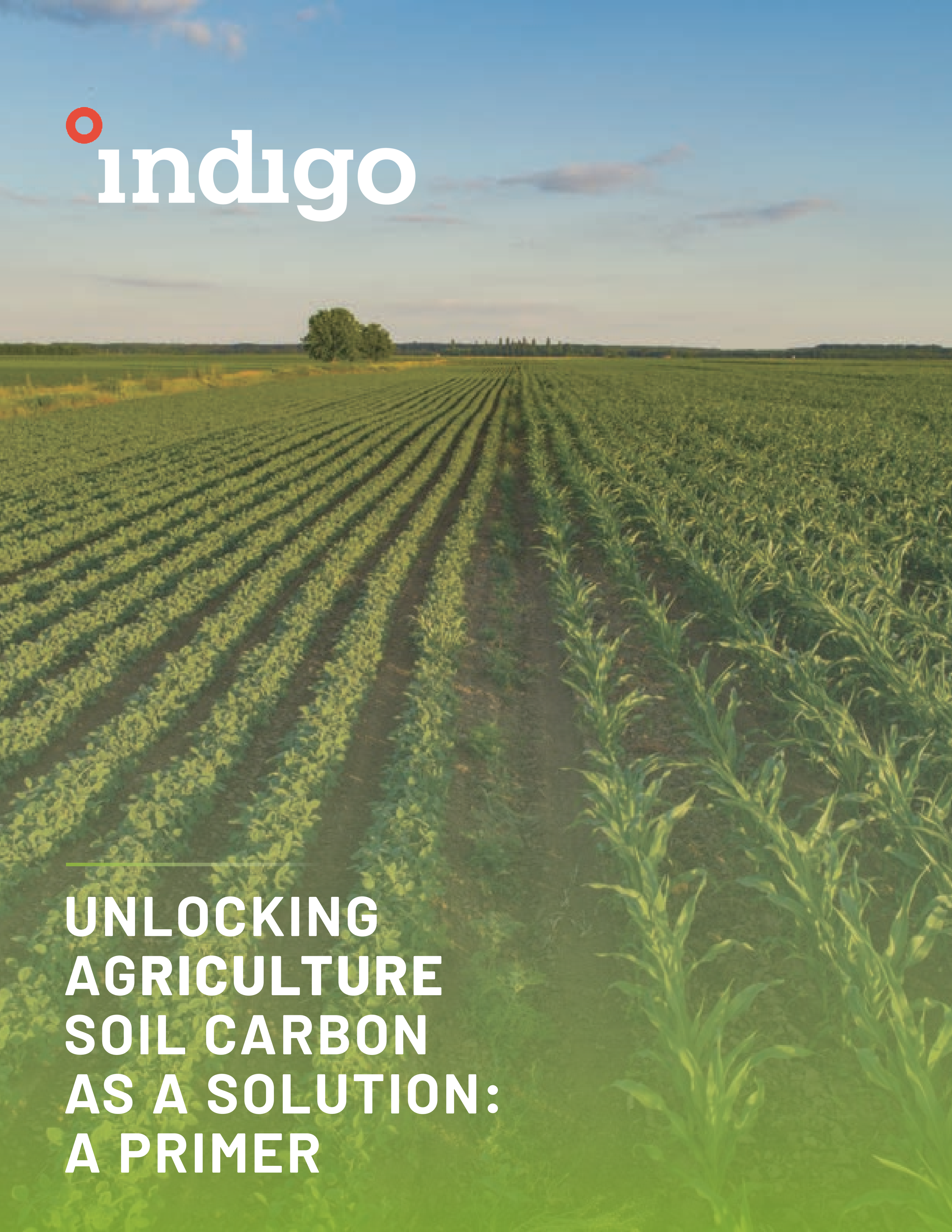
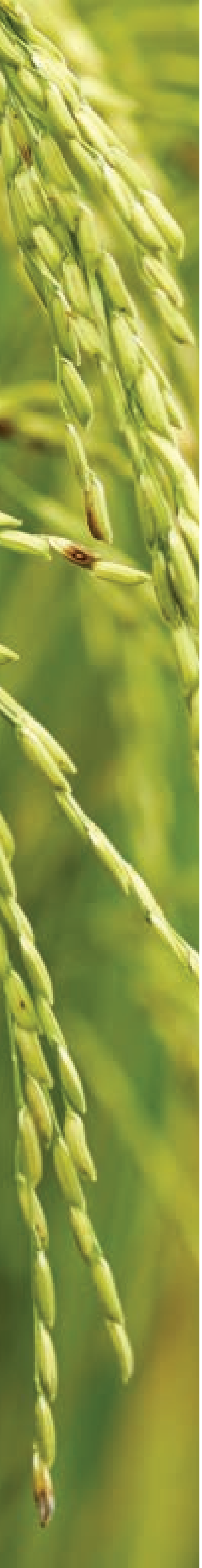


UNLOCKING AGRICULTURE SOIL CARBON AS A SOLUTION: A PRIMER



indigo

INDIGO AG (2025)

ABOUT INDIGO AG

Indigo Ag is the innovative leader and trusted partner in sustainable agriculture and biological solutions. Powered by science and technology, Indigo helps farmers and agribusinesses optimize today's yields and profitability, while nourishing the soil for better tomorrows. The company's biotrinsic® natural microbial solutions help farmers maximize crop performance by empowering plants to combat environmental and biological stresses and improve nutrient access. Indigo's Sustainability solutions include its carbon and sustainable crop programs that enable farmers to choose how to best profit from their sustainable practices while promoting practices that help land keep its value for future generations. Indigo is the largest and fastest growing issuer of nature-based, registry issued agricultural soil carbon credits in the world, offering both high quality agricultural carbon credits and scope 3 emissions reductions at scale to help corporations reach their sustainability goals. The company's state-of-the-art digital software facilitates greater efficiency, accuracy and profitability for crop transactions. Established in 2013 and operating in 15 countries around the world, Indigo Ag turns on-the-farm sustainable practice into value for farmers, agribusinesses, and corporations, creating a world with thriving farmers and environmentally prosperous companies.

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SOIL IS AN IMMEDIATE, SCALABLE, AND AFFORDABLE CLIMATE SOLUTION WITH PLANETARY IMPACT

Avoiding the worst impacts of global climate change and limiting global temperature increase to 1.5 degrees Celsius requires cutting emissions in about half by 2030. With 2030 just 5 years away, our society has an urgent need to drive action, through both emissions abatement and high-integrity carbon removals. Agriculture plays a crucial role in both contributing to and mitigating climate change. Agriculture, forestry, and other land-use accounts for ~22% of global greenhouse gas (GHG) emissions, largely due to activities like livestock production, fertilizer use, and land-use changes, and thus represents a major opportunity to reduce emissions by changing agricultural production behaviors.

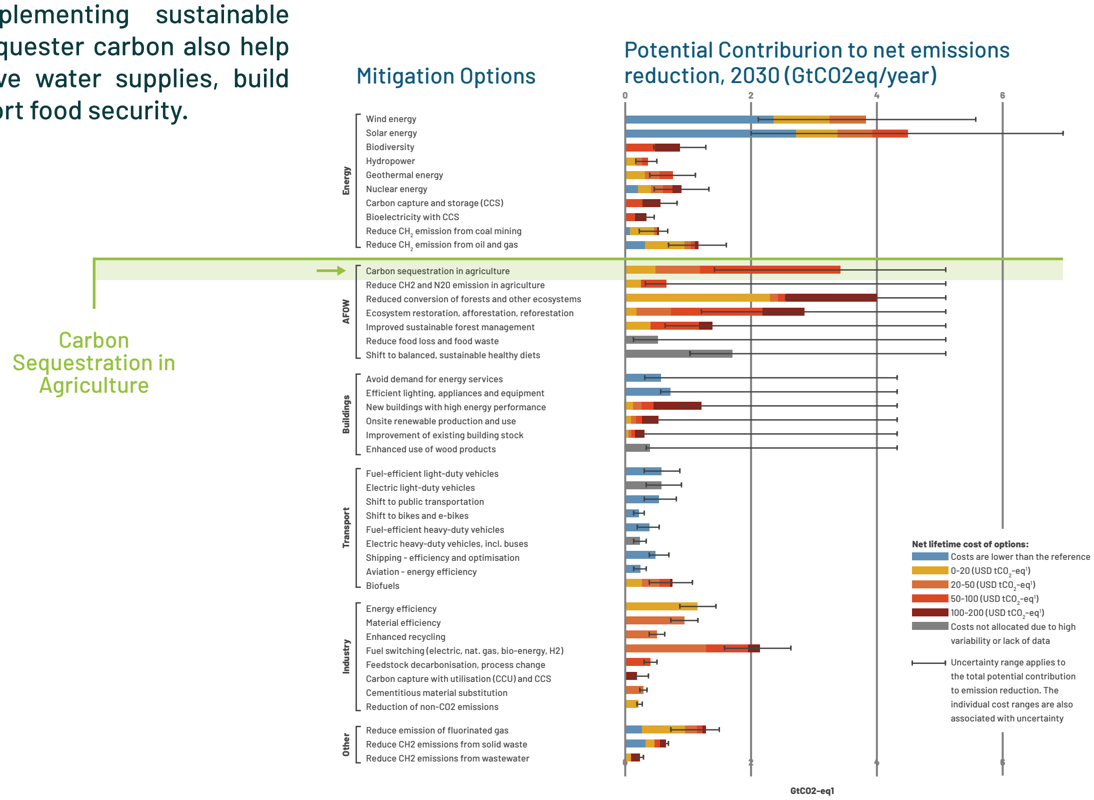
Beyond reducing emissions, there is even greater potential for agriculture to play a role as a nature-based climate solution. Agricultural soils act as a powerful sink that can mitigate up to 4 GT CO2e per year (with up to 3 GT annual sequestration potential according to the IPCC). Soil carbon sequestration in agriculture represents an immediate solution to meet the urgent need for removals, while also reducing agricultural emissions through many of the same methods. Implementing sustainable management practices that sequester carbon also help restore degraded soils, improve water supplies, build ecosystem resiliency, and support food security.

SOIL CARBON SEQUESTRATION IS A HIGH-QUALITY REMOVAL SOLUTION WHEN WE MANAGE ITS RISKS

In recent years, many carbon dioxide removal (CDR) technologies have demonstrated compelling proof of concept, but few have been able to demonstrate a path to scale, and even fewer affordable ones. Harnessing the power of nature is the greatest solution available today. Photosynthesis is society's oldest technology; the practices that regenerate soil are well known and have been in use for centuries. Minimizing disturbance, keeping soil covered, maintaining continuous living plants or roots in the soil, and increasing plant diversity builds soil organic carbon.

With soil carbon sequestration (the technology for generating removals) deployable at scale today, building confidence around this solution within the voluntary carbon market will unlock a large-scale regenerative transition that could annually mitigate up to 4 GT CO2e in the near term. As with any climate solution, understanding and managing risks enables an informed approach to build healthy soils that sequester carbon. Agriculture can be a high-quality removals solution, if the right protocols around monitoring, reporting, verification (MRV), and permanence are in place, along with incentives that mobilize farmers.

Figure 1: Potential contribution to net emissions reduction (IPCC).



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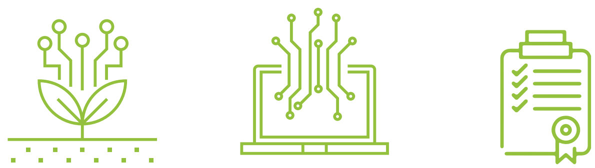
MONITORING, REPORTING, AND VERIFICATION (MRV)



While regenerative agriculture practices are well-understood, measuring the dynamics occurring underground is complex. Scientists must detect often small increases or decreases in soil organic carbon (SOC) and other greenhouse gases over short periods of time and large landscapes. Additionally, these measurements must discern whether changes occurred as a result of adopting regenerative practices or other factors, as soil type and weather conditions also contribute to fluxes in SOC. While these legitimate challenges are formidable, there are ways to reliably measure soil dynamics and quantify their impact at scale.

Measurement and re-measurement with both project and control fields is a reliable technique, but costly, and its singular focus on one form of carbon could ignore increases or decreases in other greenhouse gases involved in land management, like nitrous oxide, or other nature-related impacts. Alternatively, decades of research have mapped the interactions between factors like soil type, moisture, crop system, and farm management and put these relationships into ecosystem models that can recapitulate the impacts of practices measured in long-term studies. Critically, rather than using a single emissions factor that averages out land-based variability of practices, well-calibrated models express the variability that exists in nature – and can help direct interventions to the acres with the highest potential impact. Both methods come with tradeoffs. A measurement only approach has operational costs that scale linearly with project size, while a model only approach may have higher uncertainty or hidden biases that are not corrected for in the project.

Indigo Ag pioneered a hybrid measure and model approach that uses within-project soil sampling on a statistically representative sample to inform a calibrated ecosystem model, DayCent-CR, and default equations to quantify impacts on soil carbon and other greenhouse gases. A hybrid measure and model approach enables scale while remaining grounded (literally) in project measurements.

The quantification engine simulates both the practice changes implemented as part of the project and the counterfactual (what would have happened if farmers had continued to farm with their previous practices). The difference represents the impact the project specifically generated, and does not include changes driven by seasonal variations, weather, or previously adopted practices.

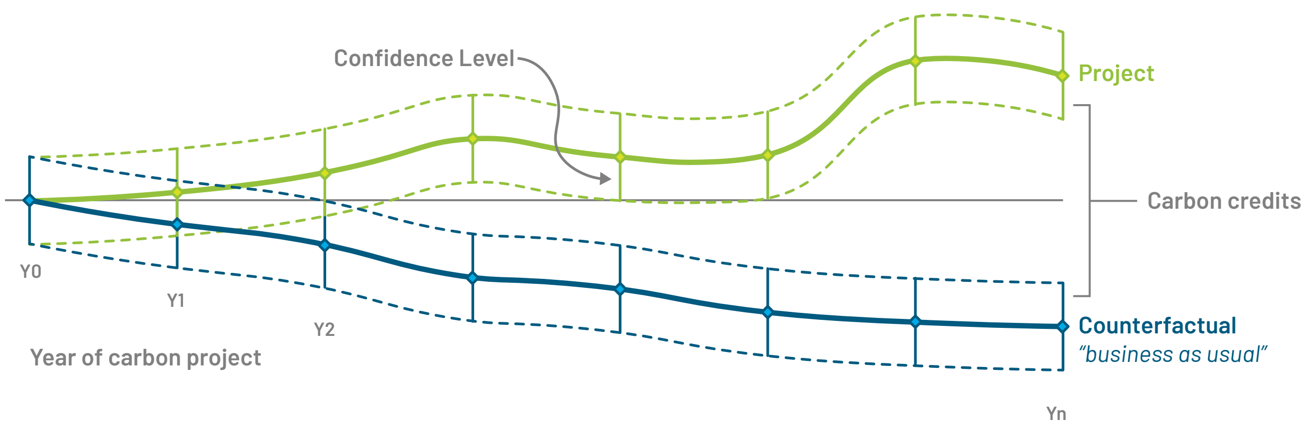
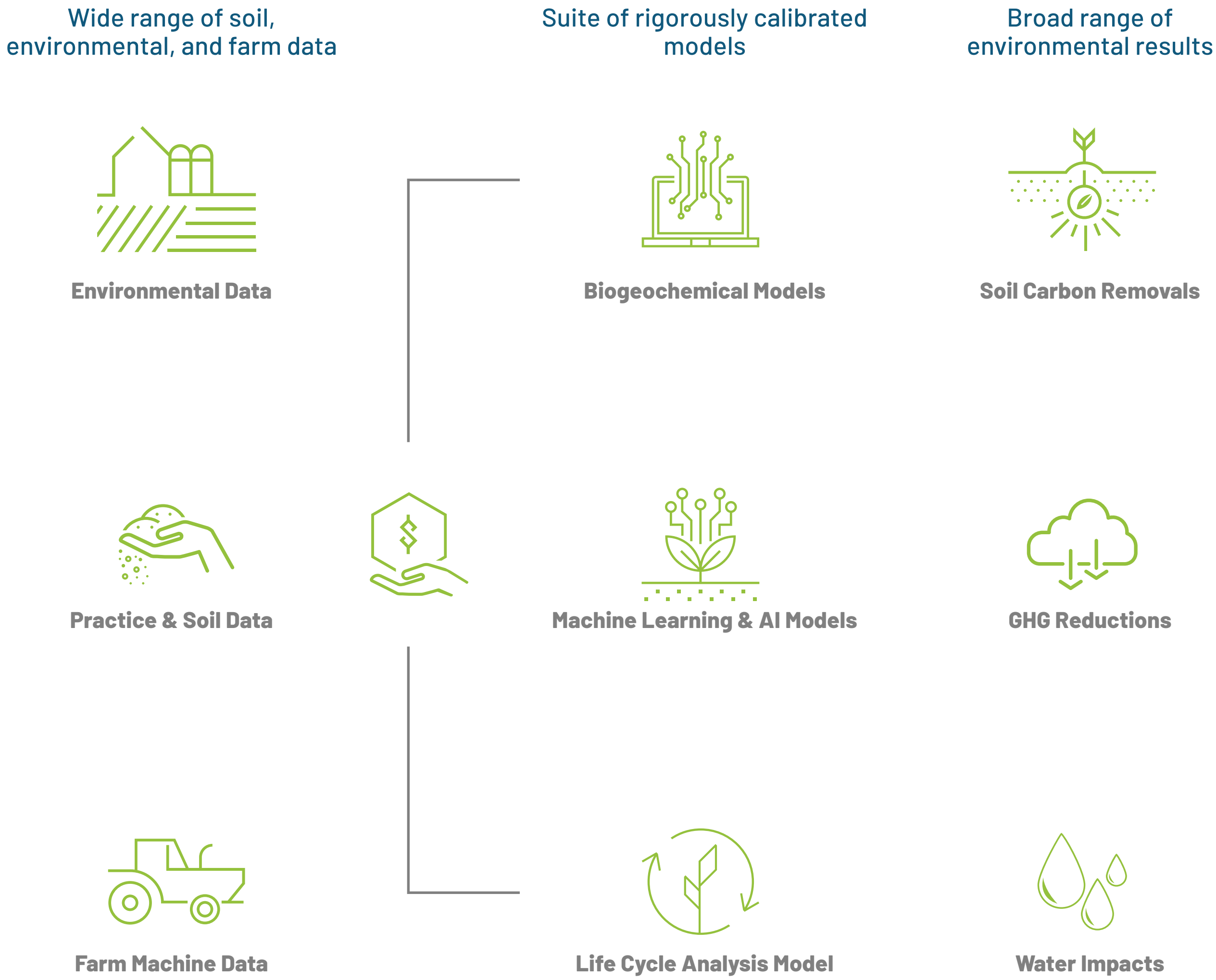


Figure 2: Net impacts measures against a dynamic baseline.

The hybrid measure-and-model approach relies on rigorous data inputs for accurate quantification. In addition to soil sampling, collecting on-farm data is important but resource-intensive for farmers. Scaling a program with farmers could come at the expense of rigor without addressing this burden, but technological innovation can successfully reduce the tradeoff. Thanks to advances in remote sensing and product design, farmers can now collect data within Indigo Ag's software in just minutes, instead of spending hours submitting information as done previously.

Figure 3: Components of a versatile montioring, reporting, and verification (MRV) pipeline.



As part of the model calibration process, Indigo quantifies an uncertainty effect from the model it uses. This uncertainty is combined with the statistical uncertainty of choosing soil samples randomly and used to calculate a project wide uncertainty deduction. This uncertainty deduction serves as a conservative protection to the realness of carbon credits generated which can instill buyer confidence. Uncertainty deductions also create an incentive for MRV providers to improve the ability of their models to capture the full variance of nature. Over the course of three iterations of modeling improvements, each with its own model validation, Indigo Ag has demonstrated continuous improvement to its MRV pipeline; reducing uncertainty and expanding the range of crops, practices, and emissions quantified by its models.

Indigo continues to monitor and support research on both measurement and modeling approaches to help each improve their scalability and accuracy. For example, spectroscopy approaches show promise as a method to reduce costs and logistics associated with traditional sampling and analysis.

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PERMANENCE MONITORING

Beyond measuring a project's impact, solutions must remove greenhouse gases from our atmosphere and store them permanently. While soils are dynamic ecosystems, and fluxes in soil organic carbon naturally occur based on weather or practices used in the field, long-term durability is possible when farmers maintain regenerative practices over the long-term. While weather and changes in land-management represent reversals risks, there are safeguards and strategies that mitigate this risk.

Within agriculture, permanence relates to stored carbon stocks throughout a project area and not in a single field. As such, permanence risk is pooled through project aggregation. While weather events and natural disasters may generate reversals in a single field, geographic spread across a large project area and monitoring permanence at an aggregate project-level can mitigate risk.

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Farmer behavior and land-use change represents another reversals risk. Regenerative practices are likely to improve a farming operation's resiliency and financial sustainability in the long-term, but farmers may experience profit loss from changing management practices upfront. Continued practice adoption throughout the transition period is important for sustained adoption and long-term durability. It's worth noting that the nature of annual cropping systems creates an opportunity for farmers to change practices and withdraw participation regularly. Supporting perennial cropping and grazing systems mitigate this risk, as these systems require decision-making on a multi-year timeframe. Regardless of the system, contractual terms and incentives that encourage continued participation across multiple years mitigate this risk. Overall, as farming operations become more financially sustainable, land-use change risk decreases.

Monitoring for reversals, whether a farmer is actively generating credits or not, and compensating for any reversals that may occur is critical for maintaining project permanence. With today's technology, it is possible to build automated remote monitoring algorithms to identify reversal events. Unavoidable reversals are commonly compensated for by registry-held buffer pools. Project developers may also hold internal buffer pools to conservatively compensate for any avoidable reversal risk. Building permanence risk into buffer pool design is a tactic to manage reversals risk. Registries like The Climate Action Reserve and Verra assign permanence risk across projects and requires project developers to contribute the corresponding percentage into a buffer pool at each issuance. Insurance products can similarly help project developers' compensation for reversal risk. With safeguards in place, soil carbon can be a solution that enables permanent carbon removals in the immediate term.

REGISTRY CERTIFICATION

The Climate Action Reserve's Soil Enrichment Protocol and Verra's VM0042 methodologies were created to address the gap of high-quality standards that enable soil to be a rigorous solution, on a similar par with other removal technologies. These protocols ensure that project developers are following rules to mitigate risks associated with the category and verify real, additional, and permanent climate impact. In addition to the summary below, more information about the registry's specific requirements around eligibility, additionality, measurement, reporting, verification, and monitoring are on their websites.

SOIL ENRICHMENT PRACTICES CREATE A SYSTEM OF FARM-LEVEL BENEFITS

Cover cropping, no-tillage systems, crop rotations, balanced input usage, and animal integration are examples of management practices that have been proven to reduce farm emissions, draw down carbon dioxide, and build carbon content in soil. These practices also generate co-benefits, including improvements to soil health, water and nutrient availability, crop productivity and yield, habitat and species diversity, and resilience to extreme weather events. Take water as an example: these practices improve water quality in rural regions due to reduced transport of sediment, nutrients, and chemicals into waterways. Cumulatively, across the first three credit issuances, Carbon by Indigo impacted more than 44 billion gallons of reduced surface water runoff, saving critical water supplies for communities. At a larger scale, these benefits mitigate climate change and improve resiliency, biodiversity, and water stewardship efforts.

Beyond the environmental co-benefits, regenerative farming creates long-term economic benefits at the farm. This has been supported by many rigorous 3rd party analyses:

- **Soil Health Institute:** an economic study on the soil health of 100 farms adopting sustainable practices (namely no-till and cover cropping) resulted in conclusive findings that net income increased by 85% of farmers growing corn and 88% growing soybeans.
- **Bain & Company:** farmers who adopt practices, including planting cover crops, reducing tillage, and rotating crops, can recognize an increase in their profit margins by as much as 30% by year six and breakeven in year three or four after experiencing modest losses in the first few years as they learn these new techniques.
- **USDA Sustainable Ag Research and Education Program (SARE):** farmers who plant cover crops can recognize a reduction of input costs, including fertilizer and herbicide spend, resulting in a positive net return by year three from cover crops alone.
- **Boston Consulting Group:** U.S. wheat farmers adopting regenerative practices (including cover crops and reduced tillage amongst other practices) were modelled to achieve 70-120% higher profitability, with return-on-investment potential of 15-25% over 10 years.

Despite long-term benefits, there are substantial financial and non-financial barriers to adoption:

- Barriers associated with existing market structures and a lack of motivating incentives to get farmers to shift practices.
- Barriers associated with whether farmers believe they can feasibly adopt new practices, implications of decisions, and their feelings towards risk.
- Barriers associated with openness to new ideas, the perceived magnitude of shifting practices, and their trust of the messenger.
- Barriers associated with the story farmers tell themselves about who they are, their values, and how they fit into their community.

The role that carbon markets can play in overcoming these barriers to adoption and scaling this solution is clear. Carbon programs reward farmers with additional revenue that can help offset concerns around adopting new practices that generate climate benefits. Carbon by Indigo has delivered a total value of $10M carbon payments directly to farmers from private capital sources (entirely independent of government funding and other initiatives) over three issuances of carbon credits. Overall, regenerative farming and sustainable program opportunities bring new revenue into agricultural communities, building increased economic returns for farmers and long-term financial sustainability that may support sustained operations for future generations.

WHAT'S STILL NEEDED?

Despite clear agronomic and economic benefits to adopting sustainable agriculture and participating in sustainability programs, adoption remains low amongst farmers due to financial, technical, and socio-cultural barriers. According to the USDA 2017 Agricultural Census, adoption rates for impactful practices, such as no-till and cover crops implementation were 20% and 5%, respectively. Buyers within the voluntary carbon market provide signals that mobilize farmers to participate and build a supply of high-quality removals. Pre-payment for offtakes and advanced market commitments facilitates incentives that specifically support farmers to overcome barriers to adoption.

While challenges remain, achieving megaton scale is within reach for Carbon by Indigo. Continued demonstration of on-farm earnings and sustained buyer demand will meaningfully catalyze supply. As buyers continue to understand this solution's potential, its associated risks, and the ways in which projects and methodologies mitigate those risks, soil carbon can become the preferred solution for companies looking to invest in high-quality climate solutions.

APPENDIX

Table 1: Detailed descriptions of cornerstone sustainable practices and their environmental & economic impacts for farmers. Sustainable agriculture improves soil health and increase drought tolerance and flood resistance, leading to more stable and higher yields for farmers. Additionally, these practices result in cost avoidance due to reduced fertilizer use, reduced input use, and reduced equipment and fuel use. Together, higher, more stable yields and cost avoidance can meaningfully impact farmer profitability.

Practice Category *Description*	**Environmental Impact**	**Economic Impact**
Cover Crops *A non-cash crop planted in the off-season to improve soil health and prevent erosion. They are generally not meant to be harvested and sold.*	(+) Common cover crops species have large plant canopies, which can physically block the sun to reduce the emergence of weeds, slow down the velocity of rainfall to reduce erosion and surface runoff, and maintain roots in the soil to prevent erosion and loss of soil nutrients (USDA NRCS). (+) All cover crops also increase organic matter, and some are legumes, which can naturally increase the amount of nitrogen in the soil (USDA NRCS).	(+) Cover crops can increase the yield of cash crops over time by reducing soil erosion and improving soil nutrient availability. USDA Sustainable Ag Research and Education Program (SARE) surveys on cover crop adoption show that yields increased from 0.5% to 3%, and 1% to 5%, over five years for corn and soybeans, respectively. (+) Many farmers elect to use herbicides for termination each year, but over time can lead to less total herbicide usage on a per acre basis. Rates and prices vary regionally, but our models indicate per acre savings of ~15% in Year 1, and ~30% from Year 3 onwards from cover crop usage. We use regional university crop product budgets as a default (Regional Surveys, Indigo Tools and Analysis). (+) Research indicates that planting a legume cover crop blend results in ~25 lbs./acre of incremental plant-available nitrogen released in Year 1 of adoption. A non-legume cover results in ~9 lbs./acre in Year 1, 13.5 lbs./acre at Year 3, and 18 lbs./acre at Year 5. This incremental plant-available nitrogen from cover crops enables less synthetic fertilizer to be applied on the same acre, without sacrificing yields. If a farmer adds cover crops and reduces nitrogen application, they have been shown to save on total fertilizer costs per acre and increase profits (Regional Surveys, Indigo Tools and Analysis). (+) Cover crops also can contribute to economics associated with pest suppression, including weeds (and thus pesticide/herbicide use). Generally, we see that in Year 1 of adding cover crops, a farmer's application and input costs will not change. However, from Year 3 of adoption onwards, there is stable reduction in equipment costs by one pass of spraying equipment and a reduction in volume of chemical inputs needed. This results in outsized economic benefits over time (Regional Surveys, Indigo Tools and Analysis). (-) Cover crop seeds add an incremental expense to farmer production operation, along with incremental spend associated with planting cover crops. Additionally, there are incremental costs associated with purchasing and applying herbicides for termination (Regional Surveys, Indigo Tools and Analysis).
Reduced or No Till *Tilling is the practice of turning or plowing soil to control weeds and prepare it for planting. Tilling can increase soil erosion and disturb the organic matter in the soil.* *Reduced or no-till requires farmers to reduce the number of times they till the soil, reduce the intensity of the tillage practice, or eliminate tillage entirely.*	(+) By adopting no till or reduced tillage practices, farmers can increase the amount of water that infiltrates into the soil and improve organic matter retention and the cycling of nutrients, thereby reducing or eliminating soil erosion (USDA NRCS).	(+) By reducing the number of tillage passes, a farmer can save on fuel costs and equipment repair (USDA NRCS). These savings depend on farmer location, but we use regional surveys in our models to calculate these cost savings (~$38 per acre of total costs for two tillage passes in planting season for Iowa farmers).
Crop Rotation *Crop rotations are planned sequences of different crops over time on the same field.*	(+) Crop rotations are a critical tool to increase the diversity of soil microbiology, reduce the impact of disease and pests, and increase the nutrients available in the soil. For example, rotating a legume crop like soybeans helps to increase the availability of nitrogen in the soil (Rodale Institute).	(+) Crop rotations can break weed, pests, and disease cycles which reduces overall input spend (Regional Surveys, Indigo Tools and Analysis). (+) Crop rotation can also increase soil health and nutrient availability, which can improve yield (Rodale Institute).
Nutrient Management *Nutrient management refers to the practice of reducing the total number of nutrient applications by moving application closer to planting.*	(+) Nutrient management improves the amount of nutrients available to a plant and reduces run-off (USDA NRCS).	(+) Nutrient management can reduce overall input costs and increase yield by making more nutrients available to the plant (USDA NRCS).

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