

Regenerative Agriculture Beyond the Farm: Why Food Systems Need a New Approach

Executive Summary

For years, regenerative agriculture has been presented as the pathway to healthier soils, resilient farming systems, and climate action. Yet the global debate has largely become polarized, with simplified narratives – organic versus minerals, productivity versus sustainability, farmers versus environment – that fail to reflect the realities faced by millions of smallholder farmers.

While there is broad agreement that agriculture must become more sustainable, there is far less consensus on how to achieve this transition at scale, particularly in regions where farmers face degraded soils, low productivity, and limited access to finance and agricultural inputs.

The International Fertilizer Development Center (IFDC) believes that regenerative agriculture will only succeed if it moves beyond a narrow focus on farm practices toward a broader transformation of entire food systems, balancing multiple priorities rather than choosing one or the other.

IFDC's approach rests on three principles:

- Regeneration begins **before the farm** with improving fertilizer innovation and reducing emissions across supply chains.
- Regeneration happens **on the farm** through integrated nutrient management and the 8R Framework.
- Regeneration continues **beyond the farm** with strengthening markets, policies, partnerships, and farmer resilience.

This integrated model aligns directly with IFDC's strategic priorities:

- Fertilizer Innovation. (Feed the Soil)
- Farmer Impact at Scale. (Fuel the Farmer)
- Sustainable Systems Transformation. (Foster the Future)

IFDC's vision for regenerative agriculture is a practical, science-based, and systems-oriented approach that simultaneously improves soil health, farmer prosperity, and environmental sustainability.

The Challenge

On-farm regenerative approaches alone are insufficient for agricultural transformation. Agriculture today faces a triple challenge:

- Feeding a growing global population.
- Restoring degraded natural resources.
- Building resilience to climate change.

More than 1 billion hectares of land are degraded worldwide, much of it a legacy of nutrient mining and tillage-intensive practice. Many regenerative agriculture approaches focus almost exclusively on changing practices at farm level, for example, through cover cropping, reduced tillage, or organic amendments. However, these practices overlook the wider systems that determine whether farmers can adopt and sustain regenerative practices. The poor nutrient balances in low-input systems routinely undermine the adoption of cover crops or crop diversification and organic amendments because yields fall during the transition period, and farmers cannot absorb that risk.

India and Africa illustrate two contrasting scales of the problem. India's fertilizer consumption has grown over 400-fold since the 1960s while its agri-food production grew only six-fold. Around 65 million metric tons (mt) of fertilizer has been consumed annually with U.S. \$25 billion in subsidies, yet India represents the world's lowest fertilizer use efficiency. This is a system of excess fertilizer applied poorly, where regeneration would mean precision, deep placement, and subsidy reform that rewards efficiency over volume.

Sub-Saharan Africa presents the opposite image: less than 20 kg of nutrients are used per hectare (compared to the global average of more than 130 kg per hectare), with over 30% of arable land degraded and yields of only 1-2 mt where yields of 4-5 mt are attainable. This is a system of chronic scarcity, thin markets, high farm-gate prices, and weak extension. Africa's regeneration demands investment in production, blending, finance, and last-mile delivery.



Neither system can be fixed through on-farm practices alone; both require systemic intervention across the entire nutrient value chain, adapted to radically different starting points. Access to appropriate quality inputs, finance, markets, advisory services, and enabling policies are not peripheral to regeneration, but are instead preconditions.

IFDC's Perspective: Regeneration Must Go Beyond the Farm Gate

Regenerative agriculture cannot be reduced to a single production approach or even a universal set of practices. Different regions require different solutions, and local contexts must guide decision-making. IFDC's approach therefore integrates productivity, profitability, resilience, and environmental sustainability, recognizing that these objectives are complementary rather than competing.

Regenerative agriculture must be founded on four interdependent pillars: soil health (physical, biological, chemical), stewardship of inputs (water, energy, plant nutrients), biodiversity above and below ground, and most critically, nutrient management. Without addressing nutrient status directly, the other three pillars cannot deliver yields or livelihoods; poor nutrient balances undermine every other regenerative practice a farmer might try to adopt.

IFDC's Field Experience

IFDC's expertise is shown across Africa and Asia, where the organization has been translating knowledge into action for decades through programs such as [Soil Values](#), a 10-year program working to establish sustainable soil fertility management in the Sahelian and Guinea Savanna regions, and [HortiNigeria](#), which worked toward a sustainable and inclusive horticulture sector in Nigeria, especially among women and youth. Other programs include [Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship \(2SCALE\)](#), an incubator program that managed a portfolio of public-private partnerships for inclusive business in agri-food sectors and industries, and [Triple Resilience \(3R\)](#), which aimed to build and strengthen social, climate, and economic resilience in Mozambique by accelerating the shift from humanitarian aid to long-term sustainable development.

Along with the data collected over numerous studies, this experience positions IFDC to present its framework for regenerative agriculture.

A New Framework for Regeneration

Before the Farm: Fertilizer Innovation – Feed the Soil

Innovation begins long before fertilizers reach farmers. At IFDC, it starts with advancing low-carbon fertilizer manufacturing, developing enhanced efficiency fertilizers, promoting circular nutrient systems, and improving logistics to reduce environmental impacts across the value chain.



Roughly 80% of global ammonia, the feedstock for urea and most nitrogen fertilizers, is brown – ammonia produced from fossil fuels (natural gas or coal) with no capture of the associated carbon dioxide. Blue ammonia is chemically identical but is paired with carbon capture and storage, lowering its carbon intensity. Green ammonia uses renewable electricity to electrolyze water into hydrogen before synthesis, a functionally zero-carbon pathway.

Global projections suggest blue ammonia production could reach roughly 21 million mt and green ammonia up to 9 million mt by 2030, against an existing brown ammonia base of approximately 190 million mt. Brown ammonia will therefore remain dominant for years, which is precisely why the *transition pathway itself*, not just the end state, is a regenerative agriculture issue.

IFDC's 2026 review, *Exploring Cleaner Pathways for Decentralized Green Ammonia Fertilizers in Sub-Saharan Africa*, argues against waiting for centralized green ammonia megaprojects, instead proposing decentralized farm- or cluster-scale green ammonia production powered by locally available renewable energy, paired with low-cost local sorbents for ammonia capture and hydrogels for controlled release. For a region with low existing ammonia manufacturing capacity and strong renewable potential, this is an opportunity to bypass brown ammonia dependency altogether rather than replicate it and decarbonize later.

On the Farm: Farmer Impact at Scale – Fuel the Farmer

IFDC believes the 4R Principles of Nutrient Stewardship has served agriculture well but is no longer sufficient on its own. That is why, alongside the new Strategy 2026-2035, IFDC has introduced the 8R Framework, which expands upon the original 4Rs (right source, right rate, right time, right place) with the addition of *recycle* (closing nutrient loops through localized circular economies), *rebuild* (rebuilding soil health and local nutrient cycling), *record* (making nutrient management measurable and verifiable), and *resilient* (withstanding climate shocks, market fluctuations, and geopolitics).

IFDC sees the 8R Framework as inseparable from its long-standing work in Integrated Soil Fertility Management (ISFM), which the organization pioneered in 1974, first promoted in Africa then expanded for global implementation. The 8R Framework is also attached to Participatory Integrated Planning (PIP), IFDC's bottom-up, farmer-centered methodology that treats farming households as co-innovators, not just recipients of advice. Together, IFDC regards 8R, PIP, and ISFM together as a single, multi-layered architecture for regenerative agriculture, wherein PIP ensures interventions are participatory and locally owned, ISFM ensures productivity and nutrient efficiency at farm level, and the 8R Framework expands this process for system-wide sustainability and innovation at scale.

On-Farm Evidence

IFDC's 2026 meta-analysis of urea deep placement (UDP)/fertilizer deep placement (FDP) across Asia and Africa found that one-time UDP/FDP raised grain yield by 14.6%, agronomic nitrogen use efficiency by 38%, and nitrogen recovery efficiency by 21.3%, relative to farmers' practices. The environmental co-benefits are equally significant: combined with nitrification inhibitors, deep placement has been shown to cut ammonia emissions by 67-90% and nitrous oxide emissions by 73-100% in independent trials, with global mitigation potential estimated at 3.86-5.47 Tg nitrogen per year for ammonia alone. Productivity and environmental performance therefore can improve together when nutrient placement, not just nutrient source, is engineered correctly.

Asia's experience with mechanized UDP offers one of the most compelling examples of the technology. Since labor has historically been the single greatest obstacle to UDP adoption at scale, mechanization is an effective solution. Building on research in Bangladesh, modified paddy transplanters and zero-till drills saved 82.8% of application time against hand placement, and across sites, mechanized UDP has enabled farmers to reduce urea use by 25-30% while raising yields by 10-20% and improving agronomic nitrogen use efficiency by 30-40%.



Combining mechanized FDP in India with organo-mineral fertilizers (locally blended organic and mineral nutrient products that rebuild soil organic matter while supplying balanced nutrition) and a digital agronomist tool that generates near-real-time, site-specific fertilizer recommendations from field-level agronomic data advances the *rebuild*, *recycle*, and *record* dimensions of the 8R Framework. This combination is one of the highest-leverage interventions in IFDC's entire portfolio and provides a replicable model.

In Nigeria, UDP trials recorded average dry season rice yields of 7 Mg per hectare against 4.4 Mg per hectare under farmers' practices, with nitrogen use efficiency gains of 40%. In Rwanda, urea briquettes combined with a fertilizer blend raised the benefit-cost ratio from 1.89 to 3.16. In Ghana, UDP was the only treatment to deliver a positive gross profit under submergence conditions. These results are evidence of the same underlying principle: placing nitrogen where and when crops can best use it works across radically different agroecologies, provided solutions are adapted locally.

These solutions are supported by soil testing, precision agriculture, digital advisory services, and context-specific recommendations.

Technology as an Enabler

Innovation accelerates regeneration. Digital advisory services, satellite-based nutrient recommendations, artificial intelligence (AI), precision application technologies, and decision-support systems help farmers improve productivity while reducing environmental impacts. Technology is not an alternative to regenerative agriculture; it is an essential enabler of it.

A strong example is IFDC's support for the [Hydro-Agro-Meteorological Information System \(SIHAM\)/West Africa Food System Resilience Program \(FSRP\)](#) program in Togo. SIHAM, along with its new program resource [Togo AgriMarket Insights](#), delivers climate, weather, and market information to farmers through digital platforms and helps farmers make better decisions, strengthen resilience, and adapt to changing conditions by providing timely, actionable insights.

Digital technologies like these can turn data into action, empowering farmers and accelerating the transition toward more productive and regenerative agricultural systems.

Beyond the Farm: Sustainable Systems Transformation – Foster the Future



True regeneration does not end at the farm level. Farmers cannot sustain regenerative transitions without enabling ecosystems that empower them and markets that reward better practices and sustainable production. This is the reasoning behind the IFDC initiatives 2SCALE and HortiNigeria, which built the market ecosystems, aggregation, finance, and buyer linkages that let farmers capture the value of improved practices.

Additionally, IFDC's Global Network of Fertilizer Innovation Centers (GNFIC) formalizes public policy, private sector capacity, and global research into a single platform for validating and scaling innovations across regions. IFDC does not believe market development, fertilizer innovation, or on-farm stewardship are sufficient in isolation; a combination is required.

Above all, lasting transformation requires strong public-private partnerships that bring together governments, research institutions, the private sector, development partners, and farming communities to scale regenerative solutions and build resilient food systems.

One World, Different Approaches

IFDC recognizes that improving soil health and agricultural productivity is a global challenge with no single global solution. Farming systems around the world differ widely in terms of climate, soil conditions, resources, and farmer needs, making it clear that locally adapted solutions are needed for regenerative agriculture.

IFDC takes this as confirmation of its position: regenerative agriculture is not a fixed technology package, but rather a decision architecture, consisting of the 8R Framework, site-specific diagnostics, digital advisory, locally appropriate fertilizer chemistry, and continual recalibration to soil, climate, and market contexts. Therefore, IFDC promotes flexible strategies that can be tailored to diverse contexts. There is no universal pathway to soil regeneration – only practical, evidence-based approaches that respond to the realities on the ground.

Our Path Forward: IFDC's Commitment

IFDC intends to draw on its 50-year legacy to scale this integrated vision of regenerative agriculture through the following.

- **Generating Evidence:** Producing localized data through programs like Soil Values and methods such as [Soil SMaRT](#) to build context-specific regenerative packages in which nutrient management is central, not incidental.
- **Developing and Scaling Innovations:** Advancing carbon-based fertilization, enhanced-efficiency products, and digital decision-support tools such as geographic information system (GIS)-based Space to Place (S2P) to make precision nutrient management accessible to smallholders, not just commercial farmers.
- **Strengthening Markets and Resilience:** Through projects like 2SCALE, 3R, and HortiNigeria, building the finance, aggregation, and market infrastructure farmers need to sustain the transition.
- **Forging Partnerships:** Working with farmers, research institutions, the private sector, and governments to mainstream nutrient management in policy and investment, globally and nationally.

Priority actions for the next one to three years include incentivizing starter nutrient packages and precision tools for early adopters; priority actions for the next three to six years include piloting smart subsidy reform and performance-based payments; and priority actions over the long term (the next six years or more) include supporting landscape restoration at million-hectare scale and integrating nutrient stewardship fully into national climate and food security strategies.



What This Means for Stakeholders

The evidence from India's fertilizer inefficiency crisis and Africa's soil fertility scarcity demonstrates that regenerative agriculture will fail at scale unless multiple actors align with a shared, evidence-based strategy. IFDC's Strategy 2026-2035 and 8R Framework are designed precisely for this alignment. The following are recommendations for each group of stakeholders.

Governments

Design policy for efficiency, not volume. Governments hold the greatest leverage over fertilizer outcomes through subsidies, pricing, and regulation. Yet policy based on volume has produced unsustainable extremes, as in India and Africa.

Requirement: Stop funding fertilizer volume; start incentivizing measurable efficiency and soil health outcomes.

Action Path:

- **Shift subsidies from price control to performance.** Link incentives to verified improvements in nutrient use efficiency (NUE) tracked via digital record systems, rewarding farmers and retailers for applying less fertilizer but with more effective placement.
- **Invest in public soil data infrastructure.** National soil mapping and digital soil testing networks are prerequisites for precision tools like IFDC's S2P. Generalized state-level recommendations are obsolete.
- **Streamline regulations for local fertilizer innovation.** Fast-track approval for low-carbon ammonia, organo-mineral blends, and local blending to lower costs and build supply chain resilience in underserved markets such as sub-Saharan Africa.
- **Integrate nutrient stewardship into climate commitments.** Include targets for NUE and emissions reduction in Nationally Determined Contributions; adopt deep placement and other 8R practices as reportable mitigation actions.



Development Partners

Fund the transition arc, not just the pilot. Development funding remains trapped in single-intervention projects. IFDC's field work shows farmers need sustained, multi-season support to transition to regenerative practices like UDP, organo-minerals, and conservation agriculture. The two- to three-year window before returns stabilize is where financing most often falters.

Requirement: Provide long-term, flexible capital that finances the entire transition from pilot to profitability.

Action Path:

- **Commit to multi-year funding cycles.** Support initiatives like IFDC's 3R in Mozambique, designed to shift communities from humanitarian aid to long-term sustainable development through sustained agronomic and market support.

- **De-risk private co-investment.** Use blended finance instruments in initiatives like 2SCALE to attract commercial capital into inclusive agri-food business models in underserved markets.
- **Fund digital public goods.** Support the scaling of digital advisory infrastructure (e.g., IFDC's digital agronomist pilots in India) as a public good, amplifying impact of all other investments.
- **Demand integrated outcomes.** Back only programs delivering productivity, resilience, and environmental gains together, such as mechanized FDP.

The Private Sector

Co-invest in innovation beyond distribution. Manufacturing and distribution are necessary but insufficient on their own. Private sector capital, research and development, and market reach are critical for scaling innovations like mechanized FDP, enhanced-efficiency fertilizers, blended organo-minerals, decentralized green ammonia, and digital advisory services.

Requirement: Move from transactional value chain participation to strategic co-investment in climate-smart fertilizer innovation and farmer-facing digital tools.

Action Path:

- **Accelerate climate-smart fertilizer investment.** Commercialize efficient nitrogen products and organo-mineral blends. Invest in lower-carbon ammonia pathways (i.e., blue, green) as competitive advantages, recognizing that brown ammonia still dominates around 80% of production.
- **Pioneer decentralized production models.** Co-fund farm-/cluster-scale green ammonia production in Africa, using local sorbents for capture, to bypass fossil fuel dependency and reach smallholders. This is a market-building opportunity, not just a technology pilot.
- **Co-develop digital decision tools.** Leverage data science and last-mile networks to build the digital agronomists that turn agronomic data into trusted field recommendations faster than public institutions can.
- **Create markets for efficiency and circularity.** Establish offtake agreements for recycled nutrient products and blended fertilizers, turning circular economy waste-to-wealth models from IFDC pilots into scalable commercial ventures.

Research Institutions

Prioritize context specificity over universals. IFDC's core finding across every cited study is: no single technology is universally superior. Sorghum trials showed product performance varied by soil; mechanization outperformed manual placement in some Bangladesh and India trials, but not all; decentralized green ammonia is right for parts of Africa but not everywhere.

Requirement: Strengthen the evidence base for locally adapted solutions and ensure research flows into practical tools accessible to extension and farmers within seasons, not decades.

Action Path:

- **Validate contexts specifically.** Move beyond universal recommendations; extend S2P mapping and decision-support tools to new agroecologies.
- **Accelerate research-to-practice pipelines.** Partner through multi-actor consortiums to get controlled trial results directly into extension and digital tools.
- **Report fully on what fails.** Understanding where a technology underperforms is critical for effective scaling decisions.
- **Expand evidence on emerging solutions.** Build data on organo-mineral fertilizers, decentralized green ammonia, and AI-enabled recommendations – areas where data is currently thin compared to established technology like UDP.

A Call to Action

Regenerative agriculture will not succeed through ideology or isolated interventions. It will succeed through science, innovation, partnerships, and systems thinking. IFDC believes the future of regenerative agriculture lies in expanding the perspective from the fertilizer supply chain to the farm, from the farm to markets, and from markets to resilient food systems. The 8R Framework, Strategy 2026-2035, and the partnerships the organization builds with governments, donors, corporations, and farmers are how IFDC operationalizes that belief.

By integrating fertilizer innovation, farmer-centered solutions, and sustainable food systems, partners and farmers can move beyond restoring soils to transforming agriculture itself.

Fuel the Farmer. Feed the Soil. Foster the Future.