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Balancing Competition and Cooperation in Agritech Ecosystems

Ashish H.K. Jha[1*], Sanjeev Kapoor[2], Avinash H.K. Jha[3], Prodyumno Mondal[4]

[1*]IIM Lucknow, PhD Scholar, ashishhkjha@gmail.com
[2]IIM Lucknow, Professor Agribusiness Management, sanjeev@iiml.ac.in
[3]Department of Financial Studies - University of Delhi, jhavinash@yahoo.co.in
[4]IIM Lucknow, MBA, mprodyumno@gmail.com

Abstract
Positioned at the intersection of digital transformation and institutional evolution, this review critically investigates the role of coopetition as a structuring logic for agritech ecosystems. The objective is to interrogate how competition and collaboration co-exist in agri-innovation networks, not as binary opposites but as co-constitutive forces mediated by governance structures, platform infrastructures, and contextual imperatives. The paper synthesizes theoretical frameworks, typological ecosystem classifications, and empirical insights to build a multidimensional understanding of cooptative ecosystem design. Through an integrated analysis of stakeholder dynamics, modular architectures, and platform governance regimes, the review demonstrates that resilient agritech ecosystems depend on adaptive governance, reciprocal transparency, and institutional legitimacy. It identifies key ecosystem types—competitive-led, cooperative-led, and hybrid-orchestrated—and presents a strategic ecosystem matrix tailored to the unique roles of startups, agribusinesses, policymakers, platform providers, and farmer-led cooperatives. The study also highlights critical ethical concerns such as digital colonization, regulatory fragmentation, and the marginalization of smallholders in data-centric innovation architectures. The article transforms coopetition from a practical method into a normative governance model that creates inclusive, sustainable digital agricultural futures that are also just. The article demands that ecosystem actors and researchers, and global institutions to transition from innovation scaling to governance scaffolding through participatory frameworks that are context-sensitive and justice-oriented.

Keywords: coopetition, agritech ecosystems, platform governance, stakeholder dynamics, adaptive governance, interoperability

1. Introduction
Agritech ecosystems represent a complex entanglement of socio-technical innovation, capital accumulation, policy orchestration, and platform governance—all coalescing in an era of accelerated digital transformation. These systems, which link startups with corporates and farmers along with research institutions and state actors, now operate through digital platforms that consolidate data exchange while managing supply chain activities through platformization processes. The agricultural transformation extends beyond technological changes because it affects both structural elements and epistemic and strategic dimensions. Agriculture now operates as a fast-paced innovation space where different stakeholder groups including orchestrators and enablers and integrators and users maintain distinct roles regarding their influence and system access and design capabilities (Chowdhury et al., 2023; Turgut et al., 2024; Rampalli et al., 2024). The dual increase of innovation and inequality has made coopetition an essential strategic approach for ecosystem actors to simultaneously compete and cooperate for value co-creation and capture. The market consolidation strategy of venture capital-backed firms relies on their data infrastructure and intellectual property (IP) whereas other companies build market share through consortia collaboration and public-private partnerships (PPPs) and their associated platforms. The authors Klerkx and Villalobos (2024) show that AgriFoodTech start-ups change food systems through structures that curtail digital autonomy, especially for small farmers and peripheral stakeholders. According to Fiocco et al. (2023), the ‘farmer adoption dilemma’

emerges because exclusionary data systems push away users who become less likely to adopt the value chain optimization systems.

The situation becomes more complex because of spatial unbalance between regions. Algorithmic governance, together with IP consolidation in North America, creates competitive-led ecosystems according to MacDonald et al. (2023). The state-led initiatives of e-NAM and Digital AgriStack in India aim for cooperative-led architecture designs, but their governance legitimacy is under ongoing scrutiny (Rampalli et al., 2024 and Interagency Agricultural Projections Committee, 2023). The mobile-first innovation ecosystem in Kenya demonstrates how institutional scaffolding helps create hybrid models that specifically include smallholders, and the Netherlands uses data-intensive high-tech approaches developed through research partnerships with the private sector (Bassine et al., 2023; Uzunoz Altan & Nabatov 2024). The worldwide differences in agritech development demonstrate that this field progresses through multiple dependent routes, which are formed by historical factors together with policy decisions and infrastructure development, and financial resources. AI-driven crop recommendations from Turgut et al. (2024), alongside integrated aquaculture-agriculture systems from Ibrahim et al. (2023), along with autonomous farming technologies from Rampalli et al. (2024) showcase both technological advancements alongside conflicting governing approaches. The direction and inclusivity of such innovations depend heavily on innovation governance, which determines both who benefits and who gets excluded and what terms they receive (Bengtsson, 2024).

The increasing academic research about agricultural digitalization fails to address key analytical issues sufficiently. The field lacks sufficient theoretical explanations about adaptive governance systems which help ecosystems adapt to developing risks without losing their ability to withstand stress. Innovation asymmetries that stem from IP regimes and venture-backed scaling models and proprietary ecosystems simultaneously increase systemic exclusion and marginalization of non-dominant actors according to Singh et al. (2023) as well as Anwer et al. (2023). The ethical side effects of asymmetries in agritech systems have received limited treatment from academic authors who study this field. The main barrier exists in the field of data interoperability because this infrastructure provides the technical interoperability requirements and policy framework that permits different digital systems to transfer agricultural data. The fundamental requirement of interoperability stands as a basis for fair collaboration but faces both competition-based barriers alongside organizational governance disagreements. The absence of common digital protocols alongside trust frameworks creates conditions for data ecosystems to isolate into inaccessible, siloed systems, which deepen social inequalities. PPPs, together with community data cooperatives, try new approaches for mutual data disclosure and member legitimacy to build better digital resources. The review article investigates how digital innovation environments with agritech ecosystems tackle the competing forces between competition and cooperation within their operational framework.

Review Objectives

1. To critically synthesize the strategic, institutional, and ethical dimensions of coopetition within digitally mediated agritech ecosystems across diverse geopolitical contexts.
2. To develop a typology of agritech ecosystems based on governance logics, stakeholder roles, and innovation architectures, highlighting power asymmetries and coordination challenges.
3. To propose a context-sensitive strategic framework that enables adaptive governance, stakeholder legitimacy, and balanced value creation in agritech innovation networks.

2. Theoretical Foundations

2.1. Agritech Ecosystems: A Multistakeholder Innovation Landscape

Contemporary agritech ecosystems function as socio-technical assemblages where innovation emerges not within isolated organizations but through dynamic, multistakeholder interactions. These ecosystems comprise a wide spectrum of actors—including venture-funded startups, transnational agribusinesses, smallholder collectives, policy institutions, and public research bodies—

interconnected through a shared technological and institutional infrastructure. Unlike traditional agri-value chains, agritech ecosystems are characterized by modularity, where various subsystems such as satellite monitoring, cloud-based farm management, and AI-driven advisory tools operate semi-autonomously but remain interdependent. This modular architecture facilitates parallel innovation and localized specialization while enabling broader systemic coordination.

Orchestration within these ecosystems is a function of both institutional intent and technological capacity. Public innovation platforms, corporate intermediaries, and hybrid governance alliances often assume the role of meta-governors, managing knowledge flows, technical standards, and financial resources. However, orchestration is not neutral. The authors Klerkx and Villalobos (2024), together with Singh et al. (2023), state that this phenomenon demonstrates significant structural asymmetries affecting capital access and data infrastructure alongside policymaking influence. The structures of intermediation through platforms and standards carry embedded power along with their built interfaces, which determine both innovation pathways and what types of knowledge will receive value. The agritech ecosystem operates as more than an interconnective network since it functions as a place where opposing forces negotiate and compete while establishing their political and economic status.

2.2. Coopetition Theory and Ecosystem Strategy

Agritech ecosystems now use coopetition as their strategic framework, which combines elements of collaboration and competition. Brandenburger and Nalebuff first introduced the coopetition concept, which now explains how high-tech ecosystem participants generate shared value through collaborative efforts that lead to competitive value appropriation. Agritech's competitive and collaborative system exists as an organizational foundation because stakeholders need common digital systems and endure regulatory discrepancies in addition to high development expenses. The theoretical models of cooperative game theory demonstrate how platform leaders and startups work together in ecosystem innovation but strive to gain distinct market powers, including monopoly data control, while achieving market domination, according to Granstrand (2024).

The two competing strategic goals create profound strategic conflicts. Participating actors gain advantages from joining open consortia, public R&D partnerships, and pre-competitive alliances because these structures speed up innovation and validate their platforms. The same actors implement defensive IP measures while blocking data exchange between systems and accelerate platform expansion to control particular agricultural sectors. The dual approach of collaborative innovation and competitive dominance becomes evident through policy initiatives such as India's Digital AgriStack and Australia's innovation accelerators (Farsani et al., 2024; Kumar et al., 2024). New academic research demonstrates that coopetition operates through both inclusion and exclusion dynamics. Startups use peer innovation as a survival mechanism to counteract capital inequality and dominant player control of their ecosystems, according to Primario et al. (2024). The strategic positioning of businesses within ecosystems is structured by coopetition, which also determines their access to governance participation and innovation equity and their legitimacy within the ecosystem.

2.3. Platform Governance and Digital Agriculture

Platform governance represents the primary method that coordinates innovation within digital agriculture. Platforms operate as institutional actors beyond enabling market efficiency because they establish institutional governance mechanisms that use algorithms along with protocols and access rules, and data classification systems. The implementation of digital agricultural systems leads to fundamental doubts about individual freedom and the proper representation of actions within these systems. Agricultural platforming includes two approaches to governance, which differentiate between corporately led centralized systems that monitor entire operations from top levels and stakeholder federated systems built on standardized infrastructure (Wolfert et al., 2023; Zhang et al., 2023).

Economies of scale are possible with centralized systems, yet they maintain structural dependencies, especially during times of limited resources when smallholders, along with cooperatives, have limited bargaining power. Computer systems create long-term data dependency while keeping algorithm workings undecipherable alongside exclusive access to analytical infrastructure. The construction of federated platforms such as GAIA-X in Europe and e-Choupal in India seeks to establish governance models that promote inclusivity as well as resilience and involve multiple stakeholders. The promise of federation remains unfulfilled because of insufficient standards enforcement and fragmented policy requirements and technological disparities according to Dutta (2021) and Bruni et al. (2025).

Platform governance of agritech requires decisions about valid knowledge, assignment of algorithmic expertise, along with defining and enforcing sustainability measurement criteria. Agricultural data sovereignty and computerized system operation methods unite with wider conflicts about land rights and food independence. The administration of agritech platforms requires both platform technical operations and the contestation of standards regarding their principles. Digital agriculture sustainability and equity advancement demands major changes in innovation models according to Lammi (2024) and Orlova and Nikolaev (2015) because it should move towards participatory governance systems with increased trust and transparency and negotiation-based legitimacy.

3. Stakeholder Dynamics and Power Structures

3.1. Stakeholder Typology and Ecosystem Roles

Industrial tech ecosystems demand beyond basic actor segments for stakeholder identification because we need typology-based models that analyse specific capabilities and functions and influence patterns of digitally connected innovation structures. The four main stakeholder categories include enablers, orchestrators, integrators, and users. The enabler category consists of financial institutions, together with policy bodies and NGOs, which deliver infrastructure and policy direction and capacity-building services. The process of ecosystem evolution under Orchestrators is controlled by their standard-setting and interface coordination activities, which they perform from their roles as platform owners or public agencies. The integration process performed by tech developers and agri-entrepreneurs connects different layers to create usable applications that users (mainly farmers and cooperatives) utilize in their operations (Monticone et al., 2024).

The neat classification system reveals extensive unbalanced control structures throughout these groups. The distribution of power among groups in the agricultural value chain shows corporate actors holding data platforms and controlling supply chains to have significant advantages over farmers, who mainly make up user segments (Shao et al., 2024). Platform governance activities from farmer cooperatives remain nominal because they lack technical abilities and financial strength, as well as institutional representation needed to negotiate fair arrangements for data sharing and algorithm transparency. The structures of technological networks enhance central positions of powerful actors who restrict peripheral users to maintain low-agency roles (Monticone et al., 2024). Modern participatory innovation needs a new strategy to transform stakeholder inclusion into contests of power within the advancing digital infrastructure framework.

3.2. Competitive Strategies in Agritech

Agritech industry competition exists through three main factors including strong intellectual property management practices as well as venture capital investment tactics and business consolidation via platform infrastructure. The startup funding environment promotes quick scalability above all else thus startups develop platform-driven operations that use proprietary data with restricted APIs and vertical analytics as their most valuable competitive tools (Bethi & Deshmukh 2023). The model stimulates novel ideas while blocking information exchange, which generates both social equality questions and long-term operating problems. National ecosystems experience competition based on geographic factors. Israel focuses on precision agritech and water-saving technologies via heavy investments, and India employs e-NAM platforms alongside AgriStack public infrastructure, and the

Netherlands organizes its agricultural sector through high-tech greenhouses which stem from institutional research networks, according to Yoganandham (2024) and Dutta (2021). Strategic development logics underpin these models, which have distinctive effects on innovation distribution goals and worldwide market penetration ability as well as policy integration capabilities. Startups typically participate in strategic deals with major established corporations as they seek to join value chains by providing modular components. The co-optive strategy allows startups to gain market access and capital inflow, yet it diminishes their ability to develop disruptive innovations (Dhivya & Monika, 2024). In agritech, the competition focuses more on ecosystem placement and industry standard creation, and control of data systems alongside analytics cycles instead of market size dominance.

3.3. Cooperation in Practice

Agritech ecosystem competition depends on institutionalized cooperation that occurs through public-private partnerships, along with consortia and data sharing agreements between multiple stakeholders. Agricultural businesses engage in short-term basic public-private partnerships to create long-term strategic coalitions that support national innovation agendas and sustainable development objectives. Hartwich et al. (2008) and Srikanth et al. (2025) explain that effective PPPs include partnerships that enable simultaneous technological development through joint governance structures combined with defined benefit-sharing plans. The seed certification, as well as market linkage, along with digital extension initiatives of India, demonstrate ongoing efforts to establish grassroots participation within the innovation core. Shared technological platforms that construct open-data archives and IoT sensor networks function as important infrastructure for multiple stakeholders' innovation. The models transition cooperation away from traditional contracts to an architecture-centered framework, which determines the distribution of trust and innovation responsibility and accountability standards (Shao et al., 2024).

However, cooperation is not frictionless. Alliance incentive challenges continue as one of the main obstacles that occur when actors possess different time perspectives alongside dissimilar risk tolerances and knowledge structures. When institutions are weak, implementation of cooperative work can reduce to ceremonial interactions controlled by donors or lose meaning through empty compliance activities. The future development of agritech cooperation requires collective governance models implementing balanced strategies that connect market incentives to promote equity to achieve sustainable innovation results.

4. Coopetition Mechanisms and Models

4.1. Alliance Structures and Innovation Networks

Agritech ecosystems implement strategic alliances and innovation networks as functional value generation methods and as foundational structures through which technological directions, along with institutional validation and scientific expertise, arise and encounter conflict. Syngenta's ecosystem demonstrates the data integration between stakeholders in digitized agriculture through which the corporation maintains full control of market forces and proprietary information aggregation. The API-based integration mechanisms, along with customizable services, enable ecosystem access, yet the proprietary analytics alongside restricted feedback operations reduce true co-creation potential (Goodman, 2023). The pre-competitive public-good research operations of CGIAR engage in distributed experimentation and climate-resilient varietal development throughout their global research coalitions that weave into Southern national innovation networks. ITC's e-Choupal represents an alternative platform alliance based on trust broker intermediaries who help rural users translate digital potential into embedded social knowledge networks as described in Bakshi (2023). The alliances transform NGOs and universities from peripheral supporters into epistemic intermediaries and legitimacy brokers according to Lewandowski & Czech (2024). The combination of universities with their reflexive governance practices and normative accountability mechanisms

pairs up with NGO operations for platform-based inclusion models. Experienced hybrid entities that combine organizational elements from different sectors dismantle traditional beliefs about innovation authority while proving that institutional entities across boundaries are essential for sustaining inter-cooperative models.

4.2. Data Platforms and Interoperability Frameworks

The use of data-driven farming requires interoperable digital infrastructure despite the fact that these systems typically lack neutrality or reach users equally. Multiple stakeholders use interoperable data systems to construct shared infrastructure layers for agricultural innovation through which they can develop satellite-linked soil analytics and real-time weather systems, and disease surveillance networks. There are multiple barriers preventing data interoperability in real-world situations because data silos exist with incompatible schemas and when governance models lack symmetry (Kroupová et al., 2025; Thilakarathne et al., 2025). The rising need for interoperable platforms from precision agriculture has led to monopolistic control through dominant actors who keep operating interfaces open for modular applications while blocking access to proprietary backend analytics and data, according to Goodman (2023). The mismatch of political policies between jurisdictions results in governance barriers that slow down the process of establishing data compatibility across national borders. The interpretation of interoperability needs to progress from technical aspects to include integrative institutional frameworks alongside equal infrastructure provisions and a clear principle of transparency.

4.3. Smart Contracts, Blockchain, and Trust Systems

Blockchain, along with smart contracts, works to establish trust frameworks for digitally fragmented agritech innovation systems. Through these tools, businesses can achieve automated agreement execution alongside decentralized record tracking, direct connection across supply chains as well as financial service institutions. The technology finds applications in verifying land titles and providing dynamic crop insurance and tracking certified inputs (Puthenveettil & Sappati, 2024). Blockchain's potential as a general trust instrument overlooks fundamental differences between digital users' technical expertise level and their countries' technological autonomy, along with their capacity to handle new systems. Apeh and Nwulu (2025) explain that blockchain technology improves auditability but creates its challenges through operational opacity, which occurs when blockchain systems lack transparent algorithmic governance. Santa Bernardo de Santarém et al. (2017) demonstrate that smart contract inflexibility deepens exclusion in environments lacking reliable internet and facing social instability since these systems lack mechanisms to obtain user approval or provide remedies. According to Mokgomola et al. (2024), blockchain protocols should operate inside combined human-focused systems of accountability, which incorporate cooperative data control and participatory algorithm creation.

Users engage with coopetition systems through complex institutional architecture, which creates a supportive structure that enhances various cooperation mechanisms. The operational success of these mechanisms depends on the quality of alignment with specific governance requirements and on the redistribution of knowledge, authority, and enabling mutual developmental activities between different ecosystem participants. These mechanisms embed the coopetition paradox into digital agriculture systems so they become its foundational operational principle rather than resolving competitive-cooperative tensions.

5. Challenges, Risks, and Ethical Concerns

5.1. Inclusivity vs. Extraction

The dual nature of agritech innovation demonstrates its double function between empowerment of users as well as its capacity to exploit through innovative technological applications, particularly in inclusive practices. The data-collection mechanisms of digital agriculture acquire more and more characteristics of data extraction as smallholder farmers become sources of raw information without

governing status in their controlled value chains. Abdulai et al. (2023) demonstrate how digital platforms come to African smallholders with design elements that originate outside their communities. The platforms focus on data transmission to higher levels of institutions while disregarding local information systems, which results in exploitative practices that hide behind technological progress.

Agrarian restructuring through digital platforms creates a pattern where leaders using tech firms and financial institutions promote inclusivity while developing control systems for infrastructure and algorithms. According to Wolfert et al. (2023), centralized decentralization defines this type of governance through interfaces that obscure important differences in power dynamics, including decision-making processes and value assessment, and technological authority. True inclusion requires thoughtful control of digital value design processes, combined with governance administration along with redistributive capacity over digital value systems.

5.2. Regulatory and Institutional Gaps

Agritech governance exists within a fragmented regulatory matrix that lags far behind the pace of digital innovation. This vacuum exacerbates systemic vulnerabilities, allowing dominant actors to shape norms, concentrate value, and resist accountability. The absence of global and local policy harmonization on issues such as data localization, cross-border platform regulation, and IP rights renders ecosystem-wide governance ineffective and uneven (Change, 2023). Fuglie and MacDonald (2023) demonstrate that the extension of IP protections to software and biological assets has entrenched monopolistic control over critical agri-inputs and analytics infrastructure. The platform economy's expansion into agriculture further complicates traditional regulatory categories, requiring antitrust tools to be reimagined for multisided markets that blend infrastructural power with informational asymmetry (Watson & Winfree, 2022). Without such revision, regulatory inertia becomes a tool of consolidation.

Moreover, the regulatory status quo disproportionately benefits well-resourced firms with cross-jurisdictional legal capacity, while excluding smaller players from setting or even understanding the rules that govern digital participation. To address this, regulatory reform must adopt an anticipatory rather than reactive stance, crafting adaptive legal infrastructures capable of governing fast-moving, heterogeneous, and geopolitically entangled ecosystems.\

5.3. Cultural, Social, and Institutional Barriers

Digital transformation initiatives for agriculture need to recognize that their success relies on the socio-cultural context of trust, plus power distribution, as well as historical experiences of marginalization. Farmers choose to either reject or adopt digital technologies because of unresolved knowledge gaps and unclear data management practices, and insufficient understanding of how these systems fit their local needs (Abdulai et al., 2023). Digital interventions face stronger resistance when implemented into new systems using centralized decisions that disregard community cultural frameworks, together with their organizational patterns and heritage. The success of digital initiatives in these situations depends on institutional entrepreneurs who understand how to connect different logics and transform digital systems into local stories and serve as intermediaries between state institutions and market forces, and community needs (Schut et al., 2017). The donor-established frameworks that control the work of institutional entrepreneurs restrict their capacity to achieve transformational change. Full-scale transformation needs investments beyond hardware or applications to develop institutional frameworks that support meaningful encounters and interactive and co-development activities. The innovation platforms should function as spaces for negotiation between commercial and community-led, and ecological agritech visions to allow their institutional embedding. The ethical and risk-related issues within agritech systems emerge from the political and social structures that incorporate technology rather than the technology itself. A shift towards

transformational governance based on pluralistic approaches to justice and ecology represents the key solution for addressing these challenges.

6. Strategic Framework for Balanced Ecosystem Design

6.1. Principles for Resilient Coopetition

A framework combining governance adaptability with infrastructural modularity and procedural transparency, and participatory legitimacy within strategic design enables understanding of resilient coopetition in agritech ecosystems. The elastic nature of institutions in a resilient agritech ecosystem enables navigation of external disruptions and internal dissent, which arise through technological revolutions and climate anomalies or political disputes, according to May (2022) and Schneider et al. (2021).

The process of adaptive governance involves institutional learning along with regular adjustments of actor roles as well as adaptation of responsibilities across temporal and spatial dimensions. The modular architecture system functions simultaneously as a design principle for systems and a decentralization method for authority distribution, which divides governance into flexible, interoperable units. The modular structure provides agility as well as accountability because actors can follow defined interfaces to navigate through the ecosystem.

Open data must be accompanied by institutionalized mutual disclosures of governing algorithms and administration processes, and terms of benefit sharing. Stakeholders gain legitimacy through formal collaborative processes of co-design as well as institutional systems of opposition and integrated stakeholder participation. The practice of resilience operates proactively as an institutional capability that merges plural systems with clear standards.

6.2. Ecosystem Typology

Agritech ecosystems are not monolithic; they exhibit typological divergence based on actor configuration, innovation logic, and coordination regime. Three dominant archetypes are evident. First, competitive-led ecosystems, primarily fuelled by venture capital and private equity, prioritize scalability and IP capture. These ecosystems, prevalent in the United States and Israel, are characterized by proprietary platforms, closed data architectures, and winner-takes-most dynamics (Genome, 2022). They produce high innovation throughput but concentrate benefits, marginalizing smaller players and non-technical stakeholders.

Second, cooperative-led ecosystems are grounded in institutional public goods logic—prioritizing knowledge commons, community ownership, and shared benefit. Examples include international research coalitions such as CGIAR or regional agroecological hubs. While their inclusivity and epistemic plurality are strengths, these ecosystems often lack the capital influx, market orientation, or scalability mechanisms needed to shift sectoral baselines.

Third, hybrid-orchestrated ecosystems—exemplified by FAO–WFP–CGIAR networks or India's AgriStack—blend elements of both. These ecosystems operate through negotiated institutional architectures that integrate public oversight, private innovation, and civic participation. Their advantage lies in institutional complementarity; their weakness lies in coordination complexity, where overlapping mandates and fragmented ownership structures hinder long-term resilience (Keith et al., 2020).

6.3. Ecosystem Strategy Matrix

A strategic framework development process requires separate planning for different participant groups. The proposed strategy matrix enables startups and agribusinesses and policymakers and platform providers, and farmer-led cooperatives to identify specific intervention points by positioning them in different ecosystem types. New startups must create their strategic framework by implementing ecosystem docking approaches that develop modular components that work with core infrastructures yet maintain collective administrative control. Stakeholders should unite with

standard-setting forums and cross-sectoral coalitions to support plural IP regimes that reward co-invention (Bethi & Deshmukh, 2023). Agribusiness operations must migrate from running platform control systems to ecosystem protection frameworks. Companies need to adopt interoperability standards and data commons governance by all stakeholders and multi-participant procurement systems to reach this goal. Such strategic moves help organizations establish system stability and build market timeline trust between participants. Public officials need to establish regulatory polycentricity by uniting national laws with local regulations and international agreements through governance systems that support equitable innovation development (Ali et al., 2025). The government should apply data management guidelines while disclosing algorithm information, while create specialized protections for platforms against antitrust activities that target this business model. The leadership of orchestration, along with platforms, must transition from supplying services to taking responsibility for their infrastructure. The approach requires governance democratization for backends while providing governance APIs for third-party connection in addition to dispute resolution tools, which rely on local legitimacy. The agricultural cooperative movement needs to evolve into epistemic actors because they possess native agroecological expertise and durable farming system intelligence. The strategic backing of these actors requires more than digital literacy support because it needs participatory innovation labs and cooperative-owned platforms, and funding for decentralized experimentation (Singh et al., 2024). This framework situates ecosystem strategy not as technical optimization but as a political and institutional project—one that acknowledges the contested nature of innovation and positions governance as the primary locus of sustainable transformation. True balance in agritech coopetition is achieved not through equilibrium, but through structurally embedded pluralism, adaptive capacity, and equity-driven orchestration.

7. Global Perspectives and Contextual Variations

Understanding the global dynamics of agritech coopetition requires critical attention to how regional ecosystems encode technological innovation within historically contingent, politically charged, and structurally uneven institutional contexts. The premise of globally replicable agritech architectures is increasingly untenable; instead, coopetition must be seen as an adaptive institutional logic, conditioned by sociopolitical histories, infrastructural capacities, and the cultural embeddedness of innovation regimes. A comparative analysis of India, Kenya, and the Netherlands illuminates three divergent trajectories of agritech ecosystem design, each demonstrating how coopetition can enable or constrain inclusive innovation.

Table 1. Typological Comparison of Regional Agritech Ecosystems and Their Coopetition Dynamics

Region	Ecosystem Model	Key Features	Challenges
India	Hybrid-Orchestrated	State-led platforms (e-NAM, AgriStack), centralized governance, market integration	Platform paternalism, smallholder exclusion, weak pluralism
Kenya	Polycentric, Entrepreneurial	Mobile-first innovation, distributed networks, NGO-led digital tools	Ecosystem fragmentation, limited interoperability, and policy gaps
Netherlands	Strategically Coordinated	Public-private R&D consortia, precision farming, national standards for data and sustainability	High entry barriers, path dependency, and epistemic closure

Sources: *Singh & Alagawadi (2021); Patnaik (2024); Elliot (2023); Kim (2022); Berkers & Geels (2011); Dayıoğlu & Turker (2021)*

In India, digital agrarian transformation has been spearheaded through state-centric architectures like the *Electronic National Agriculture Market (e-NAM)* and the *Digital AgriStack*. These platforms represent attempts to engineer market transparency, data integration, and financial inclusion at scale. However, the centralization of governance and data infrastructures has raised concerns about institutional asymmetry and farmer marginalization. Singh and Alagawadi (2021) argue that while e-NAM rationalized market linkages, it remains structurally biased toward market-integrated actors. Patnaik (2024) extends this critique by underscoring the risk of platform paternalism, wherein top-down governance may obscure smallholder needs, limit consent over data, and reproduce patterns of

agrarian exclusion. The Indian model thus reflects a hybrid orchestration regime, marked by state ambition and private sector alignment but hampered by fragile institutional pluralism.

Agritech development in Kenya operates through an entrepreneurial framework based on mobile startups and civil society organizations, and informal cooperative networks. An infrastructure system based on mobile penetration operates within the ecosystem to enable actors who create locally appropriate tools in distributed networks (Elliot, 2023). Such a system preserves embedded connections in its context but shows reduced stability together with increased network segments. Without centralized data governance, the nation faces useless digital storage systems that prevent cross-system connections while making national data vulnerable to single-provider control. The open competition framework Kenya implements carries positive potential alongside possible challenges because network speed depends on strong policy frameworks.

The Netherlands demonstrates a strategic ecosystem coordination system that stems from its long-standing strong state-market-science partnership. The Dutch agritech model was developed through successive institutional learning cycles between government entities and research institutions, and cooperatives that co-evolved precision agriculture standards and sustainability benchmarks, and innovation funding mechanisms according to Kim (2022) and Berkers and Geels (2011). This arrangement actively designs regulatory systems to establish data exchange standards and intellectual property management protocols, as well as operating environment connections. The strong interconnected structure of the Dutch model leads to issues regarding entry restrictions and paths continuing in place while shutting down alternative ecological agricultural systems.

These cases collectively illustrate that coopetition is not a universal algorithm but a site-specific negotiation of technology, governance, and power. Contextual governance—defined as the strategic alignment of innovation design with institutional capacity, cultural resonance, and developmental priorities—is thus the linchpin of resilient agritech ecosystems. As Dayıoğlu and Turker (2021) assert, realizing the promise of Agriculture 4.0 necessitates moving beyond techno-optimism to construct situated innovation infrastructures that are reflexive, equitable, and ecologically just. Instead of global blueprints, what is required is a typology of governance-responsive coopetition architectures that foreground institutional agency, grassroots legitimacy, and adaptive capacity.

Conclusion

The objective of this review has been to demonstrate that the evolution of agritech ecosystems is neither linear nor ideologically neutral. Rather, it is defined by a persistent and generative paradox: the need to reconcile the centripetal logics of market competition with the centrifugal demands of systemic cooperation. This tension, far from being a flaw, is a constitutive feature of the digital transformation of agriculture. In contemporary agritech landscapes, coopetition emerges not as a transitional strategy but as a foundational institutional logic—a dynamic through which stakeholders coordinate, contest, and co-produce innovation in an environment marked by asymmetry, fragmentation, and opportunity. Theoretical, empirical, and conceptual analyses presented throughout this article reveal that coopetition cannot be adequately captured by simplistic binaries or linear frameworks. The agritech infrastructure operates as a system of relations because it distributes power and mediates knowledge, and designs the moral and physical agricultural innovation landscapes. Ecosystem management success does not require technological progress because proper governance needs reflexive ability and modular institutions combined with ethical responsibility. Cooperation among ecosystems during disruptive events requires two essential traits that incorporate both democratic governance systems and redistributive justice and sustainability advancement elements. Agritech development depends on governance systems that build innovation sustainability by using institutional and pluralistic frameworks that identify and meet social needs. The current circumstances demand that stakeholders reassess their strategic positions. Ecosystem builders must establish ethical frameworks that defend consent and enhance participation alongside awareness of local characteristics. Local understanding has become their main duty. Academic researchers must broaden

their techno-economic optimization research to political epistemology to understand which entities control innovation definitions. Whose knowledge systems are valorized? Which authorities maintain authority over defining future visions, and who yields power to forge such future directions? Global institutions and multilateral funders, too, bear responsibility. Institutional scaffolding development should be their priority because it establishes protocols and platforms for inter-difference collaboration to prevent system monotony. Partnerships need to adopt open standards and locally developed policy development and governance test sites that actively involve marginalized populations in digital agricultural policy formation. Strategic grammar defines coopetition as a governing system that manages complexity through sustainable development and fair innovation practices and environmental sustainability. The following objective demands the development of coopetition as a normative framework to integrate technology into social structures for collective agricultural development under planetary threats.

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