From Biosafety to Attention: A Scoping Review and Controversy Mapping of GMO Governance in the Andean–Amazonian Region

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In mid-2020, a brief video from Virgilio, a world-renowned restaurant chef, circulated widely in Peru claiming that *los sabores del mañana* could disappear if genetically modified crops replaced native potato varieties. Although the clip was later clarified as a symbolic provocation, it sparked a national debate that extended far beyond the message's truth value. It raised questions about agrobiodiversity loss, seed sovereignty, cultural identity, and the institutional responsibilities involved in approving or restricting biotechnology. The intensity of the public response revealed what Stengers (2015) calls a *controversy*: a situation that thickens the present by obliging societies to attend to the consequences of their decisions, the distribution of risks, and the forms of authority through which knowledge circulates.

Such controversies are especially visible in the Andean–Amazonian region, where GMOs are not merely technological artifacts but political–epistemic events. They unfold in contexts marked by Andean agrobiodiversity, Amazonian ecological interdependence, coastal food systems, and long-standing struggles over land, identity, and scientific credibility. In these settings, the classical separation between facts and values is untenable. As Latour (2005) argues, scientific facts are inseparable from the networks (bureaucratic, scientific, territorial, and public) through which they are enacted. Haraway's (1991) notion of situated knowledge further emphasizes that responses to biotechnology depend on historically embedded experiences of vulnerability, marginalization, and ecological interdependence. In this sense, GMOs make visible different grammars of responsibility: from pro-innovation frameworks that foreground efficiency and global competitiveness, to critical socio-environmental perspectives attentive to inequality, contamination, and extractive agrarian regimes, to operational–methodological approaches focused on bio-surveillance, traceability, and regulatory harmonization. These broad perspectives structure the field and coexist tensely rather than forming simple binaries.

The Andean and Amazonian regions amplify these tensions. Peru, for example, sits at the intersection of Andean agrobiodiversity, Amazonian ecological complexity, and coastal food systems. This geopolitical and ecological triad turns GMO governance into a regional controversy embedded in broader struggles over seed sovereignty, scientific authority, institutional credibility, and the cultural significance of food. The 2020 *#LosSaboresDelMañana* campaign, misinterpreted online but influential in public debate, illustrated how a symbolic provocation about the potential disappearance of native

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potatoes could trigger national conversations about biodiversity loss, cultural heritage, and the demand for "public proof" before altering living systems at scale. The regulatory update issued in 2023 — via the Supreme Decree 012-2023-MINAM — formalized the moratorium on GM organisms in Peru until 2035, highlighting a shift in governance from static prohibition toward practices of attention, transparency, and collective accountability.

Although research on GMOs in Andean–Amazonian countries is extensive, it remains analytically fragmented across regulatory, technological, political-economic, socio-environmental, and ethical rationalities. Faced with this dispersion and the absence of a unifying synthesis, we conducted a scoping review to map and organize this heterogeneous field systematically and to illuminate the political–legal–institutional dimensions of GMO governance in the Andean region and the Member States of the Amazon Cooperation Treaty Organization (ACTO). Our analysis shows that existing studies draw on diverse categories — governance and regulation; biosafety and risk assessment; political economy and intellectual property; labeling and monitoring; social participation and conflict; innovation; and ethics, justice, and rights. They also position themselves differently in the debate, ranging from technologically and economically pro-GMO, to regulatory-focused or neutral, to critical socioeconomic/political-ecological or health-risk-based perspectives. To synthesize these disparate orientations, we ask: How are debates on GMOs structured in the Andean–Amazonian region across three major governance dimensions — (1) Governance, Politics, and Institutional Legitimacy; (2) Risk, Technical Control, and Biosafety; and (3) Knowledge, Ethics, and Scientific Reflexivity — and how do texts align with distinct discursive positions within these dimensions?

Our objective is not to settle the ontological or normative status of GMOs, but to characterize the institutional, legal, and political conditions that shape their governance — following Stengers's (2015) proposal that characterization functions as a method for preserving openness, consequence, and public responsibility when engaging with complex problems.

Research Design and Method

Purpose and type

The study aims to clarify how different rationalities are articulated, mobilized, contested, and stabilized in contexts where scientific authority, cultural heritage, ecological interdependence, and seed sovereignty intersect. By synthesizing these diverse bodies of evidence, the study develops an analytical framework that makes visible the configurations and patterns that structure GMO governance in the Andean–Amazonian region.

We conducted a scoping review to develop a unifying framework and offer insights into the political-legal-institutional dimension of Genetically Modified Organisms (GMOs) in the Andean region and the Member States of the ACTO. Scoping reviews have increasingly been recognized in management and organization studies (e.g. Bolino, Henry & Whitnay, 2024; Watson et al., 2025) as rigorous methods for mapping fragmented or interdisciplinary fields (Kunisch et al., 2023; Watson et al., 2025).

A scoping review maps the breadth, depth, and boundaries of a body of knowledge, prioritizing the identification of themes, gaps, and types of evidence. It is particularly suited for topics with a broad scope that have not been comprehensively reviewed before. Following the methodological framework of the Joanna Briggs Institute (Peters et al., 2015) and the reporting recommendations of the PRISMA-ScR extension (Tricco et al., 2018), we registered our PRISMA-P–formatted protocol in the Harvard Dataverse repository (https://doi.org/10.7910/DVN/4HTMPY), ensuring transparency, reproducibility, and public auditability of all procedures.

Although some reviews have addressed biosafety regulation (e.g., Rosado & Erikson, 2022; Turnbull et al., 2021), no previous synthesis has systematically examined the political–legal–institutional dimension of GMOs as an integrated governance problem. Following Nyberg et al. (2025), scoping reviews are particularly appropriate for emerging or fragmented domains of inquiry where evidence is dispersed across disciplines. The political-legal-institutional dimension of GMOs exemplifies this, as relevant studies are found across distinct research traditions (ranging from biotechnology and biosafety to administrative law, international relations, and public policy) without an integrative framework to connect them.

Source choice

We selected two of the most comprehensive and widely used databases for social sciences and policing research: Scopus and Web of Science (WoS). These databases ensure peer-reviewed quality and broad coverage of interdisciplinary studies relevant to the political-legal-institutional dimension of GMOs.

Search terms and keyword strategy

Following the Joanna Briggs Institute methodological guidance for scoping reviews (Peters et al., 2015), the PCC framework (Population, Concept, and Context) was applied to define the scope and boundaries of the research question. This framework helps ensure that the search strategy remains conceptually coherent and systematically aligned with the study objectives.

- Population: The body of scientific and technical literature addressing genetically modified organisms (GMOs).
- Concept: The political-legal-institutional dimension of GMOs, encompassing policies, policymaking, legislation, regulatory frameworks, governance mechanisms, legal instruments, biosafety regulations, risk assessment and management procedures, labeling and traceability systems, compliance and enforcement practices, as well as public consultations and participatory governance processes.
- Context: Countries of the Andean region and the Member States of the Amazon Cooperation Treaty Organization (ACTO). Studies situated in these countries or explicitly referring to these geopolitical regions will be included.

This delimitation ensures that the review remains focused on the intersection of GMOs, their political-legal-institutional dimension, and the specific geopolitical contexts. On the other hand, the search terms were initially derived from preliminary readings and the controlled vocabulary of prior biosafety and biotechnology reviews,

iteratively refined after pilot tests and discussion sessions with our research team to ensure contextual sensitivity to the Andean and Amazonian regions. New terms were progressively added until retrieving additional records no longer improved coverage (saturation). In other words, search strings were developed iteratively through pilot tests and term-saturation checks until recall no longer improved. The final string query used in each database is provided in Appendix A.

Eligibility criteria

To ensure methodological rigor and transparency, eligibility criteria were defined a priori and applied consistently across databases and sources. These criteria guided the inclusion and exclusion of documents during the screening process, ensuring alignment with the research question and the PRISMA-ScR framework.

- Document type: peer-reviewed articles and review articles.
- Publication stage: published and early access.
- Language: English, Spanish, or Portuguese.
- Period: No temporal restriction was applied, as the aim was to capture the evolution of political-legal-institutional governance since the introduction of GMO biosafety regimes in Latin America.
- Geographic scope: Andean America and ACTO.
- Source quality: journals in the higher/best quartile (2024 SCImago/Scopus or JCR/WoS = Q1) and not included in predatory journals "The List".

Data management and coding

The documents were collected from WoS and Scopus on September 5, 2025, and imported into Covidence, where reviewers screened them by title and abstract and classified them as included or excluded. Before import, Scopus/WoS duplicates were verified in Power BI; the same tool was used to cross-check journals in SCImago/Scopus to retain first-quartile (Q1) outlets and to exclude those listed as predatory. JCR/WoS Q1 articles were then manually filtered. Only after this process were the records screened (title/abstract and full-text).

Two reviewers independently conducted these stages. Discrepancies between reviewers during both title/abstract and full-text screening were resolved through discussion. Inter-rater reliability between reviewers exceeded 0.80 (Cohen's Kappa), indicating almost perfect agreement according to Landis and Koch (1977), and Proportionate agreement exceeded 0.9 (see Appendix B for details).

After screening, 86 documents were retained for inclusion in the review. All included articles were analyzed according to their substantive content, and research results were organized following a PRISMA 2020 flow diagram (Figure 1). The 86 records were coded in step with Gioia et al. (2013) to ensure theoretical transparency and grounded analytical development. The coding unfolded through three cumulative cycles that progressively bridged empirical detail and conceptual abstraction. In the first cycle, 173 first-order codes were inductively derived from the empirical vocabulary of the texts—terms such as "regulatory opacity," "weak enforcement," "seed dependency," "indigenous knowledge exclusion," "biosafety committees without autonomy," "labeling controversies," and "loss of native varieties." These codes captured the multiplicity of

expressions used by the literature to portray how political and institutional arrangements mediate biosafety regulation and its social consequences.

In the second coding cycle, the 173 first-order empirical codes were progressively clustered into coherent analytical categories through constant comparison and axial coding. This process produced eight second-order themes that captured distinct yet interdependent domains of GMO governance: (1) Governance and Regulation, encompassing studies on institutional design, legal frameworks, and inter-agency coordination; (2) Biosafety and Risk Assessment, gathering technical and procedural analyses of laboratory validation, environmental safety, and molecular uncertainty; (3) Political Economy, Markets, and Intellectual Property, integrating studies on patents, royalties, and the concentration of biotechnological value chains; (4) Labeling, Traceability, and Monitoring, focused on mechanisms of transparency and post-market accountability; (5) Social Participation, Resistance, and Conflict, covering mobilization, public controversies, and legitimacy disputes; (6) Innovation and Genome Editing, addressing new breeding techniques (NGT/CRISPR) and their emerging regulatory boundaries; and (7) Ethics, Justice, and Rights, which foregrounds distributive, environmental, and epistemic justice in Andean biosafety debates, alongside (8) Methodological and State-of-the-Art contributions that synthesize and assess regional evidence bases.

Through theoretical abstraction, these second-order themes converged into three broader aggregated dimensions that synthesize the field's main logics of inquiry. The first, Governance Legitimacy and Institutional Responsiveness, integrates the clusters of Governance and Regulation, Labeling and Monitoring, and Methodology, foregrounding concerns with transparency, accountability, and institutional credibility. The second, Distributed Authority and Knowledge Plurality, connects Biosafety and Risk Assessment, Political Economy, and Social Participation and Conflict, highlighting how scientific, governmental, corporate, and community actors negotiate epistemic authority in settings of asymmetric knowledge. The third, Commons Protection and Seed Sovereignty, incorporates Ethics, Justice, and Rights and Innovation and Genome Editing, framing GMO governance as part of broader struggles over biodiversity, collective rights, and the ethical boundaries of biotechnological experimentation.

Table 1

Analytical Dimensions of GMO Governance Identified in the Scoping Review

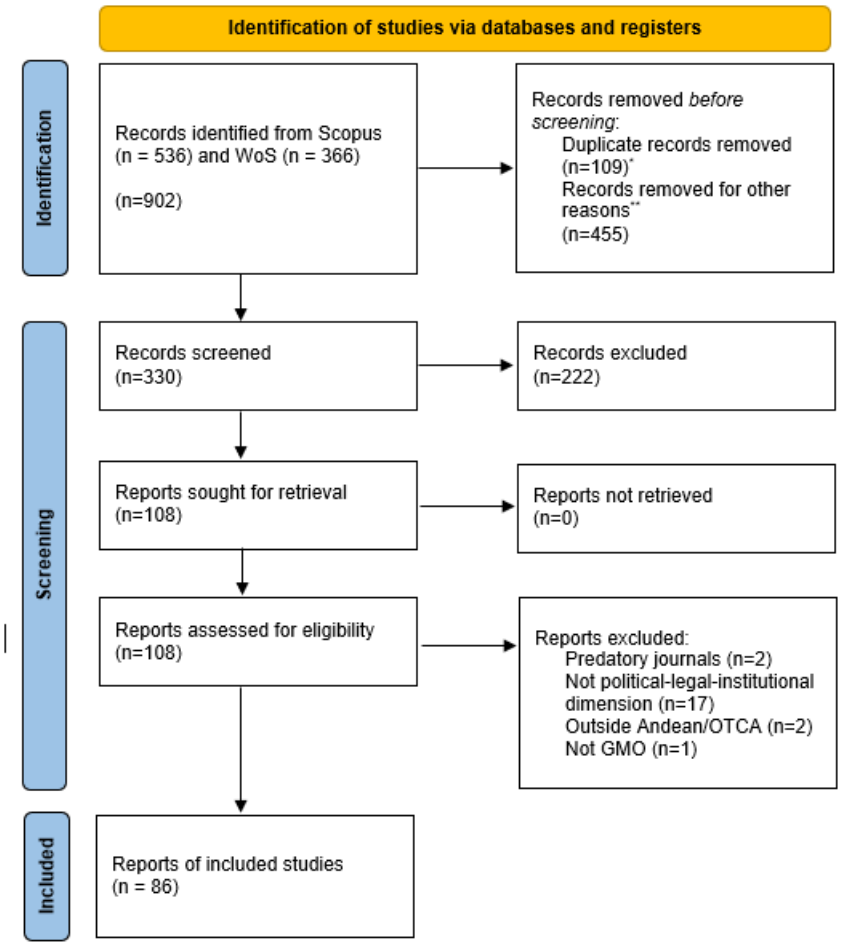
Dimension	Included Categories	Type of Linkage	Main Focus
Governance, Politics, and Institutional Legitimacy	Governance and Regulation; Political Economy and Intellectual Property; Social Participation, Resistance, and Conflict	Central and articulating	Political-institutional and social
Risk, Technical Control, and Biosafety	Biosafety and Risk Assessment; Labeling, Traceability, and Monitoring; Innovation and New Techniques	Technical-normative	Scientific-technological and regulatory
Knowledge, Ethics, and Scientific Reflexivity	Methodology and State of the Art; Ethics, Justice, and Rights	Peripheral and reflexive	Epistemological and ethical

Together, these layers reveal a governance architecture that is at once institutional, epistemic, and moral. The thematic synthesis combined inductive discovery (Ryan & Bernard, 2003) with a deductive organization structured around governance levels—local

(seed and community rights), national (institutional responsiveness and biosafety), and regional (policy harmonization within Andean and Amazonian frameworks). This dual analytical movement integrated peer-reviewed and grey sources within a unified coding matrix (Adams et al., 2017), ensuring consistency and comparability across evidence types. In sum, the eight second-order themes coalesce into three interdependent dimensions of GMO governance: Governance, Politics, and Institutional Legitimacy; Risk, Technical Control, and Biosafety; and Knowledge, Ethics, and Scientific Reflexivity.

Figure 1

PRISMA flow diagram



*Automatically (n=106) and manually (n=11).

** Predatory journals (n=57) and higher/best quartile < Q1 (n=398).

- - - Grey literature search in progress

Main Findings

Bibliometric Descriptive Results

Temporal Evolution of the Literature

The annual evolution of publications begins with Bartley and Hallerman (1995), the earliest article in the dataset and an important baseline for understanding the institutional emergence of GMO governance. Their global FAO survey—covering regulatory information from more than 60 countries—documented the early use of genetically modified organisms in aquaculture and fisheries alongside the widespread absence of biosafety frameworks, institutional capacity, and regulatory guidelines. The study reported that public perceptions of GM aquatic organisms tended to be favorable regarding moral acceptability, economic potential, dietary improvement, and environmental safety. However, it did not advance any normative endorsement of GMOs. Instead, it offered a technocratic and operational assessment of regulatory gaps, institutional constraints, and challenges to harmonization. In this sense, the article occupies a neutral, operational position, providing an early descriptive mapping of governance structures rather than a pro-technology or risk-oriented stance. See Table 2.

Table 2

Annual Scientific Production

Year	Freq	cumFreq	Year	Freq	cumFreq	Year	Freq	cumFreq
1995	1	1	2005	3	10	2015	3	49
1996	0	1	2006	1	11	2016	7	56
1997	0	1	2007	2	13	2017	7	63
1998	0	1	2008	5	18	2018	2	65
1999	0	1	2009	2	20	2019	6	71
2000	0	1	2010	4	24	2020	7	78
2001	0	1	2011	4	28	2021	2	80
2002	1	2	2012	2	30	2022	4	84
2003	2	4	2013	9	39	2023	2	86
2004	3	7	2014	7	46			

The temporal evolution of the literature reveals a clear upward trajectory from this early foundation, with a marked inflection point in the mid-2000s as scholarly output began to expand steadily—and even more sharply after 2010. This pattern aligns with the implementation of the Cartagena Protocol on Biosafety (adopted in 2000, in force since 2003), which stimulated both the development of national regulatory frameworks and the proliferation of research on biosafety governance, regulatory divergence, and the emerging challenges posed by new breeding techniques. Studies such as Ishii and Araki (2017) illustrate this shift by examining how countries have begun to differentiate between transgenic and transgene-free genome-edited crops, reflecting a broader trend in the literature: the movement from risk-oriented analyses of GMOs toward evaluations of regulatory models, public acceptance, and the governance implications of rapidly evolving biotechnologies.

Authors and Scholarly Productivity

The distribution of scholarly productivity in this field follows a characteristic pattern: a small group of highly active authors anchors the intellectual development of GMO-

related research across Latin America, while most contributors publish only occasionally (see Table 3). These core authors not only produce a substantial share of the literature but also shape its methodological, thematic, and epistemic directions.

Ana Carolina Maisonnave Arisi stands out as the most prolific contributor, with a consistent body of work focused on analytical methods, qPCR calibration, surveillance, traceability, and regulatory compliance (e.g., Brod et al. 2013; Brod & Arisi, 2007; Dinon et al., 2008, 2010a, 2010b; Venturelli et al., 2018). Rather than engaging political or socio-environmental debates, her contributions provide the laboratory infrastructure that underpins GMO governance systems, consolidating what can be described as a Neutral–Operational, Governance-Focused research stream. Closely associated with this methodological line is Andreia Zilio Dinon, whose publications, all co-authored with Carolina Arisi, specialize in PCR-based detection, monitoring of approved and non-approved events, and assessment of labeling compliance (Dinon et al., 2008, 2010a, 2010b). Together, Carolina Arisi and Andreia Dinon constitute the field's central methodological cluster, responsible for standardizing and ensuring the reliability of GMO analytical surveillance across multiple food matrices.

In contrast, Valeria Arza provides a substantively different but equally central contribution. Her work—often conducted in collaboration with Patrick van Zwanenberg—examines the political economy of biotechnology, institutional failures, technological upgrading, and the socio-technical configurations of GM cotton in Argentina (Arancibia et al., 2022; Arza et al., 2014; van Zwanenberg & Arza, 2013). These publications anchor the Critical-Socioeconomic / Political-Ecological stream by demonstrating how GM technologies are embedded within unequal agrarian structures, fragmented state capacities, and contested socio-technical regimes. Arza shows how GM crops reinforce inequalities, territorial restructuring, and institutional asymmetries, becoming integral to broader dynamics of agrarian change. Patrick van Zwanenberg extends this critical line through analyses centered on the institutional, political-economic, and territorial dynamics of agricultural biotechnology (van Zwanenberg & Arza, 2013; van Zwanenberg et al., 2011). His work functions as an analytical bridge between socio-technical studies and political-institutional critique, tracing how regulatory arrangements, power asymmetries, and market structures co-produce trajectories of GMO adoption. By detailing how governance configurations—state-centered or decentralized—interact with economic interests, corporate influence, and uneven rural development, he demonstrates that biotechnology circulates not as a neutral technology but as a socio-political artifact embedded in conflicts over sovereignty, inequality, and institutional design. Importantly, this critical cluster also includes Florencia Arancibia, whose analyses of corporate appropriation, regulatory regimes, and the political dynamics of the bioeconomy reinforce the critical-socioeconomic, political-ecological, unfavorable-in-structural-terms position (Arancibia, 2013). Her work introduces a counter-hegemonic perspective centered on inequality, neoliberalization, and collective action, expanding the field’s critical epistemic repertoire by foregrounding how transgenic agriculture is entangled with struggles over governance, power, and socio-environmental justice.

To balance these methodological and critical poles, the field also includes several influential pro-GMO authors who contribute to a third stream: the Technologically and Economically Favorable perspective. Notably, Eriksson et al. (2019) advocate for regulatory harmonization and criticize overly precautionary frameworks, positioning genome editing as a safe and necessary innovation. Ishii and Araki (2017) support transgene-free genome editing through a regulatory lens, emphasizing proportionality in

biosafety governance. Qaim and Traxler (2005) present GM soy as economically and environmentally beneficial, explicitly countering arguments about its risks. Fatoretto et al. (2017) frame Bt maize as a valuable technology whose durability must be protected, critiquing institutional failures rather than GMOs themselves. These authors collectively represent a robust pro-innovation cluster, widening the field's conceptual and ideological diversity and preventing the emergence of a simple dichotomy between “methodological neutrality” and “political critique.”

Taken together, the field displays a tri-polar structure assembled by a Methodological–Operational stream (Arisi, Dinon), a Critical socio-political and environmental stream (Arza, van Zwanenberg, Arancibia) and a Pro-GMO innovation and regulatory optimization stream (Eriksson, Ishii & Araki, Qaim, Fatoretto). These streams coexist and sometimes intersect, illustrating the field’s internal diversification and epistemic pluralism.

Table 3

Most Relevant Authors

Authors	Articles	Articles Fractionalized
ARISI, A. C. M.	6	1,71
DINON, A. Z.	4	1,08
ARZA, V.	3	1,25
VAN ZWANENBERG. P.	3	1,14
ARANCIBIA, F.	2	1,25
BRANQUINHO, M.	2	0,53
BROD, F.	2	0,67
BURACHIK, M.	2	1,25
ANDRADE, P. P.	2	0,41
MELO, M. A.	2	0,41
ERIKSSON, D.	2	0,60
FERREIRA, R.	2	0,53
FONTES, E.	2	1,08
LEMA, M.	2	1,50
MOTTA, R.	2	2,00
NEPOMUCENO, A.	2	0,18
RAUCHECKER, M.	2	2,00
REIS-CASTRO, L.	2	1,50
SALAZAR, M.	2	0,58
TIRONI, M.	2	0,58
TREML, D.	2	0,38
VALENZUELA, D.	2	0,58
WHELAN, A.	2	0,60

Note. Nº articles > 1

This multi-cluster structure—methodological, pro-innovation, and critical—demonstrates not polarization but differentiation, revealing how varied epistemic commitments contribute to the field's consolidation. Moreover, the gradual entry of new authors, especially those working on governance, socio-environmental justice, and regulatory harmonization, indicates generational renewal and the expansion of

collaborative networks. These dynamics are typical of a field transitioning toward maturity, thematic breadth, and more profound theoretical articulation.

Lotka's Law and Concentration Patterns

The distribution of author productivity in this corpus closely follows Lotka's Law, exhibiting a strongly skewed pattern in which a small number of researchers account for a disproportionately large share of publications. Table 4 confirms that 88.7% of all authors appear only once, whereas fewer than 3% produce three or more papers. This asymmetry reflects the structure of an emerging research field or, as we said above, of a field transitioning towards maturity: a dense core of stable contributors provides methodological, theoretical, and empirical continuity, while a broad periphery sustains thematic variation and introduces new problematizations.

Table 4

Lotka's law

Documents written	N. of Authors	Proportion of Authors
1	180	0.887
2	19	0.094
3	2	0.010
4	1	0.005
6	1	0.005

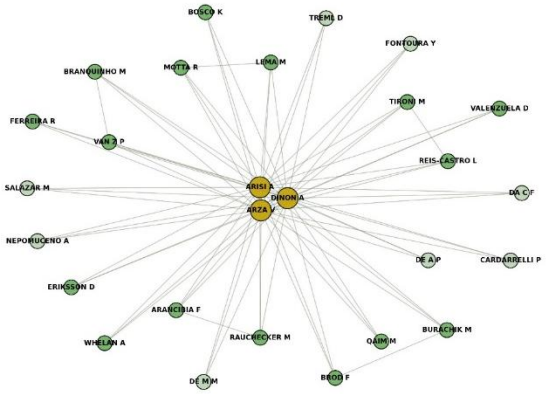
Several features of this distribution help illuminate the field's internal architecture. First, a small cluster of methodologically oriented authors—most notably Carolina Maisonnave Arisi (e.g., Brod et al. 2013; Brod & Arisi, 2007; Dinon et al., 2008, 2010a, 2010b; Venturelli et al., 2018)—anchors the operational and regulatory–technical subfield. Their sustained output over nearly two decades has shaped the evidentiary and analytical infrastructure of GMO traceability, qPCR calibration, and surveillance systems in the region. The high centrality of these authors in the co-authorship network reflects not only productivity but also their role in stabilizing procedural and laboratory standards, enabling the governance-focused research stream to cohere.

Second, a parallel but conceptually distinct core is formed by socio-political analysts such as Valeria Arza (e.g., Arancibia et al., 2022; Arza et al., 2014; Van & Arza, 2013) and Patrick van Zwanenberg (Van & Arza, 2013; Van et al., 2011). Their work problematizes biotechnology through political economy, socio-technical configurations, and environmental justice—particularly in the context of GM cotton and the Argentine soy–glyphosate regime. These authors constitute the intellectual backbone of the Critical-Socioeconomic / Political-Ecological cluster, articulating themes of institutional failure, agrarian inequality, and contested biopolitical regimes.

Bridging these two poles are regulatory governance scholars—such as Eriksson et al. (2019) and Ishii & Araki (2017)—whose contributions examine transnational harmonization, biosafety architecture, and genome-editing regulation. Though fewer in number, these publications introduce a pro-GMO but governance-oriented perspective, enriching the field by mediating between operational and political–institutional concerns. See Figure 2.

Figure 2

Collaboration network



The field's temporal layering becomes especially visible when contrasting the long-standing core of authors who entered the literature in the late 1990s and early 2000s with the surge of new contributors publishing from 2018 onward. While early work helped consolidate methodological, regulatory, and political–economic baselines, recent publications articulate a markedly broadened agenda that reflects the evolving socio-environmental and geopolitical landscape of GM agriculture. Studies on transnational issue formation and frontier expansion (Mempel & Corbera, 2021) show how debates over soybean production increasingly unfold across global public spheres, linking ecological pressures, land-use conflicts, and discursive struggles. Research on legal mobilization and intellectual property (Peschard & Randeria, 2020) reveals how courts have become central arenas for contesting the governance of GM seeds, complementing inquiries into grassroots political engagement in seed-law reform and food sovereignty (Felicien et al., 2020). At the same time, scholars have examined how Southern regulatory states manage technological and market risks, as illustrated by analyses of Argentina's GM wheat approval process (Jeon, 2023), and how national political regimes stabilize or contest GMO trajectories, as in studies documenting the consolidation of GMO hegemony in Brazil (Fontoura et al., 2022) and the tensions surrounding consumer trust and labeling (Hakim et al., 2020). Work on Argentina's soy sector further demonstrates how transgenic crops become sites of struggle over rent appropriation, state authority, and farmer resistance, highlighting the political character of crop biotechnologies (Rauchecker, 2022). Parallel research on market differentiation and the economic positioning of GM versus non-GM products (Martinez-Ribaya & Areal, 2020) underscores how the biotechnology debate extends beyond agrarian systems into consumer markets and value chains. Together, these studies illustrate how, since 2018, the field has expanded from earlier concerns with seed systems, institutional capacity, and regulatory design toward a wider set of questions involving transnational publics, legal activism, socio-environmental health, political hegemony, and market differentiation. This thematic diversification marks the consolidation of a more interdisciplinary and globally connected research landscape.

The co-authorship network mirrors these dynamics. Highly connected hubs—Arisi, Dinon, and Arza—occupy structurally central positions, linking method-oriented teams with socio-political research circles. Authors with intermediate productivity (e.g., Qaim & Traxler, 2005; Whelan & Lema, 2015) form meso-level clusters tied to economics, innovation studies, or global regulatory debates. Peripheral authors—those represented by a single contribution—play a crucial role in expanding the field's thematic

and epistemic reach. Their studies often introduce issues that lie outside the dominant clusters shaped by established scholars, thereby enriching debates around biosafety, regulatory design, and socio-technical futures. For instance, research on genome-edited crops (Ishii & Araki, 2017) offers a regulatory foresight perspective that frames transgene-free genome editing as an opportunity to streamline oversight systems, revealing how pro-innovation regulatory imaginaries circulate even in scholarship that is empirically modest. Similarly, work examining the global governance of GMOs in aquaculture (Bartley & Hallerman, 1995) provides a technocratic and institution-focused survey that maps regulatory gaps, biosafety capacities, and operational constraints across countries. Rather than promoting GM technologies, the study offers a neutral–descriptive assessment of governance preparedness, expanding the field toward early institutional diagnostics that had been largely absent from subsequent socio-political debates. Together, these single-publication contributions—whether cautiously promotive or technologically optimistic—demonstrate how peripheral authors introduce distinct problem framings that diversify the field beyond the more recurrent political-economy, socio-environmental, or governance-oriented analyses produced by core contributors.

Taken together, these patterns indicate a field transitioning from dispersion toward structured pluralism. The dominance of a few methodological and political-ecological anchors reflects consolidation, while the growing influx of new contributors reveals generational renewal and thematic expansion. The coexistence of operational–regulatory, pro-GMO governance, and critical sociotechnical perspectives suggests a maturing research arena characterized by epistemic heterogeneity rather than ideological uniformity—a feature that aligns with other interdisciplinary domains in science, technology, and society.

Publication Sources and Bradford's Law

The distribution of publication venues reveals a structured pattern of concentration and diversification consistent with Bradford's Law (see Table 5). A compact core of journals (Zone 1) accounts for a disproportionate share of the scholarly output, while successive peripheral zones host occasional but thematically important contributions. This configuration reflects both the intellectual consolidation of the field and its transversal orientation across science and technology studies, agrarian political economy, food policy, environmental governance, and socio-legal research.

Table 5

Bradford's law

Source	Rank	Freq	cumFreq	Zone
TECHNOLOGY IN SOCIETY	1	6	6	Zone 1
GM CROPS AND FOOD	2	4	10	Zone 1
FOOD CONTROL	3	3	13	Zone 1
JOURNAL OF AGRARIAN CHANGE	4	3	16	Zone 1
JOURNAL OF FOOD COMPOSITION AND ANALYSIS	5	3	19	Zone 1
JOURNAL OF PEASANT STUDIES	6	3	22	Zone 1
WORLD DEVELOPMENT	7	3	25	Zone 1
ENVIRONMENTAL SOCIOLOGY	8	2	27	Zone 1
GEOFORUM	9	2	29	Zone 1
JOURNAL OF AGRICULTURAL AND ENVIRONMENTAL ETHICS	10	2	31	Zone 2

JOURNAL OF INVERTEBRATE PATHOLOGY	11	2	33	Zone 2
JOURNAL OF RESPONSIBLE INNOVATION	12	2	35	Zone 2
JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE	13	2	37	Zone 2
PLANTS PEOPLE PLANET	14	2	39	Zone 2
POLITICAL GEOGRAPHY	15	2	41	Zone 2
PUBLIC UNDERSTANDING OF SCIENCE	16	2	43	Zone 2
REVIEW OF POLICY RESEARCH	17	2	45	Zone 2
TRANSGENIC RESEARCH	18	2	47	Zone 2

Note. Nº articles > 1

Zone 1 consists of a small cluster of high-frequency journals These outlets provide the editorial arenas where the central debates on agricultural biotechnology are continuously shaped and stabilized. Their consistent presence signals that the field remains anchored in questions of socio-technical governance, regulatory capacity, agrarian restructuring, and food-system transformation. Rauchecker's (2022) analysis of rent appropriation and political conflict surrounding transgenic soy in Argentina, or Peschard and Randeria's (2020) recent work on legal mobilization and intellectual-property struggles in Brazil and India, exemplify how Zone 1 journals institutionalize political-economic perspectives on biotechnology.

Surrounding this stable nucleus, Zone 2 brings together journals from adjacent but increasingly interconnected domains. These outlets accommodate emerging lines of inquiry that extend the field beyond its original bio-technical and regulatory foundations. For instance, scholarship on agricultural biodiversity and the territorial politics of conservation (Graddy, 2014) illustrates how GM debates intersect with broader struggles over peasant knowledge, place-based ecologies, and agrobiodiversity governance. Similarly, analyses of Peru's GMO moratorium highlight how competing stakeholder epistemologies and neoliberal scientific framings structure conflict over biosafety and national sovereignty (Dondanville & Dougherty, 2020). Research on place-based technology rents in the GM corn seed industry further demonstrates how GM technologies become embedded in spatialized regimes of accumulation and regional advantage (Ipsen, 2016). Together, these studies show that Zone 2 journals host work that foregrounds socio-environmental health, political contention, and the socio-technical infrastructures through which citizens, experts, and states negotiate the governance of agricultural biotechnology.

Bradford's distribution reveals a field structured by a stable editorial core and an increasingly diverse periphery. The two zones jointly map a widening thematic landscape in which long-standing concerns about biotechnology governance are progressively enriched by emerging inquiries into justice, participation, and contested knowledge. This hybrid structure illustrates the field's growing maturity: a robust and coherent center coupled with an open, permeable, and methodologically plural periphery.

Most Cited Documents

The set of most cited documents reveals the field's intellectual architecture (see Table 6). These works function as conceptual anchors around which debates on GMOs—particularly in Latin America and the Global South—have consolidated. High citation counts signal not only scholarly visibility but also the capacity of these studies to serve as shared reference points across distinct epistemic communities, including agricultural

economics, political ecology, biosafety regulation, science and technology studies (STS), and environmental governance.

Table 6

Most cited documents

Paper	Total Citations	TC per Year	Normalized TC
WHELAN A, 2015, GM Crop. Food	159	14,45	2,56
QAIM M, 2005, Agric Econ	146	6,95	1,63
LEGUIZAMÓN A, 2014, Groforum	131	10,92	4,96
SCOONES I, 2008, J. Agrar. Chang.	118	6,56	3,30
FATORETTO J, 2017, J. Integr. PEST Manag.	116	12,89	2,53
HERRING R, 2007, J. Dev. Stud.	115	6,05	1,76
ISHII T, 2017, GM Crop. Food	114	12,67	2,49
ERIKSSON D, 2019, New Phytol	85	12,14	2,68
ARANCIBIA F, 2013, Technol. Soc.	83	6,38	2,85
HAKIM M, 2020, Food Res. Int.	69	11,50	3,12
LEMA M, 2019, TRANSGENIC Res.	64	9,14	2,02
ORTEGA E, 2005, Bull. Sci. Technol. Soc.	62	2,95	0,69
CARDARELLI P, 2005, Food Control	61	2,90	0,68
HEINEMANN J, 2013, Environ. Int.	54	4,15	1,85
COHEN J, 2004, World Dev.	50	2,27	1,40
MUCCI A, 2004, Food Qual. Prefer.	45	2,05	1,26
PHÉLINAS P, 2017, World Dev.	43	4,78	0,94
MACNAGHTEN P, 2016, J. Responsible Innov.	43	4,30	2,06
DELVENNE P, 2013, Technol. Soc.	42	3,23	1,44

Note. Normalized TC > 1

A first cluster of highly cited contributions consists of economically oriented, pro-innovation analyses. Foundational papers by Qaim and Traxler (2005) established the dominant narrative of GM crop adoption as delivering productivity gains, cost reductions, and welfare increases, particularly for farmers in developing economies. Likewise, regulatory analyses by Whelan and Lema (2015) and Lema (2019) demonstrate how Argentina's pioneering case-by-case, product-based biosafety framework shaped global governance trends in genome editing, reinforcing the view that flexible regulation can accelerate technological innovation. Comparative regulatory studies such as those by Ishii and Araki (2017) and Eriksson et al. (2019) further expanded this orientation by highlighting global divergence in oversight of GMOs and genome editing and advocating for risk-proportionate, science-aligned frameworks.

A second, equally influential cluster is composed of critical political-ecological and socio-environmental analyses that interrogate the structural consequences of GMO-based agrarian development. Arancibia (2013) examines the bioeconomy as a neoliberal political project, highlighting corporate appropriation, regulatory conflicts, and counter-hegemonic collective action. Leguizamón (2014) further demonstrates how Argentina's transgenic soy regime produces territorial restructuring, deforestation, ecological degradation, and socio-environmental conflict, situating GM agriculture within broader dynamics of land concentration and export-dependent accumulation. Scoones (2008) extends this structural critique through a comparative analysis of India, South Africa, and Brazil, showing how regulatory capture, democratic deficits, and uneven forms of

participation shape contentious trajectories of GMO adoption. Complementing these political-ecological accounts, Arancibia et al. (2022) document epidemiological patterns of illness in "sprayed villages," linking toxic exposure from GMO–pesticide packages to struggles over institutional accountability, public health recognition, and the suppression of community-generated evidence. Together, these works consolidate a critical-socioeconomic and political-ecological perspective that foregrounds power, inequality, ecological harm, and socio-technical contestation as central to GMO governance in the region.

A third set of frequently cited documents comprises operational, governance-focused, and biosurveillance studies. Classic contributions such as Cardarelli et al. (2005) and Heinemann et al. (2013) lay the institutional foundations of biosafety oversight—developing detection protocols, refining risk-analysis frameworks, and identifying regulatory inconsistencies. These works form the methodological core of public-sector surveillance and continue to guide enforcement of labeling and traceability regimes. Complementing this regulatory infrastructure, Hakim et al. (2020) examine consumer knowledge, trust, and perceived risk surrounding GMO labeling in Brazil, highlighting how informational asymmetries and institutional trust shape the effectiveness of biosafety communication.

Finally, environmentally oriented assessments—such as those by Ortega et al. (2005) and Fatoretto et al. (2017)—have become pivotal for understanding the sustainability challenges associated with agrobiotechnology. Ortega et al. (2005), situated within the critical-socioeconomic, political-ecological stream, use emergy accounting to expose the ecological intensities, geopolitical dependencies, and structural vulnerabilities that shape Brazil's soybean frontier. Their analysis foregrounds technological dependence, macro-structural pressures, and the socio-environmental burdens imposed on small farmers. By contrast, Fatoretto et al. (2017) fall within the pro-GMO with Regulatory Emphasis category. Their work examines the adaptive evolution of fall armyworm resistance to Bt crops. It highlights how failures in refuge compliance, shortcomings in IRM adoption, landscape-scale dynamics, and gaps in institutional coordination undermine the long-term durability of the technology. Rather than questioning GMOs themselves, the paper stresses that operational, regulatory, and stewardship deficiencies are the critical obstacles to sustaining biotech efficacy over time.

The presence of pro-GMO economic analyses, critical socio-environmental studies, regulatory and governance frameworks, and ecological sustainability assessments among the most cited documents highlights the field's intellectual pluralism. Normalized citation metrics (Normalized TC > 1) reveal that both foundational and recent contributions have achieved sustained influence, indicating that contemporary scholarship is not merely cumulative but actively reshapes conceptual boundaries. Together, these highly cited works have propelled the field toward an increasingly integrative understanding of GMO governance, spanning agrarian political economy, regulatory science, ecological sustainability, consumer behavior, and the geopolitics of biotechnology.

Analytic Results

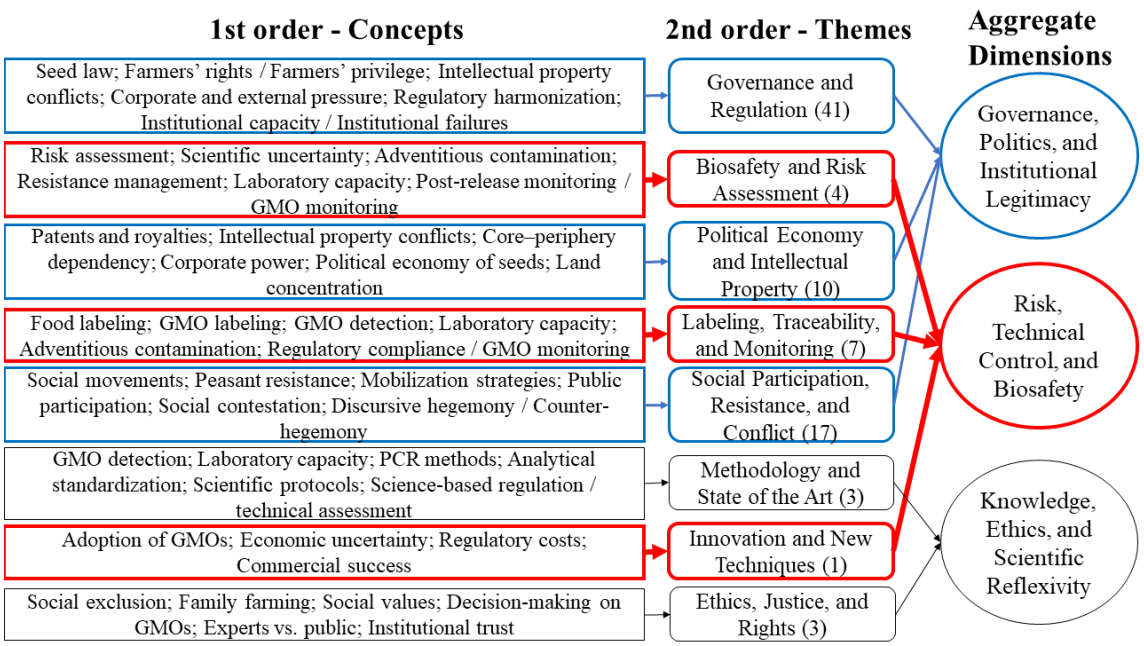
The analytical phase consolidated the multilayered coding structure described in the methodology, translating the 86 included documents into a coherent thematic synthesis. Rather than reiterating procedural details, this section highlights the substantive patterns that emerged. The inductive coding process revealed a dense vocabulary of governance-

related concerns—ranging from regulatory opacity and institutional fragmentation to biosafety controversies, intellectual-property tensions, seed dependency, and forms of social resistance.

Through iterative comparison, these dispersed empirical signals converged into eight second-order thematic categories that articulate how GMO governance is problematized across Andean and ACTO-aligned contexts. For analytical coherence, these eight themes were integrated into three aggregated domains, each grouping conceptually affiliated strands of inquiry, as demonstrated in the following figure.

Figure 2

Data Structure



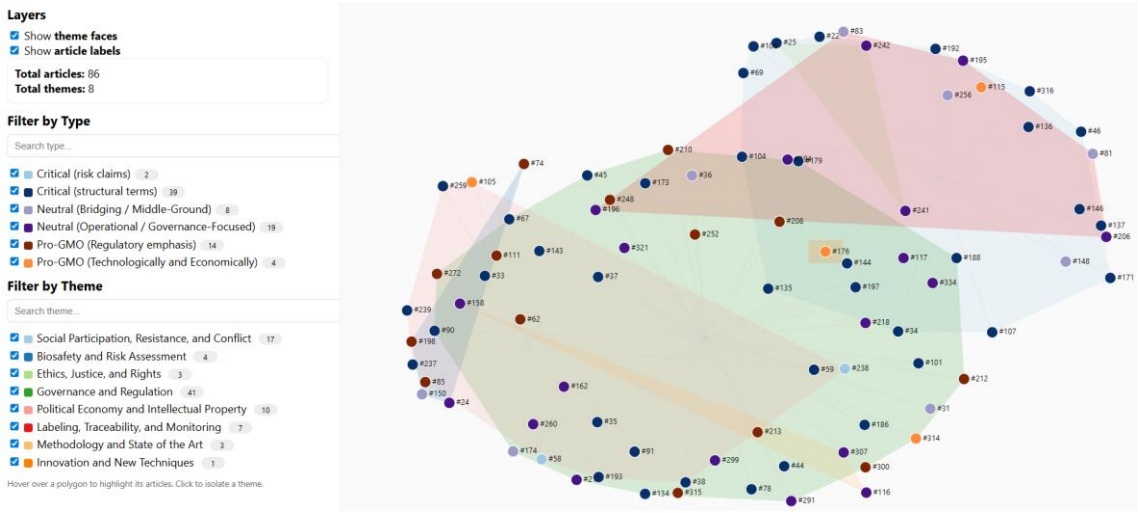
Cross-referencing these aggregated domains with the positional matrix (pro-, neutral-, and anti-GMO) revealed important internal distinctions within each normative orientation. Pro-GMO studies bifurcate into two patterns. Category 1 articles frame GMOs as technologically and economically advantageous, presenting precautionary regulation as an impediment. In contrast, Category 2 studies endorse GMOs but foreground regulatory efficiency, harmonization, or system design, treating obstacles as operational rather than technological. Neutral studies also split. Category 3 adopts a middle-ground or controversy-mapping stance, presenting multiple perspectives without adjudication. Category 4 maintains neutrality by focusing on administrative instruments, compliance, and procedural mechanisms rather than on desirability or risk. Critical or anti-GMO studies present a parallel bifurcation. Category 5 analyses critique GMOs on political-ecological and structural grounds—highlighting land concentration, dependency, inequality, and governance capture—without invoking toxicological claims, whereas Category 6 centers explicitly on biomedical, toxicological, or environmental risks linked to GMO cultivation or associated chemicals.

Together, these layers offer a cartography of the epistemic, political, and institutional tensions through which GMO governance is constructed, contested, and justified in the region. Building on this cartography, the following sections examine each of the three aggregated domains in greater depth. Rather than treating governance, biosafety, and epistemic–ethical concerns as isolated spheres, the forthcoming analysis traces how pro-, neutral-, and critical positions (Categories 1–6) materialize within each

domain and how they shape divergent interpretations of the promises, risks, and institutional arrangements surrounding GMOs (please, see the image below and play with it online).

Figure 3

Interactive Network of Positions, Themes and Domains



Note: Link to the interactive network here: https://doi.org/10.7910/DVN/4HTMPY

By situating the positional matrix within the thematic architecture developed above, the discussion foregrounds the heterogeneous ways in which actors justify, contest, or negotiate GMOs across the region.

Governance, Politics, and Institutional Legitimacy

This domain highlights how regulatory design, political economy, and social conflict condition the uptake of GMOs. It emerges from the second-order themes of governance and regulation, political economy, and intellectual property, as well as social participation, resistance, and conflict. It captures questions about who decides, under which institutional procedures, and how trust is (or is not) produced.

Across the three clusters that compose this domain, the combination of thematic coding and positional classification reveals a heterogeneous but patterned distribution of normative stances. These positional configurations confirm that this domain is not organized around a single normative center. Instead, stances emerge from each study's empirical focus, methodological commitments, and assumptions about whose interests governance structures serve, enable, or marginalize.

Throughout this domain, pro-GMO studies (Categories 1 and 2) converge on the idea that biotechnology is desirable and that governance should *enable* rather than restrain it. Category 1 papers present GM crops as agronomically and economically successful technologies that enhance productivity, competitiveness, and aggregate welfare, often framing regulatory obstacles as irrational or excessive—for example, analyses of Roundup Ready soy in Argentina and the broader Argentine experience with GM crops (Burachik, 2010, #314; Qaim & Traxler, 2005, #105). Category 2 contributions share this favorable orientation but relocate the problem to the architecture of regulation. Hence, the challenge is to "unlock" or streamline approvals, strengthen biosafety procedures, and

harmonize international rules so that innovation can proceed safely (Bartholomaeus et al., 2015, #213; Capalbo et al., 2003, #300; Cardwell & Kerr, 2008, #85; Cohen & Paarlberg, 2004, #62; de Andrade et al., 2014, #252; Eriksson et al., 2019, #315; Ishii & Araki, 2017, #210; Lema, 2019, #248; Whelan & Lema, 2015, #212; Winham, 2009, #111; Zannoni, 2019, #272).

Across Category 2 studies, regulatory inefficiency—not the technology itself—is consistently framed as the primary barrier to realizing the potential benefits of agricultural biotechnology. For example, Cohen and Paarlberg (2004, #62) show that in low-income contexts the key constraint is not agronomic performance but the limited capacity of national biosafety systems to deliver timely, science-based approvals. Likewise, Whelan and Lema (2015, #212) demonstrate how Argentina's case-by-case, product-based system for new breeding techniques reduces uncertainty, accelerates innovation, and functions as a regulatory model for neighboring countries. A similar pattern emerges in the literature on genome editing. Ishii and Araki (2017, #210) argue that transgene-free edits should not be subjected to the same process-based oversight as classical GMOs, as doing so risks overregulation of low-risk applications. Zannoni (2019, #272) and Eriksson et al. (2019, #315) likewise document that disproportionate or inconsistent rules lead to asynchronous approvals, trade frictions, and disincentives to domestic breeding programs. Even biosafety-centered contributions—such as Bartholomaeus et al. (2015, #213) and the international guidelines initiative described by Capalbo et al. (2003, #300)—emphasize the need for harmonized criteria, risk-proportionate assessment, and procedural clarity rather than more stringent controls. Together, these examples illustrate how the literature positions regulatory design, coordination, and predictability as the central levers for enabling safe, legitimate, and socially accountable innovation in the Andean and Amazonian regions, where legitimacy is understood to depend on science-based, efficient, and internationally aligned regulatory regimes that protect trade and innovation while minimizing forms of precaution deemed unnecessary.

Neutral studies in this domain (Categories 3–4) collectively suspend judgment on the desirability of GMOs, instead illuminating how regulatory ambiguity, public reasoning, and socio-technical controversies take shape across institutional and cultural arenas. Lieberman and Gray (2006, #31) trace how uncertainty and competing interpretations of precaution became embedded in the EU moratorium, a concern echoed by Kothamasi and Vermeylen (2011, #174), who map tensions between expertise, democracy, and corporate influence without advocating for or against GMOs. Complementing these governance-oriented analyses, Parales-Quenza (2004, #148) reconstructs the heterogeneous interpretive frames through which Colombian publics make sense of GM foods, while Reis-Castro and Hendrickx (2013, #36) and Reis-Castro (2021, #256) show, respectively, how promissory discourses and multispecies practices materialize the socio-technical life of transgenic mosquitoes in Brazil. Together, these studies reveal neutrality not as detachment but as an analytic mode that exposes how biotechnologies acquire meaning, legitimacy, and contestation through intersecting regulatory processes, public imaginaries, and everyday relational encounters.

Category 4 contributions push this neutrality further by shifting entirely to the operational and governance infrastructures through which GMOs are rendered administratively knowable and controllable. Across these studies, GMOs appear not as agronomic promises or sociopolitical threats but as regulatory objects requiring detection protocols, institutional coordination, and legally enforceable procedures. For example,

Cardarelli et al. (2005, #117) foreground laboratory-based surveillance. Marcoux and Létourneau (2014, #217) and Mitre and Reis (2014, #218) reconstruct how regulatory mandates, bureaucratic conflicts, and policy transfer dynamics shape national biosafety regimes. Salazar et al. (2019, #260) show how governance cultures—rather than technological performance—structure decision-making around GM plants. Technical-methodological contributions such as Brod et al. (2013, #291), Fontes (2003, #299), Rosado and Eriksson (2022, #321), and Miaw et al. (2017, #334) consolidate this orientation by developing reference materials, risk-assessment procedures, legal mappings, and detection methods that underpin compliance and labeling systems. Taken together, these papers treat legitimacy as a function of procedural clarity, analytical standardization, and institutional coherence, demonstrating how biosafety governance is stabilized through practices of measurement and administrative ordering rather than through normative judgments about the value of GMOs themselves.

By contrast, critical contributions (Categories 5 and 6) use the same governance lens to foreground power, inequality, and harm. Category 5 articles interrogate how regulatory styles, biosafety institutions, IP regimes, and international harmonization projects reproduce structural asymmetries between corporations, states, and agrarian communities. For instance, studies of the Southern Cone soy and cotton complexes show how GM crops are embedded in unequal agrarian and trade regimes; the "soy-ization" of Argentina and Brazil is analyzed as a neoliberal restructuring that concentrates land, capital and decision-making power while displacing peasants and eroding food sovereignty (Delvenne, Vasen, & Vara, 2013, #38; Torrado, 2016, #135; Leguizamón, 2014, #107; Liberali, 2008, #259; Fontoura, Krieger, & Peci, 2022, #78). Work on GM cotton and Bt crops similarly demonstrates that the promised benefits materialize mainly for large, well-capitalized producers, whereas smallholders face low-quality seeds, debt, market exclusion and institutional neglect (van Zwanenberg & Arza, 2013, #33; Arza & van Zwanenberg, 2014, #59; Tripp, 2011, #186; Ortega et al., 2005, #197). Rather than treating biosafety as a neutral technical exercise, these authors show how regulatory choices crystallize structural risk, reinforcing a peripheral, export-dependent insertion into global markets (Jepson, 2002, #91; Jeon, 2023, #67; Lapegna, 2016, #46; Carroll, 2017, #316). A second strand interrogates how legal architectures, IP regimes, and harmonization projects reallocate authority and value. Analyses of patents, royalties and seed laws depict GM seeds as instruments of "bioproperty" that reorganize sovereignty over genetic resources and generate new dependencies for farmers and states (Herring, 2007, #173; Ipsen, 2016, #193; Barragán-Ocaña et al., 2019, #237; da Rosa Ferreira et al., 2020, #239; Peschard & Randeria, 2020, #44; Felicien et al., 2020, #45). Regulatory studies of Brazil, Argentina, Peru and China highlight "states of exception," regulatory capture, and scalar politics in which biosafety councils, ministries, and courts are mobilized to secure corporate or export interests while marginalizing precautionary and agrarian-justice claims (Pelaez, 2009, #188; Pizella & Souza, 2012, #179; van Zwanenberg et al., 2011, #101; Mempel & Corbera, 2021, #22; Dondanville & Dougherty, 2020, #192). Finally, work on social movements, "responsible innovation" and farmer perceptions links these structural configurations to everyday forms of contestation and collaboration, showing how communities, NGOs and peasant organizations negotiate risk, dependence and resistance within constrained institutional fields (Scoones, 2008, #137; Motta, 2015, #104; Motta, 2016, #136; Almeida & Massarani, 2018, #146; Sica de Campos et al., 2017, #143; Macnaghten, 2016, #144; Pezzini, Delborne, & Reisig, 2023, #171; Tironi, Salazar, & Valenzuela, 2013, #34; Graddy-Lovelace, 2014, #69). Taken together, these Category 5 texts recast GMO

governance as a site where corporate food regimes, territorial struggles and seed politics are continuously produced and contested, rather than as a neutral apparatus for managing technological risk. Category 6 papers deepen this critique by linking governance arrangements to health and toxicological harms, notably where regulatory failures or permissive regimes are correlated with pesticide-intensive GMO agriculture (Phélinas & Choumert-Nkolo, 2017, #58; Arancibia et al., 2022, #238). In these accounts, legitimacy is not achieved solely by better technical procedures but is fundamentally questioned when institutions are seen as captured, opaque, or complicit in socio-environmental damage.

Taken together, these strands show that governance, politics, and institutional legitimacy are themselves contested objects: pro-GMO studies seek to rationalize and streamline regulation; neutral works document and instrumentally refine it; and critical analyses expose how regulatory architectures entrench particular constellations of power, risk, and vulnerability. The domain also reveals that legitimacy is relational, for it depends not only on formal compliance with international protocols but also on social recognition, distributive effects, and institutional responsiveness to those who bear the everyday consequences of GMO-based agrarian change. In the following subsections, we examine how these same positional configurations (Categories 1–6) are rearticulated when the focus shifts to risk, technical control, and biosafety, and to knowledge, ethics, and scientific reflexivity.

Risk, Technical Control, and Biosafety

Derived from the Biosafety and Risk Assessment, Labeling, Traceability, and Monitoring, and Innovation and New Techniques second-order themes, the Risk, Technical Control, and Biosafety domain examines how risk is constructed, measured, validated, institutionalized, and governed across Andean and ACTO-aligned contexts. Whereas Domain 1 interrogates how legitimacy is negotiated within political and regulatory arenas, the present domain foregrounds epistemic infrastructures—laboratory protocols, surveillance systems, analytical standards, and risk-assessment practices—through which uncertainty is rendered actionable. Its central questions concern how uncertainty is managed, whose evidence counts, and how precaution is balanced with technological innovation.

Cross-referencing positional categories with the domain's internal structure reveals distinctive patterns. Biosafety and Risk Assessment concentrates a mix of pro-GMO (Category 2) papers emphasizing regulatory rigor and scientific validation, alongside neutral (Category 3–4) contributions that treat risk as a technical or administrative object. Labeling, Traceability, and Monitoring is strongly dominated by neutral studies (Category 3–4). These papers construct GMOs primarily as analytical targets within compliance regimes, rather than as agronomic promises or political threats. Innovation and New Techniques clusters exclusively around favorable (Category 1) economic-technological evaluations that describe GM crops as profitable, efficient, and strategically advantageous investment options. Unlike Domain 1—where governance acted as a conceptual bridge—Domain 2 illustrates how technical infrastructures subtly

shape normative positions, stabilizing some forms of evidence while marginalizing others.

Across this domain, four studies articulate pro-GMO views, though they differ in emphasis. Andrade et al. (2016, #74) defend the release of transgenic Aedes aegypti OX513A through a biosafety-regulatory lens. In light of the Zika epidemic, the authors update CTNBio's 2014 risk assessment and reaffirm that no new hazards have emerged and that existing evidence supports continued field deployment. The study anchors legitimacy in science-based evaluation, procedural scrutiny, and alignment with the Cartagena Protocol, positioning biosafety as the mechanism for restoring public trust. Fatoretto et al. (2017, #198) assess the evolutionary risks of Bt resistance in Brazil, highlighting failures of refuge compliance, weak stewardship, and gaps in institutional coordination. Nevertheless, the authors do not problematize the technology itself. Bt crops remain effective and desirable; it is governance and implementation that fall short. Their diagnosis is that stronger IRM regulation and science-based coordination are required. Andrade et al. (2016, #74) and Fatoretto et al. (2017, #198) are positioned within Category 2, Pro-GMO with Regulatory Emphasis. The two other studies constitute a paradigmatic Category 1 contribution, Technological and Economic Favorability. Martinez-Ribaya & Areal (2020, #115) analyze market differentiation between GM and non-GM soybean products in Argentina. While acknowledging niche opportunities for non-GM verification, the authors treat GMOs as the default, efficient, and economically rational standard, with labeling functioning as a market segmentation tool rather than a risk-communication mechanism. Nadolnyak et al. (2011, #176) conceptualize GM crops as high-return strategic assets, using real-options modeling to quantify profitability across regulatory and market environments. GM adoption is associated with reduced uncertainty and higher expected returns, particularly in industrialized contexts with stable regulatory signals. Environmental, social, or agrarian considerations remain analytically absent. Therefore, across these studies, favorable positions emerge through two logics: economic-technological optimism and regulatory confidence. Both construct risk as manageable through better data, improved stewardship, or clearer institutional design.

Neutral papers dominate this domain, reflecting the prevalence of technical–operational research within risk-control infrastructures. Category 3 studies adopt descriptive and controversy-mapping approaches, examining perceptions, discourses, and policy ambiguity without advancing a normative stance. Taken together, these contributions — from Hakim et al.'s (2020, #81) investigation of consumer trust and perceived risk, Smith and Katovich's (2017, #83) assessment of trade-related policy effects, and Mucci and Hough's (2004, #150) examinations of public perceptions — consistently suspend judgment on GMOs, privileging analytical reconstruction and empirical mapping over substantive claims about desirability or harm. A second, and even larger, cluster of neutral contributions consolidates the operational core of biosafety governance by treating GMOs primarily as objects of analytical detection, regulatory classification, and compliance verification. Heinemann et al. (2013, #24) compare risk-assessment frameworks for dsRNA crops, identify methodological gaps, and propose improvements to exposure scenarios, endpoints, and uncertainty analysis, without taking a normative stance on the technology itself. Monitoring studies on the Brazilian food supply by Dinon et al. (2008, #196; 2010, #194; 2010, #206) and Branquinho et al. (2010, #195) further embed GMOs within routines of laboratory control, once they validate PCR

protocols, define detection limits, quantify GM content against the 1% labeling threshold, and audit market products for conformity with Decree nº 4.680/2003 and Codex-aligned standards. Together, these papers refine the technical and legal infrastructures of biosafety by stabilizing reference materials, thresholds, and surveillance procedures, while remaining silent on questions of social desirability, agrarian transformation, or distributive justice. Thereby, neutral contributions demonstrate how risk becomes "administratively real" through standardized procedures that translate biological variation into regulatory categories. In doing so, they sustain an infrastructure that is neither explicitly promotional nor overtly critical but indispensable to the day-to-day functioning of GMO governance.

Across these positional configurations, the Risk, Technical Control, and Biosafety domain shows how uncertainty is progressively converted into a governable object through scientific protocols, analytical infrastructures, and institutionalized assessment practices. Favorable studies treat risk as something controllable by improving data quality, stewardship, and regulatory design—so that better models, stricter IRM rules, or more predictable market and policy signals can secure the safe expansion of GM technologies. Neutral contributions, in turn, enact biosafety as an administrative infrastructure: they stabilize thresholds, labels, detection limits, and survey categories that make GMOs legible to regulators without pronouncing on their social desirability or agrarian consequences. The absence of Category 5 and 6 contributions in this domain is itself revealing: structural inequalities, corporate concentration, and health or toxicological harms are displaced to other parts of the literature, while here risk is framed primarily as a technical and institutional management problem. Together, these strands indicate that risk is not a pre-given property of GMOs but an outcome of epistemic and bureaucratic work that defines what counts as acceptable uncertainty, credible evidence, and "safe enough" exposure. In this sense, Domain 2 reveals biosafety not as a neutral subsystem, but as a field where scientific authority, regulatory capacity, and latent social contestation intersect to shape the conditions under which biotechnological futures become thinkable, permissible, or effectively closed off.

Knowledge, Ethics, and Scientific Reflexivity

Knowledge, Ethics, and Scientific Reflexivity draws together Methodology and State of the Art and Ethics, Justice, and Rights, illuminating how epistemic debates, justice concerns, and ethical boundaries shape biotechnology assessments in Latin America. Across these two second-order themes, positional patterns differ markedly from the domains of governance and risk. No study in this domain adopts a favorable stance toward GMOs (Categories 1 or 2). Instead, Methodology and State of the Art is populated exclusively by operationally neutral contributions (Category 4), while Ethics, Justice, and Rights is dominated by neutral and critical interventions (Category 4 and 5). The pattern is revealing: methodological advances tend to bracket normative controversy by focusing on analytical precision and regulatory compliance, whereas ethical and justice-oriented studies explicitly address and interrogate the socio-political orders in which biotechnology is embedded.

In the methodological strand, neutral contributions such as Santa-Maria et al. (2014) (#116), Venturelli et al. (2018) (#158), and Brod & Arisi (2007) (#307) treat GMOs not as political or moral entities but as objects requiring increasingly sophisticated tools for detection, quantification, and traceability. These texts stabilize the technical conditions under which biosafety norms can function, offering qPCR calibrators, nested PCR protocols, and analytical thresholds that strengthen surveillance regimes without adjudicating the desirability of GM technologies themselves. Similarly, studies in regulatory ethics journals—Duarte & da Silva (2016) (#241) and Braña et al. (2012) (#242)—frame GMO release decisions as institutional processes structured by procedural rationality, role expectations, conflict-of-interest governance, and evidentiary standards. Their neutrality stems from an explicit focus on how decisions are made, rather than whether the outcomes are just, safe, or socially legitimate. Across all these studies, epistemic authority is produced through method, calibration, and institutional design, not through normative argument or distributive critique.

By contrast, the ethical and justice-oriented strand introduces the only critical contribution in this domain. Hall et al. (2008) (#25) position transgenic agriculture within a development model that systematically privileges export-oriented agribusiness while undermining alternative rural futures. Here, GMOs are not framed as neutral technical objects but as socio-economic instruments that reinforce exclusion, dependency, and corporate power. Unlike the methodological papers, which bracket questions of justice in favor of technoscientific rigor, this study foregrounds distributive and ethical asymmetries as constitutive of the biotechnology regime itself. Its critique is structural, political-economic, and overtly concerned with rights, marginalization, and the moral economy of agricultural development.

Taken together, these strands reveal that knowledge production in the GMO field is stratified by epistemic orientations: operational studies consolidate methodological infrastructures that enable regulatory functioning. At the same time, ethical analyses expose the socio-political hierarchies that such infrastructures may inadvertently stabilize. Although both strands contribute to understanding how GMO is governed, their positional configurations differ profoundly. Neutral methodological texts naturalize GMOs as measurable entities amenable to standardized oversight, whereas critical scholarship reframes them as technologies embedded in unequal agrarian systems. These divergences highlight that the governance of GMOs depends not only on biosafety standards but also on contestations over whose knowledge counts, which futures are prioritized, and how justice is conceptualized in agrarian and scientific domains. Ultimately, Knowledge, Ethics, and Scientific Reflexivity articulates the moral, epistemic, and distributive foundations of GMO governance in the region. It underscores that debates over biotechnology cannot be detached from broader struggles over rural development, equity, and institutional legitimacy. The domain, therefore, demonstrates how scientific reflexivity and ethical inquiry reconfigure the positional landscape established in earlier sections, expanding the analysis from questions of regulatory adequacy and risk calibration to the deeper issue of how societies ought to value, contest, and democratize biotechnological innovation.

Regional Regulatory Context: Interactions Among Cartagena, Nagoya, and Nagoya–Kuala Lumpur

Across the reviewed literature, international regulatory regimes emerge as structuring forces that shape how Andean and Amazonian countries define, classify, and govern biotechnology (please see the figure below).

Figure 4

OGM and Protocols

Note: Link to the map here: https://doi.org/10.7910/DVN/4HTMPY

Several studies explicitly engage the Cartagena Protocol on Biosafety, either to justify regulatory alignment or to explain strategic forms of distancing. Pellegrini (2013, #37) demonstrates that Argentina's refusal to ratify Cartagena is not a technical choice but a political-economic strategy designed to avoid trade barriers and preserve export competitiveness. Thereby, it shows how global biosafety norms are selectively incorporated depending on national commercial interests. By contrast, de Andrade et al. (2016, #74) mobilize Cartagena as the backbone of Brazil's biosafety assessments, emphasizing that national risk evaluation procedures comply with the Cartagena Protocol, thereby grounding pro-release arguments in the legitimacy of globally standardized risk frameworks. Other studies extend the analysis beyond Cartagena. Whelan and Lema (2015, #212) and Ishii and Araki (2017, #210) examine how the Protocol's definition of novel combination of genetic material underpins regulatory decisions on genome-editing and new breeding techniques, highlighting the Protocol's indirect but decisive influence on domestic rulemaking. Graddy-Lovelace (2014, #69) broadens the scope by showing how the Nagoya Protocol, the Convention on Biological Diversity (CBD), TRIPS, and national moratoria interact to configure conservation governance in Peru, illustrating that GMO regulation cannot be disentangled from broader genetic resource and intellectual property regimes. Rosado and Eriksson (2022, #321) further document how most Latin

American and Caribbean countries explicitly adopt Cartagena's definition of LMOs in national law, reinforcing its position as the region's dominant legal anchor for biosafety classification.

Taken together, these studies depict a heterogeneous but deeply interdependent regulatory landscape. Countries such as Peru and Venezuela prohibit both cultivation and imports, while Ecuador permits imports but bans cultivation; Chile and Colombia, conversely, remain outside the Nagoya Protocol, signaling divergent commitments to access-and-benefit-sharing frameworks. The interaction between Cartagena's biosafety norms, Nagoya's genetic-resource provisions, and the Nagoya–Kuala Lumpur Supplementary Protocol's liability architecture generates regulatory tensions that reflect competing priorities—biodiversity protection, biosafety oversight, trade competitiveness, and innovation incentives. As shown in the supplementary regional map (Figure 3), these global instruments do not operate uniformly but become refracted through national political economies, institutional capacities, and ecological histories, producing hybrid governance models that anchor GMO regulation in a complex web of international obligations and strategic omissions.

Conclusion: Integrating Science, Politics, and Ethics

This scoping review set out to map—rather than resolve—the heterogeneous governance of GMOs in Andean and ACTO-aligned contexts (Webster & Watson, 2002; Torraco, 2005; Kunisch et al., 2018; Breslin & Gatrell, 2020).

Building on a PRISMA-ScR logic and an explicitly cartographic ambition, the review identifies three aggregated domains—Governance, Politics and Institutional Legitimacy; Risk, Technical Control and Biosafety; Knowledge, Ethics and Scientific Reflexivity—crossed with six positional categories that differentiate pro-GMO, neutral and critical stances. This architecture transforms a dispersed body of work—from Bartley and Hallerman's (1995) early FAO survey to contemporary analyses of genome-editing regulation (Eriksson et al., 2019; Ishii & Araki, 2017) and agrarian political ecology (Arancibia, 2013; Leguizamón, 2014)—into a coherent taxonomy that conceptualizes the field (Webster & Watson, 2002).

The review also provides a critical synthesis of evidence, tensions, and absences by linking bibliometric patterns to the field's positional architecture. The tri-polar authorial structure—comprising a methodological–operational stream on qPCR, traceability, and surveillance; a pro-innovation stream centered on economic and regulatory optimization; and a critical socio-political stream highlighting inequality, land concentration, and regulatory capture—translates, in positional terms, into favorable assessments of GMOs clustering around techno-economic and regulatory framings. At the same time, structural and justice-oriented critiques concentrate on governance and ethics. Risk and biosafety, by contrast, remain framed mainly as technical–administrative issues, with limited connection to socio-environmental harms. This integrative outcome of this scoping review is identified as central to theory-informed review work (Torraco, 2005). To make these configurations explicit within the thematic architecture, the following table cross-references the three aggregated domains with the six positional categories identified earlier. Rather than classifying individual articles, the matrix synthesizes how pro-GMO, neutral, and critical orientations coalesce around distinct governance problems, risk imaginaries, and epistemic–ethical concerns. In doing so, it renders visible how different normative stances anchor specific vocabularies, problem definitions, and evidentiary standards in each domain, while also reflecting the

asymmetric distribution of positions observed empirically: Domain 1 (Governance, Politics, and Institutional Legitimacy) encompasses the full range of stances (Categories 1–6), Domain 2 (Risk, Technical Control, and Biosafety) is composed exclusively of favorable and neutral studies (Categories 1–4), and Domain 3 (Knowledge, Ethics, and Scientific Reflexivity) contains only neutral and critical contributions (Categories 4–5).

Table 7

Positional Matrix of GMO Governance: Aggregated Domains Crossed with Six Stance Categories

Domain / Position	Pro-GMO (Technologically & Economically Favorable)	Pro-GMO with Regulatory Emphasis	Neutral–Bridging / Controversy Mapping	Neutral–Operational / Governance-Focused	Critical Socio-Political	Critical Risk / Toxicological
1. Governance, Politics & Institutional Legitimacy	Frames GMOs as agronomically and economically successful technologies; regulatory obstacles are portrayed as excessive or irrational, and governance should facilitate rather than restrain innovation.	Emphasizes harmonization, regulatory efficiency, strengthening biosafety systems, and predictable, "science-based" approval pathways as the main levers for enabling safe innovation.	Maps institutional controversies, public reasoning, and conflicts around precaution, expertise, and democracy without adjudicating the desirability of GMOs.	Focuses on administrative instruments, detection protocols, institutional coordination, and policy-transfer dynamics that render GMOs administratively knowable and controllable.	Critiques land concentration, dependency, inequality, corporate food regimes, IP-based "bioproperty," and regulatory capture; it shows how governance arrangements reproduce asymmetric power relations.	Links governance arrangements and permissive or failed regulatory regimes to health, toxicological, and environmental harms associated with pesticide-intensive GMO agriculture.
2. Risk, Technical Control & Biosafety	Constructs risk as a solvable technical problem; GM crops are treated as profitable, efficient, and strategically advantageous, with uncertainty reduced via better data and models.	Anchors legitimacy in robust biosafety procedures, IRM regulation, surveillance systems, and alignment with international frameworks such as the Cartagena Protocol; governance failures, not the technology itself, are problematized.	Examines perceptions, ambiguity, and competing framings of risk (e.g., consumer trust, trade-related effects, public perceptions) without endorsing or opposing GMOs.	Dominant stance in this domain: develops qPCR protocols, detection thresholds, analytical standards, labeling procedures, and monitoring protocols that translate biological variation into regulatory categories and compliance routines.	**Absent in this domain** (structural political–ecological critiques are displaced to other domains).	**Absent in this domain** (health- and toxicity-centered critiques do not appear alongside biosafety infrastructure papers here).

Domain / Position	Pro-GMO (Technologically & Economically Favorable)	Pro-GMO with Regulatory Emphasis	Neutral–Bridging / Controversy Mapping	Neutral–Operational / Governance-Focused	Critical Socio-Political	Critical Risk / Toxicological
3. Knowledge, Ethics & Scientific Reflexivity	**Absent in this domain** (no techno-economic endorsements of GMOs).	**Absent in this domain** (no studies focused on optimizing regulatory frameworks to enable innovation).	**Absent in this domain** (neutral contributions here are methodological/operational rather than controversy-mapping).	Exclusively populated by operationally neutral contributions: methodological and "state-of-the-art" studies that refine detection, quantification, traceability, and institutional ethics procedures, focusing on how decisions are made rather than on whether GMOs are desirable or just.	One critical contribution: structural, development- and justice-oriented analyses that position GMOs within agrarian models that privilege export-oriented agribusiness and reinforce exclusion, dependency, and unequal rural futures.	**Absent in this domain** (no biomedical/toxicological critiques are located within this epistemic–ethical domain).

Hence, the review proposes a conceptual framework—not as a closed theory but as a scaffolding that organizes how themes, positions, and authorial strands interrelate. The intersection of three domains, six positional categories, and a tri-polar authorial structure offers what Breslin and Gatrell (2020) call an organizing frame for this device supports both prospecting (opening new questions) and mining (deepening established lines). The framework highlights where the literature talks past itself, where governance challenges intersect, and where dialogical and justice-sensitive approaches to biotechnology regulation could be developed.

Building on these insights, the review advances a research agenda that is both empirically grounded and strategically oriented. A central priority is to bridge the persistent divide between technical–biosafety research and structural–political critique by examining how specific detection protocols, risk-assessment procedures, and labeling rules intersect with land regimes, patterns of rent appropriation, and socio-environmental inequalities. A second avenue concerns the need for systematic analyses of the multi-level governance dynamics linking the Cartagena Protocol, the Nagoya Protocol, and the Nagoya–Kuala Lumpur Supplementary Protocol—an architecture that is frequently acknowledged but rarely interrogated as an interconnected regulatory regime. A third direction involves expanding scholarship on epistemic justice and reflexivity in biosafety assessments, particularly with respect to whose knowledge counts, how community-generated evidence circulates or is silenced, and how scientists and regulators negotiate their own positionality within GMO controversies. This agenda is not an ancillary addendum but a core deliverable of the review (Kunisch et al., 2018, 2023; Webster & Watson, 2002), specifying where integrative, interdisciplinary work is most needed to advance a more reflexive and analytically coherent understanding of GMO governance.

The review also contributes by explicitly documenting the field's mapping. Bibliometric regularities (Lotka's and Bradford's laws) were combined with inductive coding of governance mechanisms, risk framings, and ethical concerns to generate eight second-order themes and three aggregated domains, which were then intersected with a six-category positional matrix. This transparent and iterative movement between data structure and conceptual synthesis (Breslin & Gatrell, 2020; Kunisch et al., 2018; van Maanen, Sørensen & Mitchell, 2007) makes visible the interpretive operations through which heterogeneous contributions were organized into a coherent analytical architecture. By detailing how search procedures, inclusion criteria, coding decisions, and thematic aggregations were connected to interpretive judgments, the review aligns with contemporary expectations that literature reviews articulate not only what they found but how those findings were produced. Such methodological transparency positions the review as a replicable and extensible platform for future research on GMO governance.

By mapping how GMOs are justified, contested, and governed in Andean and Amazonian contexts, this scoping review provides a transparent, critically synthesized, and visually organized platform for advancing a more reflexive and inclusive scholarship on biotechnology governance in the Global South. In line with Latour's (2005) insistence that knowledge is always produced through heterogeneous networks, the review foregrounds how such networks shape the very conditions under which GMOs become matters of concern. Within this configuration, the review functions not merely as a synthesis but as a reflexive mediating device that assembles heterogeneous forms of knowledge—technical, sociological, legal, ecological—and places them in analytic relation, enabling a mode of inquiry attentive to plural epistemic authorities and to the demands of public accountability; in this sense, it resonates with Stengers's (2015) call for a "politics of hesitation" in the face of technoscientific interventions. The conceptual

architecture developed here thus serves not only academic purposes but also institutional and civic ones, offering a structured basis for informed deliberation, policy design, and public communication across multiple formats, from infographics and pedagogical materials to interviews and documentary outputs. Ultimately, the review positions GMO governance as a dynamic interplay of legitimacy, precaution, and distributive justice—an interplay that must remain open, contestable, and responsive if biotechnology is to contribute meaningfully to biodiversity protection and social well-being in Andean and Amazonian regions, a stance consonant with Haraway's (1991) understanding of knowledge as situated, partial, and accountable.

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Role of the funding source

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used ChatPGT 5 to assist with content organization, English language refinement, and preliminary structuring of the dataset. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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Appendix A

Table 1

Search Strategy (Scopus and Web of Science)

Source	Search string
Scopus	TITLE-ABS-KEY (("Bioengineered organism" OR "Bioengineered food" OR "Biotech Crops" OR "green Biotechnology" OR Cisgenic* OR "Gene-Edited organism" OR "Genetically Engineered organism" OR "Genetically Engineered crop" OR "Genetically Modified food" OR "Genetically Modified Microorganism" OR "Genetically Modified Organism" OR GMO* OR "Genome Edited Organisms" OR "GM corn" OR "GM cotton" OR "GM soy" OR "GM foods" OR Intragenic* OR "Living Modified Organism" OR "Recombinant DNA organism" OR Transgenic* OR "OGM Bt" OR "Bt crops" OR "Bt corn" OR "Bacillus thuringiensis (Bt) crops" OR "Bt cotton" OR "genetically modified animals" OR "genetically modified plants" OR "genetically modified insects") AND (public OR polic* OR "institutional analysis" OR Regulat* OR political OR governance OR law OR legal OR enforcement OR government OR agreement OR compliance OR "risk assessment" OR transparen* OR "precautionary principle" OR moratorium) AND (Argentin* OR Bolivia* OR Chile* OR Colombia* OR Ecuador* OR Peru* OR Venezuel* OR Andean* OR "South Amer*" OR "Southern America" OR "Latin America" OR Brazil* OR Surinam* OR Guyana* OR "Amazon Cooperation Treaty Organization" OR ACTO)) AND (LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese"))
WoS	(TS= (("Bioengineered organism" OR "Bioengineered food" OR "Biotech Crops" OR "green Biotechnology" OR Cisgenic* OR "Gene-Edited organism" OR "Genetically Engineered organism" OR "Genetically Engineered crop" OR "Genetically Modified food" OR "Genetically Modified Microorganism" OR "Genetically Modified Organism" OR GMO* OR "Genome Edited Organisms" OR "GM corn" OR "GM cotton" OR "GM soy" OR "GM foods" OR Intragenic* OR "Living Modified Organism" OR "Recombinant DNA organism" OR Transgenic* OR "OGM Bt" OR "Bt crops" OR "Bt corn" OR "Bacillus thuringiensis (Bt) crops" OR "Bt cotton" OR "genetically modified animals" OR "genetically modified plants" OR "genetically modified insects") AND (public OR polic* OR "institutional analysis" OR Regulat* OR political OR governance OR law OR legal OR enforcement OR government OR agreement OR compliance OR "risk assessment" OR transparen* OR "precautionary principle" OR moratorium) AND (Argentin* OR Bolivia* OR Chile* OR Colombia* OR Ecuador* OR Peru* OR Venezuel* OR Andean* OR "South Amer*" OR "Southern America" OR "Latin America" OR Brazil* OR Surinam* OR Guyana* OR "Amazon Cooperation Treaty Organization" OR ACTO))) AND (DT==("ARTICLE" OR "REVIEW" OR "EARLY ACCESS") AND LA==("ENGLISH" OR "SPANISH" OR “PORTUGUESE”))

Appendix B

Table 1

Screening metrics and reliability details

Stage	Cohen's Kappa	Proportionate agreement
Screening title and abstract	0.81 (almost perfect)[a]	91.5%
Screening full text	0.97 (almost perfect)[a]	99.2%

[a] According to Landis & Koch (1977), values of κ between 0.81 and 1.00 are interpreted as "almost perfect" agreement.

Appendix C

Table 1

Articles ID

ID	Title	Authors	Year	Journal
#22	Framing the frontier – Tracing issues related to soybean expansion in transnational public spheres	F., Mempel, Finn; E., Corbera, Esteve	2021	Global Environmental Change
#24	A comparative evaluation of the regulation of GM crops or products containing dsRNA and suggested improvements to risk assessments	J.A., Heinemann, Jack A.; S.Z., Agapito-Tenfen, Sarah Zanon; J.A., Carman, Judy A.	2013	Environment International
#25	Social exclusion and transgenic technology: The case of Brazilian agriculture	J.K., Hall, Jeremy K.; S.V., Matos, Stelvia V.; C.H., Langford, Cooper Harold	2008	Journal of Business Ethics
#31	The so-called 'moratorium' on the licensing of new genetically modified (GM) products by the European Union 1998-2004: A study in ambiguity	S., Lieberman, Sarah; T.S., Gray, Tim Stuart	2006	Environmental Politics
#33	Biotechnology and its configurations: GM cotton production on large and small farms in Argentina	P., van Zwanenberg, Patrick; V., Arza, Valeria	2013	Technology in Society
#34	Resisting and accepting: Farmers' hybrid epistemologies in the GMO controversy in Chile	M., Tironi, Manuel; M.P., Salazar, Maite P.; D., Valenzuela, Daniel	2013	Technology in Society
#35	Challenging the bioeconomy: The dynamics of collective action in Argentina	F., Arancibia, Florencia	2013	Technology in Society
#36	Winged promises: Exploring the discourse on transgenic mosquitoes in Brazil	L., Reis-Castro, Luísa; K., Hendrickx, Kim	2013	Technology in Society
#37	What risks and for whom? Argentina's regulatory policies and global commercial interests in GMOs	P.A., Pellegrini, Pablo Ariel	2013	Technology in Society
#38	The " soy-ization" of Argentina: He dynamics of the " globalized" privatization regime in a peripheral context	P., Delvenne, Pierre; F., Vasen, Federico; A.M., Vara, Ana María	2013	Technology in Society
#44	Taking Monsanto to court: legal activism around intellectual property in Brazil and India	K., Peschard, Karine; S., Randeria, Shalini	2020	Journal of Peasant Studies
#45	Exploring the ‘grey areas’ of state-society interaction in food sovereignty construction: the battle for Venezuela’s seed law	A., Felicien, Ana; C.M., Schiavoni, Christina M.; E., Ochoa, Eisamar; S., Saturno, Silvana; E., Omaña, Esquisa; A., Requena, Adrianna; W., Camacaro, William	2020	Journal of Peasant Studies

#46	Genetically modified soybeans, agrochemical exposure, and everyday forms of peasant collaboration in Argentina	P., Lapegna, Pablo	2016	Journal of Peasant Studies
#58	Is GM Soybean Cultivation in Argentina Sustainable?	P., Phélinas, Pascale; J., Choumert-Nkolo, Johanna	2017	World Development
#59	The politics of technological upgrading: International transfer to and adaptation of GM cotton in Argentina	V., Arza, Valeria; P., van Zwanenberg, Patrick	2014	World Development
#62	Unlocking crop biotechnology in developing countries - A report from the field	J.I., Cohen, J. I.; R.L., Paarlberg, Robert L.	2004	World Development
#67	Managing risk in the regulatory state of the South: the case of GM wheat in Argentina	S.Y., Jeon, Su Yeone	2023	Review of International Political Economy
#69	Situating in situ: A critical geography of agricultural biodiversity conservation in the peruvian andes and beyond	G., Graddy-Lovelace, Garrett	2014	Antipode
#74	Use of transgenic aedes aegypti in Brazil: Risk perception and assessment; Utilisation d'une souche transgénique d'Aedes aegypti au Brésil: Perception et évaluation des risqué; Uso de Aedes aegypti transgénicos en Brasil: Percepción y evaluación de riesgo	P.P., de Andrade, Paulo Paes; F.J.L., Aragäo, Francisco José Lima; W., Colli, Walter; O.A., Dellagostin, Odir Antônio; F., Finardi Filho, Flavio; M.H., Hirata, Mário Hiroyuki; A.D.C., Lira-Neto, Amaro De Castro; M.A., de Melo, Márcia Almeida; A.L., Nepomuceno, Alexandre Lima; F.G., da Nóbrega, Francisco Gorgônio	2016	Bulletin of the World Health Organization
#78	"No turning back": The emergence and settlement of GMO hegemony in Brazil	Y., Fontoura, Yuna; M.G., Krieger, Morgana G.martins; A., Peci, Alketa	2022	Journal of Rural Studies
#81	The mandatory labeling of genetically modified foods in Brazil: Consumer's knowledge, trust, and risk perception	M.P., Hakim, Mariana Piton; L.D., Zanetta, Luis D'Avoglio; J.M.D., Oliveira, Julicristie Machado De; D.T., Da Cunha, Diogo Thimoteo	2020	Food Research International
#83	Are GMO policies "trade related"? Empirical analysis of Latin America	P.J., Smith, Pamela J.; E.S., Katovich, Erik S.	2017	Applied Economic Perspectives and Policy
#85	Protecting biotechnology IPRs in developing countries: Simple analytics of a levy solution	R., Cardwell, Ryan; W.A., Kerr, William A.	2008	Journal of Agricultural Economics
#90	The territorial and sectoral dimensions of advocacy – The conflicts about pesticide use in Argentina	M., Rauchecker, Markus	2019	Political Geography
#91	Globalization and Brazilian biosafety: The politics of scaleover biotechnology governance	W.E., Jepson, Wendy E.	2002	Political Geography

#101	Regulatory harmonization and agricultural biotechnology in Argentina and China: Critical assessment of state-centered and decentered approaches	P., van Zwanenberg, Patrick; A.V., Ely, Adrian V.; A., Smith, Adrian; C., Chuanbo, Chen; D., Shijun, Ding; M.E., Fazio, María Eugenia; L., Goldberg, Laura	2011	Regulation and Governance
#104	Transnational Discursive Opportunities and Social Movement Risk Frames Opposing GMOs	R.C., Motta, Renata Campos	2015	Social Movement Studies
#105	Roundup ready soybeans in Argentina: Farm level and aggregate welfare effects	M., Qaim, Matin; G.J., Traxler, Greg J.	2005	Agricultural Economics (United Kingdom)
#106	Transgenic soy as a political crop and a resistance crop in Argentina – The struggle around control and rent appropriation between the state, seed corporations and soy farmers	M., Rauchecker, Markus	2022	Geoforum
#107	Modifying Argentina: GM soy and socio-environmental change	A., Leguizamón, Amalia	2014	Geoforum
#111	The GMO panel: applications of wto law to trade in agricultural biotech products	G.R., Winham, Gilbert R.	2009	Journal of European Integration
#115	Is there an opportunity for product differentiation between GM and non-GM soya-based products in Argentina?	B., Martinez-Ribaya, Bernardo; F.J., Areal, Francisco José	2020	Food Control
#116	Adventitious presence of transgenic events in the maize supply chain in Peru: A case study	M.C., Santa-Maria, Monica C.; G., Lajo-Morgan, Gabriela; L., Guardia, Lorena	2014	Food Control
#117	Detection of GMO in food products in Brazil: The INCQS experience	P., Cardarelli, Paola; M.R., Branquinho, Maria Regina; R.T.B., Ferreira, Renata Trotta Barroso; F.P., da Cruz, Fernanda P.; A.L., Gemal, André Luís	2005	Food Control
#134	Are good ideas enough? The impact of socio-economic and regulatory factors on GMO commercialisation	N., Vàzquez-Salat, Núria	2013	Biological Research
#135	Food Regime Analysis in a Post-Neoliberal Era: Argentina and the Expansion of Transgenic Soybeans	M.J., Torrado, Marla J.	2016	Journal of Agrarian Change
#136	Global Capitalism and the Nation State in the Struggles over GM Crops in Brazil	R.C., Motta, Renata Campos	2016	Journal of Agrarian Change
#137	Mobilizing against GM crops in India, South Africa and Brazil	I.C., Scoones, Ian C.	2008	Journal of Agrarian Change

#143	Responsible Innovation and political accountability: genetically modified mosquitoes in Brazil	A.L., Sica de Campos, André Luiz; S., Hartley, Sarah; C., de Koning, Christiaan; J., Lezaun, Javier; L., Velho, Lea	2017	Journal of Responsible Innovation
#144	Responsible innovation and the reshaping of existing technological trajectories: the hard case of genetically modified crops	P., Macnaghten, Phil	2016	Journal of Responsible Innovation
#146	Farmers prevailing perception profiles regarding GM crops: A classification proposal	C.D.S., Almeida, Carla Da Silva; L.M., Massarani, Luisa Medeiros	2018	Public Understanding of Science
#148	Preferences need no inferences, once again: Germinal elements in the public perceptions of genetically modified foods in Colombia	C.J., Parales-Quenza, Carlos José	2004	Public Understanding of Science
#150	Perceptions of genetically modified foods by consumers in Argentina	A., Mucci, Andrea; G.E., Hough, Guillermo E.	2004	Food Quality and Preference
#158	New plasmid calibrators for geminivirus-resistant (EMB-PV051-1 event) common bean (Phaseolus vulgaris L.) quantitation using simplex and duplex qPCR	G.L., Venturelli, Gustavo Luiz; K.J., Silva, Kelly Justin; D., Treml, Diana; P.B., Navas, Paola Beatriz; M.O., Vargas, Maryella Osório; J.L., Bischoff, Joana Laura; J.C., de Faria, Josias Corrêa; A.C., Arisi, A. C.M.	2018	Food Bioscience
#162	A global perspective on the utilization of genetically modified organisms in aquaculture and fisheries	D.M., Bartley, Devin Michael; E.M., Hallerman, Eric M.	1995	Aquaculture
#171	How can policymakers and researchers develop effective insect resistance management guidelines? A quantitative and qualitative study of Brazilian farmers' perspectives and attitudes	D.T., Pezzini, Daniela Tamara; J.A., Delborne, Jason A.; D.D., Reisig, Dominic D.	2023	Plants People Planet
#173	Stealth seeds: Bioproperty, biosafety, biopolitics	R.J., Herring, Ronald J.	2007	Journal of Development Studies
#174	Genetically modified organisms in agriculture: Can regulations work?	D.M., Kothamasi, David Manohar; S., Vermeylen, Saskia	2011	Environment, Development and Sustainability
#176	Genetically modified crops as real options: Identifying regional and country-specific differences	D.A., Nadolnyak, Denis A.; M.J., Miranda, Mario Javier; I.M., Sheldon, Ian M.	2011	International Journal of Industrial Organization
#179	Brazilian GMO regulation: Does it have an environmental approach?	D.G., Pizella, Denise Gallo; M.M.P.D., Souza, Marcelo Marini Pereira De	2012	Journal of Environmental Assessment Policy and Management

#186	Developing country experience with Bt cotton: Institutional constraints in the diffusion of transgenic crops	R.B., Tripp, Robert B.	2011	Outlook on Agriculture
#188	State of exception in the regulation of genetically modified organisms in Brazil	V., Pelaez, Victor	2009	Science and Public Policy
#192	Porousness and Peru's moratorium on genetically modified organisms: stakeholder epistemologies and neoliberal science	T.W., Dondanville, T. W.; M.L., Dougherty, Michael L.	2020	Environmental Sociology
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