American Journal of Advanced Multidisciplinary Innovation and Research (AJAMIR)

E-ISSN: XXXX-XXXX ● Website: www.ajamir.com ● Email: editor@ajamir.com

Smallholder Data Rights in Digital Agricultural Platforms

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Abstract

Digital agricultural platforms increasingly mediate access to farm advisories, weather forecasts, input recommendations, machinery services, market information, credit assessment, remote sensing, farm records, and precision-management tools. These services can generate substantial value for smallholder farmers, yet participation also produces detailed datasets concerning farm location, production, input use, yields, transactions, land characteristics, and household-linked economic activities. When platform terms are complex, data cannot be exported, secondary uses remain undisclosed, or aggregated datasets create value without meaningful farmer participation, digital adoption can generate new asymmetries between smallholders and platform operators. This study develops a simulation-based framework for assessing smallholder data rights within digital agricultural platforms without presenting hypothetical farmer interviews or platform contracts as empirical evidence. Five governance configurations are compared: opaque platform control, disclosure-oriented governance, consent-centered governance, portable and purpose-limited data governance, and farmer-centered rights with accountable benefit sharing. A Smallholder Agricultural Data Rights Index is constructed using informed consent, access and portability, purpose limitation and transparency, security and accountability, and equitable value participation.

Simulated index values increase from 27.8 under opaque platform governance to 91.6 under the farmer-centered model. A complementary cumulative analysis indicates that explicit consent, portability, purpose restrictions, auditability, and benefit sharing contribute distinct layers of protection and cannot be replaced by a generic declaration that farmers “own” their data. The study argues that smallholder data rights should be understood as a bundle of actionable controls rather than a narrow ownership claim. Stronger governance requires plain-language terms, granular permissions, accessible copies of farm data, interoperable export, transparent secondary use, reasonable retention and deletion provisions, safeguards against discriminatory analytics, and mechanisms through which farmers can share in value generated from aggregated agricultural data. Such protections can strengthen trust while allowing digital agriculture to support innovation rather than intensify platform dependence.

Keywords: agricultural data rights, smallholder farmers, digital agriculture, data governance, farm data, platform economy, data portability, informed consent

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1. Introduction

Digital platforms are becoming important intermediaries in agricultural production and exchange. A single application may provide localized weather information, crop recommendations, pest alerts, input procurement, machinery booking, digital payments, traceability, credit services, market prices, satellite-derived crop information, and farm-management records. These services depend increasingly on data generated by farmers, their fields, machines, transactions, and interactions with digital systems. Wolfert and colleagues observed that big-data applications in smart farming extend beyond individual farms into wider agricultural supply chains and that data governance, ownership, privacy, security, and business models are consequently central institutional questions rather than peripheral technical concerns.

The value of agricultural data creates an important tension for smallholder participation. Data sharing can improve agronomic recommendations, forecasting, service targeting, research, risk assessment, and market coordination when information from many farms is responsibly combined. At the same time, the farmer contributing the underlying data may possess less technical, contractual, and bargaining capacity than the organization aggregating it. Wiseman and colleagues found that concerns regarding unclear data licenses, ownership, privacy, sharing, bargaining inequality, and benefit distribution can reduce farmers' willingness to participate in smart-farming data systems. Jakku and colleagues similarly identified trust, transparency, and perceptions concerning who benefits from agricultural data as central socio-technical issues in digital farming.

These concerns may become more pronounced for smallholders. A farmer using a platform to access agronomic advice or a marketplace may accept standardized terms because there is no realistic opportunity to negotiate them individually. Limited digital literacy can further weaken the ability to identify secondary data uses, retention periods, data-sharing partners, automated decision processes, or restrictions on export. Research on mobile agricultural advisory systems also indicates that digital access itself is not socially uniform; women, older farmers, and smallholders can interact less intensively with services when differences in access, device control, or user capability persist. Digital rights therefore cannot be separated from broader questions of digital inclusion.

The language of “data ownership” provides only a partial response. Agricultural data can involve several parties and legal interests simultaneously: a farmer may generate agronomic information using equipment supplied by one company, software provided by another, and satellite or weather data originating elsewhere. OECD analysis accordingly emphasizes control, access, privacy, confidentiality, economic interests, sharing, and institutional trust rather than assuming that one ownership label resolves every data-governance question. Sectoral initiatives such as the European agricultural data-sharing code similarly address access, control, portability, transparency, privacy, security, liability, and contractual rights as separate but related dimensions.

2. Objectives of the Study

2.1 To Evaluate the Practical Scope of Smallholder Data Rights

The first objective is to identify the rights that become relevant when a smallholder interacts with a digital agricultural platform. These include understandable consent, access to contributed and derived data, correction, portability, withdrawal from optional uses, reasonable deletion mechanisms, information concerning recipients, and transparency regarding automated or secondary processing.

The study treats these rights as functionally distinct. A farmer may technically own information while being unable to download it in a usable format, prevent its reuse, or transfer historical records to another service provider. The analytical framework therefore measures effective control rather than relying on ownership terminology alone.

2.2 To Examine Platform Dependence, Bargaining Power, and Benefit Distribution

The second objective is to assess how platform design can affect bargaining power. Platforms generate value partly through aggregation: data collected from many farms can improve predictive models, market intelligence, insurance products, benchmarking tools, credit assessment, or commercial services. Wysel and colleagues emphasize that agricultural data-sharing platforms create value through interactions among communities, data, and facilitating systems, demonstrating that data value emerges from relationships rather than isolated records alone.

The study therefore examines whether farmers understand who may derive value from aggregated data and whether their participation produces reciprocal benefits. Benefit sharing is interpreted broadly and can include improved services, reduced costs, collective analytics, access to derived insights, cooperative revenue arrangements, or other credible forms of farmer participation in the value created.

2.3 To Develop a Farmer-Centered Platform Governance Framework

The third objective is to formulate a governance model that allows agricultural data innovation while reducing unnecessary smallholder vulnerability. The study does not propose that every dataset remain exclusively under individual control or that responsible data sharing should be prevented. Agricultural research, public policy, cooperative services, and commercial innovation can benefit from appropriately governed data access.

Instead, farmer-centered governance requires proportionality. The amount and sensitivity of data collected should correspond to the service provided, additional uses should be transparent, security should be appropriate to risk, and farmers should not lose reasonable control simply because participation is mediated through standardized digital contracts.

3. Review of Literature

3.1 Agricultural Data, Control, and Trust

Wolfert and colleagues' review of big data in smart farming identified data ownership, privacy, security, governance, and business models among the principal socio-economic questions surrounding digital agriculture. Their analysis also described the possibility of a spectrum between closed proprietary systems and more open collaborative infrastructures, with standards and platform design influencing farmers' ability to choose among technology and business partners. This early framing remains important because data rights are inseparable from the technical architecture through which information is stored and exchanged.

Bronson and Knezevic similarly argued that agricultural big-data systems can alter relationships of power across the food system. Their analysis questioned who controls data, who has analytical capacity, and how apparently technical systems can redistribute decision authority between farmers and

large organizations. Rotz and colleagues subsequently examined digital agricultural technologies through a political-economy perspective and identified data ownership and control, technology development, and cybersecurity as significant dimensions requiring greater attention to equity.

Farmer trust provides a practical link between these structural questions and technology adoption. Jakku and colleagues' study of smart farming found that stakeholders perceived potential benefits from agricultural data but were concerned about transparency and the distribution of benefits.

The authors argue that data systems are socio-technical arrangements whose legitimacy depends on institutions and relationships as much as on technical functionality. Wiseman and colleagues reached a compatible conclusion from their examination of agricultural data licenses, showing that ambiguity surrounding access, sharing, privacy, ownership, liability, and benefit distribution can undermine willingness to share data.

3.2 Platformization, Lock-In, and Smallholder Vulnerability

Digital agricultural platforms can create efficiencies because one interface can connect multiple data sources and services. The same integration can, however, generate switching costs. Historical records, field maps, advisory outputs, transaction histories, and machine data can become difficult to transfer when systems use incompatible formats or restrict exports. Prause, Hackfort, and Lindgren describe platform-related lock-in effects in which switching costs rise when data formats are incompatible and farmers lose practical control over information generated through proprietary systems.

Platform dependency is particularly important for smallholders because each farmer typically negotiates from a weaker position than a large platform provider. Standardized agreements may be offered on a take-it-or-leave-it basis, while farmers may lack technical assistance capable of interpreting complex contractual language. A World Bank discussion focused specifically on smallholders similarly identified unclear ownership, rights, privacy, security, and complex licensing as obstacles and noted that unequal bargaining power can weaken farmer control over digital data relationships.

Digital inequality can compound contractual inequality. Rotz and colleagues found that digital agricultural technologies can interact with existing differences in farm assets, infrastructure, skills, and labor relations, with potential consequences for already vulnerable rural actors. A platform may therefore satisfy formal data-protection requirements while remaining practically inaccessible to farmers who cannot understand permissions, retrieve files, or navigate digital interfaces. Data-rights design must consequently consider usability as well as legal wording.

Research on broader patterns of digital-agriculture inequality reinforces this concern. Reviews have found that digital platforms may transfer control over farm-generated information toward data aggregators through contractual terms, proprietary systems, and unequal bargaining relationships. This literature supports a shift from asking merely who is formally associated with data toward examining who can actually access, interpret, transfer, restrict, monetize, and reuse it.

3.3 Data Governance, Portability, and Fair Value Creation

OECD analysis provides one of the clearest frameworks for the agricultural data-governance problem. Jouanjean and colleagues argue that fragmented and unclear governance arrangements can weaken trust and technology uptake, while public policy must balance privacy, confidentiality, economic interests,

and the innovation benefits associated with responsible data sharing. Importantly, the report distinguishes questions concerning control of farm-generated data from broader rules governing access, sharing, and use.

The European Code of Conduct on Agricultural Data Sharing by Contractual Agreement represents an important self-regulatory response. It emphasizes the role of the data originator and addresses data access, control, portability, protection, transparency, privacy, security, liability, and intellectual-property considerations. Although a voluntary code cannot substitute automatically for enforceable law, its structure illustrates why data rights require multiple operational protections.

The distribution of value is equally important. Zhang and colleagues found that farmers' willingness to share agricultural data varied according to perceptions concerning who would benefit from aggregated datasets; willingness was stronger when farmers were perceived as the primary beneficiaries. This evidence supports the inclusion of benefit participation within a data-rights framework rather than treating it solely as a commercial issue.

Wysel, Baker, and Billingsley conceptualize agricultural data-sharing platforms as systems that generate value through communities of actors and data relationships. From a smallholder perspective, the governance question is therefore not whether aggregated data may create value—it clearly can—but whether farmers who create essential underlying information retain fair access, meaningful control, and a credible share of resulting benefits.

4. Research Methodology

4.1 Simulation-Based Governance Design

The study adopts a simulation-based multicriteria methodology. No specific commercial platform is scored, and no real smallholder participant is represented within the numerical results. The hypothetical platform environment includes services such as advisory delivery, digital farm records, market linkage, input recommendations, remote sensing, machinery access, and transaction support.

Five governance arrangements are modeled. Opaque platform control represents extensive data collection under complex or poorly understood terms. Disclosure-oriented governance provides clearer notice of collection and use but limited farmer control. Consent-centered governance adds more meaningful permission mechanisms. Portable and purpose-limited governance introduces interoperable access, data export, explicit secondary-use restrictions, and greater accountability. Farmer-centered governance adds benefit participation, contestability, transparent automated decision practices, and stronger user control throughout the data lifecycle.

The models represent governance maturity rather than specific legal jurisdictions. Actual rights will depend on applicable national legislation, contracts, sectoral codes, and the type of information being processed.

4.2 Smallholder Agricultural Data Rights Index

A Smallholder Agricultural Data Rights Index (SADRI) was developed to compare the governance arrangements. Five criteria are scored between 0 and 100.

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Table 1: Criteria Used in the Smallholder Agricultural Data Rights Index

Data-rights dimension	Operational interpretation	Weight
Informed and granular consent	Plain-language explanation of collection and meaningful choice regarding optional uses	0.20
Access, correction, and portability	Ability to view, correct, download, and transfer farm data in usable formats	0.25
Purpose limitation and transparency	Clear purposes, disclosed secondary use, recipient information, retention rules, and understandable processing logic	0.20
Security and accountability	Appropriate safeguards, incident response, auditability, complaint handling, and responsibility for misuse	0.15
Equitable value participation	Farmer access to derived value, collective benefits, fair data-exchange terms, and protection from one-sided extraction	0.20

The index is calculated as:

$$SADRI = 0.20C + 0.25P + 0.20T + 0.15A + 0.20V$$

where C represents informed consent, P access and portability, T purpose limitation and transparency, A security and accountability, and V equitable value participation.

Access and portability receive the highest individual weight because control becomes difficult to exercise if farmers cannot retrieve or transfer their own operational records. Consent, transparency, and value participation receive equal substantial weights because platform legitimacy depends on understanding, control, and reciprocity rather than security alone.

4.3 Scoring Logic, Ethical Scope, and Limitations

Scores were assigned comparatively according to the safeguards embedded in each hypothetical platform model. Opaque governance receives low values because formal acceptance of terms provides little evidence of meaningful user understanding or ongoing control. Disclosure improves transparency but does not necessarily allow farmers to refuse secondary processing without abandoning the core service.

Consent-centered governance receives higher values but remains incomplete where data cannot be moved to another provider or downstream uses remain technically opaque. The portable and purpose-limited scenario improves practical control by allowing standardized export and defining the reasons for which data may be reused.

Farmer-centered governance receives the highest scores because rights remain meaningful across the full data lifecycle. The model includes accessible permissions, export, correction, human-readable explanations, appropriate deletion or retention controls, audit records, contestability for important automated decisions, and mechanisms for sharing benefits created through aggregation.

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The simulation does not claim to provide a legal-compliance test. Data protection, competition law, consumer protection, intellectual property, confidentiality, and agricultural regulation vary among jurisdictions. Empirical application should therefore combine the index with jurisdiction-specific legal analysis and direct review of platform contracts, technical architecture, data flows, and user experience.

5. Analysis

5.1 Comparative Strength of Platform Data-Rights Models

The simulation indicates substantial differences among governance configurations. Opaque platform control produces a SADRI of 27.8. The principal weakness is not that data processing necessarily lacks all legal basis, but that farmers have limited practical knowledge or control regarding what happens after information enters the platform.

Disclosure-oriented governance improves the simulated score to 44.0. Clearer notice helps farmers understand collection, but notice alone does not guarantee genuine control where refusing additional data uses means losing access to essential services.

Consent-centered governance reaches 61.5. Granular permission improves autonomy, yet portability and benefit participation remain moderate. This distinction demonstrates why consent cannot carry the entire burden of agricultural data governance.

Table 2: Simulated Smallholder Data-Rights Performance of Digital Platform Models

Platform governance model	Consent	Access & portability	Purpose transparency	Accountability	Value participation	SADRI
Opaque platform control	30	22	25	45	20	27.8
Disclosure-oriented governance	58	34	55	52	28	44.0
Consent-centered governance	82	52	70	61	48	61.5
Portable and purpose-limited governance	88	86	90	80	68	83.3

Note: All numerical values are hypothetical and are intended solely to illustrate the analytical framework.

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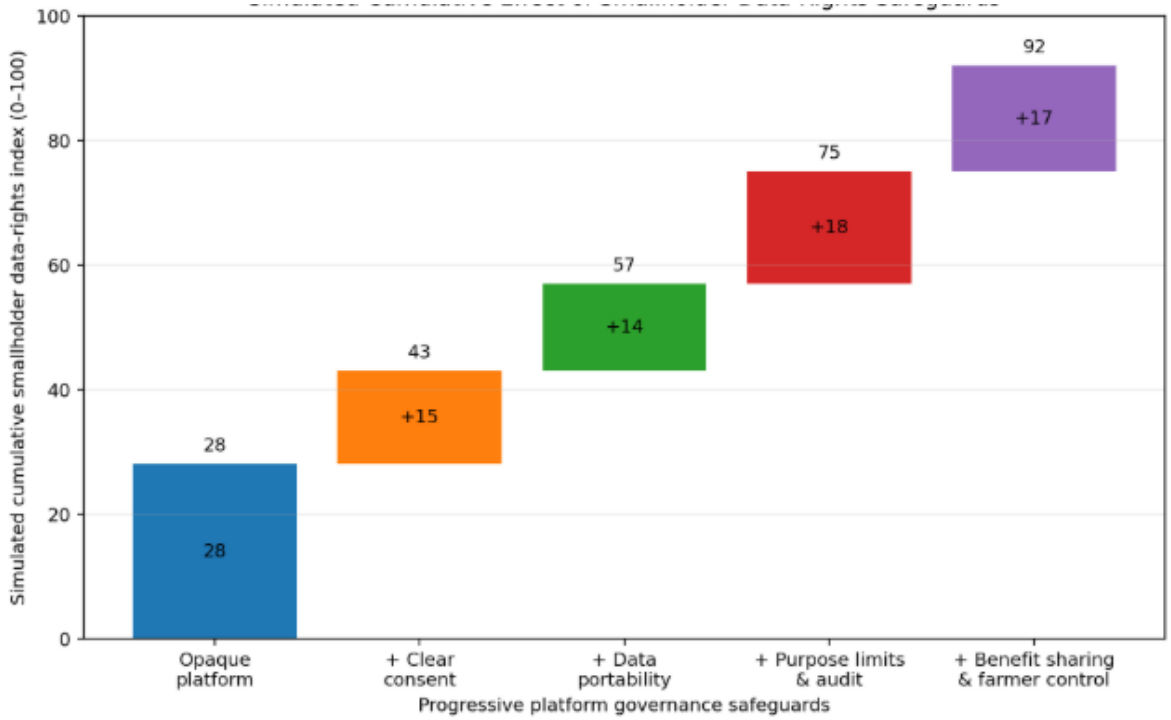
Portable and purpose-limited governance achieves 83.3, demonstrating the importance of interoperability and restrictions on secondary use. Farmer-centered governance reaches 91.6 because it addresses not only permission but also economic and institutional power.

5.2 Cumulative Effect of Data-Rights Safeguards

The second simulation illustrates data rights as cumulative protections. An opaque platform begins with a simulated rights index of 28. Clear consent raises the cumulative position to 43, portability to 57, purpose limitation and auditability to 75, and benefit sharing combined with stronger farmer control to 92.

Graph 1: Simulated Cumulative Effect of Smallholder Data-Rights Safeguards



The graph demonstrates that no single safeguard substitutes for the others. Consent without portability may leave farmers dependent on one provider. Portability without purpose limitation allows data copies to move while leaving undisclosed secondary processing unresolved. Transparency without benefit sharing can reveal value extraction without addressing its distribution.

This multidimensional interpretation is consistent with OECD analysis and the European agricultural data-sharing code, both of which treat control, access, transparency, security, and contractual governance as distinct issues.

5.3 Data Portability, Automated Decisions, and Farmer Agency

Portability is particularly significant where platforms accumulate multi-season records. Historical yield maps, input records, crop calendars, transaction histories, field boundaries, photographs, and advisory responses increase in value when analyzed over time. A farmer who cannot export these records may face a substantial cost when switching providers.

Export should therefore be both technically possible and practically usable. A downloadable image of a dashboard does not provide the same portability as structured records that another legitimate platform can import. Interoperability reduces dependence and can support competitive markets in agricultural digital services. OECD examples of controlled-access data infrastructure similarly illustrate the value of allowing farmers to authorize multiple advisers and combine different data sources within interoperable environments.

Automated decision-making creates an additional rights issue. Platforms may use farm data to recommend products, evaluate creditworthiness, prioritize users, calculate insurance risk, estimate productivity, or classify producers. Where such outputs materially affect access to services or economic opportunities, farmers should receive understandable information about the basis of the decision and a meaningful path for correction when source data are inaccurate.

Smallholder agency consequently requires more than permission to enter a digital ecosystem. It requires the capacity to leave, retrieve records, challenge errors, understand significant processing, and participate in determining how data-generated value is distributed.

6. Discussion

6.1 Moving Beyond the Language of Data Ownership

The principal implication of this study is that agricultural data governance should move beyond the question "Who owns the data?" Ownership language can be politically powerful, but agricultural datasets are often produced through interactions among farmers, sensors, public datasets, satellites, machines, software, and analytical systems. A single ownership declaration may therefore conceal rather than resolve practical questions concerning control.

Wiseman and colleagues highlight precisely this difficulty: farmer concerns involve ownership but also access, privacy, sharing, licenses, liability, bargaining inequality, and benefit distribution. The OECD framework similarly focuses on the balance among access, privacy, confidentiality, economic interests, and innovation.

The more useful policy question is consequently whether farmers possess enforceable and usable rights throughout the data lifecycle. They should know what is collected, retrieve it, understand important uses, control optional disclosures, correct errors, and exit without unnecessarily forfeiting historical records.

A rights-bundle approach also avoids overstating what "ownership" can deliver. Even where farmers are recognized as data originators, contracts may still authorize broad platform uses. Conversely, appropriately designed shared-data systems can create substantial public and private value while maintaining farmer agency through clear permissions and governance.

6.2 Preventing Platform Lock-In and Unequal Data Extraction

Platformization creates efficiencies by integrating services, but integration can make farmers dependent on one technological ecosystem. Prause and colleagues identify incompatibility and switching costs as mechanisms through which platforms can create lock-in and concentrate control over agricultural information. Rotz and colleagues similarly emphasize that digital agriculture cannot be evaluated independently of power and inequality.

Smallholders may be especially vulnerable because their individual bargaining power is limited. Cooperatives, producer organizations, public agencies, and farmer associations can therefore play a role in negotiating model contractual terms, assessing platform practices, and creating collective data-governance arrangements.

Data cooperatives or trusted intermediaries represent one possible institutional direction where farmers collectively establish conditions for data access. Such models still require careful governance because collective organizations themselves can become opaque. The essential principle is that aggregation should not eliminate accountability to the farmers whose production data make the service valuable.

Interoperability should also become a procurement criterion. Public programs supporting digital agriculture can prioritize systems that use documented formats, permit reasonable export, and avoid unnecessarily proprietary barriers. Subsidizing a platform that locks users into one provider may create a future dependency even when initial access is free or inexpensive.

6.3 Trust, Benefit Sharing, and Responsible Innovation

Trust is not produced simply by asking farmers to trust technology providers. It emerges from institutional practices that make vulnerability reasonable. Jakku and colleagues' findings are particularly relevant because farmers' trust concerns were linked to transparency and to the distribution of benefits derived from smart-farming data.

Zhang and colleagues provide further evidence that willingness to share farm data depends partly on perceptions concerning the primary beneficiary of aggregation. Farmers were more willing to share when they believed farmers themselves would benefit. A sustainable data ecosystem therefore requires a credible value proposition for participants.

Benefit sharing need not mean that every individual data point receives a direct cash payment. Agricultural data frequently create value only after aggregation, cleaning, combination, and analysis. Appropriate returns may instead include high-quality advisory services, cooperative analytics, reduced platform charges, benchmarking access, improved insurance products, collective bargaining information, or a transparent share of commercial revenues where the model supports it.

Platforms should nevertheless distinguish clearly between data required to deliver a requested service and data sought for unrelated commercial development. Optional secondary uses should not be disguised as technically necessary processing. Farmer-centered innovation is strongest when users can participate without surrendering unlimited future control.

7. Conclusion

Digital agricultural platforms can expand smallholder access to information, markets, finance, advisory services, and data-driven farm management, but these benefits depend partly on the governance of the information generated through platform participation. Agricultural data may reveal economically valuable details concerning land, production, transactions, farming practices, and business performance. When control over such information shifts disproportionately toward platform operators, digital inclusion can coexist with new forms of dependency.

The simulation developed in this study demonstrates why smallholder data rights should be conceptualized as a layered governance system. The Smallholder Agricultural Data Rights Index rises from 27.8 under opaque platform governance to 91.6 under a farmer-centered rights model. The cumulative analysis likewise shows that informed consent, portability, purpose limitation, accountability, and benefit sharing each address a different vulnerability. None can be treated as a complete substitute for the others.

The study therefore proposes a practical rights architecture centered on understandable permissions, access to farm records, interoperable portability, transparent secondary use, proportional data retention, security, correction mechanisms, explainability for consequential automated decisions, and fair participation in data-generated benefits. Data ownership terminology can remain useful, but it should not replace these more operational protections. Rights that cannot be understood or exercised provide limited protection to smallholders facing significantly more powerful platform actors.

Future empirical research should audit actual agricultural platforms by comparing terms of service, data-flow diagrams, export functionality, retention periods, third-party transfers, algorithmic decision processes, security controls, complaint systems, and benefit-sharing arrangements. Farmer interviews should examine whether formal rights are understandable and usable in practice, with particular attention to women farmers, tenants, digitally inexperienced users, and producers operating through shared devices. Comparative studies across cooperative, public, commercial, and open-source platforms would help determine which governance arrangements create genuine farmer agency while preserving the collaborative data flows needed for agricultural innovation.

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