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Food security needs reliable knowledge systems

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Food security's six-dimensional framework—availability, access, utilization, stability, agency, sustainability—assumes that actors can obtain reliable guidance to inform decisions, yet this assumption is under mounting strain across advisory ecosystems, from public extension services to algorithmic platforms. In this Perspective I propose *epistemic security*—the sustained integrity, equity and reliability of advisory systems across food production and consumption—as a foundational dimension of food security, and outline a governance and measurement agenda, together with its practical challenges, for securing the knowledge systems on which all six dimensions depend.

Food security depends on reliable knowledge systems

In 2021, a social-media firestorm revealed that Canadian dairy farmers had been adding palm-oil-derived supplements to cattle feed, altering the fatty-acid profile of butter and rendering it noticeably harder at room temperature. The episode—widely dubbed 'Buttergate'—exposed systemic data deficits and a lack of transparency in the advisory and regulatory infrastructure connecting production practices to consumer outcomes; the dairy industry initially denied any change, and months passed before a corrective investigation was launched[1]. Two years later, Tzachor et al. tested GPT-generated advice for Nigerian cassava farmers in this journal and found that the model produced fluent but region-inappropriate recommendations that, if followed, could cause agronomic harm—yet were difficult for non-specialists to distinguish from expert guidance[2]. These two cases—one involving information opacity in a high-income supply chain, the other involving AI-generated misguidance in a smallholder context—illustrate a pattern increasingly visible across food systems worldwide: consequential decisions about what to plant, spray, eat or sell are shaped by information environments whose reliability no existing food-security framework systematically addresses. Neither case is an indictment of a single technology: in Buttergate, social media performed a corrective function by surfacing a practice that formal channels had not disclosed, and generative models may improve as validation regimes mature. The point is that detection, correction and accountability currently depend on ad hoc mechanisms rather than on governed features of the advisory environment.

The canonical four-pillar framework—availability, access, utilization and stability—has organized food-security research and policy for more than three decades[3,4]. Its durability reflects genuine analytical coherence: each pillar identifies a necessary condition, and together they map the major dimensions of food insecurity. The framework has since evolved: the High Level Panel of Experts on Food Security and Nutrition and Clapp and colleagues have consolidated agency and sustainability as fifth and sixth dimensions of a six-dimensional framework, recognizing that food security is also about voice, governance and ecological viability[5,6]. This Perspective advances a different but complementary argument: that the framework does not adequately address the epistemic preconditions that all six dimensions share.

Every dimension of food security presupposes that food-system actors—farmers, consumers, policymakers, extension agents—can obtain minimally reliable guidance about what is available, safe, adaptive and uncertain. Decisions across the food system are mediated by what I term *epistemic infrastructures*: extension services, community health workers, market information systems, digital platforms and, increasingly, AI advisory tools. These infrastructures are plural and hybrid: epistemic insecurity is not an artifact of generative AI alone, but can arise wherever advice is produced and circulated, whether through recommender systems, rule-based decision-support tools, commercial input-dealer networks, broadcast media or face-to-face extension. When those infrastructures fail—through misinformation, commercial manipulation, algorithmic distortion or institutional collapse—interventions designed to strengthen availability or access can be blunted, misdirected or captured by interests that benefit from informational confusion. Epistemic security is therefore not a rhetorical addition to the framework; it is a structural precondition for the other dimensions to function as intended. Where Clapp et al.'s agency and sustainability address what food systems should be governed *for*, epistemic security addresses what conditions are required for governance to work *at all*. Agency, in particular, presupposes epistemic security: people can exercise meaningful voice and choice in food systems only when the information environments in which they form judgements are reliable, equitable and contestable[5,6].

Epistemic security underpins all dimensions of food security

I define epistemic security as the sustained integrity, equity and reliability of the information and advisory systems that shape consequential decisions

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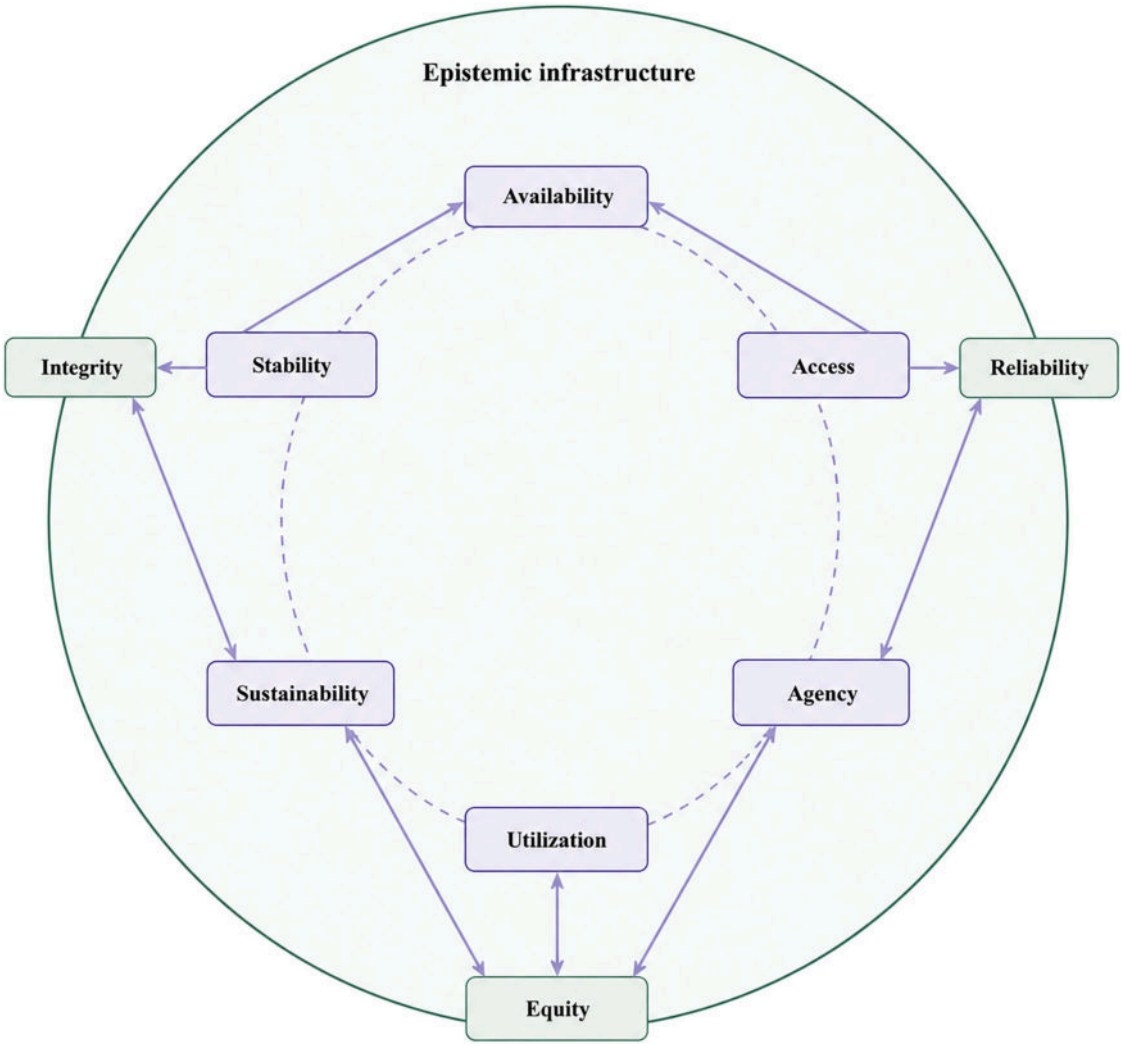


Fig. 1 | Epistemic security as a structural precondition for the six dimensions of food security. Concentric diagram in which the inner ring depicts the six dimensions (availability, access, utilization, stability, agency, sustainability) and the outer ring represents the epistemic infrastructure composed of three overlapping components (integrity, equity, reliability). Bidirectional arrows indicate that failures in any component of the outer ring propagate across all six inner dimensions irrespective of the material or economic conditions each dimension individually addresses.

across food production, purchasing and consumption. The term adapts a concept developed in security studies and democratic theory, where epistemic security denotes a society's capacity to protect the processes by which reliable information is produced, distributed and assessed[7]. Three jointly necessary components compose the concept (Fig. 1).

Epistemic integrity refers to whether information and advice are accurate, evidence-grounded, transparent about uncertainty and free from manipulation. The benchmark is alignment with best available evidence and honest communication of its limits—including when knowledge is contested or context-specific[8]. Commercially motivated misinformation, AI hallucinations and selectively amplified content all represent integrity failures even within technically functional advisory channels. The distinction matters: a system can deliver information efficiently while delivering it inaccurately, as demonstrated by evaluations of generative AI agricultural advice that found fluent but factually unreliable crop-management recommendations[2,9]. Related work on data trustworthiness offers foundations to build on: the FAIR principles (findable, accessible, interoperable and reusable) address the stewardship of the data on which advice depends[10], and epistemic integrity extends this logic from data management to the advice that data-driven systems generate.

Epistemic equity refers to whether different groups can access credible guidance and whether diverse knowledge systems are recognized rather than systematically discounted. Inequity arises from language barriers, connectivity constraints, paywalls and disability, but also from platform design choices and from knowledge hierarchies that privilege some epistemologies over others. Colonial and technocratic knowledge regimes have historically shaped what counts as authoritative knowledge about land, crops and food[8], and Indigenous knowledge continues to be sidelined despite its demonstrated relevance for resilience and adaptation[11]. This is not merely a distributive concern: it narrows the set of adaptive strategies that institutions can perceive, evaluate and deploy.

Epistemic reliability refers to the continuity and accountability of advisory systems over time: trusted institutions that can update guidance, retract errors and communicate coherently during crises. Reliability also requires contestability—the practical capacity of farmers, workers and consumers to question advice, request justification and seek independent verification. Drawing on Miranda Fricker's concept of epistemic injustice[12], advisory systems that systematically discount the testimony of some groups or withhold interpretive resources produce epistemic harm that compounds material food insecurity. The COVID-19 infodemic demonstrated how quickly advisory reliability can collapse: contradictory food-safety guidance circulated faster than institutional corrections, with measurable effects on dietary behaviour[13].

These components interact. A technically accurate recommendation that reaches only well-resourced actors is epistemically inequitable. A universally accessible AI tool optimized for engagement rather than agronomic truth is epistemically insecure even if widely used. Critically, integrity failures under conditions of limited advisory capacity are less correctable, because the institutional machinery for detecting and disseminating corrections is itself absent.

Advisory systems face growing epistemic risks

Two structural trends are jointly amplifying epistemic risk in food systems. The first is the **restructuring of public agricultural advisory services**. Comparative analyses document long-running shifts in many countries away from universal, publicly funded and face-to-face extension toward pluralistic systems in which private consultants and input suppliers play a larger role[14,15]. Evidence syntheses confirm that well-designed, adequately resourced extension yields substantial social returns in productivity, income and technology adoption[16]. When public advisory capacity contracts, the informational burden shifts to actors facing structural conflicts of interest, uneven geographic coverage and limited authority to issue and enforce corrections. Pluralism without accountability mechanisms privileges whichever actors have resources to fill the advisory space—often input suppliers whose commercial interests may not align with farmer welfare[17].

The institutional form of advisory provision also shapes its epistemic obligations. State-backed systems, such as the European Union's Farm Advisory System, India's Kisan Call Centres or national extension services, carry public-interest mandates but are chronically constrained by funding, staffing and geographic reach[14–16]. Commercial systems, including input-supplier agronomy services, proprietary digital agronomy platforms and app-based diagnostic tools, often achieve greater scale and usability, yet typically operate under no legal or professional obligation to meet exacting epistemic criteria, and their revenue models can reward product placement over impartial diagnosis[17]. Experimental evidence on digital agricultural advice likewise shows that even well-designed services produce heterogeneous effects on farmer decisions, underscoring that delivery capacity does not guarantee epistemic quality[18]. Neither institutional form automatically secures integrity, equity and reliability; the task is to specify the epistemic functions that any configuration—public, private or hybrid—must perform.

The second driver is the **rapid scaling of platform-mediated and AI-generated advisory content**. Algorithmic mediation extends well beyond generative models: recommender systems, search rankings, rule-based decision-support tools and market-information platforms all shape which advice reaches which actors. Platform information environments exhibit well-documented vulnerabilities: false information spreads faster and farther than accurate information[19,20]; recommender systems can amplify attention-rewarding content relative to uncurated baselines[21]; and infodemics during crises show how quickly low-quality content saturates digital spaces[13]. Misinformation also targets the scientific record itself through selective citation and manufactured doubt[22]. Agricultural and nutrition content now circulates through these same infrastructures. The politics of digital agricultural technologies have been shown to reproduce existing power asymmetries rather than flattening them[23,24].

Generative AI compounds this dynamic. Large language models can produce fluent, personalized guidance while generating factually incorrect outputs that current detection methods cannot reliably identify[25]. Agriculture heightens the stakes because decisions are deeply context-specific: soil chemistry, microclimatic conditions, cultivar performance and regulatory frameworks vary at fine spatial and temporal scales. Early evaluations of LLM deployment for crop management advice indicate that human-in-the-loop architectures can improve safety, but performance depends on rigorous domain validation rather than language fluency alone[9]. Tzachor et al.'s evaluation of GPT-generated advice for Nigerian cassava farmers—published in this journal—demonstrated both the transformative potential and the acute risks: recommendations were plausible but contained region-inappropriate guidance that, if followed, could cause agronomic harm[2]. These risks are systemic rather than model-specific: responsible deployment of agricultural AI requires anticipating risks and externalities across the food system rather than evaluating tools in isolation[26]. AI-mediated workflows are also reshaping how knowledge is produced within food-systems research itself, with implications for scientific authority, professional competence and governance[27].

These two drivers interact in a way that multiplies risk (Fig. 2). Where trusted human advisory capacity is limited, digital and AI tools are more likely to be used as primary sources rather than complements to informed human judgement[24]. This increases the probability that errors, biased recommendations or deliberately misleading content will be acted upon without contextual interpretation, local knowledge cross-checks or timely institutional correction.

These asymmetries raise the question of who participates in epistemic governance. Consumers and food-chain clients are not passive recipients of advisory outcomes: Buttergate demonstrated that consumer-generated scrutiny can perform detection functions that formal monitoring missed[1]. Yet downstream actors currently have few formalized channels through which to interrogate the advisory basis of upstream production decisions that affect them, from pesticide regimes to feed-additive choices, and a legitimate question is how far consumers and affected communities should have a say in crop and risk decisions whose consequences they share. Extending contestability mechanisms beyond producers—to workers, consumers and communities—aligns epistemic security with the agency dimension of food security[5,6] without collapsing the two: agency concerns whose voice counts in food-system governance; epistemic security concerns whether the informational conditions exist for any voice to be exercised on an informed basis.

Failures of epistemic security are already affecting food systems

Empirical documentation of epistemic insecurity in agri-food systems is emerging across disciplines. Two failure modes are analytically distinct: distorted beliefs caused by misinformation, manipulation or commercial conflicts of interest; and plausible but unvalidated recommendations generated or amplified by algorithmic systems.

Studies of rural information environments show that farmers navigate hybrid advisory ecosystems in which peers, input dealers and online platforms interact with formal sources in trust-differentiated ways[17]. These hybrid ecosystems mirror the broader misinformation literature: exposure is shaped not only by individual literacy but by network effects, platform design and incentive structures[13,19–21]. Farmers may simultaneously rely on place-specific experiential knowledge, supplier-funded agronomic advice and online content streams uncalibrated to evidentiary quality, with no institutional mechanism to adjudicate among them. Systematic reviews of social and online media misinformation in the agri-food sector confirm that false claims about genetically modified organisms, pesticides, food safety and sustainable agriculture circulate widely, with documented effects on farmer decision-making and consumer behaviour[28].

The climate–food nexus illustrates why epistemic security is not peripheral. Climate adaptation requires credible information about shifting risks and feasible agronomic responses, yet online climate misinformation is prevalent and persistent[29]. Psychological inoculation approaches can improve resilience against specific claims but require institutional deployment and maintenance[30]. Moreover, misinformation that has been corrected frequently continues to influence reasoning, which makes prevention and rapid response more effective than retrospective debunking[31]. Where advisory capacity is limited, producers may delay adaptation, pursue maladaptive strategies or disengage from legitimate risk warnings—outcomes that propagate through production, livelihoods and stability.

Epistemic insecurity is also produced by structural exclusion. When Indigenous and place-based knowledge systems are marginalized from official advisory channels, food systems lose adaptive strategies particularly relevant under novel climate conditions[11]. This constitutes what Fricker terms testimonial injustice: institutions fail to credit knowledgeable actors as

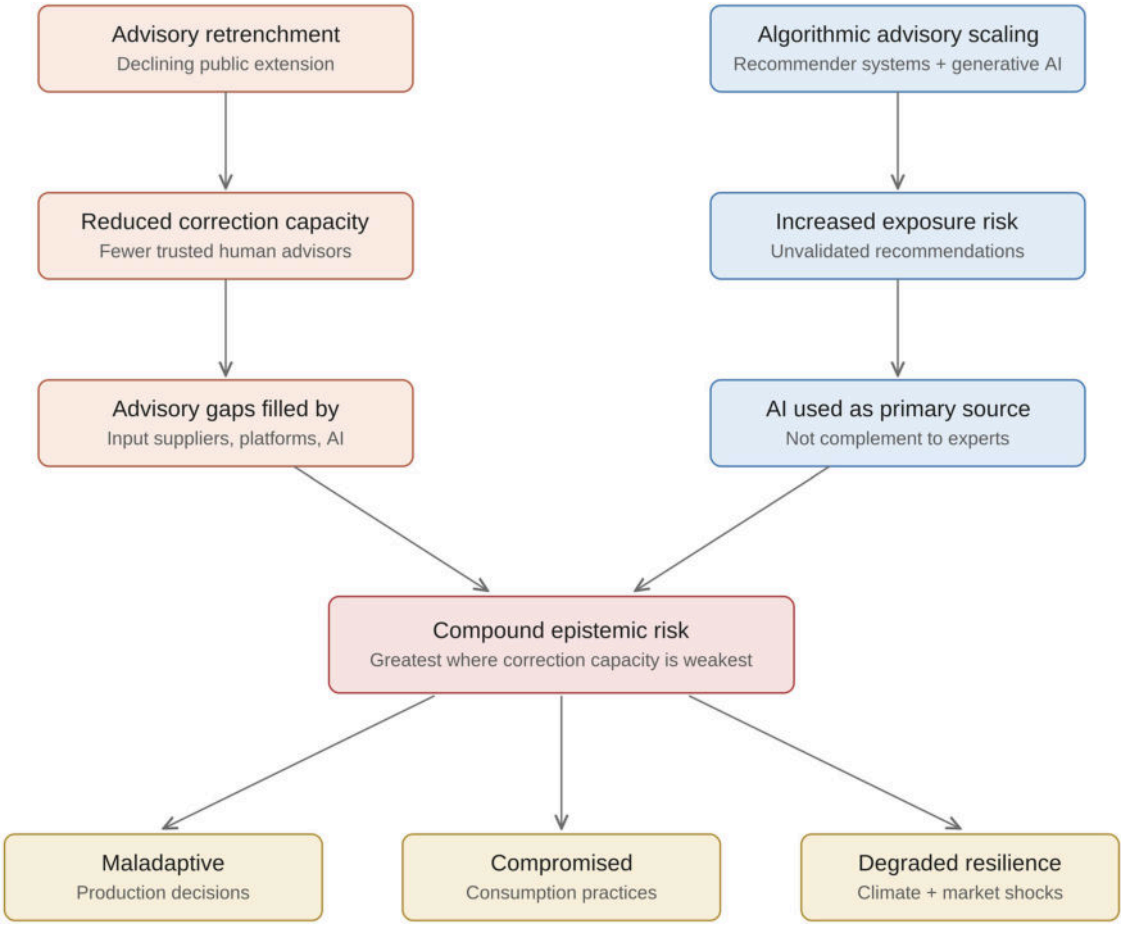


Fig. 2 | Interaction pathways between structural drivers of epistemic insecurity and food-security outcomes. Left pathway: advisory retrenchment (declining public extension staffing and budgets) reduces institutional correction capacity. Right pathway: algorithmic advisory scaling (platform recommender systems and generative AI) increases exposure to unvalidated, biased or manipulated recommendations. The two pathways converge at the centre, producing compound epistemic risk that is greatest where institutional correction capacity is weakest. Output nodes show downstream food-security failure modes: maladaptive production decisions, compromised consumption practices and degraded resilience to climate and market shocks. These downstream failure modes propagate across all six dimensions of food security — availability, access, utilization, stability, agency and sustainability.

epistemic agents[12], narrowing the options available for institutional evaluation.

Despite the centrality of advisory systems to food-security outcomes, no widely adopted cross-context standards exist for evaluating the integrity and equity of food-system advisory environments. Food-security research has developed globally comparable tools for measuring access-related insecurity and diet quality, such as the Food Insecurity Experience Scale[32]. An analogous measurement agenda is needed for epistemic security. Box 1 proposes ten candidate indicators organized across four domains.

Knowledge infrastructures require active governance

Recognizing epistemic security as a foundational dimension of food security implies that advisory systems are a form of critical infrastructure requiring commensurate governance attention. Four priorities follow; although several respond most directly to algorithmic systems, each applies across the advisory ecosystem, digital and non-digital alike.

First, **use-case-specific validation** should be required for advisory systems providing decision guidance with material welfare or environmental consequences. For AI-mediated advisory, this means domain-relevant validation protocols—including stress testing for contextually unsafe recommendations—transparent communication of uncertainty bounds and evidence-source traceability. A single general-purpose reliability claim is not meaningful in agriculture because the consequences of error depend on soil conditions, crop stage, regulatory jurisdiction and market context. The EU AI Act's risk-based classification provides a regulatory template: agricultural and nutritional advisory tools that influence livelihood-critical decisions should be classified as high-risk applications subject to pre-deployment conformity assessment[33]. Concretely, any AI advisory tool deployed for crop-protection recommendations in each agroecological zone should be validated against field-trial data from that zone before deployment, with mandatory post-deployment monitoring for hallucination rates and recommendation accuracy.

Second, **information integrity auditing** should be integrated into food- and nutrition-security monitoring. The same logic motivating standardized indicators for access and diet quality—comparability, accountability and policy learning[32]—applies to epistemic security. Box 1 proposes ten candidate indicators suitable for pilot validation. An immediate starting point would be to integrate a short epistemic-security module into existing nationally representative agricultural surveys[32].

Third, **public investment in human advisory capacity** should be reframed as food-security infrastructure rather than discretionary expenditure. Pluralistic advisory systems can be efficient, but they do not automatically provide the public-good functions food security requires: unbiased diagnosis, coordinated rapid correction during shocks and long-horizon stewardship of locally validated knowledge[14–16,34]. Policy design should evaluate not only the number of advisory channels available, but whether institutional architectures for accountability, correction and public-interest arbitration exist within those systems. Strengthening epistemic security in

Box 1 | Candidate indicators for measuring epistemic security in agri-food systems

Indicators are organized across four domains and designed for pilot integration into national agricultural surveys and extension monitoring systems. Each indicator is expressed as a measurable quantity; jointly, they compose a minimum viable epistemic-security module that can be appended to existing food-security instruments such as the Food Insecurity Experience Scale[32]. Feasibility notes are indicative; pilot validation in at least two national contexts is recommended before standardization.

ID	Indicator	Description	Feasibility
Domain 1 — Advisory capacity			
I_1	**Advisory density and reach**	Qualified advisory contacts per 1000 farm holdings, disaggregated by public/private provision and agroecological zone.	Derivable from existing agricultural census data in most countries.
I_2	**Public advisory retention**	Year-on-year change in publicly funded extension staffing and budgets as a share of total agricultural public expenditure.	Requires fiscal reporting harmonization; OECD PSE data provide a template.
Domain 2 — Information integrity			
I_3	**Misinformation exposure rate**	Proportion of sampled advisory content (social media, SMS, AI outputs) flagged as factually inaccurate by independent content audit.	Requires audit protocol development; modelled on WHO infodemic monitoring.
I_4	**Correction latency**	Median time from detection of a widely circulating inaccurate recommendation to verified correction by a trusted institutional source.	Measurable through sentinel surveillance of advisory channels.
I_5	**Conflict-of-interest disclosure**	Proportion of advisory interactions (human or algorithmic) in which commercial relationships are disclosed to recipients.	Assessable through user surveys and platform policy audits.
Domain 3 — Algorithmic advisory governance			
I_6	**Validation coverage**	Proportion of deployed AI advisory tools with documented domain-specific validation evaluated against agronomic field trials or nutritional evidence bases.	Requires a public registry of AI advisory deployments; EU AI Act database provides precedent.
I_7	**Post-deployment monitoring**	Frequency of structured audits for AI advisory tools, including hallucination rate, demographic performance disparities and error-reporting channels.	Builds on existing AI audit frameworks; adaptable from financial-sector model risk management.
Domain 4 — Epistemic equity			
I_8	**Language and connectivity coverage**	Proportion of farming population served by advisory content in their primary language accessible via prevailing connectivity infrastructure.	Derivable from telecom coverage data crossed with agricultural census language profiles.
I_9	**Marginalized knowledge inclusion**	Documented integration of Indigenous or place-based knowledge in official extension curricula or digital advisory platforms, assessed by content review and stakeholder survey.	Requires qualitative assessment protocol; Indigenous data sovereignty principles apply.
I_{10}	**Contestability index**	Availability and use of formal mechanisms through which farmers, workers or consumers can challenge, query or seek verification of advisory outputs.	Assessable through institutional mapping and user experience surveys.

non-digital and hybrid advisory environments deserves equal attention: accreditation and continuing-education requirements for advisors, mandatory disclosure of commercial relationships by input dealers, documented correction protocols within extension services and training that equips advisors to communicate uncertainty are epistemic-security instruments that require no digital infrastructure[14,15,17,34].

Fourth, **epistemic equity should be embedded by design** in digital advisory governance. This requires multilingual and low-connectivity access, accessibility-by-design, transparent disclosure of commercial relationships and mechanisms for ethically adequate integration of Indigenous and place-based knowledge[11,12]. Responsible AI principles—beneficence, non-maleficence, justice and explicability[35]—translate directly into epistemic security design requirements. The digital agriculture transformation literature has highlighted the risk that data-driven advisory systems reproduce existing power asymmetries[23,24], epistemic equity provides a normative criterion for evaluating whether digital advisory innovation is genuinely inclusive. Concretely, integration of Indigenous and place-based knowledge should move beyond consultation toward co-production. The CARE principles for Indigenous data governance (collective benefit, authority to control, responsibility and ethics) provide an operational standard for how advisory systems ingest, credit and share Indigenous knowledge and data[36]; frameworks such as Two-Eyed Seeing show how Indigenous and Western knowledge systems can be braided in environmental decision-making without subordinating either[37]; and indicator I_9 (Box 1) provides a mechanism for auditing whether such integration occurs in practice.

Participation must be resourced and governed on terms set with, not for, knowledge holders.

Epistemic security can be operationalized

An agenda of validation, auditing and monitoring immediately raises the questions of who performs these functions, under what mandate and with what funding. No single answer fits all contexts, but three institutional models are plausible. First, epistemic-security functions can be embedded in existing mandates: national statistical agencies already field the agricultural surveys into which indicator modules can be inserted[32], food-safety authorities operate surveillance and recall infrastructures that correction-latency monitoring can emulate, and the World Health Organization's infodemic-management programme offers a template for advisory content auditing[13]. Second, financing can follow established regulatory precedents in which actors who profit from advisory markets contribute to the costs of their oversight—as registration and conformity-assessment fees do in pesticide and medical-device regulation—supplemented by public core funding, because epistemic security is a public good that markets will undersupply. Third, professional and industry self-governance, including advisor certification schemes and insurer-driven audit requirements, can extend oversight where state capacity is thin; insurers of crop and climate risk have a direct commercial interest in the quality of the advice on which their clients act.

Oversight carries its own risks that deserve acknowledgement. If regulators certify advisory systems, they assume partial responsibility for outcomes, and a certified system that performs worse than an uncertified alternative exposes the regulator to legitimate criticism. Process-based accountability—certifying that validation, uncertainty disclosure and correction mechanisms exist and function, rather than guaranteeing outcomes—together with regulatory sandboxes and staged certification, limits this exposure while preserving accountability. Transparency itself is not free: uncertainty communication, disclosure requirements and audit trails impose costs and can introduce their own biases in what is measured and reported. A proportionality principle should therefore govern implementation: the stringency of epistemic-security requirements should scale with the welfare and environmental consequences of the decisions an advisory system informs.

Finally, the settings where epistemic security matters most—those with limited advisory capacity, fragmented institutions and low digital connectivity—are often the settings least able to implement demanding governance instruments[38]. This argues for a tiered pathway rather than a uniform standard: beginning with indicators derivable from existing data (I_1, I_2 and I_8 in Box 1), pooling validation capacity regionally so that individual countries need not certify every tool for every agroecological zone, and sequencing obligations so that the costliest instruments, such as algorithmic audit regimes, apply first to the largest deployments. Market structure also mediates exposure: commoditized crops pool localized informational failures across regions, whereas single-origin and specialty production concentrates them, so epistemic-security priorities should be calibrated to how strongly a production system depends on locally validated advice. Design experience with digital agriculture in low-income countries shows that well-intentioned interventions fail when they ignore local power relations and capacity constraints[38]; an epistemic-security agenda should not repeat that mistake.

Food security needs epistemic security

The six-dimensional framework remains indispensable. Yet contemporary threats to food security include failures of the knowledge environment itself: corruption, exclusion and unreliability in the systems through which actors learn what to do. In an era when generative AI can produce contextually plausible but agronomically dangerous advice at scale, and when public advisory capacity has been restructured in many settings, errors and biases in knowledge systems can propagate faster than institutional correction allows.

Epistemic security provides a foundational dimension that recognizes knowledge infrastructure as a food-security resource requiring the same stewardship, investment and governance attention applied to physical and economic access. The concept is not merely analytical: it implies concrete governance obligations—validation mandates for AI advisory tools, integrity auditing within food-security monitoring, sustained investment in human advisory capacity and equity-by-design across digital and non-digital advisory systems. Without such attention, interventions that strengthen availability, access, utilization, stability, agency and sustainability will increasingly be undermined by decisions made in epistemically degraded conditions. The knowledge environment is not a backdrop to food security; it is a load-bearing structure. A fuller comparative treatment of alternative governance and infrastructure frameworks, belief-system approaches and the roles of commercial, legal and insurance institutions warrant dedicated analysis beyond the scope of this perspective.

Data availability

No original data were generated or analysed in this Perspective. All cited datasets and sources are publicly available at the references provided.

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