STANDARDS FOR DATA-DRIVEN AGRIFOOD SYSTEMS, ONE YEAR AFTER THE ISO STRATEGIC ADVISORY GROUP FOR SMART FARMING

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A paper from the Proceedings of the

16th International Conference on Precision Agriculture

21-24 July 2024

Manhattan, Kansas, United States

Abstract.

The lack of data interoperability is a major obstacle for the data-driven, principled multi-objective decision-making required for modern agrifood systems to help meet the UN Sustainable Development Goals. Aware of this, the International Organization for Standardization (ISO) chartered a Strategic Advisory Group for Smart Farming (SAG-SF) to survey the existing standardization landscape of the domain within ISO, to identify gaps where additional standardization is needed, and to provide a strategic roadmap for near- and longer-term action.

The SAG-SF completed its task in early March 2023. The final report (available at https://bit.ly/3olkd8x) made 49 recommendations; ISO has begun acting upon them. Five key points stand out:

***Internal coordination**. ISO has over 200 committees that develop standards. At least 40 of them have scopes intersecting the data-driven agrifood systems domain but are not necessarily aware of one another's work. An ISO Smart Farming Coordination Committee was created to provide a venue for discussions and collaboration among these committees.*

***A new technical committee on data-driven agrifood systems**. Much of the work needed to enable data interoperability in this domain does not currently have a natural home within ISO. A new technical committee (ISO/TC 347: Data-Driven Agrifood Systems) was created, with 43 national standards bodies currently registered as members.*

***A reference architecture**. Standards development is an inherently bottom-up pursuit, posing a major challenge to coordination for data interoperability. The SAG-SF strategy includes convening an ISO International Workshop Agreement to quickly develop a reference information architecture, with the least possible barriers to participation, that can serve as a guide for subsequent standards development processes. This reference architecture includes a business*

capability model evolved from the one created by the SAG-SF, as well as a set of fundamental business data objects and interfaces.

***External coordination**. Smart farming data and a data-driven approach to agrifood systems are current topics of interest to multiple standards organizations. This is an exciting development, but it increases the likelihood of duplicate efforts and divergent approaches. ISO is now discussing the creation of a Joint Smart Farming Landscaping Group with other organizations to create a collective landscaping document, discuss opportunities for collaboration and avoid overlapping initiatives.*

***Enhanced communications**. Unfortunately, it happens too often that once a standard is published, its original champions move on to other projects and the implementation momentum cools to the point where many useful standards become inadvertently well-kept secrets. The SAG-SF encouraged ISO to take a more proactive stance toward communicating the value proposition of data-driven agrifood systems standards and engaging stakeholders (especially user communities) to enable implementation, as well as provide a clear input mechanism for stakeholder needs.*

This paper elaborates on the concepts mentioned above, the backlog of upcoming standards for TC 347, and opportunities for engagement in the process.

Keywords.
standards, ISO, data, interoperability, agrifood systems, implementation.

Introduction

Agricultural and food production are growing in difficulty as climate change, supply chain disruptions, crop input price increases, regulatory pressure and political unrest introduce increasing volatility, uncertainty, complexity and ambiguity into agrifood systems. In this context producers must make hundreds of management decisions every year. In the past, most of these decisions could be based on family tradition or regional customs. They must now increasingly be made based on data, scientific principles, and a variety of models, statistical and otherwise.

This idea of principled decision-making is foundational to the concept of *smart farming*, but data-driven, principled decision-making requires data that is correct, complete, timely, available, and understandable. A major impediment to obtaining this is the lack of *data interoperability* in the industry: Hardware and software systems from different manufacturers just don't "talk to one another" due to a proliferation of proprietary data formats, code lists, and different ways of representing the meaning of data. The inevitable consequence is that practitioners must spend excessive amounts of time reformatting and translating data before it can be used to create value.

Standards provide a powerful way to enable data interoperability in an industry. Some good examples of such enablement include web standards (W3C, 2024) and business process modeling standards (OMG, 2024). Unfortunately, the agriculture and food industries are lacking in data standardization beyond agricultural machinery and supply chain traceability.

The ISO Strategic Advisory Group for Smart Farming

In June 2021, the Technical Management Board (TMB) of the International Organization for Standardization (ISO) chartered the Strategic Advisory Group on Smart Farming (SAG-SF), with a triple mandate:

- **Landscaping**: To understand which of ISO's 25000+ standards were relevant to smart farming,
- **Gap-checking**: to identify standardization gaps within that landscape,
- **Strategic roadmap:** to propose a strategy for future standardization efforts in factory floor-to-farm-to-fork agrifood systems.

The SAG-SF launched in late 2021, led jointly by co-conveners from the German Standards Institute (DIN) and the American National Standards Institute (ANSI). During approximately 18

months, some 180 experts from 20+ countries worked to produce a final report, available at https://bit.ly/3MP0SXf.

Scope was determined through a constructionist exercise requesting specific in-scope and out-of-scope items from 50+ of the experts. The conveners followed this using an affinity mapping exercise to group the topics into nine categories. Working groups were created to cover each of the categories as follows:

1. Crop production
2. Livestock and animal products
3. Greenhouse, controlled environment and urban farming
4. Climate and environment
5. Original equipment manufacturers
6. Terminology and semantics
7. Social aspects
8. Data
9. Supply chain

Each of these groups set out to document use cases, create process models, define terms, identify connections between topics and ISO standards or projects on one hand, and connections between topics and United Nations Sustainable Development Goals (SDGs) on the other. The subgroups developed a set of recommendations identifying the most urgent standards-addressable needs related to smart farming. The leaders, along with a small editing team, produced the SAF-SF Final Report from this input. The report was presented to the TMB in March 2023. The TMB noted the excellent team effort and approved all 49 recommendations. Noteworthy among them:

- **Internal coordination**: Establish a Smart Farming Coordinating Committee. This recommendation (3.1.4 in the report) has been implemented with the committee having just completed its first year of operation in June 2024.
- **A new home for agrifood system data standards**: Establish a new technical committee on data-driven agrifood systems. This recommendation (3.2.1 in the report) has been implemented as ISO/TC 347.
- **Reference architecture**: Conduct an international workshop to begin work on a reference architecture for data-driven agrifood systems (rec. 3.4.10), to be followed by a standard (3.4.11). Planning for the workshop is complete; the kickoff is scheduled for 9 July 2024.
- **External coordination**: Establish a joint smart farming landscaping group for the purpose of information sharing across various standards organizations and industry associations that touch smart-farming-related topics (Recommendation 3.1.5).
- **Enhancing communications**: Help technologists worldwide become more aware of ISO's products, thus increasing standards implementation and reducing the "reinventing of the wheel" that is common in the industry as companies expensively develop their own proprietary solutions to basic problems instead of efficiently implementing already standardized ones (Recommendation 3.1.3).

Progress Since the end of the SAG-SF

Internal Coordination

ISO has over 200 committees that develop standards. At least 40 of them have scopes intersecting the data-driven agrifood systems domain but are not necessarily aware of one another's work. An ISO Smart Farming Coordination Committee (SFCC) was created to provide a venue for discussions and collaboration among these committees, as recommended in the Strategic Advisory Group on Smart Farming (SAG-SF) Final Report (Recommendation 3.1.4).

The SFCC is currently composed of representatives from approximately 25 ISO technical committees (TCs), subcommittees (SC), and a few other high-level ISO groups, such as the ISO

committee on developing country matters (DEVCO, https://www.iso.org/committee/55004.html).

The SFCC has a five-fold mandate:

- Facilitate communication, coordination, and information sharing among ISO committees involved in standardization related to smart farming and data-driven agrifood systems.
- Identify cases of coordination needed among various ISO committees on new or existing smart-farming-relevant projects and facilitate the suggestions on internal coordination of existing ISO projects to ensure the coherence of ISO standardization work in this field.
- Oversee the introduction of proposals for new fields of technical activity as per the suggestions on the creation of new committees to be responsible for possible new ISO smart farming deliverables, and proposals for potential new smart-farming-relevant ISO standards.
- Collaborate with the ISO Communication Department to work on the development and implementation of a communications plan to promote ISO's smart-farming-related strategy and products.
- Advise the ISO Central Secretariat on ISO interfaces and partnerships with external organizations in relation to smart farming.

As of June 2024, the SFCC has met 10+ times to work on achieving its mandate. Upcoming work includes developing a triage mechanism whereby a technical committee can gap-check standards that come up for systematic review every few years to make them smart farming ready".

Technical committee ISO/TC 347, Data-driven agrifood systems

As mentioned earlier, until recently the data interoperability standards needed to enable data-driven agrifood systems did not have a natural home within ISO, i.e., no technical committee had agricultural and food data interoperability issues in scope. As a result of SAF-SF recommendation 3.2.1, technical committee ISO/TC 347, Data-driven agrifood systems, was created with 43 national standards bodies (24 participating, 19 observing) currently committing as members.

While this is arguably an opportunity that many practitioners in precision agriculture and allied disciplines have been awaiting for over 25 years, true progress will stand on two pillars, participation, and implementation (Ferreyra, 2024a):

- The Global South is under-represented in this group; finding ways to increase the participation of technologists and domain experts from developing countries will be an ongoing responsibility, as will be securing participation from all sectors of the agrifood industry in all the participating countries. Additionally, ISO/TC 347 would benefit from a greater presence of biotechnology, plant breeders, livestock processors, renderers, and other industry sectors.
- Regarding implementation, while having a forum for standards development is necessary, its value will ultimately depend on industry implementation of its standards. This will require a coordinated effort from TC 347 itself, professional associations, governments, businesses, and civil society to communicate the value of standards, listen carefully to stakeholder needs, and make the necessary investments in infrastructure to ensure a sustainable, resilient, and inclusive food system for the future (Ferreyra, 2024a).

Work toward a reference architecture for data-driven agrifood systems

Standards development is an inherently bottom-up pursuit, posing a major challenge to coordination for data interoperability. It involves two conflicting forces (Ferreyra, 2024b):

- **Speed**: This is a consequence of the high value of standards and other related deliverables. Stakeholders who are participating in standardization processes or otherwise follow and appreciate the results thereof wish to implement as quickly as possible.
- **Caution**: As pointed out by Busch (2011), standards, as "recipes for reality", have the potential to establish and perpetuate power imbalances. Even when all actors are acting in good faith, it is possible for standards to have unintended consequences that can especially affect actors with the least power.

The SAG-SF strategy for addressing this conflict included convening an ISO International Workshop Agreement (ISO, n.d.) to quickly develop a reference information architecture, with the least possible barriers to participation (and thus, the greatest possible representation). This workshop-based effort, called IWA 47, International workshop agreement for a reference architecture for data-driven agrifood systems, can serve as a guide for subsequent standards development processes. The reference architecture that will be worked on in IWA 47 includes a business capability model evolved from the one created by the SAG-SF, as well as a set of fundamental use cases, business data objects and interfaces. It will be followed by an international standard developed by ISO/TC 347. More details are provided by Ferreyra (2024b).

External Coordination

Smart farming data and a data-driven approach to agrifood systems are current topics of interest to multiple standards organizations. This is an exciting development, but it increases the likelihood of duplicate efforts and divergent approaches. ISO is now discussing the creation of a Joint Smart Farming Landscaping Group with other organizations to create a collective landscaping document, discuss opportunities for collaboration and avoid overlapping initiatives.

Enhanced communications

Unfortunately, it happens too often that once a standard is published, its original champions move on to other projects and the implementation momentum cools to the point where many useful standards become inadvertently well-kept secrets. The SAG-SF encouraged ISO to take a more proactive stance toward communicating the value proposition of data-driven agrifood systems standards and engaging stakeholders (especially user communities) to enable implementation, as well as provide a clear input mechanism for stakeholder needs. ISO/TC 347 is implementing its own proactive communications program (for example, involving a social media presence at https://www.linkedin.com/company/iso-tc-347); the SFCC mandate includes communications functions as well.

Upcoming ISO/TC 347 work streams

Leading up to the April 10th, 2024 plenary, three work streams were proposed by TC 347 members:

1) Agrisemantics (Starting with Crop definition data model)
2) Greenhouse and controlled environment automation
3) Integrated pest management.

These three initiatives, which will likely translate into several standards each, have different origins and present different challenges to the group. Looking for a way to represent the differences among them, we used a 2-dimensional graph, as shown in Figure 1, where they are represented as “Crop”, “GCE” and “IPM”.

The two axes of the graph represent the committee leadership’s perception of scope, and the perception of the degree to which those efforts are coherent with the ideas presented in the final report of the SAG-SF.

The three initiatives are being proposed initially as ISO/TC 347 ad-hoc groups, where discussions and alignment will take place, ISO new work item proposals (NWIPs) will be drafted, and upon successful balloting of which, working groups will be created to house the standards development work. As of this writing, the ballots for these initiatives are being voted upon by the members of TC 347.

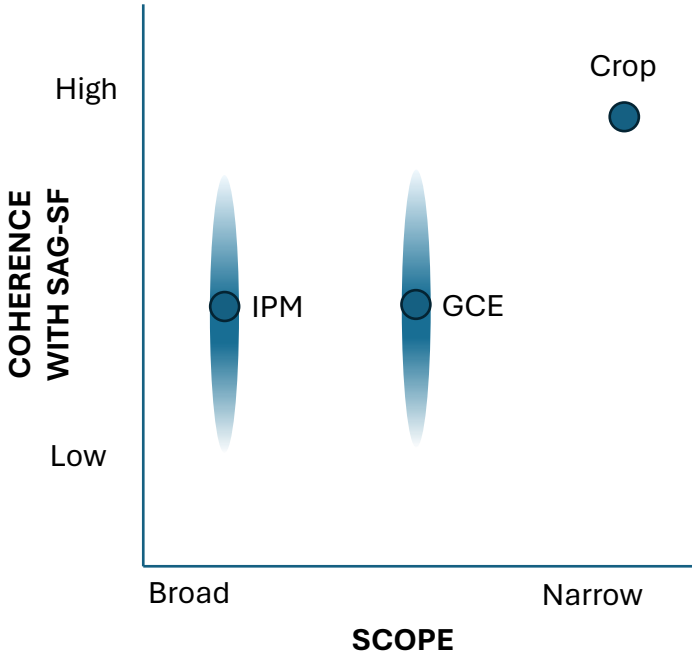

Fig 1: Three first workstreams of TC 347, categorized according to their scope and their level of coherence with the work of the ISO Strategic Advisory Group for Smart Farming

Work Stream 1: Agrisemantics

One of the primary motivations for creating TC 347 was to have a vehicle for developing standards that can enable the unambiguous representation of the meaning of agricultural data.

Code lists, identifier schemes, and other controlled vocabularies abound in the agriculture industry. Agrisemantics is an effort to bring order to the chaos through careful construction of systems for controlled vocabulary management that make content easy to add, easy to maintain, and easy to access. A principal feature of the design and implementation of these systems is that "winners" are not selected. The systems merely record, index, and make available what is in use and provide mechanisms for making associations among entries and then characterizing those associations in useful ways.

The SAG-SF identified several "low-hanging fruit"; i.e., standards that could be developed relatively quickly, yet provide significant value to the industry by better enabling capabilities such as automated label-checking, integrated pest management, and much more (See Fig. 2 below). Developing a clear definition and data model to represent the concept of "crop", currently lacking in the industry, seemed like a logical first step along this path.

Work stream 1 is the corresponding proposal, labeled as "Crop" in Fig. 2. It has a narrow scope and is highly aligned with the SAG-SF recommendations. There are a few fundamental ideas that this proposed standard would be based on:

- The idea of a crop as something that is grown on a piece of land, cared for, possibly insured, possibly registered with regulators, and which requires different management and/or record-keeping from other crops. For example, a grain corn crop grown on river bottom land, or organic plum tomatoes grown for fresh consumption, or cherries grown for processing, or burdock grown with the intent to market its root.
- The examples above suggest that the idea of a "crop" transcends the merely botanical; other aspects such as intended use, growing methods, regulatory context, and even contractual stipulations may differentiate one crop from another. To some extent these different aspects can be imagined as different dimensions or coordinate axes (botanical,

intended use, color, subcrop, plant part marketed, regulatory context, etc.) that serve to position a crop within a multidimensional space.

- Different users will necessarily be interested in crops expressed at different levels of detail within this scheme, ranging from the code for “corn” returned by the task controller on a planting implement, to the rich examples shown above. The standard must accommodate these different levels of granularity.
- The standard should enable mapping and querying among different crops, to enable generalizations and queries (e.g., “What is the total area we grew corn on last year?”) that are often difficult to perform on farm management information systems that may have multiple crop codes for different variations around some crop taxon.

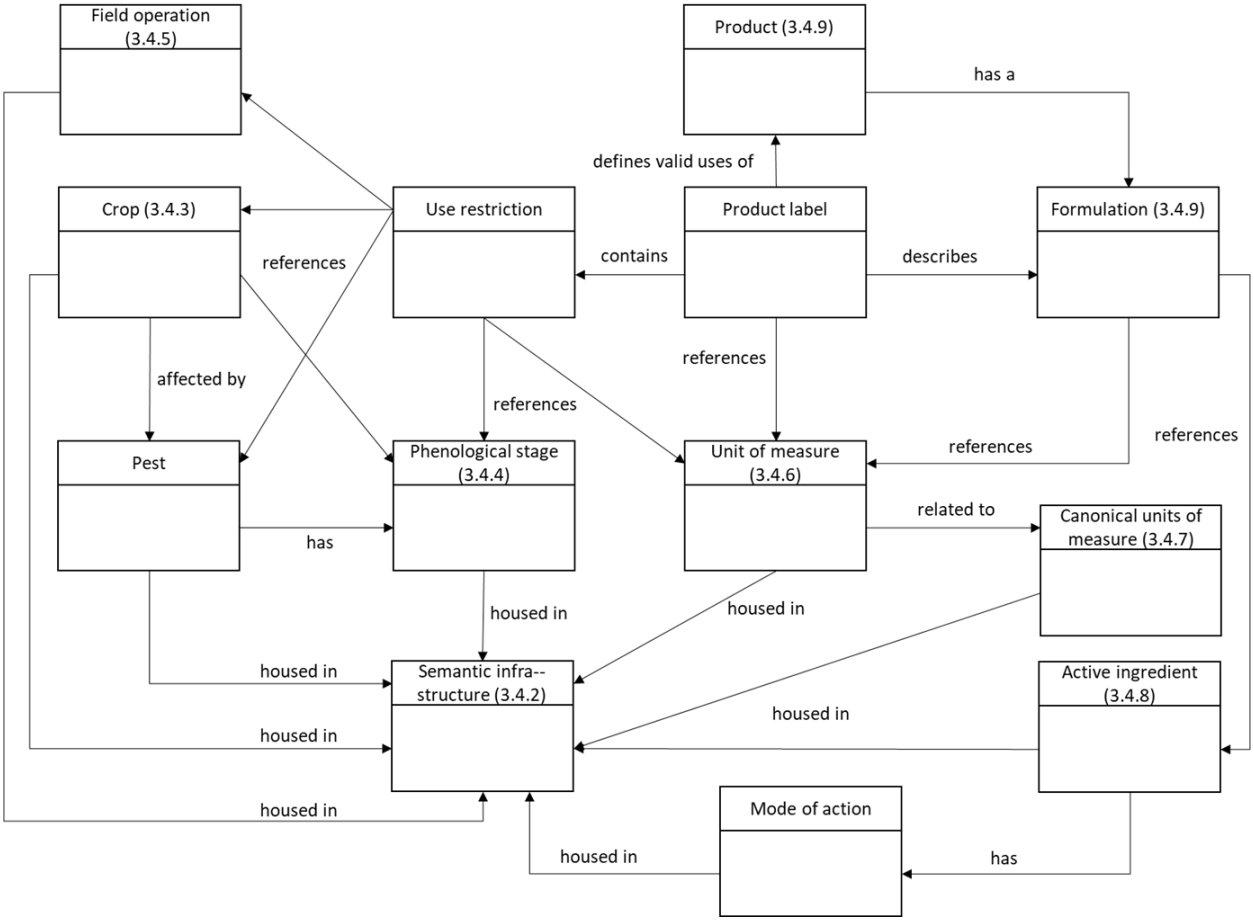

Fig 2: Set of proposed early agrisemantics, i.e. meaning-preserving, standards for ISO/TC 347. The numbers in parentheses reference the corresponding subclauses in the ISO SAG-SF final report.

The proposing team requested feedback at ISO/TC 347’s first plenary, seeking to ensure that the proposed model is robust enough to be used globally. This led to the creation of an ad hoc group where discussion can take place issues can be discussed and resolved, and one or more new work item proposals (NWIPs, the formal proposals to begin work on standards) drafted.

The timeline for this group’s work is finite, aiming to complete its work in time for discussion in the March 2025 ISO/TC 347 plenary at the latest.

Work Stream 2: Greenhouse and Controlled Environment Automation

Agricultural production in greenhouses and controlled environments (GCE) was repeatedly flagged as a topic of interest during SAG-SF scope discussions. A subgroup of the SAG-SF was subsequently organized to discuss related topics, and the SAG-SF’s final report included a recommendation (3.2.4) to establish a permanent presence of related topics within TC 347.

An unrelated proposal for standardization in greenhouse and controlled environment automation

was presented around the same time to ISO Technical committee 23, subcommittee 19, Agricultural electronics. This group decided to pass the development work on to TC 347.

The proposal initially sought to create a new series of controller-area-network (CAN)-based standards, analogous to ISO 11783 (ISO, 2017) and ISO 5231 (ISO, 2022). Subsequent conversations also yielded a rich opportunity to standardize semantics in the segment:

- Articulating what a "smart farm" and a GCE subsystem are, i.e., system boundaries.
- Determining what kinds of GCE subsystem control and monitoring functions must be supported. For example,
    - Monitoring & sensing functions for environmental parameters, plant growth status, management operations such as water supply, fertilization.
    - Controlling functions for environmental condition, fertilization, irrigation.
- Encoding the above in (meta)data

Some concerns were raised about this proposed work prior to TC 347's first plenary. This led to the creation of an ad hoc group where issues can be discussed and resolved, and one or more NWIPs drafted. These concerns are:

- **Divergence**: This immediate proposal did not arise from the SAG-SF (but rather from a national delegation), but greenhouse and controlled environment standardization were in scope of the SAG-SF recommendations. It will be important to quickly find a way to ensure that the emergent work is consistent and compatible with the reference architecture planned in IWA 47 and ISO/TC 347, while at the same time enabling rapid progress.
- **Scope and technological focus**: Transport-layer standards and industry best practices are mature at this time, and there are several technologies (CAN, PROFIBUS, wi-fi, Ethernet) being used in greenhouses. A semantics-centric approach (defining variables, message formats, system definitions) in this context may ultimately be more valuable than focusing strictly on CAN; e.g., there are greenhouses now that are so large they exceed distances being used in controller-area-network (CAN) solutions.
- **Expertise**: TC 347 is unlikely to have a significant pool of CAN experts; if a transport layer, CAN-centric approach does emerge, more recruitment will be needed. Joint work with other committees will also be explored.

The timeline for this group's work is finite, aiming to complete its work in time for discussion in the March 2025 ISO/TC 347 plenary at the latest.

Work Stream 3: Integrated Pest Management

Crop pests and diseases pose a threat to global food security, especially in the current context of global change, invasive species, disturbed habitats, and so forth. Integrated pest management (IPM) is a data- and science-driven, multi-objective approach to protecting crops; IPM can help decrease the impact of pests, maximize resource use, and increase agrifood systems' food productivity for achievement of the UN SDGs.

Digital IPM solutions can help bring these capabilities to groups that are experiencing impactful pests (e.g., fall armyworm) for the first time, and standards can help make these solutions scalable. The third early initiative in ISO/TC 347 seeks to enable IPM. It should translate into standards along three categories:

- **Basic general standards related to IPM**, including coding and classification guidelines, generally aligned with the agrisemantics domain.
- **Standards for data management in crop pest and disease control**: including data collection, data exchanges among different stakeholders, etc.
- **Technologies and methods for crop pest and disease integrated management**, including diagnosis and monitoring, prevention and control, efficacy assessment, and others.

Some concerns were raised about this proposed work prior to TC 347's first plenary. This led to

the creation of an ad hoc group where issues can be discussed and resolved, and one or more NWIPs drafted. These concerns are:

- **Divergence**: This immediate proposal did not arise from the SAG-SF (but rather from a national delegation), but IPM-enabling capabilities were in scope of the SAG-SF recommendations. It will be important to quickly find a way to ensure that this IPM work is consistent and compatible with the reference architecture planned in IWA 47 and ISO/TC 347, while at the same time enabling rapid progress.
- **Generalization**: Which aspects of an IPM standard are portable across geographies and which aren't?
- **Scope management:** Some aspects of IPM standardization may be common to all the pests of interest (e.g., a data-driven framework for expressing which environmental variables are relevant to different IPM problems), but others will be pest-specific (e.g., specifics about how to detect fall armyworm in the field)

The timeline for this group's work is finite, aiming to complete its work in time for discussion in the March 2025 ISO/TC 347 plenary at the latest.

Discussion

Data security and data ethics by design

Data security and data rights management is a major challenge in the agriculture industry. In fact, it is a challenge across all industries. Improved data correctness, completeness, timeliness, availability, and understandability will expose data security and data rights management as the biggest bottleneck to effective use of data. Artificial intelligence-related expectations will only brighten the spotlight. We envision data management experts, data security experts, and legal experts specializing in data matters to come together to workout standards and best practices to address these challenges.

Additionally, an ethical approach toward customers and other stakeholders demands transparency and informed consent, which can be a challenge when dealing with smallholders who may not be literate or familiar with technological terms. Given the importance that the ISO/TMB placed on ensuring that smart farming and data-driven approaches serve to advance the SDGs, this necessarily involves placing digital agriculture solutions in the hands of these disadvantaged populations.

Ensuring transparency and informed consent, as well as limiting the unintended harm that may accompany standardization as a form of innovation, has motivated the ISO/TC 347 to propose chartering an advisory group to study how a responsible innovation framework could be introduced into the committee's standards development processes, to ensure inclusion, reflexivity, responsiveness, transparency and equity while maintaining the ability to react as quickly as possible to industry and market needs.

Enabling AI

There is a recent surge in industry interest in artificial. Intelligence (AI) and the value it can bring to agrifood systems with applications ranging from pest identification to yield prediction, to supply chain optimization. Enabling AI as a mechanism to extend the reach of crop advisors and extension personnel seems especially valuable in contexts where human-capital-mediated assistance to producers is limited, e.g., in developing countries that need more efficient and effective agrifood systems in order to secure food agency for their populations, and thus make progress toward the SDGs.

That being said, the old adage "garbage in, garbage out" remains very relevant in the AI domain. Data quality issues such as poor yield monitor calibration and poorly annotated datasets can greatly limit the accuracy and value of AI-mediated insights in agrifood systems.

To accompany the surging interest in AI applications in agrifood systems, ISO/TC 347 has a proposal (being voted on as of this writing) for chartering an ad-hoc group to study how standards could better enable and advance the use of AI in agrifood systems through better annotation and metadata management at the attribute, record and dataset level.

Ontologies and other semantic resources

Data formats have historically been designed to be application-specific or, in more forward-thinking situations, data-exchange-specific. This has led to an overwhelming proliferation of data formats, which some describe as "out of control." Business interest in ontologies is resurging to cut through the myriad formats and specify high-quality data definitions, relationships, and rules that can enable reasoning and other artificial intelligence applications.

Unfortunately, poorly crafted ontologies are proliferating, with similar or worse interoperability consequences than the standards they seek to improve upon. However, with patience, properly trained ontologists, and the participation of domain experts, high-quality modular ontologies can be and are being developed. Provided the best rises to the top and the rest can be identified and ignored, ontologies should play critical role in enabling data-driven agrifood systems.

An important aspect in the implementation of semantic infrastructure for the industry is that ontologies developed in an agrifood systems context often have limited scope, as well as governance and maintenance models that are tied to academic funding cycles, and a licensing model that is either unclear, or perceived as limiting to business uses (e.g., GPL). Our experience is that semantic resources usable by industry typically require predictable and reliable governance and maintenance, as well as business-friendly licensing and on-demand scope expansions.

The way that has been proposed for ISO/TC 347 to address this issue, and building on the previous point about data annotation, is for the committee's standards teams to focus on implementing relatively "flat" (I.e., non-hierarchical) vocabularies and lists of semantic resources (such as the crop definition objects mentioned above), albeit each bearing a unique identifier that can then be referenced / linked to from ontologies. These resources can provide the canonical, drop-down-list-friendly reference data used by the industry, yet also enable a tight integration with ontologies used both within industry and academia, regardless of their completeness.

This is just the beginning

Each of challenges and solutions described above will be addressed faster and more effectively, yielding higher quality solutions, and with better acceptance across the agriculture and food industries, through collaboration across industry associations and standards organizations. There will always be companies who imagine value in proprietary data management practices. Similarly, there will always be industry associations or standards organizations who imagine themselves and their stakeholders to be better off isolated. It is our sincere aspiration that the growing momentum toward collaboration, of which the creation of ISO/TC 347 and IWA 47 are examples, will help make the world's agrifood systems more efficient and sustainable, help advance the SDGs, and help change the world for the better.

How to get involved

ISO/TC 347, Data-driven agrifood systems

Different countries participate in ISO technical committees by establishing *mirror committees* organized by their national standards bodies (NSBs). Readers interested in participating can contact the corresponding author for contact information about their country's delegation. The participating / observing member status of the various NSBs in ISO/TC 347 is readily available at https://www.iso.org/committee/9983782.html?view=participation.

If a country does not appear as a member of the ISO/TC 347 committee, it may mean the staff of the NSB does not know enough domain experts to establish a mirror committee. Readers wishing

to explore membership of their non-member country in ISO/TC 347 should contact their NSB, the list of which, including websites and contact information, is available at https://www.iso.org/about/members.

ISO/IWA 47, Reference architecture for data-driven agrifood systems

This international workshop is expected to run from 9 July 2024 to the end of 2024, although edits to the final document may take longer. If you are interested in participating please reach out to the corresponding author.

Conclusion

In summary, the 15 months since the conclusion of ISO's Strategic Advisory Group on Smart Farming have been consequential. Several of the group's strategic recommendations have been implemented (e.g., ISO/TMB approval; the Smart Farming Coordination Committee; ISO/TC 347 on Data-driven Agrifood Systems; greater emphasis on communication) or are in progress (e.g., international workshop IWA 47 for a reference architecture for data-driven agrifood systems; a pipeline for agrisemantics standards development). Some important work still remains to be launched, such as external coordination with other standards organizations that may be already acting in, or considering entry into, the data-driven agrifood systems space (e.g., IEC, ITU, IEEE).

The community represented by the experts and other representatives from the national standards bodies participating in ISO/TC 347, the individuals participating in IWA 47, and the representatives of committees participating in the SFCC is active and engaged, especially considering that standards work is primarily volunteer-driven. More stakeholder engagement and communications are needed, especially regarding establishing a robust standards development pipeline, completing the TC 347 strategic business plan, and staffing other advisory and ad-hoc groups to support the committee's work.

In summary, a major international effort is underway toward enabling the UN Sustainable Development Goals through better data interoperability in agrifood systems. This effort is advancing with resolve and the stage is set for it to make impact.

Acknowledgments

The authors gratefully acknowledge the effort of countless volunteer experts who worked in the SAG-SF, and those who now participate in the new ISO/TC 347, the national mirror committees therefor, IWA 47 and the ISO Smart Farming Coordination Committee. Their commitment to data standardization as a vehicle to enable principled decision-making at scale in the world's agrifood systems is a time-consuming, committed and usually thankless task.

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