Data and AI Management in Smart Agriculture Using Soil and Crop Data

The Potential of COBIT 2019

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With smart agriculture using soil and crop data gaining traction around the world, the importance of data management is also being increasingly recognized. As in any other business, the products produced (in this case, crops in agriculture) need to be safe and environmentally and socially friendly. In addition to a traditional security perspective, it is important to focus on the perspectives of accuracy and validity when actively using data in agriculture, as the detailed conditions of soil and crops are digitized by sensors. Furthermore, when using artificial intelligence (AI), it is necessary to consider the characteristics of unpredictability and black

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boxes. To address these new perspectives, COBIT's comprehensive information and technology (I&T) governance management framework can be implemented.

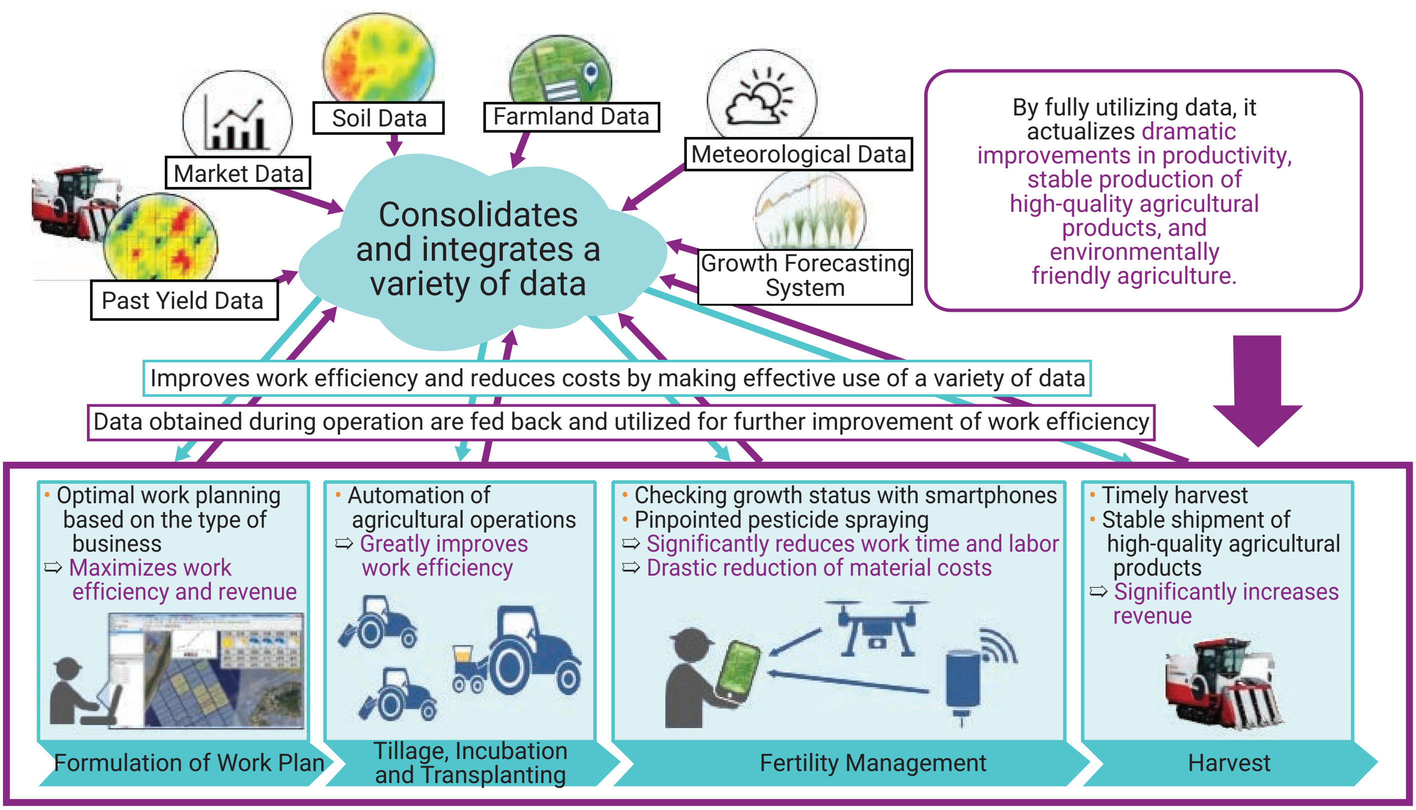
What Is Smart Agriculture?

Smart agriculture combines traditional agriculture with emerging technologies such as robotics, AI and the Internet of Things (IoT) to help improve the quality, added value and productivity of agricultural products. In smart agriculture, the research and development of support services using data analysis and AI is booming. These services use sensors to collect data on crops, soil and surrounding environments, which are then analyzed or processed by AI to help producers make decisions and take actions (e.g., production planning, tillage, sowing, fertilization, harvesting, shipping). This indicates that digital technology can support some of the advanced decisions and actions that have been made by skilled producers based on their know-how and intuition, making it easier to aim for higher quality, higher added value and higher productivity of agricultural products.

In Japan, the Ministry of Agriculture, Forestry and Fisheries (MAFF) is promoting the use of Wide Area Generalized Agricultural Data Infrastructure (WAGRI) as part of its smart agriculture promotion project, with the policy goal of having "almost all of the leaders in agriculture practice data-driven agriculture" by 2025 (**figure 1**).[1]

FIGURE 1

The Future Vision of Data-Driven Agriculture



Source: Japan Ministry of Agriculture, Forestry and Fisheries (MAFF), *About the Agricultural Data Collaboration Platform*, January 2021, *https://www.maff.go.jp/j/kanbo/smart/pdf/wagri_gaiyou.pdf*. Abridged translation by Alexander Vinson. Reprinted with permission.

Risk Associated With the Use of Data and AI in Agriculture

Risk arises from the unpredictability and opacity of AI (e.g., the black box effect)[2] and the suboptimal decisions that can be made due to diminished data authenticity and validity, which are considered particularly important for people who work in the agriculture business on a regular basis to address.

In addition to these risk factors, there are also security (confidentiality, integrity and availability [CIA]), data rights and contractual risk scenarios to consider. For example, for crops that are rare and difficult to grow, there is high value in data sets that can be used to analyze how soil, sunlight, temperature, watering and fertilization conditions affect crop quality. Guidelines on information security (including COBIT®) are helpful in ensuring the confidentiality of these data sets and how to protect them from leakage due to internal fraud, accident or cyberattacks.

Use of COBIT

The COBIT framework can be used to successfully govern and manage smart agriculture processes that use data and AI.

The basic concepts of COBIT include:[3]

- For information and technology to contribute to the achievement of enterprise goals, several governance and management objectives should be achieved.
- To achieve governance and management objectives, organizations need to establish, coordinate and maintain a governance system that is built from several components.
- The components can be of various types. The most familiar are processes. However, components of a governance system can also be organizational structures, policies and procedures; information items, culture and behavior; skills and competencies; services; infrastructure and applications.

The COBIT core model presents 40 governance and management objectives (**figure 3**).

To satisfy these governance and management objectives, an organization needs to establish, tailor and sustain a governance system built from a number of components. (**figure 4**).

Each objective has a detailed description of its components. For example, process components include practices, activities, sample metrics and related guidelines (**figure 5**).

There are several components of process, organizational structure and culture that correlate with selected management objectives that correspond to the examples of risk (**figure 2**) that are important to address on the frontlines of smart agriculture.

Management Objectives

There are multiple objectives that address the risk examples in **figure 2**: data accuracy, data validity, AI unpredictability and AI opacity. However, when going beyond one objective for data and one objective for AI, Align, Plan and Organize (APO) APO14 *Managed Data* (**figure 6**) and Deliver, Service and Support (DSS) DSS06 *Managed Business Process Controls* (**figure 7**) can be selected.

The reasons for these choices are clear from the process component of APO14 *Managed Data* and DSS06 *Managed Business Process Controls*.

The Process

The COBIT process consists of several practices. The risk examples in **figure 2** mainly correspond to the practices listed in **figure 8**.

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- Learn more about, discuss and collaborate on governance in ISACA's Online Forums. *https://engage.isaca.org/onlineforums*

FIGURE 2

Examples of Risk That Is Important to Address on the Frontlines of Smart Agriculture

Classification	Causes of Risk	Impacts of Risk
Data Accuracy	Insufficient accuracy in data collection by sensors. Example: Deterioration of the soil sensor reduces the measurement accuracy, resulting in data collection with insufficient accuracy.	Analysis is based on inappropriate data so that wrong decisions are made. Example: Fertilizer is not applied when it should be because it is judged that there are still nutrients in the soil. Crop quality and yield are impacted. Example: When pesticides are used under low rainfall conditions, the pesticides are not sprayed because it is determined that soil moisture is still present. Residues of pesticides in crops above the standard values affect the health of crop consumers and can be subject to punishment by regulatory authorities.
Data Validity	The data collected by the sensors is biased. Example: Solar radiation sensors are installed in a limited number of locations so that the data are biased when estimating the amount of solar radiation for the entire cultivated land.	Analysis is based on inappropriate data so that wrong decisions are made. Example: Irrigation (watering) is not implemented when it should be because it is judged that soil moisture is still present. Impacts crop quality and yield.
AI Unpredictability	It is not possible to verify and predict the processing results of the machine learning (ML) engine at the construction stage. Example: When building a function for sorting (grading) crops by image recognition using ML, the correct answer rate does not reach 100 percent, even with a limited amount of evaluation data.	Inappropriately processed outputs result when targets that could not be learned in the training data at the time of construction are input during production operation. Example: AI gives a low grade to crops that are rare (not included in the training data) and have high-quality characteristics. Shipping price is impacted.
AI Opacity	It is difficult to analyze what calculations were made to reach the results of the processing of the ML model. Example: It is not possible to analyze and understand the basis for sorting (grading) of agricultural products from the image recognition and sorting engine using machine learning.	One is unable to account for the rationale for the processing results of the ML engine to affected stakeholders. Example: One is unable to provide an explanatory response to a complaint received from a crop consumer that the quality of the product is poor even though it is a high grade (the response can only be that AI judged it). The reputation of the crop brand is impacted.

It is possible to consider specific measures to be taken in agricultural operations using data and AI by referring to the description of each practice.

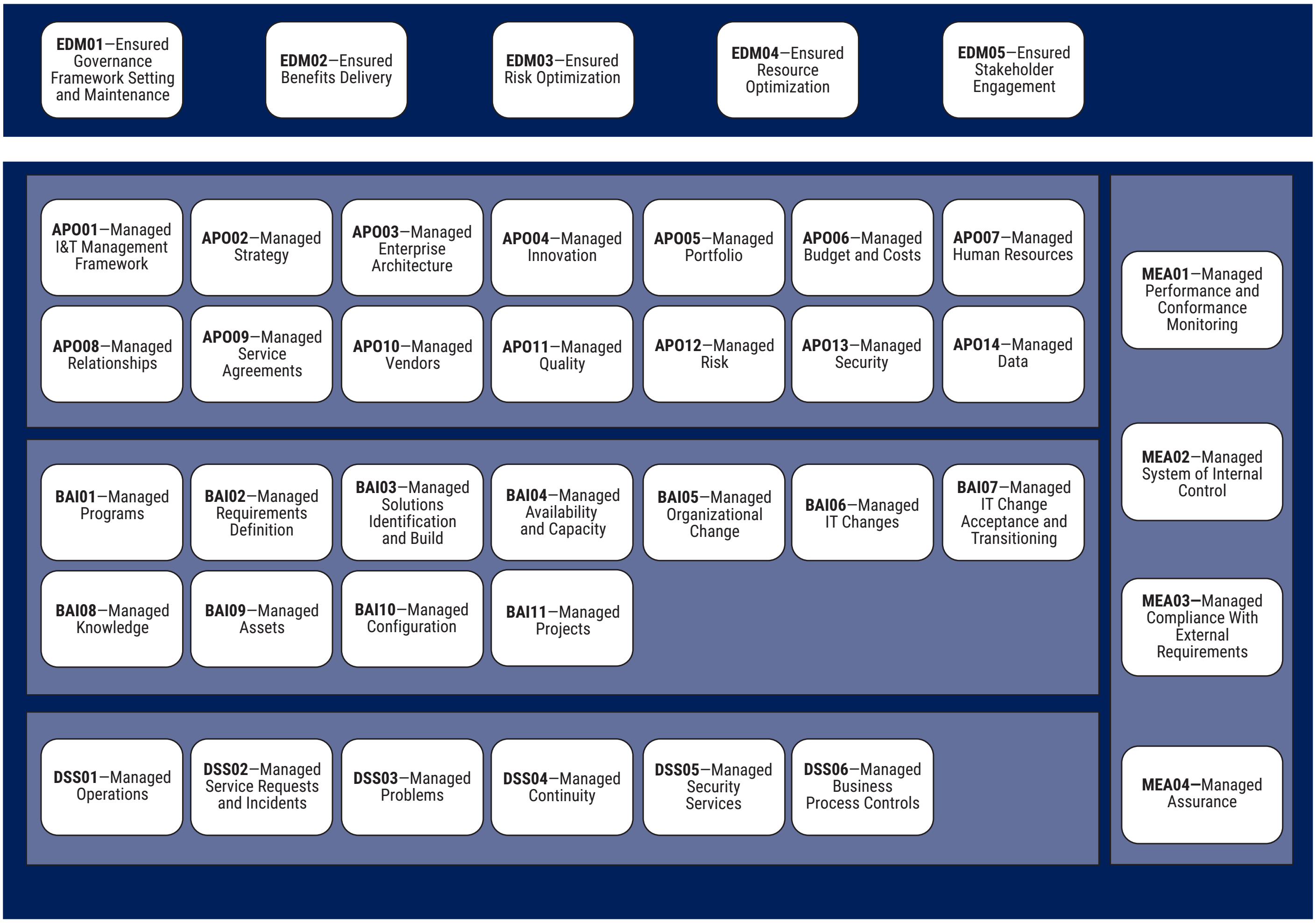
Organizational Structure

In addition to management objectives and process, COBIT provides an organizational structure for each practice as shown in **figure 9**.

Large-scale agricultural enterprises often have the option of having more than one person as a management team or administrator and also be in line with the organizational structure shown in **figure 9**. On the other hand, in family farms and small-scale agricultural enterprises, these roles are performed by a single individual. When using advanced data analysis and AI, there are many cases where external experts and solution providers are relied on, but it is important to recognize that the responsibility for implementing the measures lies with the business owner and that the management representative or business process owner (in this case, the person in charge of crop selection) is accountable.

FIGURE 3

COBIT Core Model



Source: ISACA®, *COBIT® 2019 Framework: Governance and Management*, USA, 2018. Reprinted with permission.

Culture

There are also key cultural elements corresponding to the two aforementioned management objectives and the desired state corresponding to the risk examples in **figure 2**.

For data and AI-driven agriculture, the importance of forming the desired states shown in **figure 10** is clear. This may also apply to other industries that actively utilize data and AI. Few guidelines mention culture, but in addition to implementing processes and organizational structures, fostering a culture in conjunction with them will ensure more effective governance and management.

FIGURE 4

COBIT Components of a Governance System

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FIGURE 5

Display of Process Component

A. Component: Process		
Governance/Management Practice	**Example Metrics**	
<REF> <NAME> <DESCRIPTION>	<METRIC>	
Activities		**Capability Level**
1. <TEXT>		<NR>
2. <TEXT>		<NR>
n. <TEXT>		<NR>
Related Guidance (Standards, Frameworks, Compliance Requirements)	**Detailed Reference**	
<STANDARD NAME>	<TEXT>	
<STANDARD NAME>	<TEXT>	

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FIGURE 6

COBIT Management Goals That Address Data Accuracy and Usefulness

Domain: Align, Plan and Organize Management Objective: APO14 — Managed Data	Focus Area: COBIT Core Model
Description	
Achieve and sustain effective management of the enterprise data assets across the data life cycle, from creation through delivery, maintenance and archiving.	
Purpose	
Ensure effective utilization of the critical data assets to achieve enterprise goals and objectives.	

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FIGURE 7

COBIT Management Goals to Address AI Unpredictability and Opacity

Domain: Deliver, Service and Support Management Objective: DSS06 - Managed Business Process Controls	Focus Area: COBIT Core Model
Description	
Define and maintain appropriate business process controls to ensure that information related to and processed by in-house or outsourced business processes satisfies all relevant information control requirements. Identify the relevant information control requirements. Manage and operate adequate input, throughput and output controls (application controls) to ensure that information and information processing satisfy these requirements.	
Purpose	
Maintain information integrity and the security of information assets handled within business processes in the enterprise or its outsourced operation.	

Conclusion

Digital transformation is progressing in the smart agriculture space—and across all industries and business categories. Such change presents new sources of risk, which must be taken into account when bringing a service or product idea from the concept validation stage to market. However, it is

FIGURE 8

Relevant COBIT Practices and Examples of Actions

Classification	Management Objectives	COBIT 2019 Management Practices	Explanations of COBIT 2019 Practices	Examples of Treatments to Address Smart Agriculture Risk
Data	APO14 *Managed Data*	APO14.04 *Define a data quality strategy*	Define an integrated, organizationwide strategy to achieve and maintain the level of data quality (such as complexity, integrity, accuracy, completeness, validity, traceability and timeliness) required to support the business goals and objectives.	Define the level of quality required for data to be collected by soil and solar radiation sensors.
		APO14.06 *Ensure a data quality assessment approach*	Provide a systematic approach to measure and evaluate data quality according to processes and techniques and against data quality rules.	Develop a system to measure and evaluate whether the collected soil and solar radiation data achieve the defined quality level.
		APO14.07 *Define the data cleansing approach*	Define the mechanisms, rules, processes and methods to validate and correct data according to predefined business rules.	Define how to correct (or remove) collected data that do not meet the quality level.
AI	DSS06 *Managed Business Process Controls*	DSS06.04 *Manage errors and exceptions*	Manage business process exceptions and errors and facilitate remediation, executing defined corrective actions and escalating as necessary. This treatment of exceptions and errors provides assurance of the accuracy and integrity of the business information process.	The results of the AI grading of crops will be checked by humans and corrected to the appropriate grade if necessary. This activity will be used as input for consideration of retraining the machine learning engine.
		DSS06.05 *Ensure traceability and accountability for information events*	Ensure that business information can be traced to an originating business event and associated with accountable parties. This discoverability provides assurance that business information is reliable and has been processed in accordance with defined objectives.	Be prepared to account for the readiness to improve the machine learning engine. Also, be prepared to account for the data used for training, the rate of correct answers in production, the process and results of correcting misjudgments, and the results of improvement activities through relearning.

Source: ISACA®, ***COBIT® 2019 Framework: Governance and Management***, USA, 2018. Reprinted with permission.

FIGURE 9

Relevant COBIT Organizational Structure

Classification	COBIT 2019 Management Practices	Chief Risk Officer	Chief Information Officer	Chief Data Officer	Chief Information Security Officer	Data Management Function	Business Process Owner	Service Manager
Data	APO14.04 *Define a data quality strategy*	R	A	R	R	R	—	—
	APO14.06 *Ensure a data quality assessment approach*	R	A	R	R	R	—	—
	APO14.07 *Define the data cleansing approach*	R	A	R	R	R	—	—
AI	DSS06.04 *Manage errors and exceptions*	—	R	—	—	—	A	R
	DSS06.05 *Ensure traceability and accountability for information events*	—	R	—	—	—	A	R

Note: R=Responsibility and A=Accountability. Source: ISACA®, ***COBIT® 2019 Framework: Governance and Management***, USA, 2018. Reprinted with permission.

FIGURE 10

Relevant COBIT Culture and State Examples

Classification	COBIT 2019 Management Objectives	COBIT 2019 Key Culture Elements	Examples of Desired States That Address Smart Agriculture Risk
Data	APO14 *Managed Data*	Create a culture of shared responsibility for the organization's data assets, and acknowledge the potential value of data assets and ensure that roles and responsibilities are clear for governance and management of data assets.	There is a common understanding that soil and solar radiation data are important assets for agricultural management. Roles and responsibilities for managing such data are widespread.
		Create awareness around data integrity, accuracy, completeness and protection to establish a culture of data quality. Relate data quality to the enterprise's core values. Continuously communicate the impact and risk of data loss. Ensure that employees understand the true cost of failing to implement a data quality culture.	Be aware of the integrity, accuracy, completeness and protection of soil and solar radiation data. Understand that the quality of the data can affect crop safety, quality and shipping prices, leading to consumer health damage and economical losses and profits. Furthermore, understand that financial and human resources will be invested to ensure the quality of the data.
AI	DSS06 *Managed Business Process Controls*	Create a culture that embraces the need for sound controls in business processes, building them into applications in development, or requiring them in applications bought or accessed as a service. Encourage all employees to have a control consciousness to protect all assets of the organization (e.g., paper records and facilities).	Producers understand that they are ultimately responsible for the quality of their crops and do not rely on the results of the machine learning engine's crop selection (grading). They are taking the initiative to relearn and improve the machine learning engine in order to improve the selection process and accuracy.

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often difficult to respond to new risk in a timely manner, especially for new products and services that have not yet become available. As COBIT® has evolved over the past 25 years, incorporating insights from academia and practice, it has become clear that the management objectives and components of COBIT are also very powerful tools for dealing with risk in new business domains that utilize data and AI.

Author's Note

The content of this article is based on the author's personal opinion and does not reflect an official position by PricewaterhouseCoopers Aarata LLC or PwC Consulting LLC.

Endnotes

1 Ministry of Agriculture, Forestry and Fisheries (MAFF), FY2021 Budget Estimate Request (23 Smart Agriculture Comprehensive Promotion Measures Project), Japan, 2021, *https://www.maff.go.jp/j/budget/pdf/r3yokyu_pr23.pdf*

2 European Commission, *White Paper on Artificial Intelligence: A European Approach to Excellence and Trust,* Brussels, Belgium, 19 February 2020, *https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en*

3 ISACA®, *COBIT® 2019 Framework: Introduction and Methodology*, USA, 2018, *https://www.isaca. org/resources/cobit*