Future Prospects for Smart Agriculture: Focusing on Case Studies in Japan and Asia

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Future Prospects for Smart Agriculture: Focusing on Case Studies in Japan and Asia

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PREFACE

The P-Insights, short for "Productivity Insights," is an extension of the Productivity Talk (P-Talk) series, which is a flagship program under the APO Secretariat's digital information initiative. Born out of both necessity and creativity under the prolonged COVID-19 pandemic, the interactive, livestreamed P-Talks bring practitioners, experts, policymakers, and ordinary citizens from all walks of life with a passion for productivity to share their experience, views, and practical tips on productivity improvement.

With speakers from every corner of the world, the P-Talks effectively convey productivity information to APO member economies and beyond. However, it was recognized that many of the P-Talk speakers had much more to offer beyond the 60-minute presentations and Q&A sessions that are the hallmarks of the series. To take full advantage of their broad knowledge and expertise, some were invited to elaborate on their P-Talks, resulting in this publication. It is hoped that the P-Insights will give readers a deeper understanding of the practices and applications of productivity as they are evolving during the pandemic and being adapted to meet different needs in the anticipated new normal.

INTRODUCTION

In Japan, the government began promoting smart agriculture through demonstration projects in 2019. Over the six years leading up to 2024, more than 200 such projects were carried out nationwide with government support. At the same time, each prefecture has implemented its own initiatives, revealing both achievements and challenges.

This report highlights key examples of smart agriculture practices in Japan and other Asian regions, aiming to identify core challenges and outline future directions.

So far, Japan's smart agriculture initiatives have mainly targeted large-scale agricultural corporations, emphasizing mechanization such as self-driving tractors and combines. However, moving forward, small- and medium-sized farmers, who make up the majority of Japan's farming population, will require smart agriculture practices that offer high cost-effectiveness with minimal investment. It is also important to emphasize that such practical smart agriculture solutions can be adapted for other Asian regions as well.

SMART AGRICULTURE

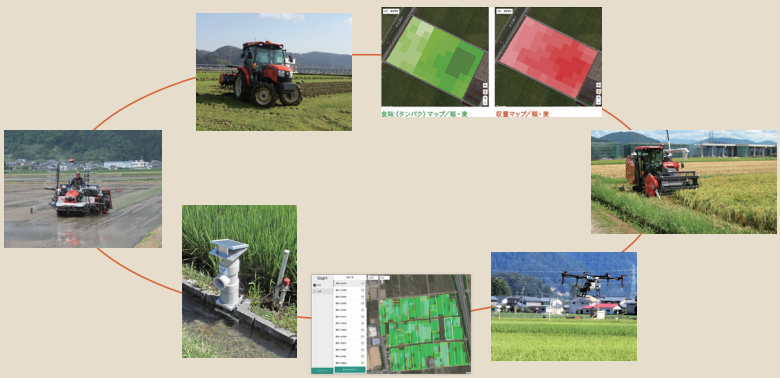
1. Definition and Drivers Behind the Promotion of Smart Agriculture

(1) What is Smart Agriculture?

First, what exactly is "smart agriculture"? Outside of Japan, it is often referred to as agri-tech or smart farming. According to the Ministry of Agriculture, Forestry and Fisheries (MAFF), smart agriculture refers to efforts to improve the productivity and operational efficiency of farming by using advanced technologies such as robotics, AI, and the IoT.

FIGURE 1

Example of Applying Smart Agriculture to Rice Farming



Source: Created by the author based on the MAFF website.

Taking rice farming as an example, smart agriculture technologies can be applied to nearly every stage, from soil preparation to harvesting. More specifically, Japanese rice farmers can adopt technologies such as auto-steering tractors, water level sensors, AI-based satellite crop analysis, pesticide-spraying drones, and robotic combines. These technologies also allow farmers to store and analyze data

through digital farm management systems, enabling precise fertilization, targeted pesticide application, and improved planning for the next season.

Source: https://www.maff.go.jp/e/policies/tech_res/smaagri/robot.html

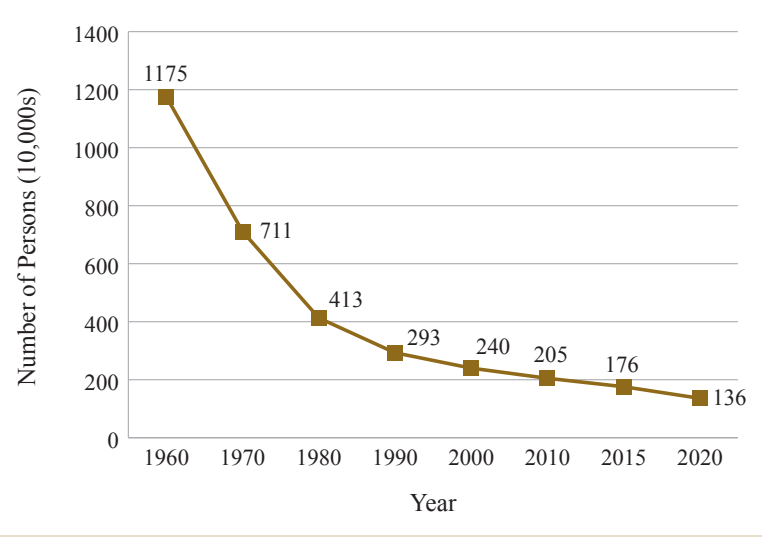
(2) Background Behind Japan's Promotion of Smart Agriculture

One major reason smart agriculture is being promoted as a national policy in Japan is the dramatic structural changes in the agricultural sector. There are four key driving factors, each accompanied by its own challenges.

First, the number of farmers in Japan has seen a dramatic drop by about 90% over the past 60 years to around one million. In 2020, the average age of farmers reached 68 years. The aging population and labor shortages in rural areas have become serious issues.

FIGURE 2

Changes in the Number of Core Farmers



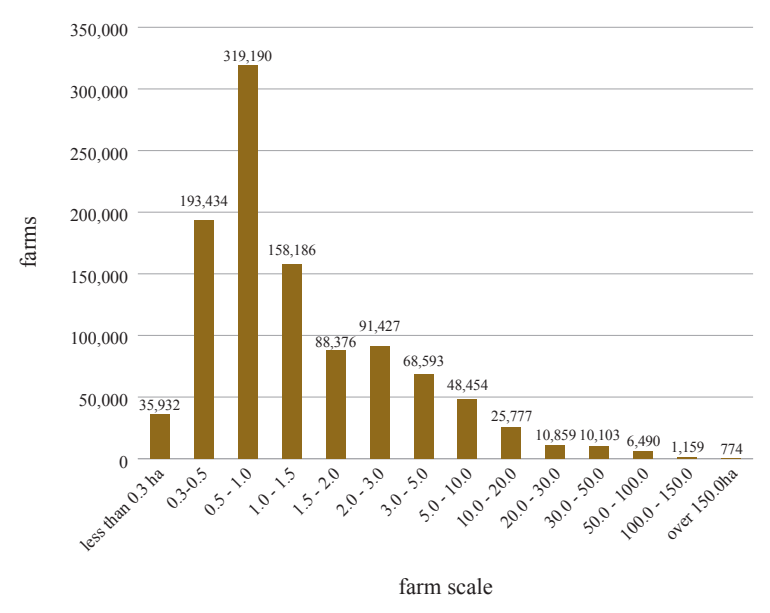
Source: MAFF.

Second, in 2023, the average cultivated area per farm reached 3.4 hectares, but the median remained between 0.5 to one hectare, indicating the continued prevalence of small-scale farms (Figure 3).

On the other hand, more than 8,000 farms in Japan now operate at a scale of over 50 hectares, and nearly 2,000 farms exceed 100 hectares. Even Honshu, the main island of Japan, has seen an increase in large-scale farms.

FIGURE 3

Number of Farms by Size

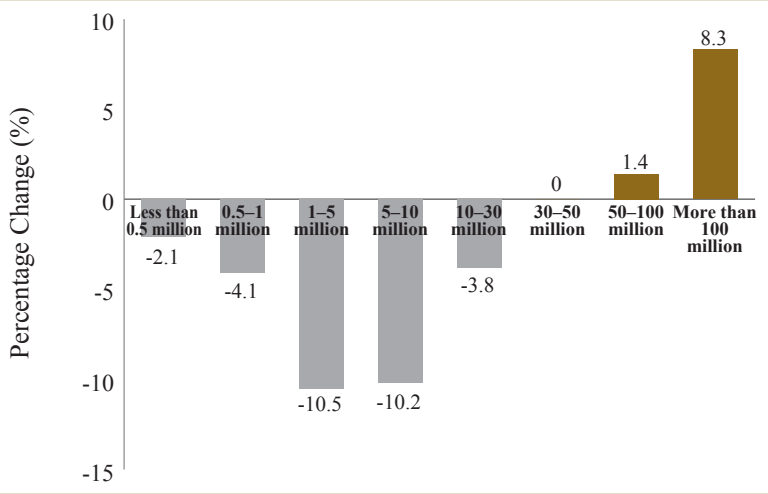


Source: Created by the author based on the MAFF website.

Third, the number of farms generating annual sales of over JPY500 million is increasing. These large-scale entities are better positioned to adopt smart agriculture technologies.

FIGURE 4

Change in the Number of Farms & Corporations by Sales Volume (2022)



Source: MAFF.

Fourth, many small-scale farms are exiting agriculture, leading to farmland being consolidated under larger rice producers. One challenge for these large farms is that their fields are often geographically dispersed.

FIGURE 5

Separated and Dispersed Fields

Source: Tohoku Hi-Tech Study Group.

Managing such dispersed fields requires accurate mapping and operational coordination. Farmers must clearly identify plots and give precise instructions to staff, which requires farm management systems integrated with digital maps.

FIGURE 6

Tomato greenhouse with a high-wire induction system (photo taken by the author)

For large-scale greenhouse operations (over one hectare), smart agriculture systems that include integrated environmental control, which involves specifically managing temperature, humidity, and automatic window ventilation, are also crucial.

2. Current State of Smart Agriculture in Japan and Other Asian Regions

(1) Spread of Satellite Systems and Auto-Steering Tractors

Smart agriculture has rapidly spread within Japan. In Hokkaido, for instance, the AI and satellite-based crop management system *xarvio*® *FIELD MANAGER* has become widely adopted. With xarvio, users can generate power zone maps based on 15 years of data and receive daily-updated biomass maps via satellite imagery.

Source: https://www.xarvio.com/us/en.html

FIGURE 7

Biomass Maps (Updated Daily)

Source: xarvio website.

xarvio enables the variable rate application of fertilizer by providing detailed information about differences in the power zone. It works in conjunction with broadcasters, which are specialized agricultural machines used to distribute fertilizers and seeds.

The system also provides crop protection alerts, enabling early protection against winter wheat brown rust, for example. According to Hokkaido farmers, the use of xarvio has led to a 10–20% increase in wheat yields compared to the previous year.

FIGURE 8

Power Zone Maps (Based on Analysis of the Past 15 Years of Satellite Images)

Source: xarvio website.

FIGURE 9

Auto-steering tractors in Hokkaido (photo taken by the author)

In Hokkaido, auto-steering tractors and water level sensors are also rapidly spreading. Some regions report that nearly 100% of farmers have adopted auto-steering systems retroactively applied to tractors for each farm. In addition to xarvio, other satellite image analysis systems are also becoming common in Hokkaido.

(2) Smart Agriculture in Flower Cultivation

In Tochigi Prefecture, a lily farm (F.F. HIRAIDE) with about 1.5 hectares of greenhouse space is among the top in Japan in terms of production volume.

This farm uses *Farmo*, an environmental monitoring system. It allows the farm not only to monitor its own greenhouse but also to share and compare environmental data with other lily growers in Yamagata and Kochi Prefectures, helping improve their cultivation practices.

The farm also adopted an AI-powered pesticide-spraying robot that can detect pests like aphids by using onboard cameras while driving through the rows and spray pesticides only where needed.

Previously, pesticides were sprayed over the entire field. Now, the robot targets only affected rows, reducing both pesticide costs and environmental impact.

FIGURE 10

F.F. HIRAIDE greenhouse, Mr. & Mrs. Hiraide with the Farmo system (photo taken by the author, courtesy of Mr. Hiraide)

FIGURE 11

AI pesticide-spraying robot (provided by EMI Lab)

(3) Introduction of Smart Agriculture in Strawberry Cultivation

In Ibaraki Prefecture, a strawberry farm called *Tsuzuku* Farm uses a system called Zero Agri, an AI-based fertigation system. This system collects data that includes soil moisture and solar radiation forecasts and calculates the exact amount of water and fertilization needed, automatically supplying them to the crops.

As a result, it stabilizes soil moisture and fertilization levels, reduces plant stress, increases the yield and quality, and ultimately improves farmers' income. The system can be remotely managed using a PC, smartphone, or tablet, with all data stored in the cloud. Any errors, such as water supply failures or low fertilization tank levels, are immediately reported to the farmer through alerts.

Daily cultivation data is stored and managed in the cloud, allowing farmers to analyze their results and improve plans for the next season. With this system, even beginners can perform advanced cultivation management and achieve stable, high-quality strawberry production.

Source: https://www.k-monobrand.com/en/ninteikai-en/11th-en/zero-agri-ict-hydroponic-cultivation-system-2/

FIGURE 12

Strawberry greenhouse and grower (photo taken by the author)

FIGURE 13

AI-based fertigation system (highlighted in blue, provided by Routrek Networks Inc.)

(4) Smart Agriculture Introduced by a Community-Based Farming Organization

In Hyogo Prefecture, smart agriculture has also been introduced by a community-based farming organization. The group consists of part-time farmers who manage around 25 hectares, mainly for sake rice and black soybeans. The leader, a former agricultural extension officer, conducted simulations using Excel and examined smart farming effects through field visits in another prefecture.

Based on their studies, they introduced two machines: a tractor and a rice transplanter with straight-line assist functions. They also recently introduced a large drone. The rice transplanter can handle both transplanting and direct seeding with attachments, enabling accurate work even by new operators and improving labor efficiency.

By introducing a large drone, they shifted from coated fertilizers to conventional ones, reducing microplastic use and the summer workload. This shows that even small-scale community organizations can successfully adopt smart agriculture.

FIGURE 14

Auto-steering tractor (photo taken by the author)

FIGURE 15

Direct seeding using an assisted rice transplanter (provided by Hyogo Prefecture)

FIGURE 16

Topdressing black soybeans with a large drone (50 kg payload, provided by Mr. Yamazaki)

(5) Current Status of Smart Agriculture in Other Asian Regions

Smart agriculture is also advancing outside of Japan. In countries like Malaysia and Thailand, about 80% of farmers use smartphones, enabling them to manage cultivation, access market information, and handle finances.

In Thailand, the government launched the *Smart Farmer Project* around 2015. A smart farmer is defined as a person who improves their operations using ICT. These farmers are officially certified by the government and resemble Japan's certified master farmers. They actively adopt technologies such as drones, obtain GAP certification, and implement automated irrigation systems.

In Nonthaburi Province, just north of Bangkok, *Temrak Organic Farm* grows kale and other vegetables while running a restaurant and café. The owner, a former engineer, built his own automatic irrigation system, which works based on temperature.

FIGURE 17

Thai farmer building an automatic irrigation system (photo taken by the author)

In Taiwan, applications developed by public institutions are widely used, allowing farmers to provide traceability information to consumers. By scanning a QR code, consumers can check detailed production information for each product. These apps are free for all producers in Taiwan.

FIGURE 18

Traceability System Developed by Taiwanese Public Institutions

Thus, smart agriculture outside of Japan emphasizes smartphone-based applications and simple technologies like irrigation systems that even small-scale farmers can use.

3. Evaluation and Challenges of Smart Agriculture in Japan

(1) Reduced Labor Hours

One example is *Suzunari*, a large-scale vegetable farming corporation that cultivates 160 hectares of broccoli and lettuce. As a result of introducing auto-steering tractors, they can now plow straight ridges, enabling efficient transplanting and harvesting. This increased operational efficiency and reduced labor hours by 55%.

Similarly, in Mie Prefecture, rice transplanters with straight-line assist functions enable beginners to accurately plant rice. Smart agriculture in Japan has made it easier for newcomers to perform skilled tasks and significantly reduced labor hours.

FIGURE 19

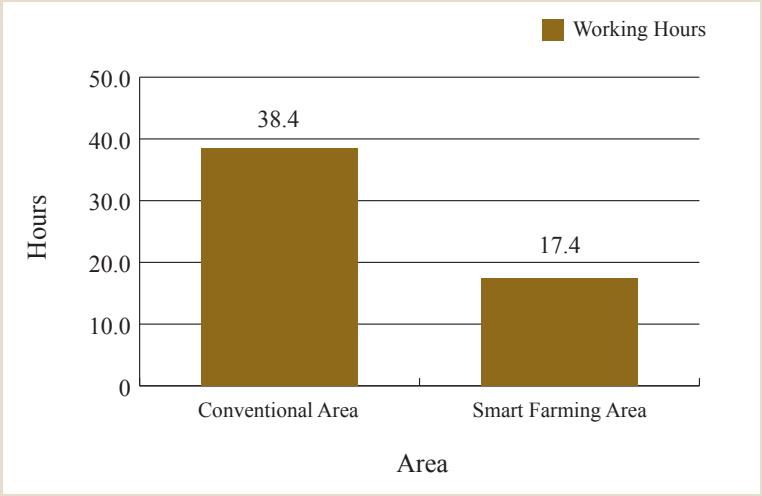
Cooperative operation of auto-steering tractors (photo taken by the author)

FIGURE 20

Broccoli harvesting machine (courtesy of Suzunari)

FIGURE 21

Labor Reduction with Smart Agriculture in Broccoli Farming



Source: Suzunari Co. (Shizuoka Prefecture).

(2) Economic Evaluation

Economic evaluation reveals that smart agriculture may not always improve financial performance, especially for family-run farms. The cost of machinery cannot always be offset by labor savings.

TABLE 1

Economic Evaluation of Large-Scale Paddy Family Farming

Classification	Conventional area (6.7ha) 1000yen/10a	Demonstration area (5.1ha) 1000yen/10a
Total income	**117.8**	**129.3**
Sales revenue	117.8	129.3
(unit sales kg)	(471)	(517)
Other sales	0	0
Total expenses	**79.4**	**123.8**
		(81.3)
Seed cost	2.1	2.1
Fertilizer cost	9.7	9.2
Agrochemicals	2.8	2.8
Machinery and facilities	13.7	59.2
		(16.7)
Labor cost	16.7	16.1
(Labor hours per 10a)	(11.1 hour)	(10.7 hour)
Other expenses	34.4	34.4
Profit	**38.4**	**5.5**
		(48.0)

Remarks: 1) ( ) ; smart equipment is fully utilized
2) Total area; 65.2ha

Source: Modified and translated from MAFF materials.

For large family farms, profits remain lower than conventional farming unless smart equipment is fully utilized (e.g., on 53 hectares or more). In contrast, large corporate farms benefit from increased yields and labor savings despite higher machinery costs.

TABLE 2

Economic Evaluation of Large-Scale Paddy Corporations

Classification	Conventional area (41.2ha) 1000yen/10a	Demonstration area (45.6ha) 1000yen/10a
Total income	128.2	142.0
Sales revenue	128.2	142.0
(Unit sales kg)	(422)	(467)
Other sales	0	0
Total expenses	80.9	77.1
Seed cost	2.2	2.5
Fertilizer cost	1.3	1.3
Agrochemicals	2.1	2.1
Machinery and facilities	12.1	14.6
Labor cost	13.7	12.8
(Labor hours per 10a)	(9.1 hour)	(8.5 hour)
Other expenses	49.6	43.7
Profit	47.3	64.9

Remarks: Total area; 160ha

Source: Modified and translated from MAFF materials.

In the case of strawberry greenhouse farming, higher quality leads to increased revenue, offsetting equipment costs and improving profitability.

TABLE 3

Current Status and Outlook of Smart Agriculture by Sector

	Paddy field cultivation	Open-field vegetables	Greenhouse vegetables	Orchard crops	Flower cultivation	Lives stock farming
Penetration rate of Smart Agriculture	◎	△	○	△	△	◎
Book keeping system	○	○	○	△	△	○
Future potential of smart agriculture	△	○	△	○	○	△
Remarks	Small-scale, mountainous areas	Mechanization of harvesting and labor-saving	Cost reduction and value addition	Labor-saving	Cost reduction and value addition	Simplification

Note: ◎: to a great extent, ○: to some extent, △: to a small extent.
Based on national case studies and the author's assessment.

Source: Created by the author.

In Japan, smart agriculture has traditionally focused on mechanization for large-scale farms, particularly in the fields of rice cultivation, greenhouse horticulture, and livestock production, with an emphasis on reducing labor hours.

Going forward, smart agriculture must also focus on fields that have yet to see widespread adoption, such as open-field vegetables, fruit orchards, and flowers, as well as on small- and medium-sized farms.

As Professor Sakae Shibusawa of Tokyo University of Agriculture and Technology noted, "Smart agriculture is not about technology, but about management." This highlights the importance of evaluating smart agriculture not only from a technology-driven perspective, but also with a focus on its management implications.

4. Future Outlook for Smart Agriculture Among Small- and Medium-Scale Farmers

Smart agriculture tools that are low-cost and simple enough for small- and medium-scale farmers are expected to become more widespread.

(1) Labeling Greenhouse Gas Reductions and Using Software for J-Credit Applications

One initiative involves labeling products to visualize greenhouse gas (GHG) reductions, a program developed by Japan's MAFF and fully launched in 2024. Even small farms can participate by filling out a simple Excel form and submitting it to the ministry. In return, they receive a sticker with star ratings indicating their level of GHG reduction. Additional stars can be awarded for biodiversity efforts.

As of March 2025, over 900 stores nationwide have adopted this program. This trend is helping farmers demonstrate their environmental contributions to consumers and differentiate their products.

FIGURE 22

Label of Greenhouse Gas Reduction & Biodiversity Conservation

Source: MAFF website.

Completing the required forms is easier for farmers who already use farm record-keeping software. With support from agricultural extension staff, even small-scale farmers can participate with minimal effort. Furthermore, extending the mid-season drainage period for rice farming to reduce GHG emissions can also enable farmers to qualify for J-Credits, government-certified carbon credits that can be bought and sold. These applications can be submitted via platforms like xarvio or Agri-note.

FIGURE 23

Using Software such as xarvio to Obtain J-Credits

(2) Use of Compact Robots

There is a growing trend of adapting smart agriculture tools for small-scale farmers. For example, the AI-based pesticide-spraying robot introduced in Tochigi Prefecture was originally designed and priced for large lily farms. In Utsunomiya City, a similar robot is now being adapted for small chrysanthemum farms.

A new farmer testing the robot said, "Spraying pesticides in the summer is tough work. With this robot, I expect a lot less physical strain." The robot's concept remains the same, but it is designed to be more compact and simpler, making it more affordable for small-scale farmers.

FIGURE 24

Robot for spraying pesticides

(3) Use of Agricultural Apps

In Ogawa town of Saitama Prefecture, an organic farmer uses Agri-note, a farm record-keeping application, to share traceability data with consumers and collaborate with other local organic farmers. With a subscription starting at around $6 per month, it's a cost-effective solution for small farms. According to the farmer, Agri-note offers various pricing plans, and local cooperatives often subscribe on behalf of members, enabling individuals to avoid individual expenses.

FIGURE 25

Agri-note (record-keeping application)

Another app rapidly gaining users is *Agrihub*, developed by a farmer in Tokyo. It offers both free and paid versions, with even the free version providing essential functionality. Compared to traditional apps, it requires fewer inputs and is easier to use, contributing to its popularity. As of March 2025, it had over 40,000 users nationwide.

FIGURE 26

Agrihub Interface

Source: Official Agrihub website.

Online sales, which enable individual farmers to ship directly and earn higher profits than traditional market sales, are expanding rapidly. Services like *Tabechoku* have gained significant popularity, especially during the COVID-19 pandemic.

Niigata-based rice farmer Ohara Farm reports that using social media platforms like Instagram along with online sales has made it easier to promote and expand their customer base. However, they argue that if consumers buy rice repeatedly online, farmers should focus more on creating distinctive, flavorful products that can compete in terms of quality and price.

FIGURE 27

Online Sales

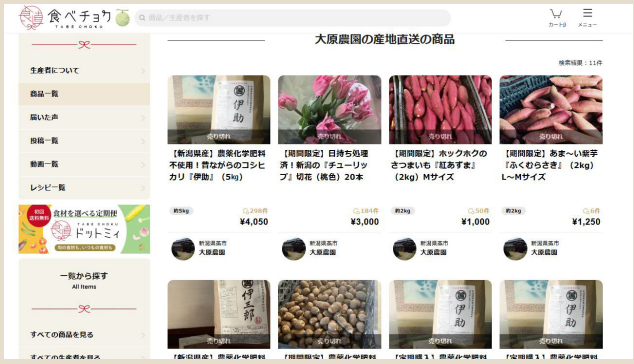
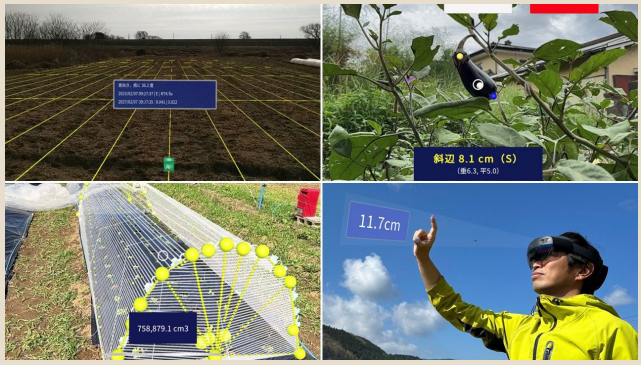


FIGURE 28

Examples of Augmented Reality (AR)-Based Applications



Source: Root Inc.

In 2024, AR-based applications aimed at improving agricultural work efficiency became available. These applications offer more than 10 useful functions for all types of farms, including parallel line guidance, ridge simulation, and various measurement tools for area, distance, and size. As of March 2025, over 350 units had been deployed nationwide, including use cases outside of agriculture. Compatibility with both smartphones and smart glasses, combined with an affordable starting price of $60, has driven widespread adoption.

Source: https://agri-ar.root-farm.com/

In addition, the introduction of AI for Japan's smart agriculture is increasing. A generative AI chatbot named *Farmer Tomi* is available for free on the LINE platform. Its chat-based interface is easy to navigate, even for elderly users.

FIGURE 29

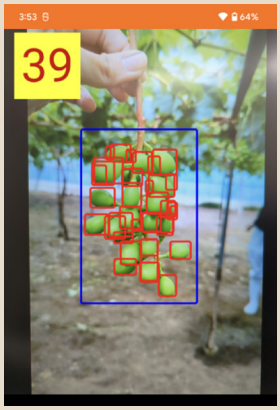
Generative AI Chatbot on LINE

Source: Example Q&A translated from Japanese (right)

In Hiroshima Prefecture, an affordable system is available that uses AI to display the number of grapes that need thinning via a smartphone or smart glasses (Figure 30). Additionally, apps such as *Diagnosis Your Crops with AI!* (Japanese version) and *AcroSeeker*™ (global version) are publicly accessible and free of charge (Figure 31). These tools are particularly helpful for new or beginning farmers when diagnosing pests and diseases or performing thinning operations.

FIGURE 30

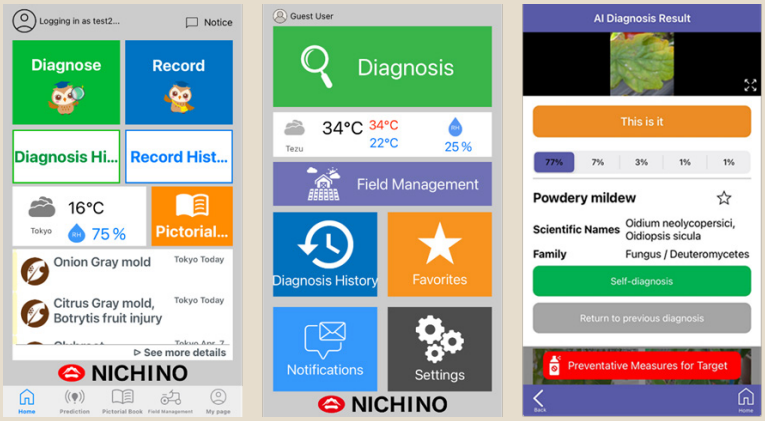
AI Image Analysis for Grape Thinning



Source: Hiroshima Prefectural Government website.

FIGURE 31

AI Pest and Disease Diagnosis Application (English Version)



5. What Kind of Farmers Will Embrace Smart Agriculture in the Future?

This report has provided an overview of the evolution of smart agriculture in Japan while referencing case studies from other Asian regions.

Until now, Japan's smart agriculture has primarily focused on large-scale rice farmers using advanced machinery. As a result, smart agriculture has become more common among large farms, but the high cost of implementation has limited its spread among smaller-scale farmers. Looking ahead, technological advances are expected to bring the following changes for Japanese farmers:

FIGURE 32

Smart Agriculture in the Future

SUMMARY

First, affordable tools like simple AR applications and compact, low-cost robots will become more accessible.

Second, Digital technologies, including distribution platforms, will also evolve, enabling farmers to use satellite imagery, production management systems, and logistics tools at low cost.

Third, the use of AI will accelerate, and generative AI will likely become a routine part of farm management and business problem-solving.

Fourth, in addition to digital transformation (DX), green transformation (GX) will progress in agriculture. Decarbonization efforts will become critical to agricultural management, making digital tools essential.

Above all, Japan's smart agriculture is expected to shift from hardware-centered solutions to software-centric, affordable technologies. The direction of smart agriculture in Japan is increasingly aligning with trends in Southeast Asia. Some of the new technologies developed in Japan might also be usable in those countries.

Just to reiterate, the majority of farmers in Japan are small-scale. Technologies that are easy for such farmers to adopt will become central to smart agriculture moving forward. With continued government support, smart agriculture is expected to spread to a wider farming population in the coming years.

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Smart Agriculture: https://www.maff.go.jp/e/policies/tech_res/smaagri/robot.html

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