“Cultivating” Agricultural Information Management System Using GIS Technology

—Improving Agricultural Efficiency through Information Technology

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OVERVIEW: Improving agricultural efficiency is an issue not just for developed countries but for the entire world including emerging economies, and it is recognized that encouraging greater efficiency will intensify the need for greater use of information technology on the farm. The Hitachi Software Engineering Co., Ltd.'s agricultural information management system uses GIS technology to utilize and provide unified management of farm information about things like products, producers, yields, and quality. The relationship between cultivation records and parameters such as product yield and quality can be presented visually by incorporating functions such as management of production records to support the recording of past production information for use in checking the appropriateness of agricultural chemical use, growth analysis using satellite images, and fertilizer planning based on soil analysis results. This allows use of agricultural chemicals and fertilizers to be reduced by managing fertilizer application in a way that makes production more uniform, and also helps lower costs and reduce the burden on the environment.

INTRODUCTION

JAPANESE agriculture faces a number of different issues including how to improve productivity further, deliver food safety and security, pass on technology and nurture the people involved in the industry, and increase the proportion of food produced domestically. In a world where we face the possibility of resource depletion, farmers also find themselves

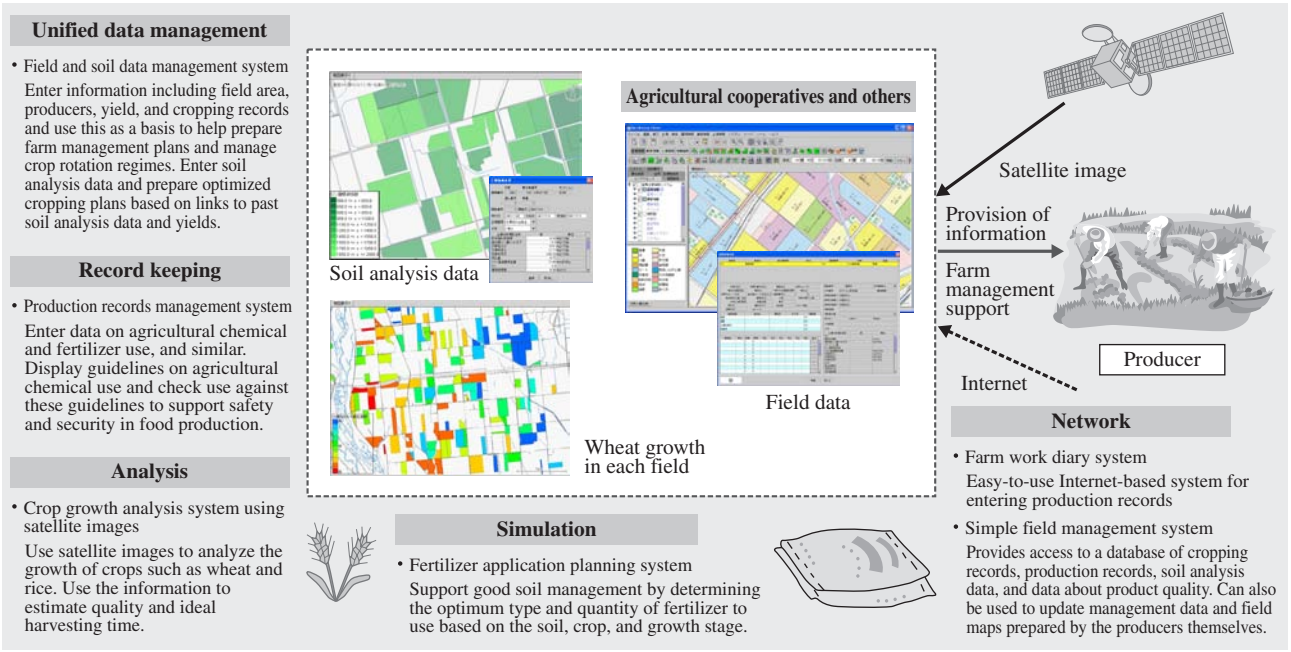

Fig. 1—Overview of Agricultural Information Management System.
Hitachi Software Engineering Co., Ltd.'s agricultural information management system applies technology from the field of GIS that it has built up over many years to overlay a wide range of different information from the farm onto a map to provide easy-to-use ways to manage and utilize this information.

in a situation where they must conduct their business in a way that takes account of numerous modern-day issues other than just producing agricultural products, including implementing sustainable agricultural practices and reducing the burden on the environment that results from agriculture[1].

As this has created a need to adopt new concepts and technologies rather than just relying on traditional inputs like agricultural machinery, agricultural chemicals, and fertilizers, expectations for the use of "information" in farming are growing[2].

This article describes the Hitachi Software Engineering Co., Ltd.'s agricultural information management system based on GIS (geographic information system) technology, while also giving some examples of its use and discussing the outlook for agricultural IT (information technology).

MAKING USE OF AGRICULTURAL INFORMATION THROUGH MANAGEMENT SYSTEM

One of the important issues facing agriculture in Japan is cost reduction. But keeping use of resources such as agricultural chemicals and fertilizers to a minimum, operating agricultural machinery efficiently, and shortening the time taken to carry out agricultural work will not only improve cost-competitiveness, it will also help reduce the burden on the environment. While delivering food safety and security requires that producers apply agricultural chemicals and fertilizers in accordance with their guidelines for use, it is also important that actual usage be recorded correctly and in a way that permits auditing by a third party at any time.

When combined with yield, quality, and other data, production records collected for the purpose of providing food safety and security can also be put to use as valuable farming knowledge. Also, using the same information for multiple purposes reduces the effective cost of that information.

HitachiSoft started supplying the agricultural information management system in 2004. The system manages agricultural data through links with a map, and to date has been adopted at approximately 40 agricultural cooperatives and other organizations (see Fig. 1).

The system aims to help provide farm operating guidance (guidance on improving agricultural management and technology) by managing information by linking it to individual farms and parcels of land using GIS technology. By managing

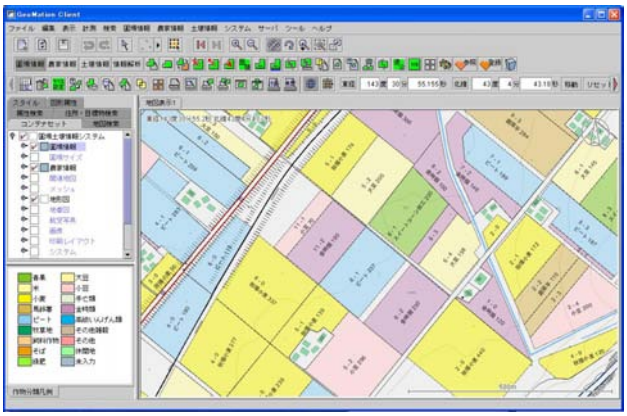

Fig. 2—Example Screen from Field Data Management System. Detailed management of field data is achieved by linking the data to a map so that it can be utilized in many different ways.

data such as types of farm products, producers, yield, quality, soil type and analysis results, weather data, and agricultural chemical and fertilizer usage by linking the data to locations on the farm, the system can be utilized for purposes such as supporting the preparation of cropping plans based on past cultivation records or identifying differences in the productivity of different locations which would be difficult to achieve using ledger-based management (see Fig. 2).

HitachiSoft's agricultural information management system incorporates numerous functions for utilizing data. These include a system for collecting and managing records of actual agricultural chemical and fertilizer usage and checking whether these comply with the guidelines, a growth analysis system that uses satellite images to estimate crop yields and crop growth over a wide area, and a fertilizer planning system that advises on optimum fertilizer application based on soil analysis results. Utilizing these functions can provide direction on what to do next to improve cultivation, determine quality and yield, and carry out farm work (see Fig. 3).

The system can be used in many different ways. These include supporting crop rotation regimes, supporting crop planning based on knowledge of the area under cultivation, and use by producers discussing decisions about the harvesting sequence based on the use of satellite images to estimate at the state of growth of crops.

The superior ease-of-use of the system allows most users to maintain for themselves data such as product information and the farm layout that changes from year to year. This keeps field data up to date and leads to continued use of the system.

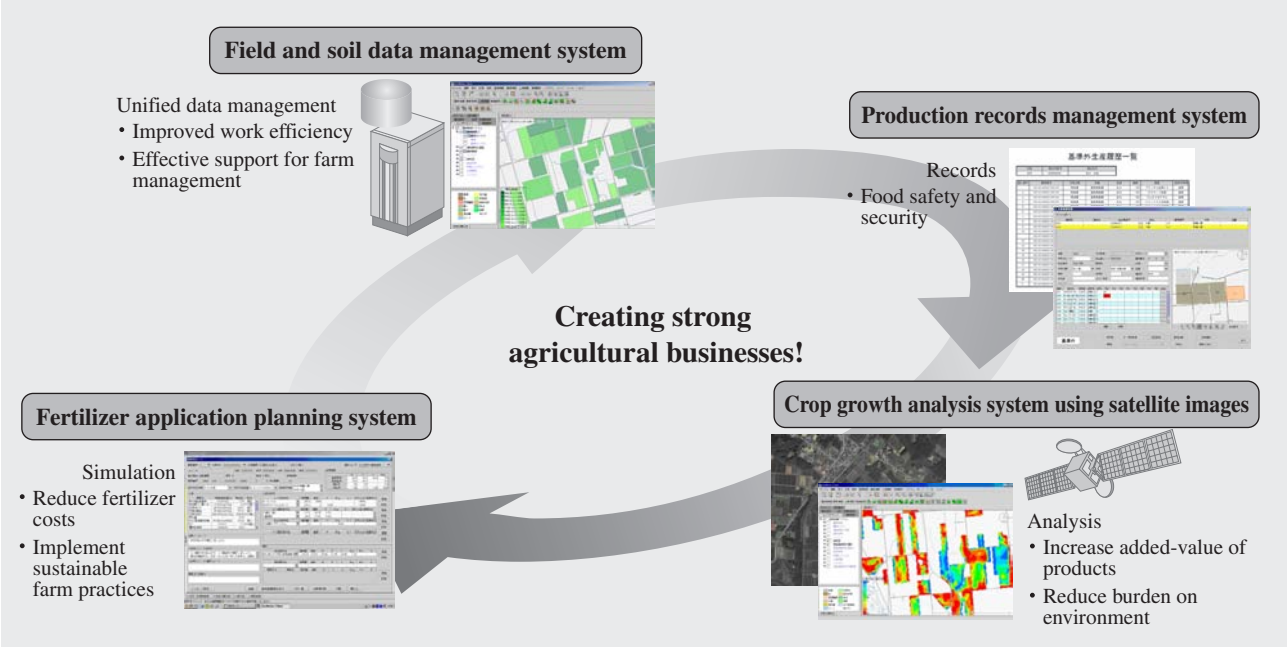

Fig. 3—Information Utilization Cycle.
Representing the relationships between data visually simplifies and makes more efficient the integrated use of data and farm management support work.

AGRICULTURAL TECHNOLOGIES UNDERPINNED BY AGRICULTURAL INFORMATION MANAGEMENT SYSTEM

GIS Technology

The Geographical Survey Institute of the Ministry of Land, Infrastructure, Transport and Tourism defines GIS technology as "a technology that supports the integrated management and processing, visual display, sophisticated analysis, and rapid evaluation of data containing location-dependent information (spatial data) based on geographic position"[(4)]. The technology facilitates the use of data by combining the data with a map and managing information that extends across space in a visual way. Using this technology shows up interrelationships that would not be evident if the individual items of data were managed in ledger form. Applications where GIS technology has been extensively used in the past include area marketing and management of utilities such as electricity, telecommunications, water, and gas.

Use of GIS for Management of Agricultural Information

In farming, environmental factors such as weather conditions and soil types vary from location to location. By taking this information along with other farming data such as cultivation records and location-based differences in yield and quality and using GIS technology to link it to locations on the farm, the information is made easier to manage and it also becomes possible to bring together and represent visually the many different factors that influence productivity. One example of what this makes possible is to achieve more uniform productivity across the land being farmed by adjusting fertilizer quantities on the basis that fertilizer application will influence differences in productivity.

There are numerous other uses for GIS technology in agriculture. Examples include taking note of past production when establishing new cropping plans in order to maintain a crop rotation regime, collating data on the total planting area for each crop, on-site reviewing of rice production adjustments, displaying the age of farmers and whether or not they have someone to take over from them on a map to determine the situation in each village, and estimation of land area on sloping land. As remote sensing technologies that use satellite images can be used to estimate differences in parameters such as crop growth and yield, this information can be used for various different purposes such as using it as a basis for soil management practices in the following year. By using GPS (global positioning system) to obtain the position of agricultural machinery in realtime, the information can also be used to support equipment allocation planning including identifying where to move agricultural machinery to next.

BENEFITS OF ADOPTING AGRICULTURAL INFORMATION MANAGEMENT SYSTEM

The purposes to which agricultural information management system can be put are many and varied. One example is its use in planning the harvesting sequence for wheat.

A property of wheat is that the moisture content of the wheat ear falls as it grows. Also, subtle differences in growth occur due to factors such as soil quality and soil conditions and these manifest themselves as differences in moisture content at the time of harvest. Traditionally, the moisture content is determined manually at the time of harvest with farmers making the decision to go ahead with harvesting after checking whether the wheat has dried sufficiently. However, as differences in growth occur even within the same field, there is a limit to how far the moisture content can be checked by sampling and it is possible that some wheat will be harvested before it is dry.

A study showed that using the satellite image analysis function of agricultural information management system to analyze wheat fields and ascertain the growth in each field so that harvesting can be performed in the order in which each field dries out reduced the quantity of heavy fuel oil used for drying and cut CO_2 emissions by approximate 33%[5] (see Fig. 4). It was in recognition of this result that HitachiSoft's agricultural information management system won, in turn, a u-Japan Prize in the environmental category[6], the Green IT Promotion Council's Chairman's Prize at the 2008 Green IT Awards[7], and the Chairperson's Awards, Eco-Products Awards Steering Committee at the 5th Eco-Products Awards[8].

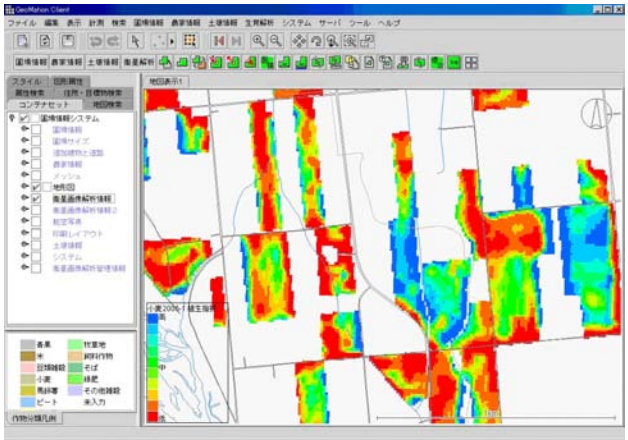

Fig. 4—Wheat Growth Analysis Screen Using Satellite Imagery. The ability to identify differences in growth so that harvesting can proceed in the order in which the wheat dries out leads to a reduction in the quantity of heavy fuel oil used for drying and cuts in CO_2 emissions.

OUTLOOK FOR AGRICULTURAL IT

Future Outlook

As we advance further into the era of ubiquitous technology, the increasing prevalence of portable terminals, the Internet, RFID (radio-frequency identification), sensor networks, GPS, surveillance satellites, and other such technologies is establishing a framework that facilitates the introduction of information technology into farming. Use of information has improved the productivity of industry and, if utilization of information in agriculture based on the use of the same ICT (information and communication technology) becomes more widespread, it will lead not only to greater productivity but also provide a start toward the resolution of many of the issues that agriculture will face in the future including the passing on of know-how, minimizing the burden on the environment through reduced use of resources, and the implementation of sustainable farming practices based on the results of scientific analysis.

Overseas Prospects

It is said that the state of agriculture in a country is strongly influenced by the general level of industry in that country. Whereas developed countries use technologies such as advanced agricultural machinery and chemical fertilizers in production, farm work in many other countries is largely a matter of manual labor and experience. Although agriculture takes on many different forms, with the limits on resources and agricultural productivity coming into sight, the task of maintaining stable farm production into the future is one faced by all countries alike whether they be developed countries, emerging economies, or some other countries.

As part of the "Pilot Demonstration Project Program to Improve Trade and Investment Environment" by the Ministry of Economy, Trade and Industry, HitachiSoft conducted a GIS standardization trial for agricultural information on the outskirts of Hanoi in the Socialist Republic of Viet Nam in 2005[9]. Visits to approximately 800 households in villages around Hanoi conducted to gain the people's cooperation in collecting data on crop cultivation found that most of the fields were only about 300 m^2 each (see Fig. 5). Even in

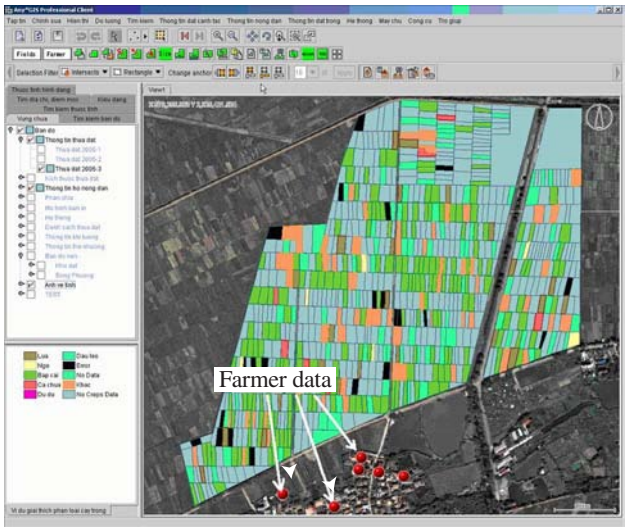

Fig. 5—Demonstration Project in Vietnam.
GIS standardization was trialed in the outskirts of Hanoi in Vietnam.

fields as small as this, we could see the effort going into improving productivity despite their limited resources, with measures such as planting four crops of vegetables per year.

Agriculture is a key industry around the world that needs to feed a population of six and a half billion or more despite limited resources and is an area where both developed and emerging countries need to work together to preserve the global environment for the future. We believe that the future will see increased moves toward the use of information technology in agriculture, and toward improvements in efficiency through the use of this technology.

CONCLUSIONS

This article has described the agricultural information management system based on GIS technology, given some examples of its use, and discussed the outlook for agricultural IT.

The 21st century is expected to be an era of sustainability. The exhaustion of all sorts of different resources including land and water is a practical problem that is becoming more evident. As resources such as water, agricultural land, raw materials for fertilizer and agricultural chemicals, and fuel oil begin to run low, the agricultural industry requires cultivation technologies that can maintain production in a way that is sustainable into the future while providing a reliable supply of food to everyone on the planet. Because it can help with things like the accumulation of know-how and the optimization of farming resources such as fertilizer and agricultural chemicals, the use of information in farming has a role as one of the technologies that will become more and more important in the future. It is also likely that Japan's carefully-crafted information utilization technologies will prove effective as technologies that can be sent out into the wider world.

While still supporting producers in Japan with information technology, Hitachi Software Engineering Co., Ltd. intends to continue to work at expanding the functions of its agricultural IT so that it can become more widely used around the world.

REFERENCES

(1) A. Shibata, "Food Struggle," Nikkei Publishing Inc. (July 2007) in Japanese.
(2) S. Shibusawa, "Precise Agriculture," Asakura Publishing Co., Ltd. (Feb. 2006) in Japanese.
(3) GeoMation Farm, http://www.hitachi-sk.co.jp/products/geomation/farm/index.html in Japanese.
(4) Geographical Survey Institute, "What is a GIS?," http://www.gsi.go.jp/GIS/whatisgis.html in Japanese.
(5) HitachiSoft CSR Report 2009, http://hitachisoft.jp/english/csr/download/index.html
(6) Ministry of Internal Affairs and Communications u-Japan Best Practice 2008 Awards, http://www.soumu.go.jp/menu_seisaku/ict/u-japan/new_r_best.html in Japanese.
(7) Green IT Awards 2008, Results of Minister of Economy, Trade and Industry's Prize and Other Awards, http://www.greenit-pc.jp/topics/release/080925.html in Japanese.
(8) Results of 5th Eco-Products Awards, http://www.gef.or.jp/ecoproducts/5th_result/index.htm in Japanese.
(9) Ministry of Economy, Trade and Industry (Commisioned to: Japan External Trade Organization), "Pilot Demonstration Project Program to Improve Trade and Investment Environment (FY2005), GIS's Pilot Demonstration Project for Standardization and Dissemination in Vietnam" (Mar. 2006).

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