Approach to Agricultural Knowledge Management using Decision Support System for Farm Planning

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ABSTRACT

Acquisition of knowledge is an important theme for business continuity on farm management in Japanese agriculture. According to the expansion of the domain of farm management activities, there is a necessity to extend the scope of acquisition of knowledge not only to production management, but also to processing and sales, etc. It is also pointed out that the use of ICT is a useful tool for effective knowledge management. And research and development of ICT-based knowledge management tools are underway.

In this study, therefore, a new tool, which was a web application software linked with the farming technology systems database, was developed to support KM for farmers.

First, we summarized requirements, functions, and operation methods for the developed tool. Second, we discussed how KM can be supported by the use of the tool for each situation.

As a result, we found that (1) the tool can be used by farmers to record the experience of their practice on farm in various formats such as numerical values, letters, images, etc., to organize them into the defined structural formats, and to share their own know-how within their organization, (2) the tool can be used by farm managers to gather know-how for important points based on management judgment, (3) the tool can be used by agricultural technology extension service center to add detailed explanation associated with farm work information to the standard cultivation information in the area, (4) the tool can be used by agricultural research center to give scientific explanation to their developed cultivation technology information, (5) educational institutions can use the tool for exercises and training for students.

Keywords: Knowledge management, Management information system, Decision support system, Farming technology system, Farm work know-how

INTRODUCTION

Acquisition of knowledge within the farm management organization through knowledge management (KM) is also an important issue in Japan. Therefore, the theme of the symposium was KM at an annual meeting of The Farm Management Society of Japan, in 2007 and 2008. After that, a book was published as a result of the discussion of that symposium and other related research. Some of the major conclusions are as follows: (1) We need to modify KM to carry out farm management, (2) We need to construct a database of data and information on farm activities for
knowledge management. (3) the farm management information system (FMIS) contributes to knowledge management.

Based on these results, research and development of FMIS has been conducted mainly on collection and accumulation of data, know-how and information, sharing and reuse of knowledge in production management scenes.

In this paper, based on Sato et al.(2013) and Sato et al.(2014), we present an information system to support the systematization of farm work know-how by linking farming technology systems database (fsdb) and farm work know-how database (fkdb).

Definition of knowledge management on farm management

Knowledge management (KM) is one of the management domains, which include production, sales, financial, human resources and information management, and corporate management. KM process includes new knowledge creation by converting implicit knowledge into explicit knowledge, knowledge storage, sharing, refinement, and usage. KM is an enterprise management method that promotes the sharing and clarification of knowledge and facilitates work efficiency and new discovery. KM is considered to be effective not only for large enterprises in the manufacturing or service industries, but also for farm management organization in Japan.

However, Monma (2011) proposed to modify KM process by introducing the concept of semi-implicit knowledge in farm management. Semi-implicit knowledge is defined as implicit knowledge that can be converted into explicit knowledge. For example, this knowledge can be conveyed into languages, images and data, among knowledge acquired by cultivating crops and operating agricultural machineries. Therefore, it is necessary to gather and record data, information and know-how with ingenuity even if that cannot be completely collected. Thus, knowledge creation in agriculture will include a knowledge creation process using semi-implicit knowledge. (Monma, 2011, p.15)

KM and ICT

Currently, new knowledge, information, technology, especially information and communication technology (ICT) are important fundamental elements of social activities. ICT-based knowledge creation activities have become so important in farm management that it is required to make effective use of ICT in agriculture.

Kobayashi (2011) conducted a case study on advanced agricultural management in Japan and examined the significance of farm management information system (FMIS) in KM, and revealed that FMIS were used to support activities of each KM process. Monma (2011) pointed out that using ICT network is significant in knowledge creation on farm management. From the viewpoint of KM, the objectives are as follows: (1) to be able to prevent isolation of farmers, to receive information beyond the region, and to establish a farmer's network; (2) to be able to collect the latest technology and management information, and to consult about technology and management almost in real time. Therefore, promotion of KM will work well together with ICT usage on farm management.
A related research in Japan

The agricultural improvement and extension center often uses "farming technology system" information referred to as "agricultural production technology system" or "farm management indicator" as a reference material for advice of farming to farmers, in Japan.

There are 47 prefectures in Japan, and every region has different ecological and socio-economic environment. So each prefecture is publishing information on crop cultivation and livestock feeding, while considering their own regional conditions. For example, cultivated crops and varieties, and cultivation methods differ from other regions. In recent years, such regional standard information has come to be provided not only as a printing medium but also as a website or a database of the Internet.

There is farming technology systems database (fsdb) as an information system that provides the data and information for farming technology system using the Internet (Nanseki et al., 2003, 2007a). The know-how of each farm work process is organized in relation to the whole farming knowledge.

It is effective for acquisition of knowledge on farming to arrange the know-how of each agricultural work in association with knowledge of the whole technical system and to accumulate know-how in agricultural work. It is important for acquisition of knowledge on farming to create or develop a structure on the know-how of each farm work so that it is easy to reuse it by associating it with the whole farming knowledge, and to accumulate know-how of farm work.

Therefore, in this paper, we describe the development study of the web application "farm work know-how structuring tool" (FKS tool). The feature of FKS tool is that both fsdb and farm work know-how database (fkdb) are linked, and Farming-systems Analysis and Planning Support Database (FAPS-DB), which is a decision support system for farm planning, is used with an interface. We describe the main feature of FKS tool, and discuss the measures to support inheritance of farming knowledge using development tools.

DSS FOR FARM PLANNING

When trying to develop a business by introducing new crops, changing cultivation system, etc., it is necessary to introduce knowledge of cultivation system which is not within their own management. In other words, the knowledge has to come from outside sources. In order to support the decision-making on farm planning under such a situation, research and development of FAPS-DB has been conducted (Nanseki et al., 2003). Currently, this system service is available via the Internet (Nanseki et al., 2007b).

The farming technology system is defined as the integrated system of individual farm work techniques based on the purpose of agricultural and livestock production. Individual farm work techniques are, for example, procurement and planting of seeds, pest control, harvesting and so on. The farming technology system is a summary of the input and output relationships of the types and amounts of labor inputs, agricultural materials and machineries, etc. for a series of farm work in the crop cultivation calendar.
There are various kinds of agricultural practices for each work, region, and management. However, it is important to integrate various information into one farming technology system for accumulation and extension of farming knowledge. Each regional system had been constructed in accordance to Japan’s five fields which include paddy farming, upland farming, livestock raising, horticulture and sericulture (AFFRC, 1966-1973). Such information has been widely used as a basic material for the creation of a vision on regional agricultural plan developed by the administration, extension of new technologies by agricultural improvement and extension center, management analysis and diagnosis by consultants, etc.

The farming technology system consists of the various kinds of data and information including crop yield, capacity of machineries and facilities, working hours by type of work, input quantity of materials, and prices, etc. In addition, metadata is also included, together with the condition of climate, soil, farm scale, etc. Information on when, where, who, what, how much, and how to produce agricultural products are likewise provided.

The handling of information and data is complicated. Changing certain data also changes other data, so it is difficult to maintain consistency. The primary purpose of our database construction of farming technology system is to overcome these problems. In addition, the database facilitates searching, sharing and reuse of information and makes it possible to have more advanced use of information.

FAPS-DB consists of a database system that stores and shares farming technology system data and a farm planning system that uses the stored data in the database (Fig. 1). The functions of this system are as follows. (1) calculating main management indicators such as financial indicators, and working hours; (2) Comparative analysis between different farm management models; (3) environmental assessment on CO₂ emissions and pesticide use; and (4) setting members of user's group and the range to share their data. The users can input by simple operation (Fig. 2) and obtain the calculation result (Fig. 3) using the web browser as an interface.
Fig. 1: Diagram of Farming-systems Analysis and Planning Support Database. (1) User creates the farming technology system of a spreadsheet file to store in the DB (fsdb). (2) Administrator registers the data in the DB. (3) The data is used for calculation of management farm management indicators. (4) DB service is shared within the private or open. Users carry out farming simulation analysis.
Fig. 2: Screen-shot of FAPS-DB input. The user selects crop, vegetables or livestock production from lists, sets the cultivation area or number of feeding, and starts simulation analysis.
FARM WORK KNOW-HOW STRUCTURING TOOL

Feature

Farm work Know-how Structuring tool (FKS tool) is a software that can create structures and/or systematize the farm work know-how, and store the information based on farming know-how in farm work know-how database (fkdb). The tool implements a program that links fsdb with fkdb and vice versa. Fig. 4 shows the conceptual diagram of the system and its basic data flow.

Fig. 3: Screen-shot of FAPS-DB output. The user gets the result of the analysis in table form, chart, etc, and can save the output file.

output 1: comparative analysis
output 2: graph
output 3: cobweb chart
Outline of various functions of FKS tool is as follows. Details are described in the user manual (Sato, 2015).

This system further extended the usability of web interface of Sato and Nanseki (2011) which improved FAPS-DB. This system provides user-friendly Web application service that supports browsing and editing of information about farming know-how, and secure data management.

**Administrator’s function**

The administrator is the person responsible for the operation of knowledge management of the organization. He registers and manages farming know-how for each farming technology system. In this system, farming know-how information is stored and shared using Contents Management System (CMS). The administrator edits the information according to the input form already prepared on the CMS. With CMS, they can flexibly edit tables, diagrams, texts, links to outside, and so on. Therefore, both standardized knowledge accumulation and flexible knowledge description can be compatible.

**User’s function**

This system is a subsystem of the farm planning support system FAPS-DB. Users can view related farming know-how information with the result of simulation analysis by FAPS-DB. For example, detailed information on tractor driving method can be viewed from the result of tractor
usage time in the spring seeding work showing the result of business analysis. It is also possible to browse know-how information for each farming technology system without executing simulation analysis (Fig. 5, 6).

Fig. 5: Screen-shot of FKS tool input. Users select a farming technology system from the pulldown list.
Development environment

This system was developed using the Linux system. Table 1 shows the main development environment such as server components.
Table 1. System development environment

<table>
<thead>
<tr>
<th>Components</th>
<th>software name</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Linux CentOS 5.9</td>
</tr>
<tr>
<td>Programming language</td>
<td>PHP5.3</td>
</tr>
<tr>
<td>Web application framework</td>
<td>cakephp</td>
</tr>
<tr>
<td>Web server</td>
<td>apache httpd</td>
</tr>
<tr>
<td>CMS for know-how management</td>
<td>wordpress</td>
</tr>
<tr>
<td>RDBMS for fkdb</td>
<td>mysql</td>
</tr>
<tr>
<td>RDBMS for fsdb</td>
<td>postgresql</td>
</tr>
</tbody>
</table>

FSDB and FKDB database linkage

An important point is how to structuralize and store various kinds of data and information obtained from farming production activities and categorize this as knowledge.

In this paper, farming practice know-how is structured and stored as knowledge based on the method described in Fujii et al. (2012).

Information on farm work know-how is structured according to five (5) points of view, which are work purpose, main point of work, basic know-how, flexible know-how and the other related information. However, because the contents described in each of these categories are diverse, it is required to be easy and flexible to edit tables, sentences, charts, and so on. Therefore, CMS is used as a support tool for knowledge management (Fig. 4-(b),(c)). Regarding the information managed by fkdb, the work purpose is one unit of know-how, and the contents are shown in Table 2.

Table 2. Tables in the FKDB

<table>
<thead>
<tr>
<th>Type</th>
<th>contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items automatically set fkdb</td>
<td>group, farming technology system, work process, ID of know-how information</td>
</tr>
<tr>
<td>Items to be selected from farming system data in fsdb</td>
<td>work process, work period · working hours · number of group workers · machineries, facilities and materials</td>
</tr>
<tr>
<td>Type</td>
<td>contents</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>Items entered by the administrator in fkdb</td>
<td>work purpose, main point of work, basic know-how, flexible know-how, and related URL</td>
</tr>
</tbody>
</table>

The fsdb and fkdb are related to each other using an ID of farming technology, work process name, login name on CMS (Fig. 4-c). When browsing farm work know-how, one can browse from work process names as well as from materials names and agricultural machinery names, etc. (Fig. 4-d). Using the above mechanism, one can view and manage farming know-how information through the interface of FAPS-DB.

**USAGE SCENE**

Table 3 shows usage scenes of the FKS tool by type of users. Users include farmers and their support agencies. In the following, we will discuss the key points in supporting inheritance of farming knowledge according to usage scene by each user.

Table 3. The usage scenes according to type of users.

<table>
<thead>
<tr>
<th>Type of users</th>
<th>usage scene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers</td>
<td>record and share know-how within the organization</td>
</tr>
<tr>
<td>Farm manager</td>
<td>know-how collection on important points based on management judgment</td>
</tr>
<tr>
<td>Agricultural technology extension service center</td>
<td>detailed explanation to regional standard farming technology system</td>
</tr>
<tr>
<td>Researcher</td>
<td>scientific explanation to development agricultural technology</td>
</tr>
<tr>
<td>Education</td>
<td>exercise, training</td>
</tr>
</tbody>
</table>

**Farming skill knowledge acquisition on individual farm**

In order to accumulate and share farming know-how in fkdb on individual farm, it will be effective that the information are collected, stored, and shared according to the PDCA cycle of farm management. The knowledge management process consists of the following five stages:

1. Data collection: to record and collect plans, farm work history data and farming know-how using farmer's diary, management software, etc.;
2. Selection of data and information: to select the necessary data and information to be stored in the own management;

3. Structuring and storage: to organize information from the viewpoint of work purpose, point, basic/flexible know-how;

4. Registration in DB: to register the organized information in the DB; and

5. Sharing and reuse: to share and reuse the contents of DB.

It is hoped that the above process will be continuously implemented to accumulate and acquire knowledge.

**Regional agricultural knowledge inheritance on support organization**

One of the main purposes of FAPS-DB was to support in order to provide technical advice, which include practical knowledge on cultivation, fertilization, pest control, feeding, etc., for improving management by staff of extension service center and consultant of agricultural cooperatives etc. However, the FAPS-DB does not include detailed information like how to estimate input quantity of required production factor, and cultivation technology. In addition, the information on cultivation guidelines such as fertilization standards (Agricultural Production Bureau, 2016) is not provided together with the information of farming technology system. By integrally managing these information and making it accessible and available to farmers, it is possible to provide information effectively. Such extension of agricultural technology knowledge may be able to support farmers’ decision making more effectively.

**CONCLUSION**

Currently, FAPS-DB and its subsystem, FKS tool are beginning to be used in lectures at Japanese educational institutions and management support services of land improvement zones. In the future, we will conduct an empirical on-farm experiment for each assumed scene, and improve the system’s usability and clarify the effective method of system operations.

**REFERENCES**


