1. National efforts to apply IT to the farm sector

Japan has enacted legislation and instituted numerous policies in an effort to help address some of the difficult issues now facing the farm sector: Japan’s diminishing ratio of food self-sufficiency, the shrinking farm population, and liberalization of agricultural markets (Table 1).

The adoption of the “New Basic Agriculture Law” (Basic Law on Food, Agriculture and Rural Areas) in 1999 marked a shift in emphasis away from the farmers, who had been at the focus of the old law, to consumers. It also underscored such basic principles as stability of the food supply, greater diversification of farming enterprises, and continuous development and promotion of farm communities [1]. The next year (2000), Japan passed the “Basic Law on the Formation of an Advanced Information and Telecommunications Network Society” with the goal of actively promoting a society in which all sectors and all citizens can have access to and enjoy the benefits of information technology.

Based on these two laws, the government declared in 2001 a specific policy objective of “applying IT to the agriculture, forestry, and fisheries sectors in the 21st century.” Emphasizing expanded use and availability of digital contents, deployment of IT infrastructure, improved data and IT literacy, and other key provisions, the guideline signals Japan’s commitment to extend IT to the agricultural sector as a matter of national policy [2]. In another development against the backdrop of recent outbreaks of E. coli O157 and BSE (i.e., mad cow disease) and heightened concern of consumers and the public at large over organic and pesticide-free farming and other food safety related issues, legislative progress has been made to ensure food safety with the Revised JAS Law, which makes it mandatory to identify the country of origin on the labels of fresh food products, and with the Emergency Countermeasures Relating to Bovine Spongiform Encephalopathy (BSE), which mandates the tagging of all cattle and accurate tracking of each animal with a data management system.

2. Initiatives on the farm

There has been significant improvement in the utilization of farmland in recent years fueled by advances in geographic information systems (GIS), soil sensing, and other scientific techniques, as well as growing public demand for better environmental protection. GIS-based modeling can be used for mapping tracts of land to show the distribution of soils, crop yields, parasites, and so on, and there has been good progress made in the investigation and adoption of modern ecologically sound farming practices (precision farming) that achieve sustained productivity with sharply reduced use of chemical fertilizers and pesticides along with improved economics [3]. And along with the phenomenal technological revolution...
symbolized most dramatically by the remarkable penetration of the Internet, we have seen a growing trend for agricultural producers to use the Internet to directly contact consumers and sell them products that are exactly tailored to their preferences.

It is a safe assumption that digitization and use of IT and sensing technologies will become increasingly important at each step from production to processing to distribution to consumption in terms of boosting productivity, establishing environmentally friendly farming practices, and providing information to consumers regarding the safety of food products.

3. Objectives and challenges of farm data distribution

The objectives and specific content of data distributed at each stage of the food production chain are shown in Table 2.

Various kinds of information are required in the production process in order for farmers to boost productivity and save labor, support business operations and train successors, and achieve ecologically sustainable farming practices. Critical data includes crop-specific information about growing conditions, environmental information including the weather and soil conditions of particular tracts of land, business diagnosis information and agribusiness support data, and information about waste products and land use.

Turning next to the processing phase, here too all kinds of information are required regarding quality, hygiene, and collection and shipping of raw materials and regarding the management of manufacturing. In recent years a great deal of interest has focused on HACCP*1 for managing the safety and quality of food. And finally in the distribution and consumption processes, the various types of information listed in Table 2 are required for quality and shipping control, customer management, and food safety control.

One can see that there is an enormous amount of useful data at every stage of the food production chain.

---

*1 HACCP (Hazard Analysis Critical Control Point) is a scientific control system for identifying and evaluating hazards that might occur throughout the entire food production chain from production, processing, and cooking right up until the food is consumed. The system focuses on preventative measures including identification of critical control points, procedures to monitor critical points, and effective record-keeping.
chain, and although it has mostly been the big corporations and organizations that have had the processing capabilities to exploit this information, it would be highly significant if this information were also available to the individual operators who are the primary producers. Indeed, the ability of producers to exploit this valuable data that is available could be instrumental in helping individual farmers break out of the hard circumstances surrounding Japan’s agricultural sector.

Table 3 shows the technologies needed to collect, store, process, and distribute these various kinds of farm-related data classified according to how the data might be used. A primary industry data distribution service could be implemented by integrating a communications network such as the Internet with a number of other technologies: sensing technologies (soil, weather, etc.), simulation technologies (business, demand, etc.), various databases, and data mining capabilities.

The application of IT to agriculture has been hampered by a number of factors, and it is clear that farming has lagged behind other sectors in seeing the benefits of IT. Some of these factors include:

- The industry is largely dependent on local conditions characterized by widely varying data that often cannot be directly utilized by a farming community in another part of the country.
- Farming is controlled to an extent by diverse weather, geographic, and other complex aspects of the natural environment.
- Agricultural products are produced in a large number of grades according to peoples’ sense of taste and quality.
- A lot of data relating to the internal mechanisms of organisms and the state of target variables is easily affected by the presence of a sensor, so it is difficult to ascertain the actual conditions.
- The diversity or uniqueness of certain food products is somehow incompatible with e-commerce or other methods that might be used for distribution.
- Content (data) or IT-support software is scarce or altogether lacking.

Indeed, the extent to which IT and sensing technology can be applied to the farm sector will largely depend on how successfully these kinds of impediments can be overcome and functional, cost-effective systems can be made available.

### 4. Agriculture network

Figure 1 shows a model of a network for the agricultural sector that links the entire food production chain from production to consumption. NTT Research Laboratories are currently focusing their efforts on finding viable ways to digitize production-stage data.

The system features an assortment of sensors (for measuring weather, soil, water quality, and other conditions) and monitoring cameras that are installed outdoors in fields and indoors in greenhouses and barns, which are networked over a wireless LAN providing data and images that are useful to the producer in raising crops and livestock. In addition to the sensor data, the producer contributes a daily record of work and progress on the farm, and this all goes into a farm database. The farmer shares some of the farm database with the local farm cooperative, agricultural...
experimental station, and livestock veterinarian, and this data contributes to the establishment of good farm management and technology guidelines. In addition, the information made available by the producer to consumers regarding agricultural chemicals, animal feed, and so on can be used for quality and safety assurance purposes. The ultimate goal is to create an environment where data in many different databases can similarly be mutually accessed including the farm cooperative database, the processing and distribution database, the retail store database, and even more specialized databases such as for the agricultural experimental station.

5. NTT R&D initiatives

Based on these developments, NTT is committed to the pursuit of three basic R&D objectives for the agricultural sector: ecologically sustainable farming, IT-based farming (precision farming), and a food safety
Farms and farm communities play the extremely beneficial role of preventing flooding by absorbing and storing immense quantities of water that they use for irrigating fields and immersing paddy lands (Table 4). But on the negative side of the ledger, farmers have used enormous quantities of pesticides and chemical fertilizers over the years to improve productivity and these have ended up as detrimental chemical substances in the soil and human body, and soil and groundwater have also been polluted by simply discarding untreated excreta from livestock. NTT is helping open the way to ecologically sound and sustainable farming practices with the development of an environmental assessment system. This system uses sensing networks and GIS to monitor and analyze the recycling of noxious substances such as livestock excreta that is already becoming subject to increasingly strict laws and regulations (see the article “Applying IT to Farm Fields—A Wireless LAN” on page 56).

Turning to the food safety network, particularly as it relates to dairy products, NTT has made good headway in the development of a traceability system and information disclosure system that tracks and records safety-related information all the way down the food production chain, then makes the information available to consumers in an easy-to-understand format. The range of safety information captured by the system is comprehensive including animal raising and quality control data from the farm where the livestock is raised, HACCP data from the processing facility, and quality control information from the distributor (see the article “Extending IT to the Dairy Farm” on page 66).

Figure 2 schematically shows how a dairy farm data distribution system might be implemented by applying NTT’s three-fold R&D approach to the dairy sector. As illustrated in the figure, this R&D approach will promote the sharing of environmental information among producers, processors, and local governments (environmental cycle); the sharing of business and technological information among producers, testing and research institutes, and farm cooperatives (technology cycle); and the sharing of food safety information among producers, test and certifying
authorities, processors, distributors and retailers, and consumers (food product cycle). With this approach, we can implement farm data distribution systems that promote sound sustainable farming practices, business stability that saves on labor, and safe food products.

Table 4. Public benefits of farms and farm communities.

<table>
<thead>
<tr>
<th>Beneficial effect</th>
<th>Valuation amount (yen per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nationwide</td>
</tr>
<tr>
<td>Prevent flooding</td>
<td>2.8789 trillion</td>
</tr>
<tr>
<td>Cultivate water resources</td>
<td>1.2887 trillion</td>
</tr>
<tr>
<td>Prevent soil erosion</td>
<td>285.1 billion</td>
</tr>
<tr>
<td>Prevent landslides</td>
<td>142.8 billion</td>
</tr>
<tr>
<td>Organic waste processing</td>
<td>6.4 billion</td>
</tr>
<tr>
<td>Atmospheric purification</td>
<td>9.9 billion</td>
</tr>
<tr>
<td>Climate moderation</td>
<td>10.5 billion</td>
</tr>
<tr>
<td>Health, relaxation, peace of mind</td>
<td>2.2565 trillion</td>
</tr>
<tr>
<td>Total</td>
<td>6.8788 trillion</td>
</tr>
</tbody>
</table>

Fig. 2. Concept of dairy farm data distribution system.

Katsuhiko Honjo
He received the Ph. D. in Applied Physics from Hokkaido University in 1998. Joined NTT in 1982. Involved in the research of systems for evaluating deteriorated telecommunication facilities, the development of operation systems in the access network, and the technical support of developing technologies for outside plants telecommunication network services. Currently working on the research and development of the environmental information and management systems.