INTERPRETATION OF THINKING PROCESS IN FARMER'S DECISION

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ABSTRACT

An idea involves (1) defining the four steps of recognition: data, information, knowledge and wisdom, (2) following the decision-making actions of evidence mining and context making, and (3) story makeup of the management. In talking to expert farmers on their practice, five factors of farming system and eleven units of thinking were derived. The five factors are crop, field, technology, constraints and motivation, which have already been introduced in a model of community-based precision agriculture. The eleven units, a new idea of analyzing farmer's decision process, are discussed with a case of weed management. A stage of technology package will bring the process of decision making into a new level of precision management. A combination of the real-time soil sensor (RTSS) and a combine harvester with a yield monitor, created a field map of missing nitrogen as an environmental impact. A keen behind story of the last worldwide food crisis needs system technology to push productivity per area, and this leads to challenge precision agriculture under different constrains across countries worldwide with trans-disciplinary collaborations.

Keywords: evidence-based, thinking process, farm management, technology package, policy

INTRODUCTION

At the current conferences on precision agriculture, the author has reported three new features in the policy of Japanese government relating to precision agriculture (Shibusawa 2007, 2008): direct funding to growers to develop a technology package, promulgating a strategy and regulation on intellectual properties of agriculture, and pushing collaboration across the sectors of agriculture, commerce, and industry for new business of branding-produce. Achievements during the last decade taught that participating farmers (1) were familiar with internet communication, (2) had higher education levels, (3) grew high quality produce, (4) had a good sales and marketing experience, (5) were greatly outgoing and sociable, and (5) had ambition to become good practice farmers (Shibusawa 2004, 2006).

In the recent years the most serious event was the worldwide food crisis by population increase, shifts of lifestyle in the developing countries, and bio-fuel market emerged. Japan a lowest self-sufficiency country also quaked with the global food-energy crisis. Furthermore natural disasters, such as typhoons and cloud-bursts, attacked agricultural areas on site by site more frequently than as they had been. This has made big changes in agricultural policy of Japan, that is, rapidly increases in production and supply of foods to combat the crisis.

New national projects were to push a modal shift in food chain focusing on vegetables and fruits, to create a skill transfer system from professional to newcomers using agro-informatics, to help a local sustainability movement of bio-fuel chains, and so on (Shibusawa 2009). Emerging is a city hall having its vision of agriculture enhancement against the low self-sufficiency in spite of its farm lands disappearing. People who know the concept of precision agriculture used to join these projects because of its potential of thinking process to solutions. The potential of precision agriculture has become attractive for not only engineers and scientists but also politicians and business people worldwide. That is why this paper has the objectives to describe precision agriculture relating issues in Japan: new responsibility of land policy, technology package in precision agriculture, and thinking process for farm management.

CRISIS RECOGNITION MAKES TARGET

Responsibility of agriculture has been to supply foods to people continuously, accompanied by its multi-functional effects such as environmental conservation and landscape preservation. As shown in **Fig.1**, the world food production could not catch up with the world demand of consumption during the last decade, and that only increases in yield per area followed the increase of consumption. Moreover the area harvested per person has fallen down to the critical unit area under a saturated net arable land. Consequently the food crisis rooted in the short of production compared with the increased demand.

The facts has requested that (1) all farm land has responsibility to be used for providing agricultural products even if it is a home garden, (2) all skills and

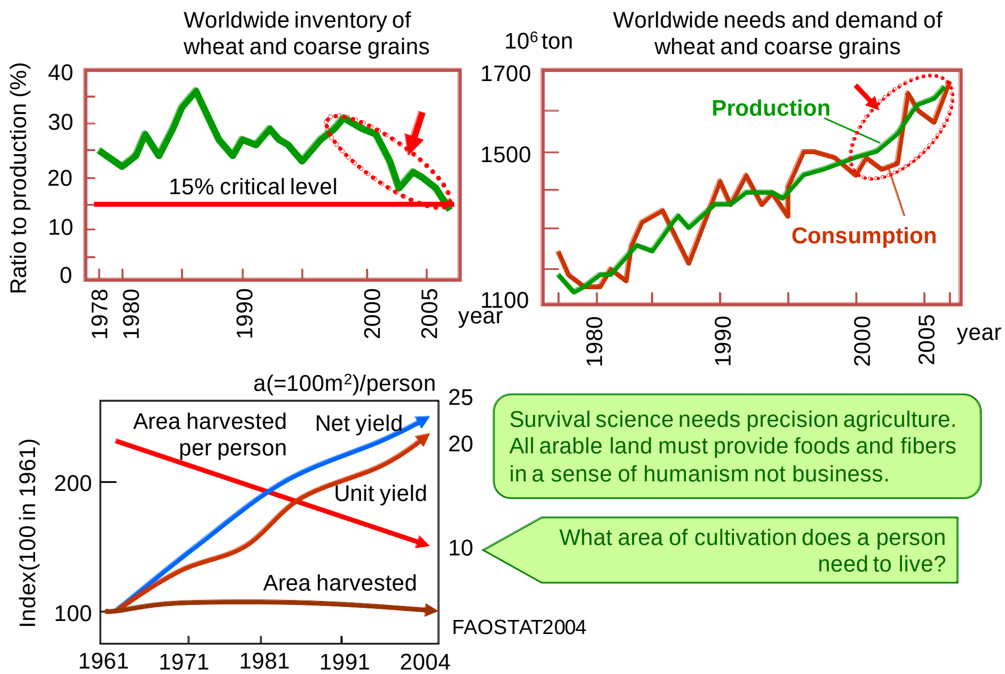
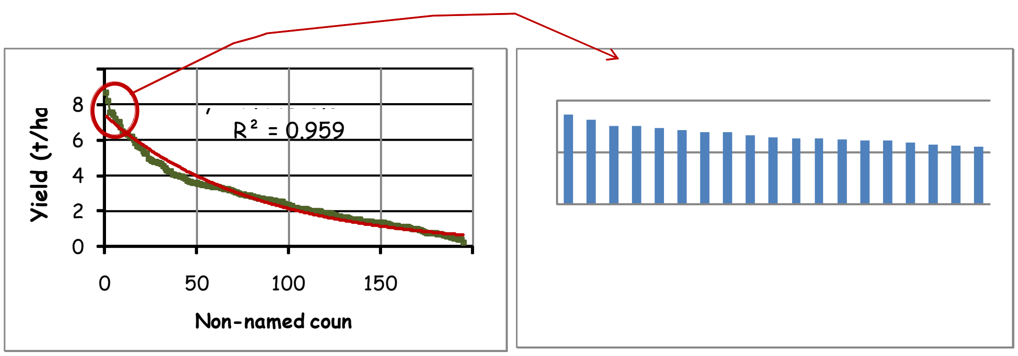


Figure 1. Foods consumption worldwide requests increases in yield.



(a) Yield of cereals on 193 countries in 2005.

(b) Top 20 high yield countries of cereals in 2005.

Figure 2. Potential of cereals production (Calculated from FAOSTAT 2005 data).

knowledge had to be used for encouraging the yield up, that is, higher productivity per area, and (3) food chains should be kept more effectively worldwide.

Productivity is variable across the countries in the world as shown in **Fig. 2** for example. The yield of production per unit area followed an exponential decrease or logarithm decrease over the 193 countries and had 35 times difference between the top and the bottom countries. The yield of the top 20 countries was twice higher than the world average and 113 countries had yield lower than the world average. There were 124 countries with yield below 3 t/ha. Consequently the top 20 countries must have responsibility to transfer their wisdom with technologies into the low yield countries. The data of FAOSTAT also indicated that each country has its own best crop management but no details of the management are described.

In this context precision agriculture will be a key issue in a global aspect as well as in an aspect of farmer's motivation. Precision agriculture should be re-discovered as evidence-based farm management, as shown in **Fig. 3**, in order to be applied across not only rural farm land areas but also the areas that people must manage the land to preserve the landscape and natural resources. It leads us to an avenue on "precision conservation" defined by Berry et al. (2005). This attitude will be attractive for global people in business and politics and for local people in industry and agriculture.

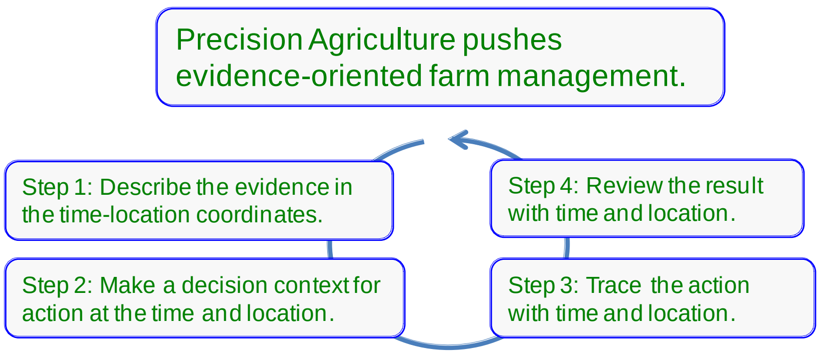


Figure 3. Time and location is a key-terminology in precision agriculture.

A STAGE OF TECHNOLOGY PACKAGE

Shibusawa (2007, 2008) reported that a stage of technology development in precision agriculture has stepped onto a new phase of technology packaging to meet the demand of market needs of grower-retailer-consumer hybrid. Paddy management is one of the best cropping system in Japan, which has required a package of technology as shown in **Fig. 4** (AFFRC 2008). Critical management points on the growth stage are practices for before-planting fertilizing and before-earring dressing, and diagnosis monitoring of tillering, earring and maturing. All these critical points were already mechanized as a precision paddy management system.

Shibusawa et al. (2008) demonstrated that a package of the real-time soil sensor and combine harvester with yield monitors provided soil maps before planting and after harvest, followed by a nitrogen management strategy associated with a spatial variability of nitrogen loss, as shown in **Fig. 5**. An idea was as follows.

$$N_{lost} = (N_{before} + N_{input}) - (N_{crop} + N_{after}) \quad (1)$$

Where:

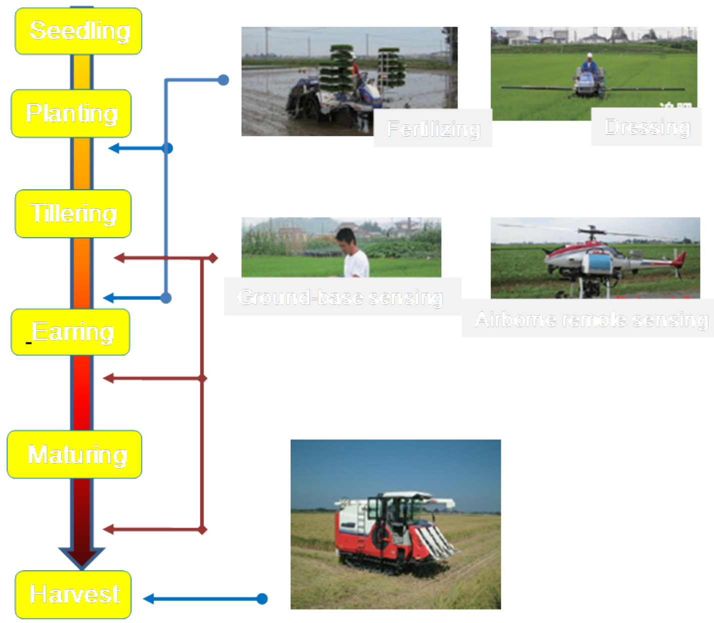


Figure 4. Demonstration of technology package on precision paddy management (AFFRC 2008).

Figure 5. Combination of real-time soil sensor and combine harvester with yield monitor creates missing nitrogen map.

$N_{before:}$ total nitrogen predicted before seeding (no fertilizer) in 2005,

N_{input}: fertilizer uniformly input on soil surface by 15 g/a,

N_{after}: total nitrogen predicted after harvesting in 2006,

N_{lost}: kinds of lost nitrogen from the field,

The technology package created a new index the missing nitrogen map showing spatial variability of environmental impacts due to paddy cultivation.

PROCESS OF THINKING

In 2009 the secretariat of the ministry of agriculture, forestry and fishery in Japan has organized a consultation on application of informatics into agriculture, called by "AI agriculture consultation", to enhance the skill transfer of expert farmers using information science, such as cognitive science, robotics and agricultural informatics. This policy helps for keeping the level of knowledge and skills in management of productivity, because millions of farmers will retire in the coming decade by their aging in Japan and their skills and wisdom will be gone.

McCown (2005) reported that a number of decision support systems developed were not used in farmer's practice but used as a learning tool. He also emphasized the differences between objective knowledge embedded in a decision

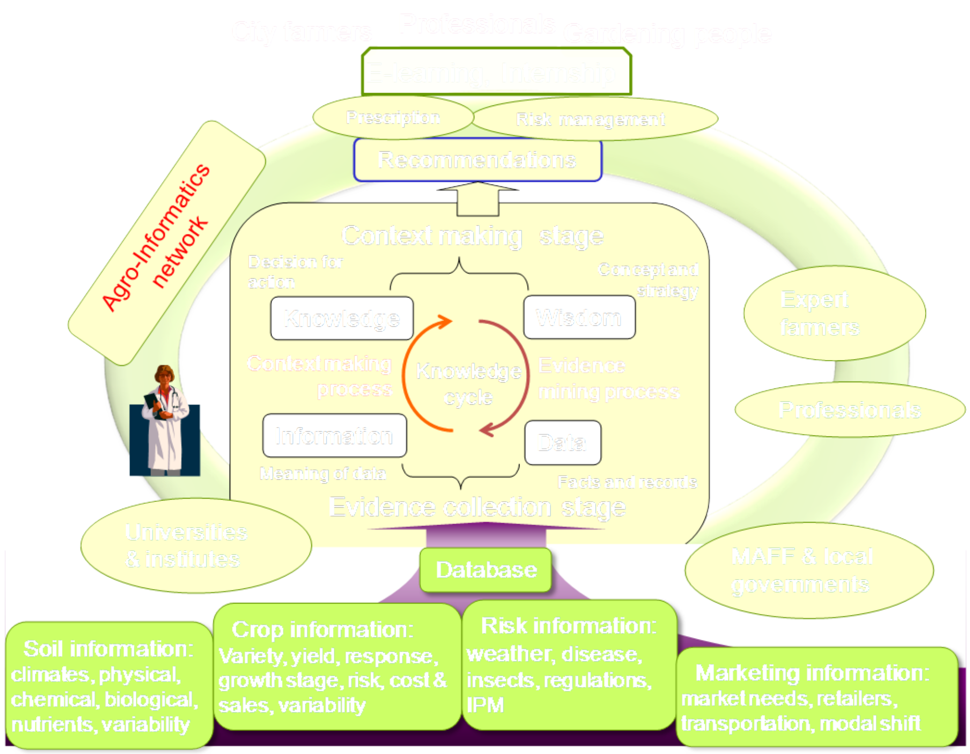


Figure 6. A plan of AI-network for decision process support.

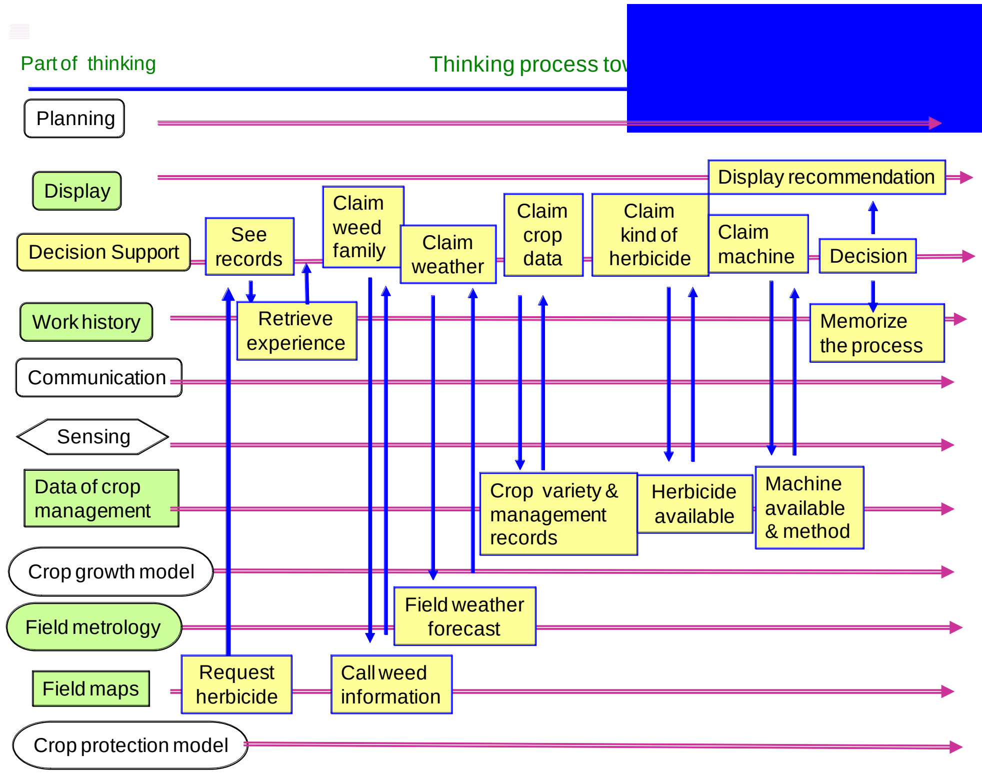


Figure 7. A process of decision for farm work of weed control.

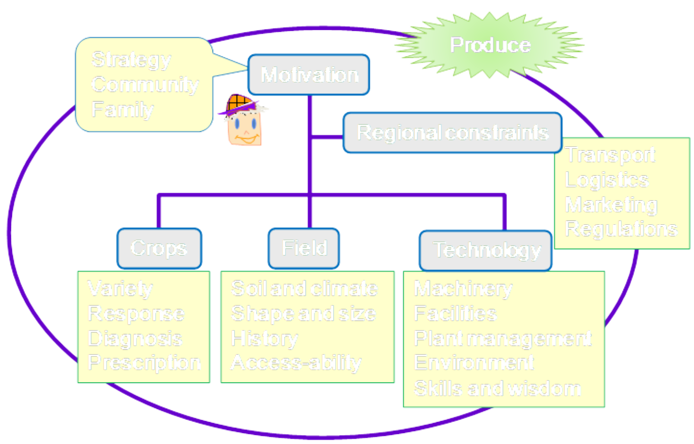


Figure 8. Five factors of farming system.

support system and the subjective knowledge which normally guides the actions of farmers in familiar situations such local, personal, and social environment.

A concept of thinking process was summarized in the middle of **Fig. 6**. Four phases of learning are assumed there, that is, data, information, knowledge and wisdom (Shibusawa 2006, Shibusawa et al. 2008). Data implies a set of facts such as digits, information implies definition of data, knowledge is logic for judgment, and wisdom is a creative concept based on experience. The four phases are classified into two stages: an evidence collection stage of data and information phases and a context making stage of knowledge and wisdom phases. The evidence collection stage has been of keen interest for researchers and they used to try decision-making on the evidence stage, but it was sometimes impossible for farmers to accept because of no business story derived from only arranging the facts.

The database must be composed of four categories: soil information, crop information, risk information and marketing information. These categories are enriched by practices and exchanges through a network. The database will provide data and facts on the evidence collection stage. Recommendation as output of the system is evaluated by the real users of city farmers, professional farmers and people who love gardening.

A thinking process was described in a case of weed control, as shown in **Fig.7**. In the figure eleven units of thinking were assumed: “planning” unit for farm management, “display” unit for showing recommendations, “decision support” unit for context making to integrate information, “work history” unit for experience library, “communication” unit for data communications, “sensing” unit for monitoring, “crop management” unit for cropping knowledge base, “crop growth” unit for growth prediction, “metrology” unit for forecasting field climate and weather, “field map” unit for describing the field variability and “crop protection” unit for integrated crop protection.

A feasible story will be as follows. The first action will be a finding of some facts to be handled. For example, "field map" unit found a bunch of weeds and made a claim to kill them. The claim was sent to "decision support" unit which referred the record of herbicide in "work history" unit and made a claim to get information on the weed against "field map" unit. The unit of "decision support" also made a claim to get the field weather forecast and called the information on crop variety to "crop management" unit, followed by calling the information on herbicide chemicals and machine for spray. Finally "decision support" unit made

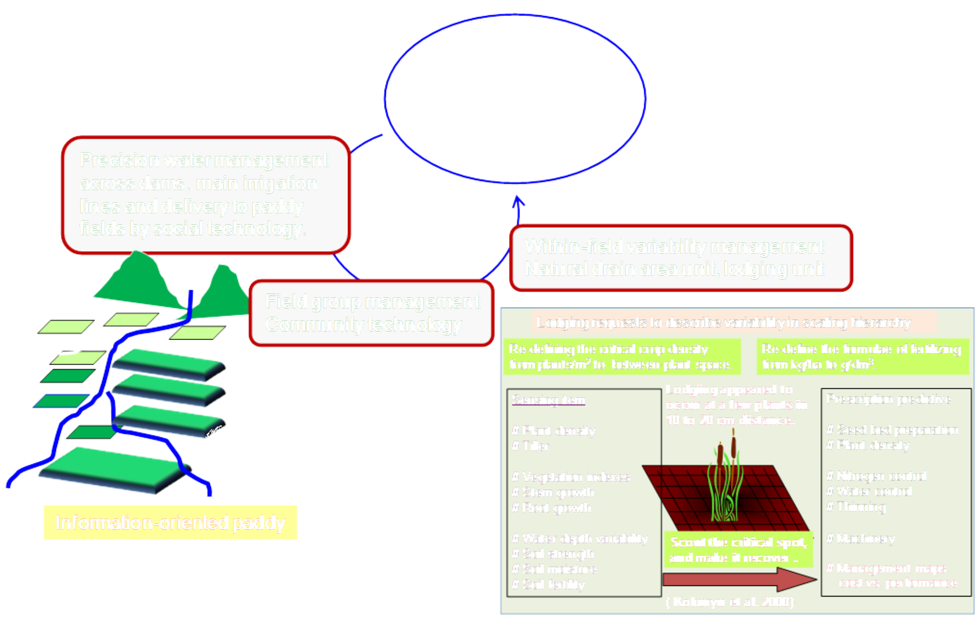


Figure 9. Paddy management requires different scale information and data from a single plant space to lake water stock in the dam.

a recommendation on the “display” unit and memorized the thinking process in "work history" unit.

Talking to farmers lead us that their thinking process was almost in a similar way as shown in **Figs 6 and 7**, based on the experience and knowledge on five factors of farming system as shown in **Fig. 8** (Shibusawa 2004). Their knowledge and skills are also embedded in multi-scaling experience, for example, as shown in **Fig. 9**. In a case of water management of paddy farming, farmers’ eyes look at water level of a dam and amount of stream in a river in 100 km scale, a flux of irrigation canal and ditch in 100 m scale, and a depth of water in the field in cm scale. The time scale is corresponding to the order of magnitude of space.

Another finding is the time for decision. The expert farmers used to make decision in a couple of seconds incorporated with a perfect story for management. This kind of actions leads us to have an assumption that they just make a choice of best story among candidates when they make decisions, and that they will have a number of perfect stories with their experience, as shown in **Fig. 10**. Their learning activity will promise to enrich their perfect stories.

The discussion above needs some assumptions to be examined in the further investigation.

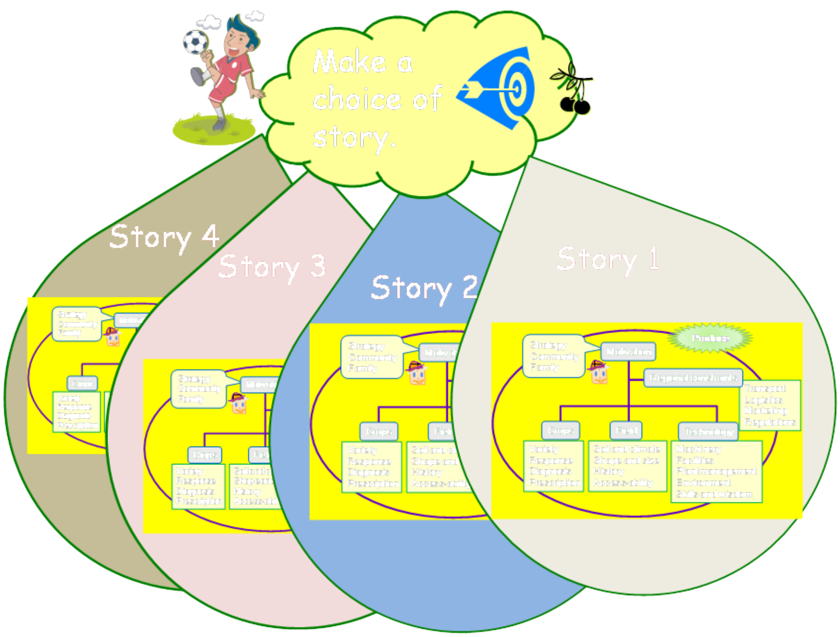


Figure 10. Assumption of farmer’s decision to take a chunk of knowledge with story.

CONCLUSION

In this paper discussed were three topics: responsibility of high yield countries against the food crisis, technology package in precision agriculture, and thinking process of farmers. Technology transfer from high yield countries will become serious task to combat against the food crisis undergoing, because the production increases worldwide could not catch up with the demand increases during the last decade. In standing on the science and technology, it was confirmed that precision agriculture has reached a new stage of technology package which involved innovations in farm management. A combination of the real-time soil sensor and a combine harvester with a yield monitor, for example, created an environmental impact ma of missing nitrogen. Furthermore, a model of decision making process was redefined by four learning phases and also provided eleven thinking units to understand the farmers' decisions. This approach provided useful tools to interpret a way of thinking of expert famers.

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