Participatory modeling for managing rainfed lowland rice varieties and seed system in lower northeast Thailand

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Abstract

Rice varieties and seed management involve a complex system dealing with various problems such as variety adoption, agro-biodiversity conservation, and quality seed supply. A participatory modeling experiment on rainfed lowland rice variety and seed management in lower northeast Thailand has been launched to better understand the system and its problems. Conceptual modeling was done through inter-institutional research team meetings, stakeholder analysis, surveying of stratified randomly sampled farmers and seed supply agents in Ubon Ratchathani Province, and by conceiving and using role-playing games (RPGs) with stakeholders. The system to be analyzed was divided into three subsystems, i.e. farmers' decision making regarding the choice of rice varieties, farmers' management of rice seeds, and the seed supply sub-system. A first RPG focusing on the first two subsystems was used with 25 farmers in two different gaming sessions. Observations and findings from the RPG helped to validate and to improve the conceptual model prepared by the research team. It also builds a shared understanding of farmers' rice varieties and seed management. Limited access to information about varieties and seeds, the need for early maturing varieties, and the scarcity of quality seeds were identified as current constraints of the system. A second RPG representing the seed supply subsystem is being conceived. Later on, a multi-agent system model of the whole system will also be developed and used to simulate scenarios identified by stakeholders and to discuss their results to facilitate collective learning and improvement of the current situation.

Introduction

This paper aims to present and discuss the research framework, research methods, and initial results of investigating the systems for rice variety and seed management through systems modeling with a participatory approach. It is a collaborative research project between IRRI-CIRAD, Office of Agricultural Research and Development (OARD) IV and Rice Research Institute (RRI) under the Thai Department of Agriculture (DOA) and Ubon Ratchathani University (UBU) that started in November 2002 in lower northeast Thailand, a major rainfed lowland rice (RLR) growing area in Thailand.

According to a survey done by the Rice Research Institute during 1982-86, more than 1,500 rice varieties were grown in northeast Thailand at that time (Chaidee and Thongpitak 1992). For a long time, the Thai government has been making a high investment to create and release new rice varieties and to supply seeds to farmers. Fourteen recommended varieties have been distributed by the DOA in the northeastern region since 1956 (Pantuwan and Jongdee 2003). Among the majority of Lao ethnic farmers, glutinous rice varieties are mainly grown for family consumption and nonglutinous ones for sale. RD6, a glutinous variety released in 1977, is the dominant one in this group. The nonglutinous one mainly grown for sale is "Hom Mali rice," which officially includes the two recommended RLR varieties, KDML105 and RD15 (Ministry of Commerce 1997). KDML105 was released in 1959 and is much more dominant than RD15, an early-maturing mutant of KDML105 released in 1978. About 77% of the farmers in the northeast have adopted these three recommended varieties

(OAE 2000). While the DOA has tried to find out why farmers have not adopted more recently released varieties, little work has been done to comprehensively analyze farmers' variety adoption, and especially to study the linkage between farmers' requirements for varieties and seeds and the government and commercial seed service systems.

It has been reported that most farmers in the northeast are still using their own rice seed, but more farmers tend to buy seeds and also to change seeds more frequently (OAE 2000). However, the seed production capacity of government agencies is only 3–5% of the demand (DOCP 2002). Meanwhile, nationwide, more organizations and projects are becoming involved in the rice seed supply system besides the Seed Centers (SC's) under the Department of Agricultural Extension (DOAE) which used to be responsible for this task since 1976. No integrated information on the rice seed supply system made of these different agents and on its linkage with variety and seed management at the farm level have been reported. The situation of seed systems in Thailand agrees with what Tripp **(**2001**)** had identified as the three main generic problems of seed systems: problems with variety release procedures, which were a monopoly of the public sector subject to bureaucratic delays; the inadequacy of information available to farmers; and weaknesses in commercial seed markets.

The impact of the adoption of a few dominant recommended varieties has led to genetic erosion concerns, resulting in more attempts to establish rice biodiversity conservation projects (Bellon et al 1998, DOA 2002, Zhu et al 2003) based on farmer participation (CBDC 2002). Presently, there is no common platform for stakeholders, particularly for farmers, who should obtain the seed of required varieties to match their consumption needs and field conditions and have access to good quality seed from agronomic and marketing points of view, while the public institutions also conserve rice biodiversity as valuable genetic sources and a source of alternative varieties.

To understand the complexity of the system, a participatory modeling approach is used for knowledge integration and communication of different perceptions among stakeholders. The rice variety and seed management system is modeled to encompass farmers' behavior under the conditions of the RLR ecosystem regarding rice variety and source of seeds, linked with the rice seed supply system at the provincial level. The modeling process encourages the participation of farmers and other key stakeholders to share their actual perceptions, needs, and roles in the common platform. The main purpose of this kind of decision support system is to provide a shared understanding of the system's behavior, to identify its key constraints, and to facilitate the collective choice of possible solutions. This paper presents the research problem, the theoretical background, the conceptualization of the model, and the methodology used to integrate knowledge. The participatory research procedures starting from the establishment of an inter-institutional research team is emphasized. It also deals with the preliminary findings obtained from conceptual modeling, stakeholder analysis, and a farm survey, together with the use of a role-playing game (RPG) as a part of the participatory modeling process. Finally, some proposed actions for the next phase of this research are listed.

Assumptions and hypotheses

The study of a seed system is dynamic and complex, spatially diverse and multilevel, and concerns many stakeholders. The management of RLR variety deals with various varieties having different purposes of use, different sources and suppliers of seed, among various types of farmers with different resources, and a diversity of organizations and agents. Such systems change over time and location, depending on many levels of decision-making, from the plot level to international concerns. The study is based on several assumptions drawn from existing knowledge. Rice biodiversity in the region tends to decrease because of the widespread adoption of a few major rice varieties demanded by markets and which fit with

farmers' preferences. Farmers are more dependent on a seed supply from different external sources with scarcity and quality concerns. However, many farmers are still using other varieties fitting their needs, resources, and environments, but without any government concern. One key question examined in this research is the contrast in objectives among the government or international agencies promoting a few recommended varieties on one hand, but also conserving biodiversity on the other hand.

Our central hypothesis is that, in the system of rice variety and seed management, what farmers decide and need does not match with what policymakers decide and implement because of the lack of system understanding, improper connections, and poor communication from farmers to policymakers and researchers. The participatory modeling approach we selected should provide a holistic explanation of the system. The model and knowledge produced should be able to produce a best-bet alternative for farmers and other stakeholders to put in place a sustainable seed supply system providing suitable varieties while supporting the conservation of rice biodiversity.

Theoretical background and state of the art

Understanding the complexity of such a seed system can be attempted by a systems approach modeling, and simulation. Several methods of simulation modeling have been developed for social sciences. Modeling of system dynamics based on differential equations with the stock-and-flow concept describes the target system as a single entity or object and aims to use simulation for prediction (Forrester, 1972). However, these models depend heavily on quantitative assumptions that are weak points of simulations involving social science that are more concerned with understanding and explaining (Gilbert and Troitzsch 1999). Multi-agent models developed from nonlinear dynamics and artificial intelligence research are able to simulate autonomous individuals and their interactions in a common environment and can be applied to the simulation of human societies. We propose to use a participatory modeling approach based on multi-agent systems (MAS) associated with RPG in which field work and system modeling are two complementary activities that are closely linked in an iterative way to produce a shared representation of the system. Recent field experiences have demonstrated the effectiveness of the use of such models to support on-farm, interdisciplinary, and action-oriented research in various contexts (d'Aquino et al 2002). In this kind of companion modeling approach, MAS modeling is associated with RPG, an interactive tool. The use of RPG derived from more complex models through simplifications facilitates dialogue during the collective and interactive learning process involving multiple stakeholders (Bousquet et al 2003). RPG are used to validate and criticize the conceptual model and our initial knowledge of the system. RPG are played in a sequence of steps reflecting actual farmers' decision-making processes. Working on the 3-D model board helps the players to visualize together and make decisions under a given spatial arrangement (Trébuil et al 2002b).

The theory of decision-making in product choice explained by the conceptual model of consumer behavior called as the MAS-based "Consumat approach" proposed by Jager and Janssen (2003) is a useful modeling approach. It integrates several decision-making theories and explains the different behaviors in choosing products as repetition, imitation, social comparison, and deliberation regarding the two dimensions of uncertainty and level of need satisfaction. This can be applied to farmers' behavior regarding the selection of rice varieties and seed sources, which seem to be diverse and influenced by the uncertainty of biophysical and social variables in RLR production systems. Moreover, modeling seed distribution to farmers by different institutions can be compared with model-based analysis and simulation of the diffusion of organic products with co-evolution between firms and consumers under the Consumat approach (Janssen and Jager 2002).

Construction of a conceptual model and data gathering

The RLR seed system was first analyzed within the boundary of Ubon Ratchathani Province, which is home to several key agricultural research and extension organizations. Several meetings of representatives of relevant institutes were organized to gradually establish the research team. The interdisciplinary team is composed of an agricultural systems specialist and a MAS modeler, a breeder and a seed production specialist from the Ubon Ratchathani Rice Research Center (URRC), a farming systems research and development team from the OARD- IV, and a systems agronomist, as well as a landscape agronomist and a rural sociologist from UBU. The unified modeling language (UML) has been used to build a conceptual model representing the team understanding of the rice variety and seed management system at the farm level. This first model was formed as a decision flow diagram explaining farmers' decision-making on varieties. Another model was constructed to represent the structure of the provincial seed supply system. Stakeholders were identified and their objectives, roles, and functions in the system précised (Table 1). Successive half-day-long meetings gradually improved the models through sharing of experiences, information, and perceptions among the team members to achieve a common picture. Missing data were gathered between meetings to improve our conceptual models. Another decision flow diagram explaining how a farmer manages rice seed or decide to buy seeds from a certain supplier was also built based on data from a farm survey and gaming sessions.

Complementary to the research team meetings, field work included interviews with different key stakeholders such as the DOA, DOAE, DOCP, agricultural cooperatives (AC), seed traders, and contract farmers. A survey of farmers' use of rice varieties in the 2002 wet season was carried out from December 2002 to May 2003 by stratified sampling of 258 farmers from all 25 Districts in Ubon Ratchathani Province to document farmers' decision-making rules regarding rice varieties and sources of seed. Results were compared with similar studies carried out in northeast Thailand by Chaidee and Thongpitak (1992) and Gypmantasiri et al (2003) to assess rice biodiversity dynamics and the spatial distribution of varieties.

Construction of a first role-playing games (RPG)

This RPG was built to simulate farmers' decision-making on rice varieties and seed sources at the farm level, while a second one will represent the decision making of different stakeholders in the provincial seed supply system. Each game will be played in different geographical locations and with several different kinds of players.

For the first game, the room is spatially arranged into two zones according to factors such as distance to major seed suppliers and degree of rice biodiversity found in our survey. The 3-D board (60 cm × 60 cm) representing the paddy landscape of each zone displays the lower, middle, and upper paddies. The selection of varieties or seed sources is represented by post-it tapes of different colors and size. For practical convenience two boards, each representing one zone managed by six farmers, are played the same day within one room. The farms represented on the boards differ in size (small, medium, and large one).

Diverse male and woman farmers are selected from the surveyed villages, but not the ones who used to be interviewed. At the beginning of the game, fields are allocated to each farmer on the 3-D board according to the amount of land resources he or she has in reality. Each farmer is given the same amount of money for buying seed. Each year the farmers are asked to select the varieties grown on each plot, select a planting method, and the seed supplier of each variety. Then, farmers spend money for seeds if they decided to purchase them. They are asked to harvest their rice crop and to decide how much paddy they keep for seed, consumption, and sale for each variety. They get money from their rice sales and wait to play the following year.

This first game explores the decision-making behaviors that include the choice of rice variety and the choice of seed source, the allocation of each variety to three kinds of paddy field, and the decision to collect or discard seed from their own field. The feedback of players' decisions that may affect their next move can be shown as the quality and/or price of rice depends on seed quality, the variety grown, and from the amount of money left after buying seed. A key methodological point consists in keeping the game interactive and flexible. Some game conditions or rules may be modified by the players if needed. After simulating two years, we asked farmers' opinions about the game compared to reality and check if they wanted to change the rules or the allocation of resources in the game. The day after the game farmers-players are interviewed about their decisions during the session, their actual farming conditions, and their opinions about the game in relation to reality. We observed that farmers bring reality, experimentation, and imagination into the gaming sessions.

A first session was played on 29 September 2003 at the Ubon Ratchathani Agricultural and Technology College with 12 farmers-players from three imaginary zones: one close to the URRC, one close to the city, and one irrigated area. A second session was played on 26 January 2004 in the more remote Det Udom District, 80 km south to Ubon Ratchathani, with 13 Khmer and Lao farmers-players of different groups, several coming from Pibun Mungsaharn District where they practice a special rice production for a niche market. This second session also included several seed producing farmers from the CSCs.

Later on, a second RPG will represent the provincial seed supply system and will be designed based on our existing conceptual model. Players will come from the seed production and supply institutions and groups of contract farmers producing seed (Table 1). Each player may play at a different scale according to its actual role in the system: the CSC at the village scale, the cooperatives at district scale, and the URRC or SC at provincial scale. This second RPG should assist in collective learning of the stakeholders' objectives, functions and interactions in a given RLR area. It will also represent the respective decision-making, planning, and implementing rules of each seed-producing agent.

Preliminary results and discussion

Farmers' choices and management of varieties

Fig. 1 displays a decision model for the farmer choice of rice varieties. The farm survey and the RPG indicated that Lao farmers prioritize the production of glutinous rice in favorable positions giving enough yield to ensure food security. From the survey, the average glutinous rice area required per family member is about 0.16–0.32 ha, or 1.6 ha per household. KDML105, RD15, and RD6 are the major RLR rice varieties confirmed by our field survey (Table 2) and the results of the first RPG sessions. Growing only RD6 for glutinous rice is most popular (61%), but other glutinous varieties are still used by many farmers (17.4%) while others grow a combination of RD6 and other glutinous cultivars (18.1%). All the farmers seem to be familiar with RD6, but some have rejected it for different reasons. Many claimed that RD6 has a hard cooking texture if its seed is not changed frequently (1–3 years). Some prefer to grow early-maturing or non-photoperiod-sensitive glutinous varieties to avoid drought or to grow post-rice crops, especially in upper paddies.

The choice of early-maturing glutinous varieties can be related to the decision to grow nonglutinous rice, whether KDML105 or RD15, and for labor sharing at harvest. Some farmers grow more than one glutinous variety for labor management reasons too as there are only 2–3 workers on the farm. Some 35 variety names of glutinous rice were found in our survey, and almost all of them seem to be early maturing varieties bearing the same names than in Chaidee and Thongpitak (1992). Frequent changes of these glutinous rice varieties,

even across province or district boundaries, are frequently observed, but the access to information on them is sometimes limited, even in the same community.

There are two alternatives for growing rice for cash as a second priority (Fig. 1). If farmers have access (proper skill and market) to produce special types of rice or rice for a niche market, such as glutinous green rice (immature rice), black glutinous rice, or yellow nonglutinous rice for dessert and red Mali rice that earn more income than Hom Mali rice, they should grow those varieties, but only on a small area of 1–10 rai (1 ha = 6.25 rai) because of the limited capacity of production and narrow markets. Based on our survey, only 2.7% of the farmers are in such situations. Generally, nonglutinous rice production is limited to KDML105 or RD15 since they are the only cultivars accepted as Hom Mali rice on the regional market, and fetch farm gate prices 10–50% higher than those of other nonglutinous rice varieties. According to our survey, 64% of the farmers are growing only KDML105, 12% rely only on RD15, and 14% grow both for several reasons (Table 2 and Fig. 1). RD15 matures in late October-early November, 2 weeks earlier than KDML105. It fetches a high price at harvest, is suitable for well-drained fields, and allows the staggering of labor at harvest. Although RD15 is becoming more popular, it is not yet very well-known and can be harvested under wet conditions while quality seeds are still in short supply.

The RPG confirmed the need of early maturity variety. When a new glutinous non-photoperiod-sensitive variety with 120 days maturity was introduced in the game, some farmers, especially in the more variety-diverse zones, chose it**.** The preliminary findings from both the field survey and the RPG indicated that the extent of rice biodiversity or number of varieties found is related to spatial patterns in this Province. In Districts close to URRC, SC, and near Ubon Ratchathani city, only three recommended varieties are found. The zones with higher rice biodiversity are located in the more remote southern and eastern Districts, with influence from irrigated rice varieties and the borders with Laos and Cambodia.

Farmers' management of seed sources

Fig. 2 displays the conceptual model of our understanding regarding the choice of seed sources by farmers. This model was developed from the survey information and further validated and improved during the RPG sessions. The survey found that 50–60% of the farmers change their seeds of the three recommended varieties every 1–3 years, whereas 10% never change them (Table 3). Similar results were obtained from the RPG sessions. A major reason for changing glutinous rice seed is the cooking quality as cooked grain becomes harder overtime. Seeds of nonglutinous KDML105 and RD15 are changed when an increase in off-type plants results in a lower paddy price. The various possible seed suppliers for the three recommended varieties are shown in Fig. 2 and Table 3.

From both the survey and the RPG, we observed that farmers' information on seed sources and suppliers is limited and incomplete. Most farmers may know some suppliers but not the actual origin of the seed, while some suppliers sell seed originating from more than one source. Our survey findings, however, showed that the seed of the three recommended varieties is mainly purchased from two sources: the SC through district level agricultural offices and traders (14–20%) and AC's (18–21%). The price of seed from AC's is lower (260–320 baht 25 kg^{-1}) but varies more than the price of seed from the SC (320 baht 25 kg^{-1} or 12 baht kg^{-1}). CSC's seem to have only a small share probably because of poor seed quality and packaging, and a distribution limited to the local community. A higher proportion of CP rice seed was also observed in 2003 though its higher price (360 baht 20 kg^{-1} or 18 baht kg^{-1}) limited access, but it had the best packaging and good seed quality. It seems that the cost of rice seed does not trouble most farmers compared with fertilizer or labor costs. Reasons often mentioned for the choice of seed supplier were distance to selling places, access to relevant information, seed quality, brand name, community influence, etc. In the

model shown in Fig. 2, we consider that quality is the first criteria when making a choice. URRC is the first choice because of its better quality of foundation seed at relatively cheap price (10 baht kg^{-1}) due to government subsidies. But they are available in limited quantity and access to URRC is not always easy. Physical or social proximity to seed suppliers is a major determinant of supplier choice. Poor accessibility to seed information was also confirmed as an important factor in the RPG as most players did not know that so many sources of rice seed were available.

For non-recommended varieties, farmers have to rely on exchanges among neighbors or relatives. Seed of recommended varieties is also exchanged among farmers in 14–20% of cases and some seed trading among farmers is also observed. Farmers may finally decide whether to grow a variety with their collected seed just after tasting the cooked grain and comparing it with other farmers' rice. RPG sessions followed by interviews with players improved our understanding of farmers' seed management and helped to design the conceptual model of the second RPG dealing with the seed supply system at provincial level.

Seed supply system

Fig. 3 displays the structure of the rice seed supply system. This conceptual model is used, with other relevant gathered information, for designing the second RPG in the next phase of the project.

Officially, every year, the URRC is the only on-station producer of foundation seed of the recommended varieties. The foundation seed is then annually distributed to other seed production agencies to produce the stock seed sold commercially. The URRC tries to produce an amount of seed of certain varieties requested in advance one year before the seed is needed by the key seed stock producer (SC) and other entities. The remaining amount can be sold to farmers. The SC has been the major rice seed producer for as long as their mandate has existed to produce stock seed at the amount planned at the national level for selling to farmers and special projects. The total amount of seed production of RD6, KDML105, and RD15 was about 1,500 t in 2001. The AC's—privatized agencies with technical and institutional assistance from the DOCP or Provincial Office of Cooperatives (POC) —have run their rice seed project since 1998. They also rely on a network of contract farmers. In 2002, there were five AC's of five districts in Ubon Ratchathani producing seed. Each AC manages its seed production system separately. The amount of stock seed, mostly KDML105, produced by the five cooperatives from 16 tons of foundation seed was about 700 tons in 2002.

We also investigated the contract farmers collaborating with seed production agencies. The basic systems of seed production of AC's and SC are similar. These organizations select farmers, signs a contract, purchases foundation seed from the URRC, and sells it to the contract farmers at the same price. The contract farmers produce seed that will be certified and sold back to the contracting agencies at a price about 10–20% above paddy price, depending on the quality of the seed and sometimes on the agency's budget and rules. Some contract farmers became unhappy with the system because of a lower seed-selling price than expected, labor limitations, and lack of technical support. Informally, some of them used to sell some seeds to the other farmers. In 2002, there were 258 contract farmers under SC in seven districts of three provinces, including Ubon Ratchathani, and about 250 contract farmers working with the five seed-producing AC's in Ubon Ratchathani Province.

The only rice seed company, CP, locally established in 2001, also orders and purchases foundation seed from the Rice Research Centers (RRC's) under DOA and produces seed through its network of contract farmers. Its contract system has not yet been investigated. In Ubon Ratchathani, CP seed is sold at the agricultural cooperative for marketing, which is supported by the Bank for Agriculture and Cooperatives and at some agricultural stores. The community seed centers (CSC) established in 2000 are also a

nationwide project supported by the DOAE to distribute seed at the tambon (sub-district) level (158 centers in Ubon Ratchathani Province in 2002). Each center is made of a group of 20 farmers. They obtain stock seed distributed from SC through the district DOAE to produce certified seed for exchange or sale in their community. Formal seed traders need to be certified each year. They purchase seed from the SC and they can receive a price deduction of 20% if they sell at the SC usual price of 320 baht 25 kg^{-1}. Seven seed traders (four in Ubon Ratchathani Province) were registered under the Ubon Ratchathani SC in 2000. Some millers who buy rough rice sell seed purchased from the URRC or SC to farmers. Many informal seed traders are observed, including the seed-producing contract farmers or ordinary farmers.

It should be noted that the rice seed supply systems of URRC (under DOA), SC (under DOAE) or CP are operating at the national level. Decisions concerning variety release, recommendations, and seed supply are being made at their headquarters in Bangkok. Therefore, the research project's provincial boundary can be used to model the farmer decision making system, but it may not be relevant to represent the whole seed supply system.

Conclusions and perspectives

Participatory modeling revealed the complexity of different aspects dealing with rice variety and seed management systems. Diversity of variety uses, farmers' choices of seed sources, linkages or competition among seed suppliers and producers are interrelated and draw on several social and biophysical factors at the field, farm, and community levels. The integration of various research tools and activities are needed to well understand this complexity.

Forming an inter-institutional research team was essential to this research project to gather the different points of view among key stakeholders. The UML diagrams for conceptual modeling showed their effectiveness for representing a complex system and for integrating and sharing of information. A complementary field survey provided missing data and improved conceptual modeling and RPG designs. RPG with 3-D board facilitated the communication between the research team and farmers to reach a common understanding of the system being examined. We have seen that such an artificial community can be used to test farmers' behavior to changes under given conditions.

A second RPG representing the seed production and supply agencies is now being conceived and will be tested soon. These RPG are tools to validate and to improve our conceptual models thanks to an active and organized participation of stakeholders.

Problems of limited access to information on seed, need for recommended early maturing variety, scarcity of quality seed, and on-farm seed production's constraints were identified during this study. These preliminary findings suggest that a comprehensive and dynamic analysis of the local seed supply systems needs to be carried out as new seed projects emerge. An improved rice seed supply system could help to mitigate the apparent contradiction between biodiversity conservation and the extension of few successful varieties.

MAS modeling will be used to unify the different and complementary conceptual models presented in this paper. This MAS model will simulate diverse scenario of changes in the seed supply system as suggested by stakeholders. The simulation results will be analyzed collectively to facilitate agreement on ways to improve the current system.

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Fig. 3. Structural diagram of the seed supply system in Ubon Ratchathani, lower northeast Thailand, 2002. Seed flow among institutions is mainly KDML105, RD6, and RD15; the others mostly belong to farmer-to-farmer systems only. Numbers below each agent indicate number of places or persons of each agent in Ubon Ratchathani, except for SC and CP seed company subsystems.

Table 1. Stakeholders in the rice seed system of Ubon Ratchathani Province, lower northeast Thailand, 2002.

Stakeholder	Role /function/linkage in the system
Farmers	Producing paddy rice for consumption and sale. Using variety and seeds as input , Collect own seed if not changing, exchange seed with other farmers.
Seed production contract farmers of each institute (SC, cooperatives, or CP)	Doing as other farmers, and also producing stock or certified seed to sell to their contract institutes.
Rice Research Centers (RRC)/ Rice Research Institute(RRI) / under the Dept. of Agriculture (DOA)	Breeding for new varieties. Maintaining quality of the recommended cultivars. Producing foundation seed for the requested seed multiplication agents and sell the surplus. Conserving rice genetics.
Seed Centers (SC)/ under the Dept. of Agricultural Extension (DOAE)	Managing contract farmer system to producing stock and certified seed, seed improvement and selling seed at the center or through agents and DAO or providing seed for special projects. Certifying seed. Certifying the seed traders.
Agricultural Cooperatives(AC) (supported by Dept. of Cooperative Promotion, DOCP)	Seed producing cooperatives (5's in Ubon Ratchathani)- producing stock seed or certified through contract farmers and doing as the other AC's activities such as trading the seed, paddy, and give loan to members.
District Agricultural Office (DAO under Dept. of DOAE)	Assisting Community Rice Seed Center and distributing seed to farmers at district levels. Collect farmers' data, provide seed and other information.
Community Seed Centers (CSC) (supported by DOAE and DAO)	Get stock seed from SC through DAO to produce certified seed through members and distributing seed for the community by exchanging or selling.
CP Seed Company, Charoen Phokpand (CP)	Running seed production business Multiply foundation seed to produce stock seed and sell seed.
Bank for Agriculture and Cooperatives (BAC)	Give loan to farmer members and support and distribute seed from the ACM
Agricultural Cooperative for Marketing (ACM)	Trading seed and other agricultural inputs and products
Rice mills	Trading rough rice and produce milled rice and sometimes selling seed, grade rice production quality when buying
Agricultural store/traders	Trading seed and paddy. Distribute stock or certified seed to farmers.

Table 2. Choice of varieties used and frequency (%) of farmers growing them with average farm household and amount of farm labor and mean, standard deviation, and range of farm size (surveyed in Ubon Ratchathani, 2002 wet season).

Choice of rice varieties	% of farmers growing (n = 258)	Mean no. of household members	Mean household labor	Rice-growing area (rai) *(1 rai = .016 ha)*			
				Mean	Standard deviation	Min.	Max.
Glutinous:							
RD6 and other glutinous	18.1	5	3	28	23	8	130
RD6 not other glutinous	61.0	5	3	20	12	3	65
Other glutinous not RD6	17.4	5	3	20	17	4	94
Nonglutinous:							
KDML105 and RD15	14.8	5	3	27	22	5	130
KDML105 not RD15	64.7	5	3	22	15	3	94
RD15 not KDML105	12.4	5	3	22	11	4	50
Special varieties for niche market	2.7	6	3	26	18	11	58

Table 3. Frequency of farmers (%) choosing rice seed suppliers of each variety from the survey of 258 farmers in Ubon Ratchathani, 2002 wet season.

Seed supplier	Seed production source[a]	Seed quality class[a]	% of farmers			
			KDML105	RD15	RD6	Other varieties
Rice Research Center (RRC)	RRC	FS	4	3	4	3
Seed Center (SC)	SC	SS	2	2	0	0
District Agricultural Office (DAO)	SC	SS	19	13	14	9
Seed traders	SC, RRC	SS, FS	5	5	2	0
Rice mills	SC, RRC	SS, FS	2	2	1	1
Agricultural Cooperative (AC)	AC, RRC, SC	SS	25	23	22	7
Bank for Agriculture & Cooperatives	CP Company, SC	SS	4	2	3	1
Community Seed Center (CSC)	CSC	CS	1	2	1	0
Others organizations/projects, e.g., NGOs	na	na	2	0	1	0
Farmer (exchange)	Farmers	–	18	27	28	47
Farmers' self-production	Farmers	–	17	22	25	32
Total			100	100	100	100

[a]FS = foundation seed (produced from breeder seed inside RRC), SS = stock seed (produced from foundation seed), CS = certified seed (produced from stock seed). na = Data not available.

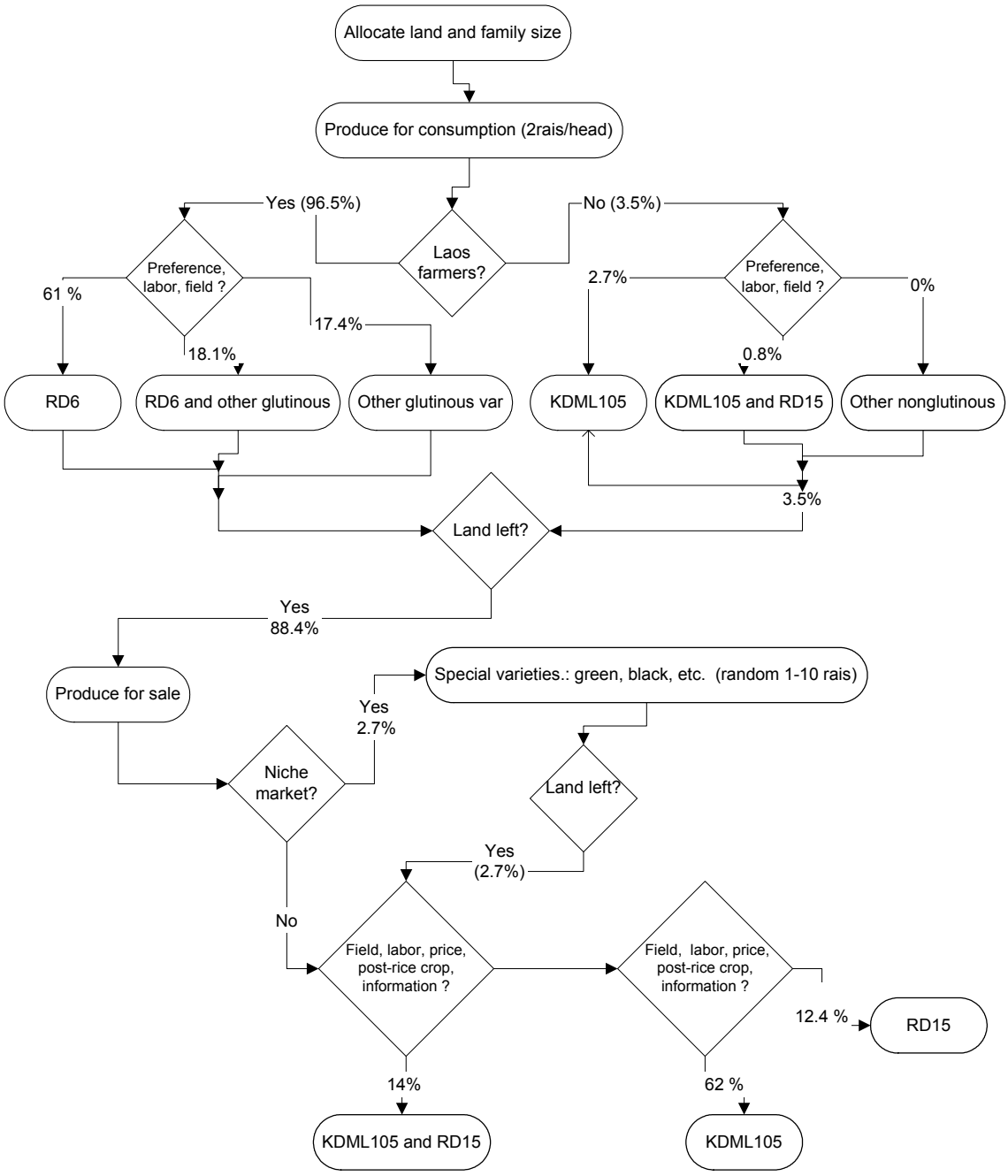

Fig. 1. Decision model for a farmer's choice of rice varieties, focusing on main varieties, lower northeast Thailand. Percentages are the proportion of farmers found in the survey in Ubon Ratchathani, 2003.

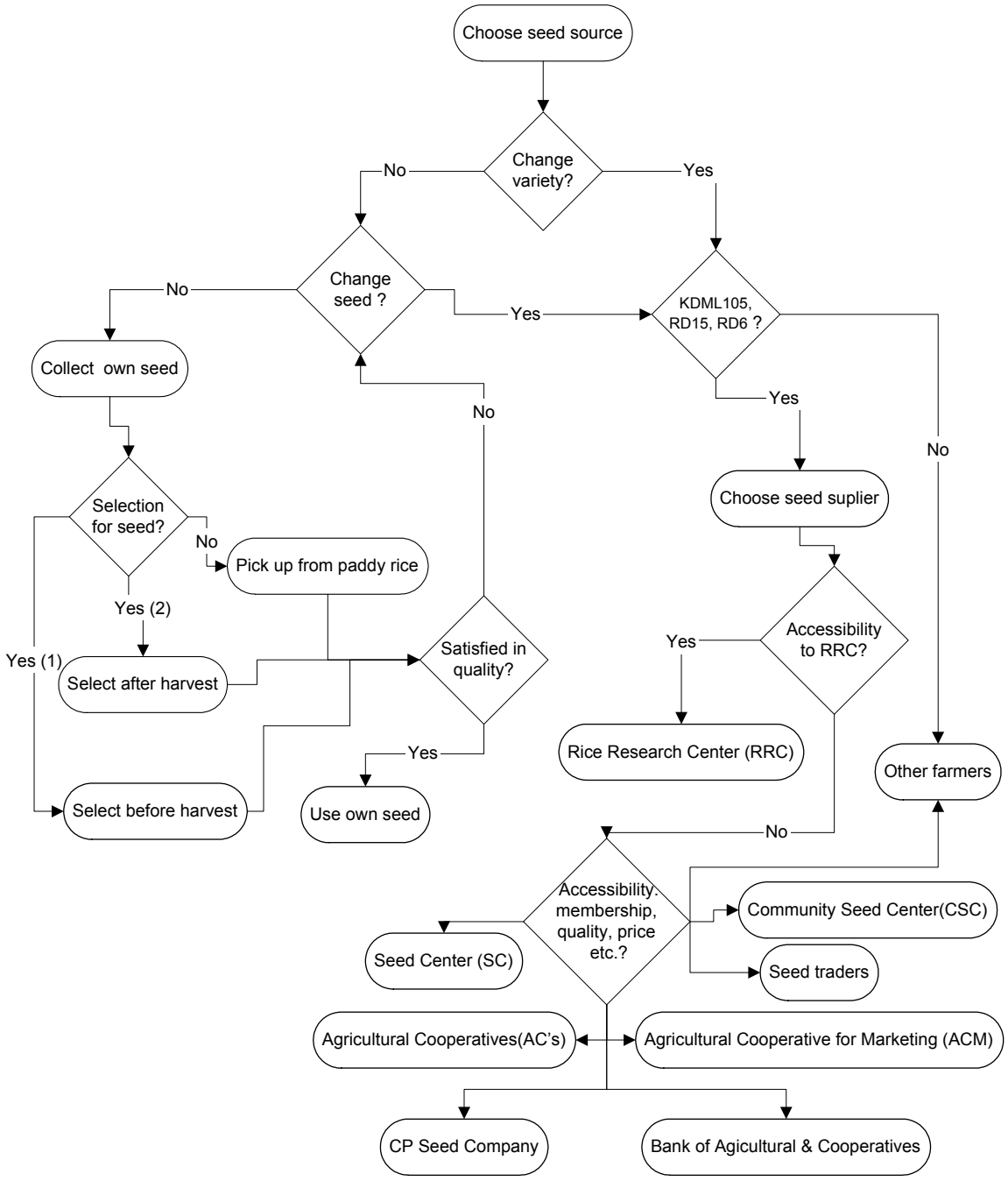

Fig. 2. Decision model for farmer's choice of seed sources and suppliers, Ubon Ratchathani, lower northeast Thailand, 2003.

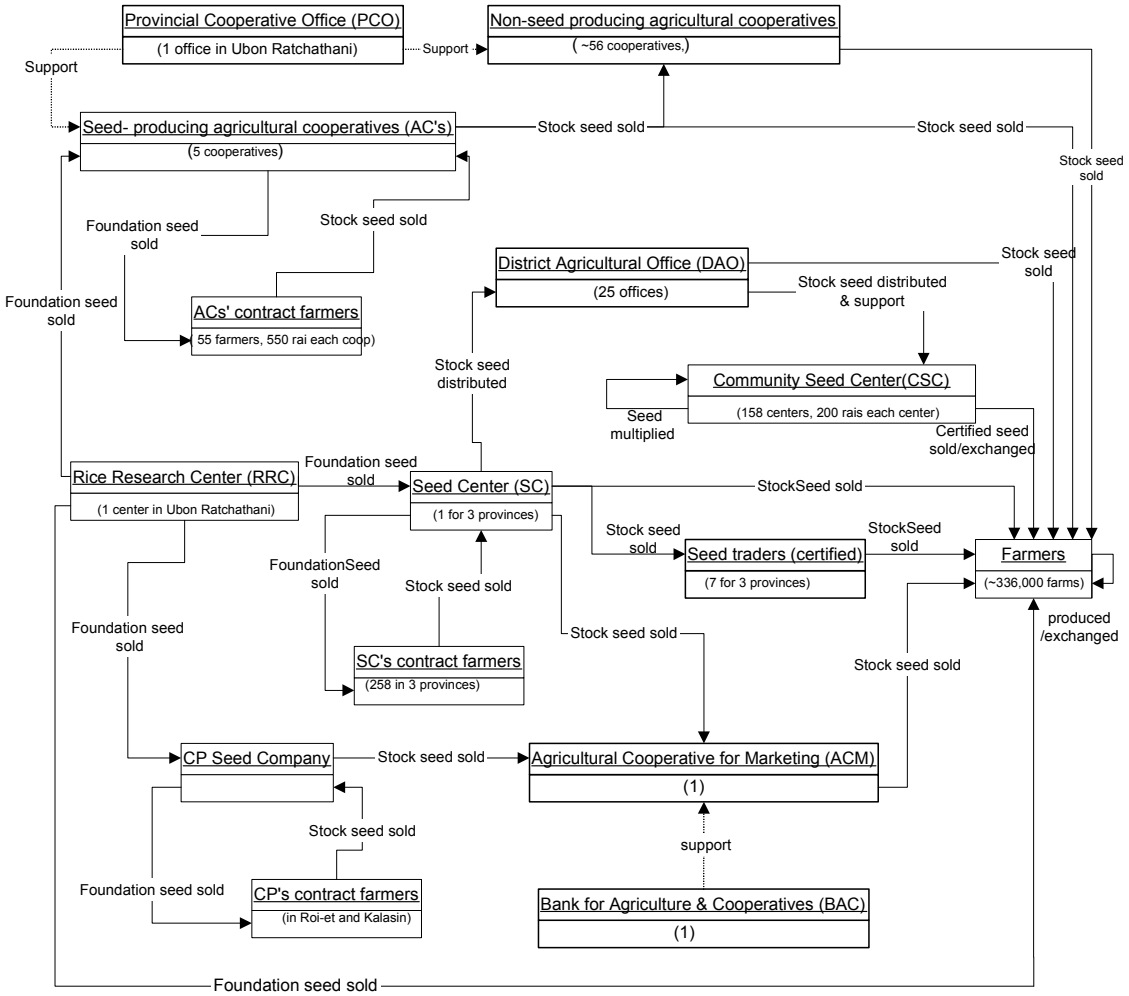

Fig. 3. Structural diagram of the seed supply system in Ubon Ratchathani, lower northeast Thailand, 2003. Seed flow among institutions is mainly KDML105, RD6, and RD15; the others mostly belong to farmer-to-farmer systems only. Numbers below each agent indicate number of places or persons of each agent in Ubon Ratchathani, except for SC and CP seed company subsystems.