Journal of Thai Interdisciplinary Research
Volume 13, Number 3, Pages 51 - 63

Role-playing game to create learning about farming in an area surrounded by national park

Sutheera Pruksakorn[1], Somboon Kiratiprayoon[2], Somkit Uttaranakorn[3], Orathai Sukreeyapongse[4], and Pongchai Dumrongrojwatthana[5,*]

[1]Interdisciplinary Program of Environmental Science, Graduate School, Chulalongkorn University, Bangkok 10330, Thailand
[2]School of Science and Technology, Thammasat University, Pathum Thani 12120, Thailand
[3]Superintendent of Phu Kao-Phu Phan Kham National Park, National parks, Wildlife and Plant Conservation Department, Khon Kaen 39140, Thailand
[4]Office of science for land development, Land Development department, Ministry of Agriculture and Cooperatives, Bangkok 10900, Thailand
[5]Department of Biology, Faculty of science, Chulalongkorn University, Bangkok 10330, Thailand

Abstract

Farming in area surrounded by national park is a major concern in developing countries. Increasing farmer's capacity for adaptive management is critical important for sustainable farming in limited areas. This study used role-playing game with low-formal education farmers inhabiting Phu Kao-Phu Phan Kham National Park, north-eastern Thailand for the objectives: i) to improve the understanding of interactions among key components involved in the farming is surrounded by the park, and ii) to improve the adaptive capacity of farmers by sharing experiences and learn about possible impacts of farming in national park area, and being able to collectively identify feasible actions to cope with the uncertainties of the future. Gaming and simulation field workshops were conducted in three villages. Players understood the game and learned through a variety of methods, and by sharing their experiences, they were able to identify actions to avoid future forest encroachment. The players also learned about uncertainties throughout different scenarios, including extreme drought, free trading and an increasing human population. They learned that forest encroachment might not increase their crop yields if natural disasters and their income are unlikely to increase if they continue to still spend high on family. After the game, all of the players changed their attitudes by confirming that they would not encroach upon the forest. Moreover, they were enthusiastic to learn more about soil quality improvement and cassava growing using the role-playing game. In addition, they asked researchers to create new games to be used with them in the near future. We may conclude that this simple role-playing game can be used effectively with farmers to increase awareness on farming in such areas. However, follow-up field workshops with new role-playing games proposed by the farmers, are required to promote knowledge sharing network on farming and better empowered to manage their adaptability.

Keywords: adaptive management, co-learning, forest degradation, gaming and simulation, park-people conflict

Article history: Received 23 November 2017, Accepted 30 April 2018

1. Introduction

Illegal farmland expansion in area surrounded by national park is an important issue in many developing counties [1]. Thailand has also been faced with such a problem. Since 1961, the country forest area has continuously decreased from 53.33% to 31.62% [2]. There are many factors causing forest areas to decrease, such as illegal encroachment by local farmers, increasing investments in the area, incorrect certificates of land ownership, and a lack of government staff to protect forest areas due to budget limitations [2].

In order to solve this problem, the Royal Thai Government has continued to declare land as conservation areas. Recently, the Royal Thai Government recently implemented a "returning forest area" strategy. The master plan is to increase forest cover of country areas by up to 40% within 10 years [3, 4]. After implementing the policy, local people across 8,148 villages had to move out from conservation areas. The master plan was not suitable for this situation because the farmers did not have their own lands and forest encroachment is still occurring everywhere in Thailand [5]. Importantly, many farmers do not understand national park laws and usually claim that they had been settled for farming, especially in the highlands, before the declaration of the national parks [6]. When the Government established

* Corresponding author; e-mail: dpongchai@hotmail.com

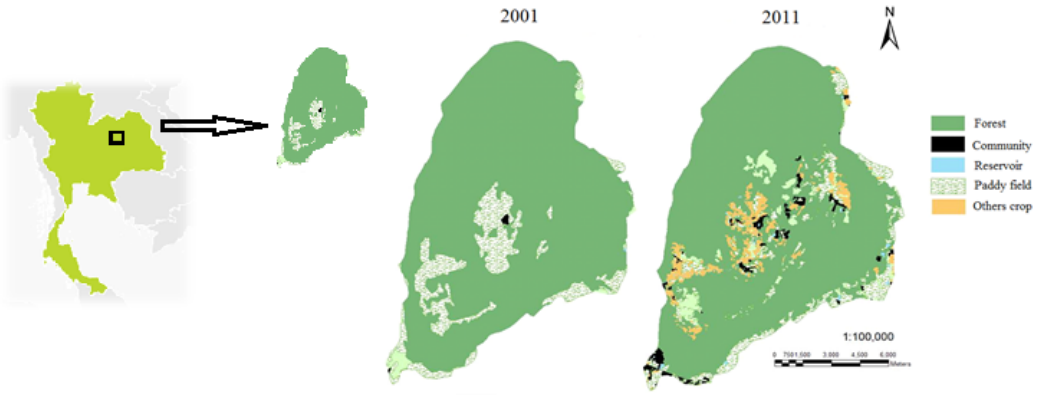

Figure 1 Phu Kao-Phu Phan Kham National Park boundary and land use inside the park in 2001 and 2011

the national parks, usually done through top-down management without consulting the local people about boundaries, and implemented stricter national laws, many famers' actions became illegal because they were suddenly farming in area surrounded by national park and were having their fallow lands slashed or burned now that they were within conservation areas. As a result, many farmers were arrested and had to pay a lot of money for fines which affected themselves and their families [7].

To solve the above problem, because of the need to recover the forest, famers, usually low-formal education level ones who lack awareness in good practice farming in area surrounded by national park, must learn about the interactions between ecology and socio-economic components in the system. This will allow them to have a holistic perception to better deal with uncertainties of farming in that areas and avoid forest encroachment. To do so, system thinking and system dynamics concepts are needed.

Companion Modelling approach (ComMod) [8, 9] was used as a tool to share the understanding of farming in areas surrounded by national park. ComMod is a transdisciplinary modelling approach integrating diverse concepts from scientific and social science disciplines [9]. ComMod uses a multi-agent system model (role-playing game or agent-based model) to facilitate stakeholders' under-standing on the interactions among components in bio-physical and socio-economic systems, and support decision-making. A common representation of the system will be co-constructed by concerned stakeholders involved in the participatory modelling process. This shared representation will help stakeholders broaden their points of view and adapt their behaviours for better co-management of natural resources. This approach has been effectively used in many management situations [10-13].

This research used a role-playing game (RPG) with farmers with low-formal education who live in Phu Kao-Phu Phan Kham National Park, north-eastern Thailand. Two main goals of this research were: i) to improve farmers' understanding on the interactions among key components in a conflicting forest-farmland ecosystem and ii) to increase their adaptive management capacity through a participatory modelling process. The RPG was used as a tool instead of a computer agent-based model because it allowed players to interact with each other, easy to understand and stimulate the players' learning skills [14-17], as well as to learn how to communicate, cooperate, negotiate, and share knowledge and experience with other people [18-21]. An RPG can also help create understanding of the conservation of natural resources [10, 22]. This study aims to implement an integrative gaming and simulation model with low-formal education farmers in a national park in order to improve their understanding on the possible impacts of farming in that areas by exploring situations, including identifying possible plans or actions to address future uncertainties.

2. Materials and methods

Study site

The Phu Kao-Phu Phan Kham National Park (16°55' 48.76"N, 102°27'40.12"E), Thailand, was selected as the study site. The park was officially established in September 1985. The park area is 32,200 ha covering three provinces, Nong Bua Lum Poo, Khon Khaen and Udon Thani [3] (Figure 1).

By interviewing key informants within the villages (village headmen and representatives from the subdistrict administrative organisation (SAO)), it revealed that some villagers had been living here since 1960. In 1970, a saw mill owner from Khon Khaen province received a logging concession in the area. Dirt roads were then constructed. It allowed more people to encroach and settle in the area. Until 1972, this area was registered as a national preserved forest. In 1979, Wangmon and Chaimongkol were registered as villages, followed by

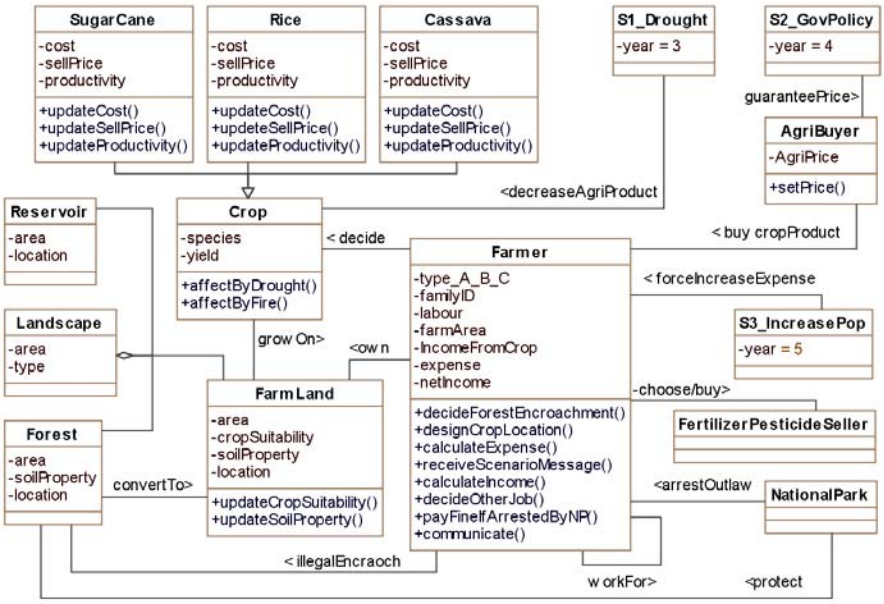

Figure 2 Unified modelling language class diagram based on the preliminary system diagnosis used to create the role-playing game in this study

Dongbak in 1981. Phu Kao-Phu Phan Kham Forest was declared as a national park of Thailand in the same year. Nowadays, there are 552 families living across three villages in this national park [3, 23]. Agricultural production from the farmland was mainly for consumption, but after roads were constructed, farmers then began to mainly plant cassavas for selling. Nowadays, most farmers only grow monocultures of cassava and some of them separate the land for planting rice for household consumption. Some other plants such as sugarcane and vegetables are also planted for consumption around the house.

After the declaration of the national park, the park manager tried to control the expansion of farmland in the national park, but it was unsuccessful due to two main causes. Firstly, farmers who followed the regulations had to repeatedly farm in the same limited areas. In a few short years, they suffered from soil quality degradation. They didn't know how to improve the soil quality in their farmland, so they decided to encroach upon the forest again. Secondly, there are still many farmers who claim that they have been farming in the area long before the establishment of a national park. Therefore, they feel they have the right to continue encroaching upon the forest.

However, the staff of the SAO, Mr. Bavorn Duangsaeng, gave the information about the area that government authorities began to strictly enforce the strategy of "returning forest area" in 2015. Many farmers were against this policy. This created a severe conflict between farmers and government staffs. As a result, more than 30 farmers in the three villages were arrested and charged with fines. This created negative effects on individual and family levels. Based on interviews with 234 farmers [23, 24], 64.53% of the population graduated from only primary school, more than half of the respondents in this interview can be identified as low-formal education farmers because of the compulsory education, Thai people should be graduated the Junior High School. Moreover, these farmers never trained in sustainable farming and lack knowledge about national park laws. A few farmers informed that they used to participate in training courses about animal rearing in the lowland, but they did not understand technical terms. Because of this, they refused to implement the lessons from the training within their villages.

A role-playing game for shared learning

Prior to constructing a simulation in the form of RPG, field surveys were carried out to understand the system context. Farmers and national park officers were in-depth interviewed. The results were used to construct the RPG as described below.

RPG objectives

The RPG had three purposes: i) to improve understanding on the interactions among key components related to farming in area surrounded by national park, ii) to facilitate shared learning among farmers about the possible impacts of national park law implementation, and iii) to collectively identify feasible plans or actions to adapt to future impacts or uncertainties.

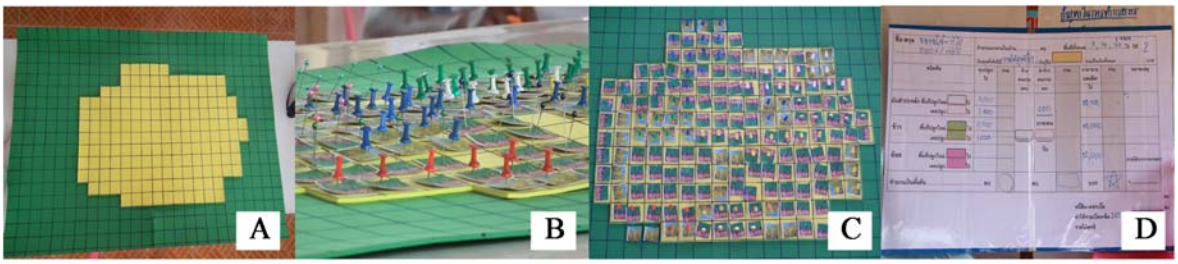

Figure 3 Game board (A), game board with crop cards (B), different colours of pins represent different farmers (C), and the recording sheet (D)

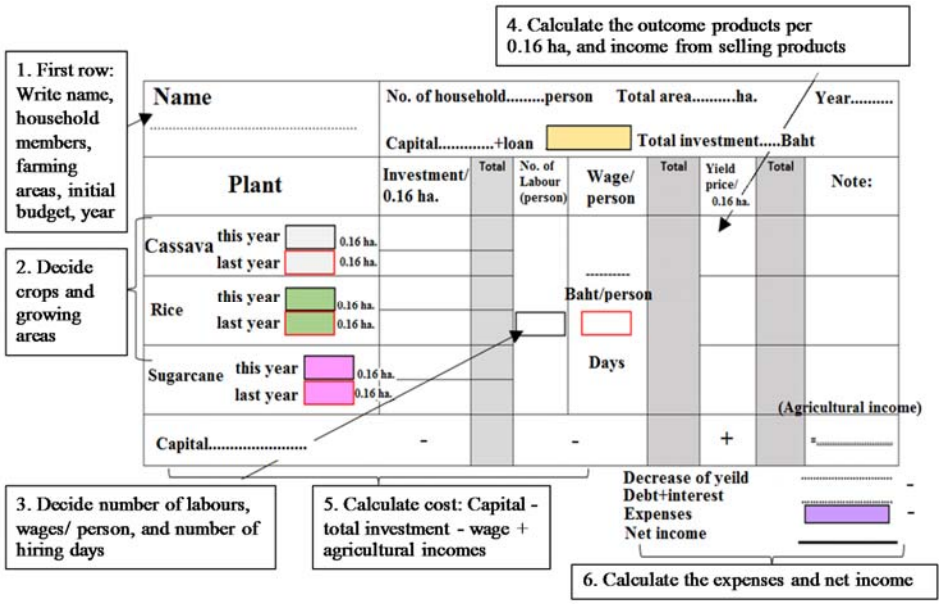

Figure 4 Guidelines for filling out the recording sheet

Expenses in farming and others	
- fertilizer/insecticide - pawning - drying of products - delivering of products	
Expenses for living	
- food per head for the whole year - cloths - medication - telephone - tuition fee - personal materials (shampoo, toothpaste etc.,) - hire car - electricity - water - lottery - donation - funeral - marriage	
Total	

Figure 5 Recording sheet for calculating household

Key components and interactions

Based on the preliminary study, the unified modelling language (UML) class diagram representing key components (actors, resources, climate, and government policies) and their inter-actions within the system was created (Figure 2).

In the UML diagram there were three types of land used in the model, “forest”, “farmland” and “reservoir”. They were aggregated into the “landscape”, which was the game board used in the gaming session. There were four main actors, including farmers (“Farmer”), national park officers (“NationalPark”), fertiliser and pesticide sellers (“FertiliserPesticideSeller”), and merchants (“AgriBuyer”). There were also four main resources and factors affecting the system dynamics, including cash crops (“Crop”), drought (“S1 _Drought”), government policy (“S_GovPolicy”), and increasing populations in the villages (“S_IncreasePop”).

Farmers in the system were classified into three groups. Group A is the farmers having less than 1.12 ha of farmland, group B is the farmers having 1.12-2.24 ha

of farmland and group C is the farmers having more than 2.4 ha of land. Each farmer has a labour force, income from crop, expenses and a net income. Farmers have to decide their cropping based on the different conditions within the different scenarios, calculate expenses and income, decide on other jobs, and pay for fines if they encroach on the forest and are arrested by the national park officers. Farmers can communicate among themselves and provide labour for the other farmers. The crop choices were cassava, rice and sugar cane, which were selected to represent the major crops in the study area in reality. Each crop had different investment costs, selling prices and yields that were affected by drought.

The national park officer plays the role of protecting the forest and interacts with farmers by arresting those who encroach on the park area. The fertiliser and pesticide sellers have the role of selling fertiliser and pesticide to farmers. Lastly, merchants have the role of setting prices and buying agricultural products from farmers. In addition, merchants will also receive government policies on guaranteed prices during a scenario (see scenario section for more details).

All of the components in the diagram were transferred to the RPG and used with the farmers during the field workshop.

RPG materials

Game materials are as follows:

1. Foam board of the landscape (26 grids x 18 grids) with two colours. Green represents forest (302 grids) and yellow represents farmland (166 grids) (Figure 3). One grid represents 0.16 ha in reality. The number of grids were calibrated for 37 players.
2. Proof paper. Used by participants to indicate related costs, yields in normal weather conditions and the selling prices of each key crop. These common values were then used in the gaming session. This process allowed players to co-construct the game by sharing parameters and avoiding black-box effects of the game [25].
3. Farming and expense recording sheets for each farmer (Figures 4 and 5).
4. Different colours of pins. Different farmers had different colours to represent their farmlands and crops on the landscape (Figure 3).
5. A public board with guidelines. Used to demonstrate how to fill out the recording sheet (Figure 3).
6. Crop cards of cassava, rice and sugarcane (Figure 5).
7. Chance cards of weather (good and normal), drought (extreme, severe and normal), and to signify arrest by a national park official (yes or no).

Table 1 Initial conditions for the first round of the game

Farmer type	No. of players	Initial budget	Owned land (ha)
A	4	50,000	<1.12
B	4	100,000	1.12-2.24
C	4	150,000	>2.24

Note: Number of players in each farm type are adjustable depending on the number of participants

Table 2 Number of participants

Session	Village	Number of players
1	Dongbak	12
2	Wangmon	13
3	Chaimongkol	12
	Total	37

RPG setting and participants

The RPG was calibrated for 12-15 players for efficient learning due to some steps of the gaming session requiring group discussion for shared learning. Participants were arranged to sit in a U-shape around the public boards. The game moderator stood (or sat) in the middle while game assistants stood (or sat) behind the participants in order to assist them with filling out the data. Initial conditions before playing the game are described in Table 1.

Three one-day gaming and simulation field workshops were conducted separately in Dongbak, Wangmon and Chaimongkol villages. A total of 37 players were selected based on farmer typology [11, 26] analysis from 234 interviewed farmers. This group of farmers cover all rich medium and poor income, as well as different decision-making processes on land use and land management. The numbers of participants are presented in Table 2.

RPG scheduling and scenarios

The gaming session started with registration. The participants registered to get name badges with player numbers. They then received a set of game materials, including recording sheets, pens, calculators, pre- and post-tests.

Before play, the game moderator explained the objectives of the workshop followed by the game materials and steps needed to play each round of the game. The gaming session composed of five rounds representing five years in reality. The game schedule and knowledge integrating/ sharing during the gaming sessions are presented in Table 3.

RPG debriefing and plenary discussion

Debriefing is one of the most important steps when using gaming and simulations for learning [27]. After finishing five rounds of play, researchers (as the game moderators) summarised the results and lessons learned from the different scenarios regarding the

Table 3 RPG scheduling, scenarios, role of players, and knowledge integrating/sharing in game

Role of game leader (researcher and team)	Role of players	Knowledge integrating/sharing in game
Welcome the participants and introduce the staff and objectives of the workshop.	Check the game materials.	Sanitising participant to the tool.
Discuss with players the cost of planting cassava, rice and sugarcane, including the costs of harvesting and crop prices, and write it all down on a piece of paper.	Discuss and agree on costs and kinds of fertilisers and pesticides. Discuss why some pay less or more. Exchange sources for buying fertilisers and pesticides.	Share different crop investment costs and learn how to reduce costs, such as buying cheaper agricultural inputs from new places, as well as parameters to be used in the game.
Explain the meaning of the game materials, such as the different coloured pins and crop cards, and explain time steps in the game (e.g., 1 round represents 1 year in reality).	Check game materials.	Share knowledge of key crops grown in the area.
Explain the meaning of the recording sheet.	Record name and surname.	Participants greet each other.
Explain the game board, (e.g., one square represents 0.16 ha).	Observe the game board.	Share different viewpoints of the national park and draw links between the simple game board and the area in reality.
Round 1 (Business as usual scenario): Farmers cultivate and sell their products as usual		
Ask players to choose the crops based on their initial given budgets and farm sizes (Table 1), and calculate the number of labourers to be employed, the number of days and the cost.	Choose the crop cards and pins on the game board.	Re-check the common costs for farming, practise recording farming accounts, observe the imitation behaviour of players.
Give examples on how to fill out data on the big board (assistants will help farmers if needed) (Figure 4).	Decided to hire labourers, choose days for planting, calculate costs for farming and re-check the data.	Learn about the cost of labour if the areas increase.
Ask players to draw a chance card for weather conditions.	Player draws a chance card.	Learn about uncertainty.
Ask players to calculate crop products per unit area and sell products.	Record each crop production based on the results from the drawn chance card.	Learn how to calculate the product per unit area.
Ask players to record the household expenses (Figure 5).	Record household expenses and update income again.	Learn to calculate expenses and make a household account.
Ask players to calculate the net income.	Calculate the net income.	Learn the net income (normally farmers consider their income only from selling products, they are rarely concerned about all investments, household expenses and debt). Learn to plan for the next crop year.
Conclude the results: check if players understood the game and were able to calculate costs and expenses. Discuss the results of the weather if they are able to see similarities to reality.	Share opinions.	Learn different results from the decision-making of different players.
Coffee break		
Round 2 (Business as usual scenario): Farmers allowed to expand their farmlands, if needed		
Announce the start of the next round (year). Players are now allowed to increase their farmland, if needed.	Repeat the same steps as the first round.	Learn that in area surrounded by national park is not enough for everyone to increase their farmland. If they increase their farmland, they have to take the risk of being arrested.
Before the harvesting step, announce that "now there is a park ranger. Those who encroach on the forest will have to draw a chance card to be arrested."	Farmers who encroach on the forest must draw a chance card (pay 100,000 Baht to game leader if arrested).	Learn about the risks of encroaching on forests for farming.
Inform players to calculate the net income.	Calculate the net income.	Learn that the net income can change due to many factors (e.g., reduce hired labourers, cut unnecessary

Role of game leader (researcher and team)	Role of players	Knowledge integrating/sharing in game
		costs/expenses).
Conclude the results: focus on the players who encroached on the forest and whether they got a good income or not.	Share opinions.	Share learning about farming on limited land resources and the risk of encroaching on forests for farming.
Lunch		
<u>Round 3</u> (Drought scenario): Drought was introduced by drawing chance cards before harvesting		
Announce the start of the next round (year). Players are allowed to increase their farmland.	Repeat the same steps as the first round.	Learn about uncertainty: if they encroach on forests, their income might not be as good as they expect because natural uncertainties are not able to be controlled. They have to prepare or improve their current farming techniques.
Before harvesting step, announce that "the weather is difficult to predict. This year will have a drought. But the severity is dependent on the chance card. There are three levels of drought: extreme, severe and normal, which can decrease crop yields by 50%, 33% and 25%, respectively."	Farmers who encroach on the forest draw a chance card (pay 100,000 Baht to game leader if arrested).	
	Farmers draw a chance card, record their productions and calculate a net income based on the effects of the drought.	
Conclude the results: focus on the drought situation in reality and monitor the income dynamics.	Share opinions.	
<u>Round 4</u> (Free trading scenario due to the opening of the ASEAN Economic Community): Crop prices are reduced due to many imported cheap crops from neighbouring countries to Thailand		
Announce the start of the next round (year). Players are allowed to increase their farmland.	Repeat the same steps as the first round.	Learn about the effects of government policy on crop prices and the effect of international trading. Moreover, worse situations can appear continuously for many years, therefore, they have to adapt current farming practices again, especially for monoculture cassava.
Before the harvesting step, announce that "now Thailand is open to the AEC due to the Government and inter-government policy. Many cheap agricultural products are now being imported into Thailand. This will effect local crop prices by decreasing 50% of their recent price."	Farmers who encroach on the forest must draw a chance card (pay 100,000 Baht to game leader if arrested).	
	Record the productions and calculate net income based on the 50% decrease of crop prices.	
Conclude the results: focus on the situation in reality and other government policies related to agriculture.	Share opinions.	
Coffee break		
<u>Round 5</u> (Increasing populations occurred in the villages): Family members increase twice for each player		
Announce the start of the next round (year). Players are allowed to increase their farmland. Announce that "we already played four rounds representing four years in reality. Now the population is increasing in the village. The number of family members double for all players. Do not forget to increase your expenses."	Repeat the same steps as the first round.	Learn about the current situation in the villages. This information came from local statistics, so farmers have to prepare for an increasing population in the near future under land limitation constraints.
Before the harvesting step, announce the drawing of a chance card of drought again.	Farmers who encroach on the forest must draw a chance card (pay 100,000 Baht to game leader if arrested).	
	Farmers draw a chance card, record their productions and calculate a net income based on the effects of the drought.	
Conclude the results: focus on a rapidly increasing population in the village.	Share opinions.	
Debriefing and plenary discussion		

Role of game leader (researcher and team)	Role of players	Knowledge integrating/sharing in game
Debrief the gaming session.	Share opinions.	Increase adaptive capacity to confront future uncertainties.
Discuss and identify other possible problems in the village.	Discuss and identify other possible problems and rank the priorities of solving or mitigating them.	Learn about the current problems and possible problems in the villages.
Discuss and identify feasible plans or actions to avoid/prevent/mitigate negative effects from unpredicted factors.	Discuss and identify plans/actions from the ranked results.	Share learning on co-management.
Learning evaluation: ask players to list the new knowledge that they have gained from the workshop.	List new knowledge obtained from the workshop on a small piece of paper.	Increase adaptive capacity to confront future uncertainties.
Collect answers and make a final list of learning aspects on a piece paper, then ask each player to evaluate their degree of learning or understanding with regards to each aspect.	Individual evaluations.	Share what other players have learned and self-evaluated.
Role-play game evaluation: ask player to evaluate the game and identify how it could be improved.	Share opinions.	Learn how to use the new tools for learning.

impacts of forest encroachment and national park law implementation. Then, a plenary discussion about the other problems that farmers confront in reality, as well as potential future problems due to uncertainty of the system, such as plant diseases, deterioration of soil quality, water shortages, was conducted. After which, a collective identification of the feasible plans or actions to adapt to such issues.

Learning and RPG evaluation

After the completion of the workshop, players were asked to list the knowledge they had obtained from the gaming session on a small piece of paper. All answers were then listed on the public board. Each player then evaluated his/her degree of learning per topic by giving a maximum of five points for full understanding and zero if they did understand. This allowed players to share what they had learned and gave them a chance to evaluate the topics again.

3. Results and discussion

Gaming session atmosphere

The atmosphere of the game and simulation using the RPG was very enjoyable (Figures 6). Farmers understood that the game was a tool for learning and not only for playing by children. They were able to link the game features to reality by recognising that the green colour on board represented conservation forest and the yellow colour represented farming area. They could also indicate where the mountain, canal or location of their farmlands were. During the debriefing and plenary discussion session, the participants exchanged their personal experiences and knowledge with each other. It should be noted that although some elderly farmers had problems with writing and calculating, game assistants were able to help them to overcome these problems. After the game, the farmers were willing to attend additional games and simulations again in the future.

Scenario explorations

Changes in income, which was a key indicator for farmers, from the initial scenario to the end of the fifth scenario is presented in Figure 7. From this figure, it is notable that five players who had the highest agricultural areas and investments could have negative income because they have poor agricultural management, such as buying too much fertiliser and employment in all stages of cultivation (e.g., spraying fertiliser, spraying pesticide and harvesting). This included the 9th, 11th and 12th players from Dong Bang Village, 13th player from Wang Mon village, and the 11th player from Chaimongkol village. After the game, most of the farmers from Dongbak, Wangmon and Chaimongkol were able to calculate costs and incomes in each year. Moreover, through the results from the different scenarios and the discussions at the end of each round, players realised that the expansion of farmland areas might not make them get good net income because of many uncertainties and high family expenses.

Farmers' learning from gaming sessions

Individual learning: Individual farmers learned about the interactions between components from different scenarios. They observed the individual impacts, especially the reduction of net income. For example, in the simulation in game of the drought year, all farmers agreed that it was possible in reality. Some of them said the wet and dry seasons are now difficult to predict compared to the past. Moreover, they learned the impact of government

Figure 6 Atmosphere of the game, introduction to the game materials, and participatory identification of farming investment costs and production prices (A); Atmosphere during the crop planting stage in the simplified game board (B); Knowledge sharing during debriefing and plenary discussions (C)

policy in free trading via the AEC scenario. All farmers agreed that the AEC might affect them in the near future because they had already bought agricultural products such as Chinese pears, seedless oranges, apples and bananas from markets for a very cheap price. Lastly, in the final scenario of an increasing population, all of them agreed that family expenses would increase. A player from Wangmon village mentioned that there are two nieces in her family and that she had just realised the increasing expense when she has recorded the family's expenses during the gaming session. All players said that they never created a household account.

Furthermore, the self-evaluation after the game showed that individual famers learned differently for different issues (Table 4). Some farmers learned knowledge about agriculture (score 5.00±0.00), some have the opportunity to communicate and share their agricultural experiences with their neighbours (score 4.92±0.27) because they had never before shared any agricultural problems in their real lives. The participants understood the problems and risks of farming in the conservation areas and they were now prepared for the adaptation (score 4.92±0.27) after having discussions from the game and simulation. Other than that, the players learned how to calculate the costs of farming (score 4.92±0.27) and calculate the household expenses (score 4.91± 0.29), something which they had never done before in real life. All of them said that they would cut unnecessary items in future.

Shared learning: After the debriefing and plenary discussions about the possible problems that could emerge from the interactions among diverse factors and farmers' decisions, players identified the possible problems (as shown in Table 5). Players ranked that drought and water shortages (100% of players), and pest and plant disease (100% of players), are the most important problems in the area. Following this, soil quality problems (such as infertile soil, hard soil, soil difficult to absorb water) and farmers' lack of knowledge to improve it is the second most important problem (64.86% of players). Most of them said they attempted to use fertilisers in the farm but the production was still not good enough. The other mentioned problems were price reductions that farmers couldn't control (48.65% of players), farmlands that were taken back by the Government, and not being allowed to dig ponds in recent farming area (29.73% of players), as well as increasing fertiliser and pesticide costs (24.32% of players).

To solve or mitigate these problems, players discussed and identified some possible actions, including growing more varieties of crops to avoid price fluctuations, using organic fertiliser and homemade compost to reduce costs, animal husbandry such as ducks, and cut the cost is not important. Consequential, they mentioned that they wanted to learn techniques to improve their crop yields. They requested researchers create another workshop using this kind of learning tool with them. They proposed to learn about how to improve crop yields and soil quality.

Players' evaluations

From the results of the evaluations, all participants enjoyed the activities and were willing to attend this kind of activity again. They have a desire to learn about specific agricultural knowledge as well, particularly about growing cassava because it is the major cash crop in the village. To improve the role-play game, players said that calculating the cost of farming and the cost of the family is very important, but the recording sheet is too complicated for farmers. They recommend changing the recording sheet to make it easier to use.

4. Discussion

RPG and awareness raising

Despite the Royal Thai Government implementing laws of returning forests to protect forest cover and arresting many local farmers who illegally encroach on forest areas, many local farmers still do not realise that it is a serious problem because they do not have enough income for their living and they do not have proper knowledge about agriculture in limited area. Therefore, the invasion of conservation areas continuous to be an important issue that leads for conflicts between local people and government. In addition to the strict laws, a

Figure 7 Dynamics of net incomes (Thai Baht) of players (represented by numbers) in Dongbak (A), Wangmon (B) and Chaimongkol (C) villages (farmer type: A=orange, B=yellow and C=green)

participatory or bottom-up approach, supported with diverse tools, has recently been accepted worldwide to make people understand the situation and prepare for adaptive management. The RPG is a kind of participatory model that has been proven as an effective tool for shared learning and improving the adaptive management capacity of local people through the different scenario explorations [10, 28-30].

Therefore, this research created an RPG for learning purposes by representing key components and interactions in the system [31]. The game is simple and easy to follow, but key dynamic interactions occurred in the game for players to observe. Different possible scenarios linked to reality were simulated for players to broaden their perceptions. If the game is effective, it will lead to self-realisation for the players. Then, the players may adapt their behaviours to better manage natural resources [32].

The results from the three gaming sessions revealed that the RPG is a suitable tool to stimulate the awareness of farmers about farming in area surrounded by national park and prepare them to confront future uncertainties. The farmers could follow the game and understood the results from the different scenarios. For example, in the first round of the game and simulation, farmers decided not to invade the conservation area in order to not be arrested or punished. However, after the second round of game, three unexpected phenomena were simulated, i.e., drought, the AEC open market and an increasing human population in the villages. These events caused income reduction to the point that they did not have enough money for them. This encourages them to risk invading the areas surrounded by national park because of their high abundance and beneficial crop yields. However, the results from the gaming sessions showed that although they increased their farmlands by invading the conservation area, their production and income were still at a loss because of weather conditions, high family expenses and debts.

After the farmers understood the future possibility, all of them realised the existing and possible problems in the area (even though some of them answered in the pre-test that there were no problems in the area and that everything was fine). They all realised that they should change their current farming practices. They say they do not want to encroach on protected areas in the future.

Table 4 Self-learning evaluation of players

No.	Learning and satisfaction	Score (mean±SD)
1	Knowledge of agricultural processes	5.00±0.00
2	Engage and share experiences with each other	4.92±0.27
3	Recognizing and adapting to life in a conservation areas	4.92±0.27
4	Knowledge of how to calculate the costs for farming	4.92±0.27
5	Knowledge of cost accounting and households	4.91±0.29

Table 5 Issues of farming in area surrounded by national park raised by the farmers after the plenary discussion

No.	Problems in the study area raised by the players	Percent
1	Drought and water shortages (37 players)	100%
2	Insects, weeds, plant diseases, fungi (37 players)	100%
3	Lack of knowledge to improve soil quality (24 players)	64.86%
4	The price of products has decreased and the farmers cannot control them (18 players)	48.65%
5	Cultivated areas located in the national park are returned to the government and cannot be dig for water storage. (11 players)	29.73%
6	Prices for buying fertiliser, pesticides and herbicides are high (9 players)	24.32%

Then after the plenary discussions, diverse feasible actions were proposed and exchanged among them based on their different experiences. This proved that the game can support shared learning and information sharing among low-formal education farmers.

RPG and future learning

Not only awareness was raised after the gaming sessions, farmers realised that they still have limited knowledge on good farming practices. They were enthusiastic to learn more by proposing researchers to conduct a new game focused on soil quality improvement and cassava planting. They said the game allowed them to think, interact, learn, and exchange their experience with other farmers. This showed that they understood the benefits of gaming and simulations, especially for shared learning [27]. Moreover, a willingness for continuous learning is very important for sustainable natural resource management [22]. As a result, the research team considered their request and plans to create a new RPG for them.

5. Conclusions and perspectives

Farm area expansion in the area surrounded by national park is a major problem in many developing countries. Strict laws by the government sometimes enforcement does not work and creates tensions between farmers and government officers because farmers usually have low-formal education and lack awareness about improving their farming practices. Therefore, this research applied the concept of participatory modelling by using a role-playing game (RPG) with low-formal education farmers in a national park, located in north-eastern Thailand, in order to increase their awareness on farming in the area surrounded by national park and prepare them to adapt to future uncertainties.

Based on the results from the gaming session and plenary discussions, we concluded that the simple RPG with its simplified landscape proved an effective learning tool for low-formal education farmers. It can be used to raise farmers' awareness about farming in that areas and about future uncertainties by showing the significant key interaction between components in the system. Based on the evaluation results, farmers changed their perceptions and seemed likely to change their behaviours in reality. Moreover, the game could also encourage farmers to learn more about the right approach farming. After the game, farmers proposed the idea using the game to learn about soil quality improvement and cassava planting to prevent forest intrusion. Therefore, needs for an ongoing process is required. The research team plans to create a new role-playing game and use it with them in the near future to improve their quality of life in areas surrounded by national park as well as to protect the forest.

Acknowledgements

We would like to thank the Department of National parks, Wildlife and Plant Conservation for their permission to conduct our research (TS 0907.4/876). This research is supported by the National Research Council of Thailand (2558RPCS52033/158387) and the 90th Anniversary of Chulalongkorn University, Rachadaphisek, Sompoch Scholarship (GCUGR1125572035D No.27).

References

[1] Food and Agriculture Organization of the United Nations (FAO). **Global Forest Resources Assessment Country Reports [Internet]**; 2017 [cited 15 April

2017]. Available from http://www.fao.org/documents/en/

[2] Royal Forest Department. **Forestry information [Internet]**. Royal Forest Department; 2017 [cited 15 July 2017]. Available from http://forestinfo.forest.go.th/55/

[3] Phu Kao-Phu Phan Kham National Park. **Phu Kao-Phu Phan Kham National Park [Internet]**. Department of National park, Wildlife and Plant Coservation; 2011 [cited 15 July 2017]. Available from http://park.dnp.go.th/visitor/nationparkshow.php?PTA_CODE=1050

[4] Ministry of Natural Resources and Environment. **National Environment Board Announcement [Internet]**. Ministry of Natural Resources and Environment; 2015 [cited 15 July 2017]. Available from http://www.onep.go.th/?page_id=21888

[5] Land Policy Study Forum. **Land Management Research [Internet]**. Land Management Research Group; 2009 [cited 15 July 2017]. Available from http://landforum.trf.or.th/index.php/en/research-project-.html

[6] Sustainable Agriculture Foundation. **Swidden/ Rotational framing system [Internet]**. Sustainable Agriculture Foundation (Thailand); 2016 [cited 15 July 2017]. Available from http://www.sathai.org/index.php

[7] Castella JC, Kam SP, Quang DD, Verburg PH, Hoanh CT. Combining top-down and bottom-up modelling approaches of land use/cover change to support public policies: Application to sustainable management of natural resources in northern Vietnam. **Land Use Policy**. 2007; **24** (3): 531-545. doi:http://doi.org/10.1016/j.landusepol.2005.09.009

[8] Barreteau O, Antona M, D'Aquino P, Aubert S, Boissau S, Bousquet F, Daré WS, Etienne M, Le Page C, Mathevet R, Trébuil G, Weber J. Our companion modelling approach. **Journal of Artificial Societies and Social Simulation**. 2003; **6** (1).

[9] Trebuil G. **Companion Modelling for Resilient and Adaptive Social Agro-Ecological System in Asia**. Proceedings of the 4th National Agricultural Systems Conference "Agricultural for Community and Environment Ready to Handle Climate Change"; 2008: 90-104.

[10] Etienne M. **Companion Modelling: A Participatory Approach to Support Sustainable Development**. France: Springer Dordrecht Heidelberg; 2014.

[11] Dumrongrojwatthana P, Le Page C, Gajaseni N, Trébuil G. Co-constructing an agent-based model to mediate land use conflict between herders and foresters in northern Thailand. **Journal of Land Use Science**. 2011; **6** (2-3): 101-120.

[12] Worrapimphong K, Gajaseni N, Le Page C, Bousquet F. A companion modeling approach applied to fishery management. **Environmental Modelling & Software**. 2010; **25** (11): 1334-1344.

[13] Naivinit W, Le Page C, Trébuil G, Gajaseni N. Participatory agent-based modeling and simulation of rice production and labor migrations in Northeast Thailand. **Environmental Modelling & Software**. 2010; **25** (11): 1345-1358.

[14] Kriz WC. Creating Effective Learning Environments and Learning Organizations through Gaming Simulation Design. **Simulation & Gaming**. 2003; **34** (4): 495-511. doi:10.1177/1046878103258201

[15] Dionnet M, Daniell KA, Imache A, von Korff Y, Bouarfa S, Garin P, Jamin JY, Rollin D, Rougier JE. Improving Participatory Processes through Collective Simulation: Use of a Community of Practice. **Ecology and Society**. 2013; **18** (1). doi:10.5751/ES-05244-180136

[16] Salvini G, Paassen VA, Ligtenberg A, Carrero GC, Bregt AK. A role-playing game as a tool to facilitate social learning and collective action towards Climate Smart Agriculture: Lessons learned from Apuí, Brazil. **Environmental Science & Policy**. 2016; 63: 113-121. doi:http://dx.doi.org/10.1016/j.envsci.2016.05.016

[17] Vongsumedh P. The development of game prototype as an educational supplementary tool to enhance student's English skill: a case study of grade 1 to grade 3 students. **Journal of Thai Interdisciplinary Research**; **11** (3): 16-23.

[18] Clapper TC. The Way Forward for Simulation & Gaming (S&G). **Simulation & Gaming**. 2016; **47** (1): 3-6. doi:10.1177/1046878116633349

[19] Turocy TL, Stengel BV. Game theory. Encyclopedia of Information Systems, **Elsevier Science** (USA). 2002; **2**: 403-420.

[20] Le Page C, Dray A, Perez P, Garcia C. Exploring how knowledge and communication influence natural resources management with REHAB. **Simulation and Gaming**. 2016; **47** (2): 257-284. doi:10.1177/1046878116632900

[21] Sher S. Confidential Communication: A Corporate Social Responsibility Game. **Simulation & Gaming**. 2015; **46** (5): 591-630. doi:10.1177/1046878115600923

[22] Stave KA, Beck A, Galvan C. Improving Learners' Understanding of Environmental Accumulations through Simulation. **Simulation & Gaming**. 2015; **46** (3-4): 270-292. doi:10.1177/1046878114531764

[23] Non Sang district. **Demographic information**. Department of Non Sang district, Nongbualamphu Province, Thailand; 2016.

[24] Yamane T. **Statistics: An introductory analysis**. New York, NY: Harper & Row; 1973.

[25] Barreteau O, Bousquet F, Attonaty JM. Role-playing games for opening the black box of multi-agent systems: method and lessons of its application to Senegal River Valley irrigated systems. **Journal of Artificial Societies and Social Simulation**. 2001; **4** (5): 5.

[26] Trébuil G, Kam SP, Turkelboom F, Shinawatra B. **Systems diagnoses at field, farm and watershed levels in diversifying upland agroecosystems: towards comprehensive solutions to farmers' problems**. In: Teng *et al*, (ed.) Applications of systems approaches at the farm and regional levels. Great Britain: Kluwer Academic Publishers; 1997: 99-114.

[27] Crookall D, Thorngate W. Acting, Knowing, Learning, Simulating, Gaming. **Simulation & Gaming**. 2009; **40** (1): 8-26. doi:10.1177/1046878108330364

[28] Bassi AM, De Rego F, Harrisson J, Lombardi N. WATERSTORY ILE: A Systemic Approach to Solve a Long-Lasting and Far-Reaching Problem. **Simulation & Gaming**. 2015; **46** (3-4): 404-429. doi:10.1177/1046878115580412

[29] Davidsen PI, Spector JM. Critical Reflections on System Dynamics and Simulation/Gaming. **Simulation & Gaming**. 2015; **46** (3-4): 430-444. doi:10.1177/1046878115596526

[30] ElSawah S, McLucas A, Mazanov J. Communicating About Water Issues in Australia: A Simulation/ Gaming Approach. **Simulation & Gaming**. 2015; **46** (6): 713-741. doi:10.1177/1046878115580410

[31] Peri S. **Community involvement key to forest management**. The Brunei times; 2011.

[32] Gurung TR, Le Page C, Nima C, Choney R, Landy F, Trébuil G. **Companion modelling to enhance spring water collection and sharing in East Bhutan [Internet]**. CPWF PN25, RNR Research Centre, Ministry of Agriculture, Wengkhar, Bhutan.; 2009 [cited 15 July 2017]. Available from http://agritrop.cirad.fr/553533/1/document_553533.pdf