

# Participatory Simulations of Competing Aquacultural and Agricultural Land Uses in Bac Lieu Province, Mekong Delta, Vietnam

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## Abstract

Rice and black tiger shrimp (*Penaeus monodon*) are produced in coastal area of the Mekong, Vietnam under different patterns depending on biophysical and social economic conditions. In the north part of Bac Lieu province in the Mekong Delta, competitions for land used among these farming systems have been appeared. Rice and shrimp rotation farming has been gradually encroached by shrimp monoculture due to its higher economic return. Monoculture of shrimp in a large scale however would hardly reach sustainability. This study aims to make explicit the criteria used by local producers in choosing their land use. To collectively discuss about these criteria and to build a common understanding of this complex agro-hydro system, we have been using role-playing games (RPGs). Three RPG sessions have been organized in three selected villages in Bac Lieu coastal province in the Mekong Delta (i) to understand the competition of land used between rice and shrimp production at a village level; (ii) to understand decision making of farmers under complex biophysical and socio-economic conditions. By playing their own role during a RPG session, local farmers are embedded in participatory simulation. Following the companion modeling approach, the next methodological step will consist in implementing an agent-based model to formalize the shared representation that was built during RPG sessions. Local farmers are then expected to be comfortable in following and discussing computer simulations as they will be able to relate the “agent-based simulations” to what they have experienced as participants of “players-based simulations” (the RPG sessions).

**KEYWORDS:** Companion modeling, Mekong Delta, participatory simulation, rice and shrimp production, role-playing game.

## Introduction

The Mekong Delta in Vietnam covers roughly four million hectares of land. It is a most productive area for rice and aquaculture production in the country (Wilder and Phuong, 2002). Bac Lieu province occupies an area of 254,700 hectares in the coastal zones of the Mekong Delta. Aquaculture product, particularly black tiger shrimp (*Penaeus monodon*) and rice are two major products of the province.

In this province, besides being grown in areas where fresh water is available year-round, rice crop is also encouraged in areas where fresh water is supplied only in the rainy season and brackish water shrimp is possible in the dry season. Due to much higher profit, shrimp production has been preferred by farmers over rice, in particular in the acid sulphate soil area at the western part of the province (Figure 1). Therefore in stead of rice-shrimp rotation according to water quality supplied seasonally, shrimp monoculture has gradually encroached on the rice land in the province. However shrimp monoculture would be much sensitive to environment, high risk and considered unsustainable in the long term. The vulnerability of shrimp monoculture appears more in the area where limited

saline water is supplied in the dry season. Moreover, to expect a higher benefit from shrimp, the producers have attempted to increase the intensity level regardless scientific recommendations. Shrimp producers therefore are not only competing against rice producers by declining rice area, but also can affecting each others among shrimp farmers.

Several issues concerning land used decision making such as uncertainty, sustainability and economic differentiation involving farming of rice-shrimp rotation and shrimp monoculture system have been questionable. Among these issues, the uncertainty and economic differentiation in the communities where people practiced these farming systems have been investigated. However, none of them have been studied under dynamic conditions so far. An innovative approach of companion modeling (Bousquet *et al.*, 1999) is first time applied for this study. This approach would expect to (i) to understand the competition of land used between rice and shrimp production within a village level; (ii) to understand decision making about choosing between rice and shrimp production under complex biophysical and socio-economic conditions; (iii) to provide a supportive tool for promoting dialogue about water demanded from both rice and shrimp producers at different villages in different parts of the province; and (iv) to understand the dynamic of economic differentiation among producers who are farming different production systems in the province.

In this paper, we present and discuss the first series of Role Playing Game (RPG) sessions that were conducted in three selected villages (locations in Figure 1) in Bac Lieu coastal province in the Mekong Delta during the summer 2006.

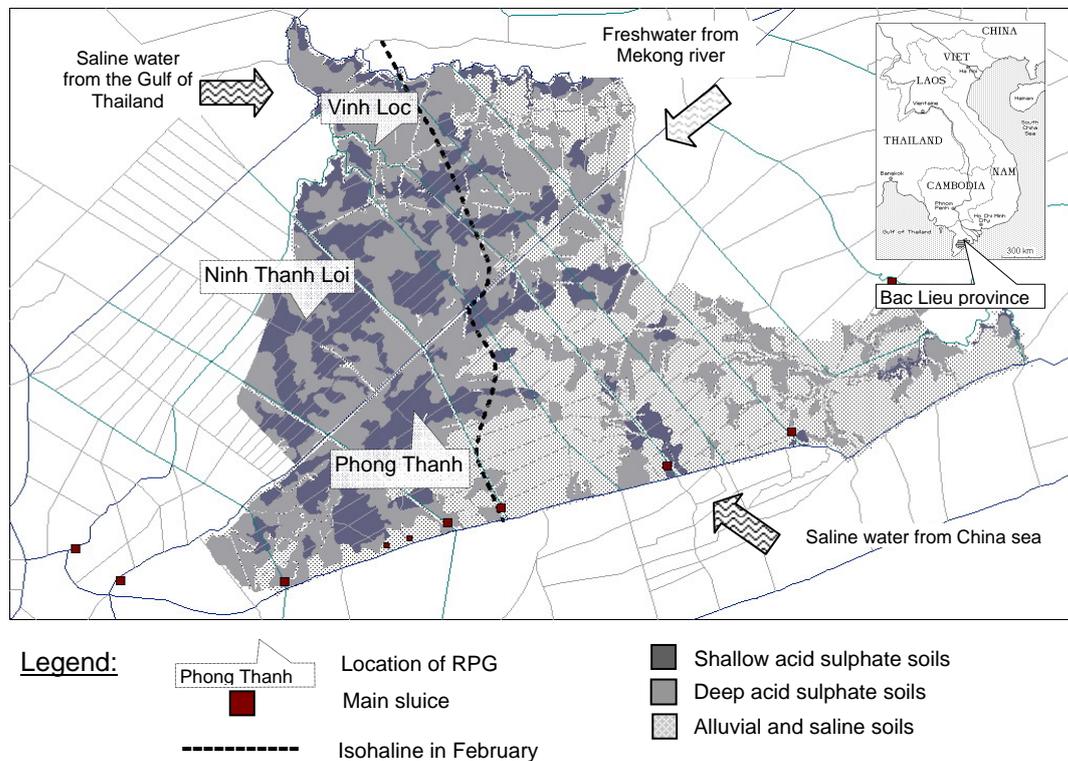


Figure 1: Location of RPG sites in Bac Lieu province, Mekong Delta, Vietnam

## Materials and methods

### Tackling the complexity of agro-systems based on rice and shrimp production

Rice and shrimp production systems rely largely upon the interactions between biophysical and socio-economic factors. These factors would be land/soil conditions, water quantity and quality, weather, market price of inputs and outputs, and also risk of losses due to shrimp diseases. Among these factors, water for rice and shrimp farming is of most importance. Saline water from the sea is supplied through sluices connected with a dense canal network (Figure 1). The sluice and canal system is managed by a provincial water control authority, the Company for Hydraulic Works Operation since it is functioning to control water supply for a large part of the province.

Although the construction of sluices is generally fixed, it can be flexibly operated to take saline water for shrimp production in the dry season. Before the beginning of that season, the provincial authorities approve a planned schedule of opening and closing the sluice system, but during the dry season this schedule may be adjusted depending on the salinity in the canal system and the instantaneous demand for shrimp production. However, due to the difference in water quality required for rice and shrimp production in different parts of the province, a significant adjustment of the sluice operation schedule would require long time for approval of the provincial authorities, and usually can be applied only in the next year. This means that farmers have to adapt to a planned water condition during their cultivation season when making their decision on either shrimp and/or rice production. Farmers' decisions are related to this water supply schedule, but also to other factors directly affecting their production such as capital availability, input supply, market price of inputs and products, etc.

Two main types of competition among rice and shrimp producers exist in Bac Lieu province. The first one is a competition of land within a village for shrimp production in wet season that would have been allocated for rice production. The second one is the conflict in water demand required by both rice and shrimp producers at the same time in different villages served by a sluice and canal system. In developing models to tackle the complexity of such agro-systems and at the same time to mitigate conflicts, the related methodological framework should promote dialogue among the stakeholders and enable them to discuss about sensitive issues in a dispassionate context.

Companion modeling (ComMod) is a modeling approach used as a tool in the mediation process. As an adaptive methodological framework, ComMod has to be implemented to co-evolve with the social process (Bousquet *et al.*, 2005). Role-playing games (RPGs) are widely used in ComMod. They are used as a social laboratory where stakeholders, asked to play their own role, can experiment some decision-making (the relation to the way they are doing in reality has to be investigated) with presumably few consequences in the real world. It may represent an interesting arena for discussion. In the next section, the structure of the RPG that has been played in three villages in Bac Lieu Province (Figure 1) is presented.

## General structure of the model

Stakeholders directly used natural resource and those who supported for production systems are included in the initial conceptual model. Their roles and functions are presented in Table 1. The UML (unified modeling language) (Le Page and Bommel, 2005) class diagram shows the structure of the initial conceptual model (Figure 2). Each box represents either a stakeholder or a physical component of the system. It contains attributes or characteristics of each entity and various methods defining its behaviors. The extremities of an association are indicating its multiplicity (an integer or a range of integer values) and the role of this class under the other class's point of view. These are obtained by analyzing secondary data as well as checking with local relevant stakeholders, especially through employing key informant panel (KIP) interview in the study area.

Table 1: Selected stakeholders and their roles in the production systems

Stakeholders	Roles/functions in the production systems
Farmer	<ul style="list-style-type: none"> <li>To produce rice in their rice or rice-shrimp fields in rainy season.</li> <li>To produce black tiger shrimp and fish/crab in shrimp or rice-shrimp fields in both dry and rainy seasons.</li> </ul>
Sluice operator	To open/close gate to supply saline water for shrimp production in dry season but not cause damage to rice production in upper stream areas.
Shrimp seed supplier	To provide shrimp seeds and fish fingerling to farmers for stocking
Middle man	To visit the farm for buying marketable shrimp, fish and crab by cash Price of products is bargained between middle man and farmers.
Government Bank	To provide loan to farmers for rice and shrimp production based on their farm size and production capacity.

Figure 3 is a sequence diagram of the model that has been applied in the game. Time step of the model is set of one month. Therefore within one year there are twelve steps corresponding to twelve months. At beginning of the sequence the farmer checks his/her household economic condition before

deciding whether to borrow loan at government bank. Within the year the farmer can produce either shrimp or rice crop according to seasonal salinity which is dependent on water supplied from the canal. The last action is to update economic status after selling all products to the middle men.

### Implementation of role playing game

Saline water is the most important factor for shrimp production. Based on information from participatory meetings and KIP interview early, two scenarios of saline water supply were played during the RPG sessions: (1) Early opening (early February) and then sufficient saline water supply; and (2) Late opening (early to mid March) and then insufficient saline water supply.

In each RPG session, we invited both husband and wife of eight farm households randomly selected in the village. However, not all of them could participate in the game. In Phong Thanh and Vinh Loc there were only 4 couples and 4 single players, and in Ninh Thanh Loi only 5 single players came. Players were free to discuss with each others during the game.

According to the saline water scenarios announced at the beginning of the RPG session by the sluice operator, players were asked to make decisions about borrowing loan from the bank, buying shrimp seed and material, deciding time to start their cropping and so on (see the sequence of basic decisions in Figure 3). In addition, risks of shrimp disease and losses at harvest were also randomly imposed during farming period in the game.

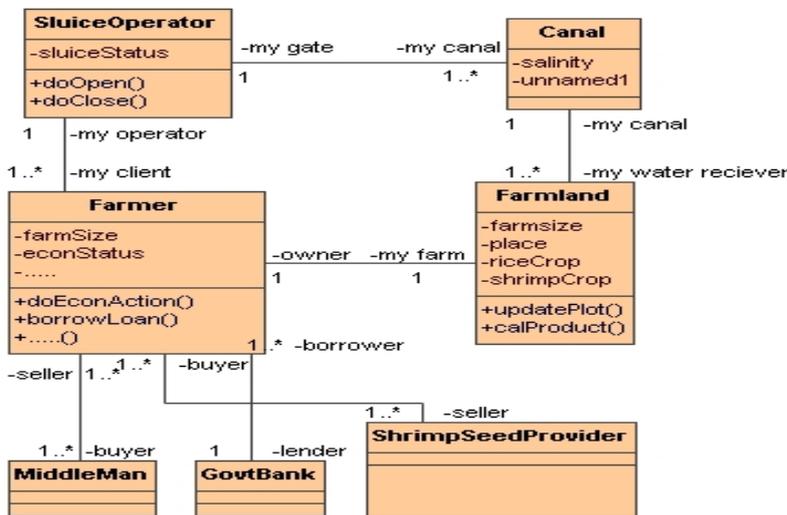


Figure 2: Class diagram of initial conceptual model of Bac Lieu case study.

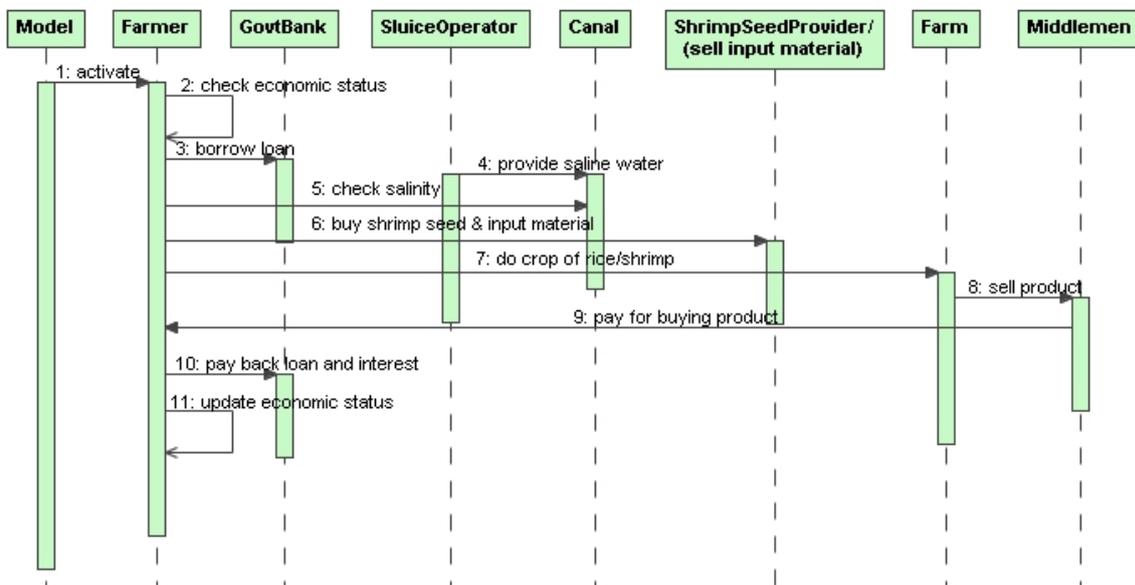


Figure 3: Sequence diagram of initial conceptual model applied in RPG at Bac Lieu case study

## Results

Average incomes by scenario and site of RPG sessions were used to understand the development trend of production systems. Key features of players' decision making as well as their production outcome are presented in Table 2 below.

The first series of RPG sessions conducted in the two first villages (Phong Thanh and Ninh Thanh Loi) show that land-use systems planned by provincial authorities are applied by local people in innovating way. Instead of the proposed shrimp-rice rotation, shrimp monoculture and shrimp-fish/crab are practiced. In these two villages, due to high profits from shrimp and shrimp-fish/crab, farmers are trying to prolong the duration of saline water in their fields instead of replacing by fresh water for rice production. Many innovative techniques have been implemented by farmers for extending shrimp raising duration that lasts approximately eleven months in both scenarios of early and late saline water supply. In the third village (Vinh Loc), shrimp raising duration was much shorter and accordingly the number of stocking times and the shrimp density were lower.

Due to different farm sizes of players, net income per hectare was used for comparison as shown in Table 2. Net income from shrimp in the late saline water scenario was a little lower than that in the early saline water scenario. This reflects the efforts of players in raising more fish and crab to compensate the lost in shrimp production if the supply of saline water is late and insufficient.

Table 2: Total planted area, total yield and price of mango in Upper North in 1999

Site	Scenario	Shrimp raising duration (month)	Shrimp yield (kg ha <sup>-1</sup> )	Rice yield (ton.ha <sup>-1</sup> )	Shrimp net income (VND 10 <sup>3</sup> )	Fish net income (VND 10 <sup>3</sup> )	Rice net income (VND 10 <sup>3</sup> )	Total net income (VND 10 <sup>3</sup> )
Phong Thanh	Early	10.50	412	-	0,671 (94%)	2,068 (6%)	0 (0%)	32,739 (100%)
	Late	10.63	339	-	28,991 (89%)	3,626 (11%)	0 (0%)	32,617 (100%)
Ninh Thanh Loi	Early	11.20	278	-	25,545 (70%)	10,707 (30%)	0 (0%)	36,252 (100%)
	Late	10.20	262	-	22,109 (66%)	11,576 (34%)	0 (0%)	33,685 (100%)
Vinh Loc	Early	6.00	250	3.92	18,172 (74%)	498 (2%)	5,866 (24%)	24,537 (100%)
	Late	5.63	204	3.72	11,551 (68%)	216 (1%)	5,279 (31%)	17,046 (100%)

Source: Synthesis from RPG data in Bac Lieu in 2006.

Note: Numbers in parentheses are percentages of total income

The above remarks are also justified by the income in Vinh Loc village. The total net income in this village was much lower than that in Phong Thanh and Ninh Thanh Loi villages under both saline water scenarios, and income from rice contributed about 24-31% of that total income. Moreover, the late saline water supply to this village caused a sharp decline in the total net income due to a great lost in shrimp production while income from fish/crab was minor (1-2%) and income from rice was almost unchanged (about 5 mil VND).

In summary, players in Ninh Thanh Loi village obtained the highest total net income per hectare in the RPG, followed by Phong Thanh and Vinh Loc villages. Net income from shrimp contributed a large share in the total net income, from 66% to 94%. Late saline water supply highly influenced the total net income by great lost in shrimp production. To compensate this lost, players tried to raise more fish and crab. Income in Vinh Loc village relied on both saline and fresh water resources, while in Phong Thanh and Ninh Thanh Loi villages it completely depended on saline water supply.

## Conclusions

The RPG results reveal different responses of players to the change of environmental factors. This remark is reflected by different decision on shrimp, fish/crab and rice production by farmers in different villages under two saline water scenarios. The results also expose the competition between aquaculture and agriculture. Rice land in Phong Thanh and Ninh thanh Loi villages were used for shrimp and fish/crab production due to high net income, therefore rice crop disappeared, even in the rainy season. Selection of shrimp or rice production is an economic tradeoff for farmers. In Vinh Loc village, however, shrimp and fish/crab can be raised only during shorter period in the dry season. Therefore in this village, rice is still cultivated during the rainy season. So, we could state that due to the water conditions, shrimp production has not completely dominated over rice production in this village yet. In other words, farmers in Vinh Loc village have more diversified income sources from both aquaculture and agriculture.

Conflicts among producers in different villages were not targeted in this series of RPG sessions although they are reflected by the existence of rice crop still cultivated with good harvest in Vinh Loc village while farmers in Phong Thanh and Ninh Thanh Loi villages are trying to prolong the duration of saline water. This issue probably needs to be addressed at a higher management level than village.

The RPG has proved its usefulness for understanding players' decision when they are dealing with changes of environmental factors. As stated by Friedman and Sunder (1994), RPGs are useful experiments to provide data to study behavioral patterns and interactions among participants.

The follow-up step of the study will be the development of computer simulations based on the results from RPGs. Since local farmers have experienced as participants of "players-based simulations" in the RPG sessions, they are then expected to be comfortable in following and discussing computer simulations as they will be able to relate the "agent-based simulations" with the their experiences.

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