

Supplementary Material

An agent-based model to support community forest management and non-timber forest product harvesting in northern Thailand

A. Successive phases of the preliminary studies.

The preliminary studies of this research project consisted of the two main successive phases of the (i) ecological field investigations and (ii) initial participatory modelling and simulation field workshop.

The ecological field investigations were conducted at the study site in 2015–2016 and their results, reported by Wimolsakcharoen (2020) and Wimolsakcharoen et al. (2020), were used by the research team to build its own viewpoint on the issue at stake and the question to be examined with local stakeholders, and to construct the first conceptual model of the community forest SES, as shown in Figure S1.

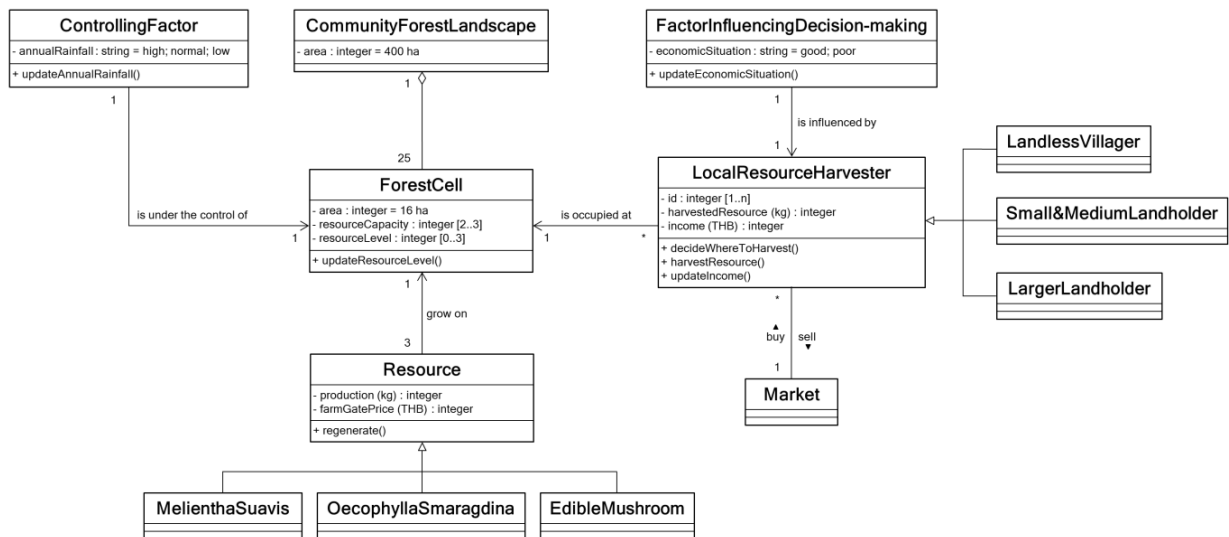


Figure S1: The first conceptual model as a Unified Modelling Language (UML) class diagram.

In the following phase, the first model representing NTFP dynamics in relation to the harvesters’ behaviour was developed. The first model was implemented as a RPG through a two-day field workshop in April 2017 at Chulalongkorn University Research Station, which is located nearby the community forests of village 2 (Figure 1). Thirty-three heterogeneous stakeholders took part in this initial event, including (i) local villagers with no administrative role in CFM covering all the three main types of local resource harvesters, (ii) village leaders, (iii) CFM committee members, and (iv) SAO staff members. Most local villagers avoid sharing their ideas and opinions or arguing with others, particularly when they have to be with their leaders, the participants were, therefore, separated into two groups to participate in this initial workshop on different days. The first group was comprised of the local villagers. Another group was comprised of village leaders, CFM committee members, and SAO staff members. The local leaders (village leaders, CFM committee members, and SAO staff members) already had experience of working with the research team from the previous phase of ecological field investigations. Therefore, they were invited to participate in this initial workshop by the research team based on their role in CFM during the last five years and their willingness to participate. The local villagers were selected by their leaders based on their NTFP harvesting practices. The main purpose of this workshop was twofold: (i) to validate this first model with various types of local stakeholders, and (ii) to explore possible future scenarios for improving the volumes of NTFPs. The results from the first day of this workshop with local villagers confirmed that most of them concede that they have less knowledge and abilities in CFM than their leaders. Based on this perception, they consider that the CFM issues are not their duty, so they tended to remain passive during the plenary debriefing following the gaming and simulation sessions.

The key outputs from this phase were as follows:

- (i) suggestions from the participants to improve the initial RPG and its underlying conceptual model to be implemented as a cRPG. They are mentioned in the main text; and
- (ii) two scenarios proposed by the participating leaders on the second day: firebreak establishment to prevent damages to NTFP resources from wildfire, and introduction of outsiders intensively harvesting NTFPs. Only the scenario of firebreak establishment had been tested through the initial RPG during the second day of the workshop while the introduction of outsiders was proposed during the individual in-depth interviews after the workshop.

Literature cited

Wimolsakcharoen, W. (2020). Ecosystem Function Assessment and Participatory Modelling for Community Forest Management at Lainan Sub-district, Wiang Sa District, Nan Province. Doctoral Dissertation, Chulalongkorn University, Thailand.

Wimolsakcharoen, W., Dumrongrojwatthana, P., & Trébuil, G. (2020). Production of non-timber forest products (NTFPs) and diversity of harvesters' practices and decision-making processes in northern Thailand community forests. *Bois et Forêts des Tropiques*, 343, 39–52. <https://doi.org/10.19182/bft2020.343.a31845>

B. Contents of the semi-structured guideline used for individual interviews of the participants after the field workshop.

Note: Due to the limited number of literate participants, they were interviewed individually and all the information was recorded by the research team.

1. The most striking souvenir from the workshop

- 1.1 What do you (best) remember from the workshop?
- 1.2 What did you get/find interesting/learn?

We started the interview with a couple of broad questions to break the ice and to assess if the interviewee remembers the activities that occurred during the workshop or not. We also showed the poster of photos taken during the workshop to the interviewee to refresh his/her mind before looking for further details.

2. Learning about the issues

- 2.1 What did you learn about (i) the resource dynamics influenced by the number of harvesters, (ii) the benefits from the establishment of firebreaks and declaration of protected areas, and (iii) the roles of outsiders to harvest NTFPs in the community forests?
- 2.2 Did you learn new things regarding the issue of the current CFM problem(s) examined?
- 2.3 Did you feel that it is urgent to take the actions upon this(these) CFM problem(s)?
- 2.4 Did you get better insight in the consequence(s) of the CFM problem(s)?
- 2.5 Did you learn new kinds of possible ways to improve the current situation?

3. Learning about situation and opinions from other participants

- 3.1 Did the workshop process encourage you to exchange your viewpoints with others?
- 3.2 Do you now better understand situation and opinions, concerns and priorities of other players, specifically their NTFP harvesting practices and related decision-making processes?
- 3.3 What were the critical topics you need to discuss together?
- 3.4 What was the result(s) of the discussion(s): what things did you agree on, and on what were the points of disagreement?

4. Collective engagement

- 4.1 During the second participatory gaming and simulation session, what do you think about the collective engagement to establish firebreaks leading to the improvement of resource availability in the community forests? How far they can be done in reality?
- 4.2 Did the workshop process raise your engagement to solve the CFM problem(s)?

- 4.3 Did the workshop process mobilize the community (the representatives from all seven villages and the SAO) as a whole? Does everyone feel engaged to solve the CFM problem issue(s) together? Are there any fractions/disagreements?
 - 4.4 Did the community come to a joint agreement?
 - 4.5 Did you observe any changes in some participants' relationships during the workshop process? If yes, how did they change?
- 5. Specific effects of the model used as a cRPG**
- 5.1 Do you think that the cRPG can help you to better grasp the CFM issues (as mentioned in the second topic) and understand their effects/impacts? If yes, can you specify?
 - 5.2 Do you think that the model can help you to identify the possible ways to improve the current unsatisfactory CFM situation?
- 6. Capacity building**
- 6.1 Did you (or your leaders) organize additional meetings on the CFM issues examined (as mentioned in the second topic) without anyone from the research team?
 - 6.2 Are you interested and capable to lead the workshop process in the future to tackle similar problems?
- 7. Anchoring of the local decision-making process in the context of networking to get the recognition and resources for implementation**
- 7.1 Did you tell what you had done in the workshop to your family member(s), your neighbour(s), or others? If yes, what issues did you discuss? What were their reactions/responses?
- 8. Actions and new practices**
- 8.1 Are there any new actions or/and practices in CFM coming out of the workshop, which have never been proposed before?
- 9. Perspectives**
- 9.1 Do you have any suggestions to improve the cRPG simulation tool or/and the workshop proceedings to be used/organized in the future?
 - 9.2 Do you have any suggestions about the suitable content(s) of future sessions and about who should participate in?

C. Capabilities and resource requirements of the CoComForest model, used as a computer-based role-playing game (cRPG) compared to an autonomous agent-based model (ABM) and a role-playing game (RPG).

The cRPG borrowed several strengths from an ABM such as a high effectiveness in spatial and temporal representations, and the capabilities to process both qualitative and quantitative parameters, as well as to handle uncertainty. However, mainly because of time limitations, the transparency of the cRPG was not high enough for all the participants to understand the results of the gaming and simulation sessions.

Table S1: Capabilities and resource requirements of the CoComForest model, used as a computer-based role-playing game (cRPG) compared to an autonomous agent-based model (ABM) and a role-playing game (RPG).

Desired model characteristics		RPG	cRPG (semi-automatic simulator)	ABM (fully autonomous simulator)
Capability	Spatial representation	Low	High	High
	Temporal (dynamics) representation	Low	High	High
	Processing qualitative results	Medium	High	High
	Processing quantitative results	Low	High	High
	Ease of communicating results	Medium	Medium	Low/Medium
	Transparency	Medium/High	Medium/High	Low
	Ease of modification	High	Medium	Medium
	Supporting feedback loops	High	High	High
	Handling uncertainty	Medium	High	High
Resource requirement	Time and cost	Medium	Medium/High	Medium/High
	Data (empirical)	Low	Medium	Low/Medium
	System knowledge (conceptual)	Medium/High	High	High
	Expertise of modelers	Medium	High	High
	Methodological expertise of stakeholders	Low	Low	Low/Medium
	Computer resources	Low	High	High

NB: A rating of 'Low' means that a tool is less able to produce outputs that have the desired capability/requires less of the resource than is a tool rated 'High' on the similar capability/resource requirement (adapted from Voinov et al., 2018).

Literature cited

Voinov, A., Jenni, K., Gray, S., Kolagani, N., Glynn, P. D., Bommel, P., Prell, C., Zellner, M., Paolisso, M., Jordan, R., Sterling, E., Olabisi, L. S., Giabbanelli, P. J., Sun, Z., Le Page, C., Elsawah, S., BenDor, T. K., Hubacek, K., Laursen, B. K., Jetter, A., Basco-Carrera, L., Singer, A., Young, L., Brunacini, J., & Smajgl, A. (2018). Tools and methods in participatory modelling: selecting the right tool for the job. *Environmental Modelling & Software*, 109, 232–255. <https://doi.org/10.1016/j.envsoft.2018.08.028>