Integrated Participatory Multi-Agent Systems (MAS) Modeling for Collective Watershed Management in the Highlands of Northern Thailand

Dynamics and management of highland natural resources

• Complex resource management problems stem from limited land and water resources and the fragile watershed ecosystem, coupled with multiple users and strategies.
• Population dynamics, market-oriented production, national security, and growing environmental concerns are the key driving forces of complex system dynamics.
• Past single-perspective development approaches failed to solve natural resource management (NRM) problems in such highland agroecosystems. Highland research and development projects have been moving toward participatory and interdisciplinary approaches to better achieve sustainable resource management.
• Adaptive and collective NRM requires participation and coordination among and from all stakeholders, especially local government agencies and other institutions.

MAS and common-pool resource management

• The MAS modeling approach helps to examine and understand the increasing complexity of human-environment phenomena.
• Integrating a participatory approach with MAS modeling, and accompanying tools, provides an open and adaptive platform for interdisciplinary research work. Allowing stakeholders to cooperate along model evolutionary processes facilitates collective management of natural resources.
• However, policy and institutional agents are rarely incorporated into the MAS model.

The Maehae watershed

• Maehae is located in a mountainous area of pine mixed with evergreen and dry-dipterocarp forest in Chiang Mai Province, northern Thailand (see fig. 1).

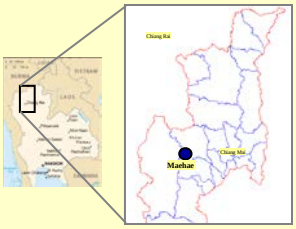
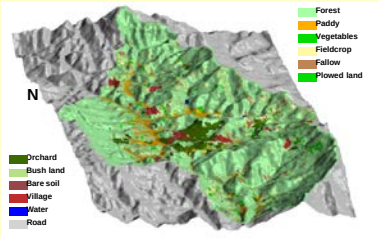


Fig. 1. Maehae watershed location.



• Multiethnic groups have been practicing diverse agricultural systems within this fragile highland watershed environment (see fig. 2).

Fig. 2. Maehae watershed landscape and land use (2000).

• Conflict on resource use arose among communities, villagers, and government agencies because of different points of view and objectives on land and forest resource management (fig. 3).
• Increasing social tensions exist between interconnected upstream and lowland communities (fig. 3).
• The government promotes decentralization aiming at empowering local institutions to participate in local NRM. However, no adapted practical tools and guidelines are provided.

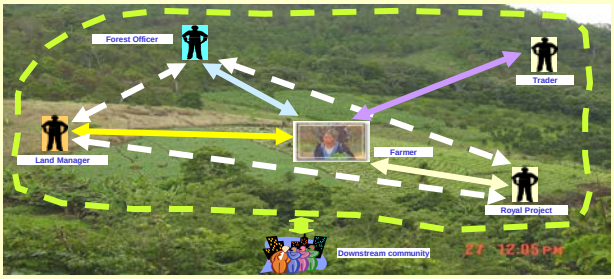


Fig. 3. Bio-physical environment and key stakeholders.

Purpose of the study

• To develop participatory MAS modeling to integrate a spatially explicit biophysical social system, to examine interconnected dynamics at different space and time scales.
• To incorporate policy and local institutions and other key stakeholders in MAS modeling and simulating processes.
• To assess the use of the integrated MAS model in facilitating adaptive learning and collective watershed management processes by researchers and stakeholders.

Research concept and methodology

• Interdisciplinary, participatory, and systems approach.
• Model design and structure using Unified Modeling Language (UML).
• Iterative development of MAS model through stakeholders' participation.
• Integrate biophysical, social, and institutional module under the Cormas platform (http://cormas.cirad.fr).

Prototype model: design and structure

• Stakeholders were identified and characterized based on information from literature review and field visits.
• Natural resources were defined as land, vegetation, and climate to represent biophysical elements.
• The UML class diagram reveals the static structure of stakeholders and other agents with their sets of characteristics and methods, including relationship and association among them (fig. 4).
• Ecological processes and spatial dynamics will be modeled using a soil-crop-climate model based on cellular automata in a spatially explicit model.
• Land resource interventions resulting from decision making of stakeholders will affect biophysical dynamics.

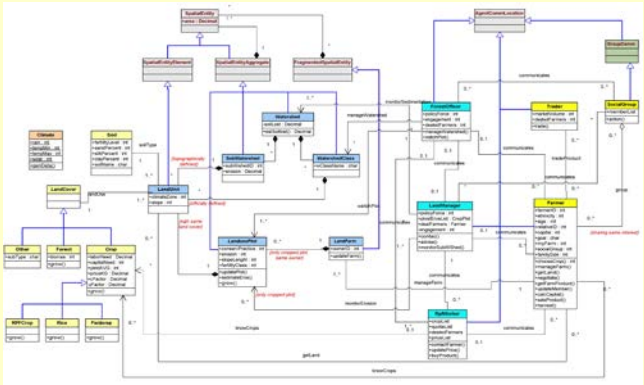


Fig. 4 . UML class diagram representing static structure of the model.

Challenges ahead

• Build the model of stakeholders' representations (perception, decision-making processes, etc.).
• Incorporate political and local institutions into a process of adaptive learning and collective model development.
• Develop a model favoring a shared representation and perception of NRM among all stakeholders.
• Combine biophysical, social, and institutional modules into a single MAS model.
• Encourage and facilitate the identification of collective watershed management scenarios and their assessment by all stakeholders.

Interdisciplinary research team

Panomsak Promburom, Methi Ekasingh, Benchaphun Shinawatra Ekasingh, Chanchai Saengchyoswat, François Bousquet, Guy Trébuil
Multiple Cropping Center, Chiang Mai University, Thailand.
[http://mccweb.agri.cmu.ac.th].
IRRI-Cirad project, Bangkok, Thailand.

IRRI CIRAD