

# Ecoregional research for integrated natural resource management in Southeast Asian rice ecosystems

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With resource management becoming decentralized in many Asian countries, new methods and capacities are needed to support truly interdisciplinary action research in the field of integrated natural resource management (INRM) to facilitate the empowerment of stakeholders. Stakeholders need access to knowledge, understanding of the problem at hand, skills and tools to facilitate communication and negotiation, and the capability to articulate their differing objectives, negotiate their demands, and finally adopt and adapt appropriate interventions at the right scale. The main research challenge is to generate pertinent INRM knowledge and the tools for using it, and to facilitate their free exchange among researchers, policymakers, managers and resource users. This paper highlights the characteristics of promising methodologies and several results obtained through collaborative research.

The three goals of the Consultative Group on International Agricultural Research (CGIAR) — alleviating poverty, increasing food security and protecting the environment — recognize that human well-being depends on the well-being of the systems in which people earn their living. This means recognizing that the livelihood concerns of farmers are closely linked with the status of their renewable resource base and that the resilience of their production systems depends on their adaptive capacity to manage it. To support the sustainable development of a given region, the comprehensive system composed of the land, its people and their activities must be researched. Past research has demonstrated that, to improve livelihoods while ensuring the sustainability and resilience of the resource base, one needs to understand and harness the interactions among policies, institutional settings and human behavior, as well as between human activities and biophysical processes.

The decentralization of resource management is under way in many Asian countries. Methodological development and capacity building are needed to support truly interdisciplinary action research in the field of integrated natural resource management (INRM) to facilitate the empowerment of stakeholders at various levels. To make informed decisions, stakeholders need access to knowledge, understanding of the problem at hand, skills and tools to facilitate communication and negotiation, and the capability to articulate their differing objectives, negotiate their demands, and finally adopt and adapt appropriate interventions at the right scale.

As INRM and environmental problems become more complex, innovative approaches, methods and tools are becoming available to deal with the adaptive management of these systems. An interdisciplinary systems perspective needs to be adopted to tackle the various dimensions of integration in INRM across disciplines and sources of knowledge, geographical and time scales, and the research-development-policy continuum.

The main research challenge is to generate pertinent INRM knowledge and the tools for using it, and to facilitate their free exchange among researchers, policymakers, managers and resource users. In particular, dynamic and interactive modeling tools can be used in communication platforms to help stakeholders understand and simulate biological, physical and social interactions at various spatial scales and hierarchical levels of social organization. Because the researchers' role is to facilitate empowerment, the emphasis is on developing research and operational methodologies while involving stakeholders and forging partnerships at every stage of the process.

## The Ecor (I) Asia initiative

In 1995, the International Rice Research Institute (IRRI) was mandated by the CGIAR to convene the Ecoregional Initiative for the Humid and Subhumid Tropics of Asia, or Ecor (I) Asia. Its main purpose was to empower national agricultural research and extension system (NARES) scientists and research managers with better methodologies for INRM. Activities focused on developing and testing operational research methodologies, and on training NARES scientists on how to use them in the field. The pilot sites were representative of the different agroecosystems, with emphasis on marginally productive and ecologically fragile environments. Partnerships were established among national and international

institutions with complementary roles in line with their mandates, resources and expertise. With a strong focus on a major INRM problem at each site, Ecor (I) activities aimed to:

- strengthening strategic research and development (R&D) partnerships to tackle the problem through information sharing, mutual learning, training and capacity building;
- understand socioeconomic and agroecological dynamics and identify intervention points;
- facilitate the use of INRM knowledge accumulated by diverse stakeholders through the use of interactive tools and negotiation support systems;
- develop interdisciplinary and participatory research on the viability of agroecosystems by associating field surveys with modeling and simulation methodologies, using them with stakeholders to assess scenarios and the effects of technological or organizational interventions;
- support capacity building in INRM nationally and regionally to develop adapted interdisciplinary approaches and tools through collaborative research and training; and
- improve the regional networking of INRM specialists and facilitate communication through effective coordinating mechanisms.

Various approaches and tools were used by the teams working at the pilot sites. This paper highlights several research results obtained through collaboration among NARES institutions, French advanced research institutes (ARIs) and CGIAR Centers. It also presents Ecor (I) training activities in participatory modeling for INRM. The following institutions took part in the Ecor (I) Asian activities described in this paper:

- NARES: Thailand: Department of Agriculture, Chiang Mai University, Chulalongkorn University, Khon Kaen University, Ubon Ratchathani University; Vietnam: Vietnam Agricultural Science Institute, National Institute for Soils and Fertilizers, Can Tho University, Cuu Long Delta Rice Research Institute.
- ARIs: Centre de coopération internationale en recherche agronomique pour le développement (CIRAD); CEMAGREF; Institut de recherche pour le développement; universities of Paris X, Montpellier II and Lyon I; Wageningen University and Research Center; and Center for the Study of Institutions, Population and Environmental Change, Indiana, USA.
- International Institutions: IRRI, Center for International Forestry Research, Resilience Alliance Network and Agent Links Network.

### Land-use changes in the uplands of the Red River basin

In the uplands of northern Vietnam, increasing population pressure, combined with privatization, land redistribution and political reforms, were the main driving forces behind the profound land-use changes that occurred in recent decades. With lowland areas fully exploited, the development of unsustainable agricultural practices on the hillsides endangers fragile upland ecosystems (Kinh et al. 1999). The Mountain Agrarian Systems (SAM) Program set out in 1998 to improve agricultural productivity, natural resource management and the living standards of ethnic minority groups in the highlands. The SAM Program comprised two subprograms. The cropping systems component — based on a preliminary agronomic diagnosis to explain intra- and inter-field heterogeneity and rank production-limiting factors — identified the need to develop improved cropping systems up to the level of the small watershed. A range of low-input alternatives to slash-and-burn agriculture was tested under farm conditions. The advantages and constraints of these innovations were documented and made available to users through demonstration plots, decision support systems and participatory simulations. The complementary regional component aimed to understand the processes of land-use changes and their main driving forces from the farm to the provincial level, prior to introducing technical and organizational innovations. This component identified keys for extrapolating to large geographic areas locally obtained research results and offered new tools to facilitate decision-making in sustainable natural resource management (Kam et al. 2002).

A multi-agent simulation model was developed to test hypotheses, derived from household surveys and remote sensing data, on the mechanisms linking the allocation of paddyland to farm households with shifting hillside cultivation and deforestation. The model represented the diversity of the current land-use systems by analyzing the interactions between land-tenure policies in the lowlands and land-use dynamics in the uplands. Translating these research results into concrete action required incorporating the most recent technical, economic and social changes that accompanied forestland allocation into a participatory process involving local stakeholders. As research and development interventions typically

involve multiple actors, a precondition for communication is a mutual understanding of each other's point of view. We used role-play games, individual interviews, multi-agent modeling and geographic information systems (GIS) to construct a shared representation of their system as a basis for discussion among stakeholders and so enhance communication.

Scenarios of land-use change resulted from dynamic interactions among (i) farmers' strategies (i.e., individuals' decision-making processes as a function of each farms' resource profile), (ii) the institutions that define resource access and use, and (iii) the biophysical and socioeconomic environments. We synthesized the knowledge generated with these tools at a sample of research sites representative of Bac Kan Province to generate a modeling framework named SAMBA. By coupling the model with GIS, we extrapolated the representation of local management rules to the whole province. Participatory simulations helped identify villages with similar trajectories of land-use change for which similar technical and/or institutional innovations could be applied. After developing scenarios of land-use change with stakeholders, we assessed the impact of these changes on the resource base and collectively designed strategies for watershed management compatible with environmental policies (Castella et al. in press).

### **Livelihood impacts of water-policy changes on the Mekong Delta coast**

In the coastal areas of Southeast Asia, the rapid development of brackish-water aquaculture has brought conflicts over the use of land and water resources. This conflict is exemplified in the Mekong River delta, where in 2001 shrimp farmers in Bac Lieu Province destroyed a major water diversion to allow tides to push brackish water upstream to their ponds. This happened within a 250,000 hectare sector of a water control scheme that involved the phased construction of 11 large sluice gates between 1994 and 2000. This was done to increase the area of land protected from inundation with saltwater and so expand and intensify rice production, which was a national priority in the 1990s. The Bac Lieu Poverty Elimination Project, financed by the United Kingdom's Department for International Development, stepped in to help provincial authorities address the complex issues underlying the emerging conflicts between shrimp and rice farmers. Its main objective was to improve the livelihoods of poor people by developing an effective and sustainable strategy for managing land and water resources in the area. Led by IRRRI, the project assembled a multidisciplinary team of researchers from international agricultural research centers, ARIs and several Vietnamese universities, research and planning agencies.

The project applied an integrated, problem-oriented framework for linking multiscale issues of production at the farm level and natural resource management at the regional level. Multidisciplinary investigations provided an understanding of how the dynamics of hydrological change influenced land-use changes and consequently the livelihoods of rural communities. Although many people gained from the construction of the sluices (rice farmers in the eastern part), there were many losers (shrimp farmers in western part, plus many poor and landless farmers dependent on catching wild fish). The authorities recognized the need for policy change towards rural economic diversification, taking advantage of the extensive coastal resources. An opportunity stemmed from results of hydrological modeling conducted by the research team, which revealed that the phased opening and closing of selected sluices would allow a dual regime of saline and freshwater that could accommodate shrimp aquaculture and intensified rice cultivation in different parts of the study area. This prompted the provincial authorities to work with regional planners and the research team to develop a land-use zoning plan and an accompanying strategy for managing water that subsequently received national approval. The hydrological model is now used as a regional management tool for scheduling sluice operation. At the farm level, researchers worked with local communities to adopt and adapt rice technologies for the specific soil and water-quality conditions in areas recently protected from salinity intrusion.

Surveys undertaken from 2000 to 2005 show that, as a result of the *doi moi* (renovation) policy supported by a more structured approach to managing water in the area, the annual per capita gross domestic product of approximately 800,000 people in the province increased from US\$250 to \$650 during the period. The income of poor communities living in areas with acid sulfate soil increased threefold, fishery production increased significantly, and there have been no conflicts between the water user groups since 2002 (Hoanh et al. 2003, in press). The success of the Bac Lieu project hinges upon the active participation of the key stakeholders. These achievements in Bac Lieu Province have interested neighboring provinces in adopting similar development strategies and have boosted the confidence of Bac Lieu provincial government to offer its leadership for a wider regional strategy of integrated water management on the Ca Mau Peninsula of the Mekong Delta.

### Capacity building on companion modeling and multi-agent systems

In 1999, the Multiple Cropping Center in the Faculty of Agriculture of Chiang Mai University organized a training course on multi-agent systems (MAS) and INRM and invited CIRAD to lead it. The aim of MAS is to understand how different processes that are in direct competition are coordinated. Researchers using this approach to INRM see the decision-making process as a series of interactions among stakeholders with various objectives, perceptions, levels or kinds of information, and degrees of influence. NARES colleagues perceived the need for innovative approaches belonging to the science of complexity to better understand and manage the interactions between social and ecological dynamics by relying on key concepts such as adaptive management, social learning and action research.



Following the course, an IRRI-CIRAD collaborative research project funded by the European Union's Asia Information Technology and Communications Program (Asia IT&C) started in 2001 to reinforce training activities on MAS, social sciences and INRM. Internationally renowned researchers delivered courses in Thailand on different disciplines' points of view on the subject, and the IRRI-CIRAD team supported NARES colleagues' development of case studies on problems such as land degradation, land-use changes, integrated watershed management, crop diversification, irrigation water sharing, seed systems, etc. This training process mobilized the expertise available at three public universities in Thailand (Chulalongkorn, Chiang-Mai and Khon Khaen), and 85 scientists from nine countries participated in it.

The project helped to refine and test the companion modeling (ComMod) approach using MAS tools with communities. ComMod facilitates dialogue, shared learning and collective decision-making through implied action research to strengthen the adaptive management capacity of local communities. MAS models integrating various stakeholders' points of view are jointly developed and used for collective learning. Stakeholders are involved in constructing these models to improve their relevance and use through the collective assessment of simulated scenarios. MAS tools are used in an iterative cyclic ComMod process comprising three stages:

- field investigations and a search for existing knowledge to generate explicit hypotheses for modeling,
- modeling (i.e., the conversion of existing knowledge into a formal tool to be used as a simulator) and
- simulations to challenge the former understanding of the system and identify new key questions for investigations in the field.

Generally, the simulator is associated with role-playing games because, intuitively, a MAS model could be seen as a role-playing game simulated by the computer. The games are used with stakeholders so that they can (i) understand the model; (ii) validate it by examining agent behavior and the properties of the system emerging from their interactions, and by proposing modifications; and (iii) follow MAS simulations and propose scenarios to be assessed.

A dozen case studies developed in five Asian countries to assess whether ComMod could be successfully used to support collective decision-making were published in a collective book (Bousquet et al. 2005). Most of the models use the common-pool resources and multi-agent systems simulation platform developed by CIRAD. Eight NARES colleagues are currently studying for doctoral degrees in this field, and the MAS-based ComMod approach for INRM is presented in several university courses in Southeast Asia. A specific methodology to assess the effects and impact of a ComMod process is being designed. It will also guide the evaluation of the improvement of the stakeholders' capacity for collective learning. At the same time, further methodological development of the ComMod approach is under way to upscale the process for facilitating communication among heterogeneous agents and organizations at higher hierarchical levels.

### Conclusion

By understanding how rural people acquire and share knowledge and experience, Ecor (I) Asia activities helped to build capacity for peer-to-peer knowledge development and learning for better decision-making in complex and fast changing systems and at multiple scales or levels of organization. This experience also proved that relevant interdisciplinary approaches and methods for INRM can be developed together with an adaptive and flexible network facilitating inter-institutional activities in Southeast Asia. A key challenge is to foster institution building at the interface between (i) community-based practices and interests and (ii) regional regulations for managing resources to support resilient livelihoods, particularly for the most vulnerable sectors of society. The promising outcomes of Ecor (I) Asia have formed the

bases of continued activities, especially under current projects of the Comprehensive Assessment of Water Management in Agriculture and the CGIAR's Challenge Program on Water and Food.

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## References

Bousquet F, Trébuil G, Hardy B (eds.). 2005. Companion modeling and multi-agent systems for integrated natural resource management in Asia. CIRAD and International Rice Research Institute, Los Baños, Laguna, Philippines. 360 p.

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 23. In press.

Hoanh CT, Tuong TP, Gallop KM, Gowing JW, Kam SP, Khiem NT, Phong ND. 2003. Livelihood impacts of water policy changes: Evidence from a coastal area of the Mekong River delta. J. Water Policy 5(5): 475-488.

Hoanh CT, Tuong TP, Gowing JW, Hardy B (eds.). Environment and livelihoods in tropical coastal zones: Managing agriculture-fishery-aquaculture conflicts. Book No. 2 of CA Series (Comprehensive Assessment of CGIAR), CABI Publishing, UK. In press.

Kam SP, Castella JC, Hoanh CT, Trébuil G, Bousquet F. 2002. Methodological integration for sustainable natural resource management beyond field/farm level: Lessons from the ecoregional initiative for the humid and sub-humid tropics of Asia. Int. J. Sustainable Devel. World Ecol. 9(4): 383-395.

Kinh NN, Teng PS, Hoanh CT, Castella JC. 1999. Towards an ecoregional approach for natural resource management in the Red River basin of Vietnam. The Agricultural Publishing House, Hanoi, Vietnam. 254 p.