Synthesis, part of Special Feature on Integrated Natural Resource Management

# Negotiation Support Models for Integrated Natural Resource Management in Tropical Forest Margins

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## ABSTRACT

Natural resource management research has to evolve from a focus on plans, maps, and regulations to an acknowledgment of the complex, sometimes chaotic, reality in the field, with a large number of actors making their own decisions. As outside actors, we can only try to facilitate and support a process of negotiation among the stakeholders. Such negotiation involves understanding the perspectives of all stakeholders, analyzing complementarities in views, identifying where differences may be settled by "science," where science and social action can bring innovative alternatives for reconciliation, and where compromises will be necessary to move ahead. We distinguish between natural resource management problems at village level, within country, or transboundary, and those that relate local stakeholder decisions to global issues such as biodiversity conservation. Tree-based systems at plot or landscape level can minimize conflicts between private and public interests in local environmental services, but spatial segregation of functions is an imperative for the core of global biodiversity values. The complex agroforests developed by farmers as alternatives to food-crop-based agriculture integrate local and global environmental functions, but intensification and specialization may diminish these non-local values. For local biodiversity functions, a medium-intensity "integrate" option such as agroforests may be superior in terms of resilience and risk management. Major options exist for increasing carbon stocks by expanding tree-based production systems on grasslands and in degraded watersheds through a coherent approach to the market, policy, and institutional bottlenecks to application of existing rehabilitation technologies. Agroforestry mosaics may be an acceptable replacement of forests in upper watersheds, provided they evolve into multistrata systems with a protective litter layer. Challenges to INRM research remain: how should the opportunities for adaptive response among diverse interest groups, at a number of hierarchical levels, be included in the assessment of impacts on the livelihoods of rural people?

**KEY WORDS:** Indonesia, adaptive learning, adaptive options, agroforests, integrated natural resource management, land-use change scenarios, negotiation support models, quantitative impact assessments, scaling rules, stakeholders, sustainability assessments, tropical forest margins.

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# INTRODUCTION

Izac and Sanchez (2001) describe the paradigm shift for international agricultural research from a focus on germplasm and technology development targeted at increased productivity, as such, to "integrated natural resource management" (INRM). INRM, in their view, aims to identify land-use practices that increase production while maintaining natural capital and continuing to provide ecosystem services at local and global scales. Once such practices have been identified, their adoption by larger numbers of farmers can be facilitated by a combination of dissemination approaches and changes in policies. The complex agroforests, developed by farmers in the forest margins of Indonesia, form a prime example of systems that combine local and global functionality and in which removal of negative incentives derived from existing policies has become the major target of INRM intervention (Izac and Sanchez 2001). However, even in this agroforest example, it is not clear why and how farmers can afford to, or are motivated to, care for longer term and externally set objectives, including biodiversity conservation and an increase of terrestrial carbon stocks. The fact that the farmer and external objectives partly coincide in these systems forms no guarantee for the future, if the alignment is "accidental" rather than based on shared values and common perceptions of the likely impacts of change.

Stakeholders other than farmers aim to modify farmer decisions. Although spatial planning and regulations about those land-use practices that are allowed have some impact in countries with strong institutions and good governance, the reality in many tropical countries is otherwise. In common with most "central planning" philosophies, many "development" projects have an overly optimistic view of their possible impact in modifying decisions by millions of rural households and the individuals that constitute them, on how to manage the rural landscape to satisfy their livelihood requirements. Introducing the "natural resource management" terminology, as such, will not make a difference. In this contribution to the debate on international agricultural research support for INRM, we want to focus on:

1. Who are the managers implied in the M of INRM?

2. What is the scale at which the various natural resources can be managed?

3. To what degree can the objectives of the farm household, and other local, regional, national, or international stakeholders, be met by integrated land-use patterns as alternatives to spatially segregated ways of addressing multiple functions of land?

4. How can the various stakeholders overcome the prevailing sense of conflict?

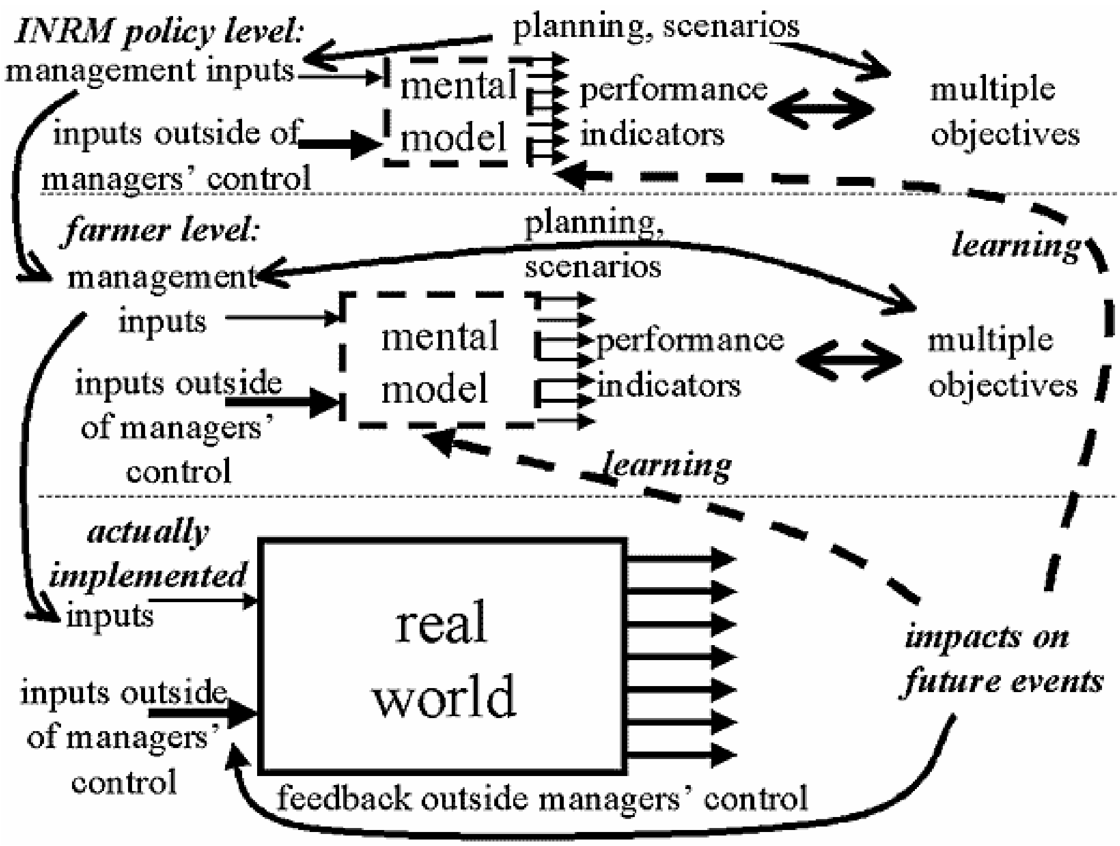
5. How can research play a role by providing negotiation support to the various stakeholders in natural resource management?

The views and concepts presented here were developed in the context of the "Alternatives to Slash-and-Burn" program of research on options for land-use change in the margins of the tropical forests (Tomich et al. 1998*a, b,* 2001, van Noordwijk et al. 1998*a*). We will summarize lessons learned in this program, which targets one of the greatest challenges in the debate over global natural resource use: finding ways to conserve the functions and existence of tropical forests while providing sustainable livelihood options for poor farmers in the forest margin.

## THE M OF INRM: RECOGNIZING AND SUPPORTING THE MANAGER

The overall objective of INRM research and development activities is to help managers at various levels do a better job of managing natural resources. We subscribe to the view that "management" of natural resources involves taking and implementing decisions that will modify the way in which the agro-ecosystem functions internally and the way it responds to external factors. These management decisions are generally taken on the basis of managers' objectives and a mental model that approximates how certain actions will influence performance indicators of the system (Fig. 1).

**Fig. 1.** Management of natural resources involves a mental model of how the real world responds to influences by the manager (thin arrow), as well as influences outside the managers' control (thick arrow), and how this overall response is reflected in performance indicators that will (partially) satisfy a set of multiple objectives. The contrast between the expected system performance and objectives may lead to a change in the managers' inputs into the real-world situation. Actual experience may lead to learning, in the sense of modifying the mental model, and changing the scenarios and plans. Because the real world involves many layers of "managers," there will be considerable feedback outside of the managers' control. The diagram shows a "national policy" management level superimposed on a "farmer" management level, superimposed on the real world.



In an abstract sense, the various steps in this cycle can summarize the targets of INRM research:

1. identifying clearer, more realistic, and/or more encompassing objectives, and constructing better performance indicators that reflect the way these objectives are met;

2. improving the mental models of all managers, based on understanding how outputs and outcomes are related to inputs, and how multiple causes can lead to similar effects; this is the primary entry point for new technologies that enlarge the array of options from which farmers can choose to influence their agro-ecosystem;

3. making better use of the mental models for planning how to obtain desirable impacts on the multiple management objectives for minimum inputs and management efforts;

4. improving implementation of these management plans and scenarios;

5. improving evaluation of the current state of the real world system;

6. determining how the factors outside the managers' control influence the system; and

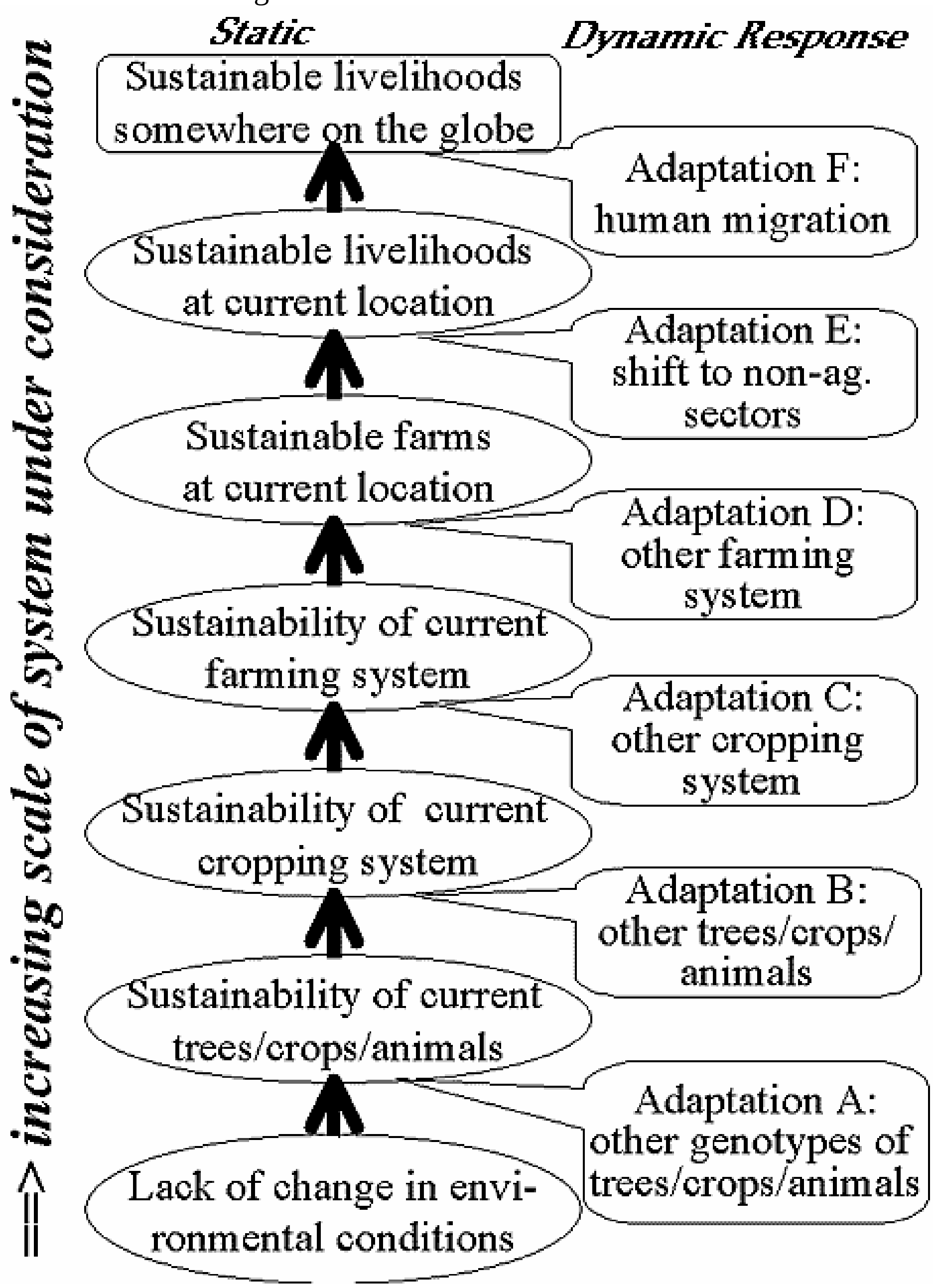
7. learning better how the real world actually responds to the change, including the feedback created by ecological, economic, social, and political interactions within and across scales.

An analysis of the weakest elements in the current management cycle may help us to focus on the domains with the largest potential for immediate or medium-term improvement. Agricultural systems aiming at full control over all factors that influence crop growth for maximum yield require more labor and chemical inputs than systems that, to a certain degree, work "with nature" and can lead to higher returns to labor, better financial performance, and fewer negative environmental effects. Yet, a no-input agriculture (that harvests whatever happens to grow) allows only low returns per hectare and consequent human population densities of hunter/gatherer communities, even though it may lead to quite acceptable returns to labor. Similarly, at the national scale, a paradigm of full control, involving plans, maps, and heavy-handed manipulation of citizen behavior cannot claim much success, nor can a complete laissez-faire approach. The search is for effective and efficient government interventions that incorporate the likely response of decision makers at lower hierarchical scales into the design and implementation of interventions.

In the past, agricultural research has been largely based on designing interventions, such as technologies, germplasm, and external inputs, that lead to a predictable increase in yields in well-defined situations, and on demonstrating the value of these technologies to farmers. This technology approach, based on a "full-control" paradigm, can certainly claim to have had successes. However, it drew criticism because its focus on yield led to an agricultural system with undue negative impacts on sustainability and other performance aspects; had little positive effect on the farmer as a resource manager, in a more complete sense; and worked against the inherent variability and diversity of real systems. The new paradigm of INRM is one of "adaptive learning" by farmers, supported by outside actors who themselves are learning in the process (Tomich 1992). Adaptive learning is closely linked to issues of sustainability.

Sustainability at any level of complexity, from cropping systems to the level of the planet, can be based on the sustainability of its components, or on adaptations, the agility in finding and introducing new components (Fig. 2). Existing sustainability indicators appear to focus on the “persistence” axis, because the adaptive capacities at the levels from crop genotype to farming system are more difficult to assess. Sustainable livelihood options outside agriculture will have to form the escape route for the majority of today’s rural population, as it has already done in the “developed” world in response to agricultural transformation (Tomich et al. 1995). Research on adaptive capacity must differ in character from that of the sustainability of existing systems. The latter has specific land-use practices as its target and can do experiments and make models of longer term behaviors. Adaptive capacity research has to consider the range of options available and the way in which these options themselves change over time and differ between stakeholders.

**Fig. 2.** Adaptive capacity as the missing link between sustainability (persistence) at different levels of organization.



Taking the "manager" seriously implies trying to understand the mental model of ecological relationships that underpin farmer resource use and investment/care decisions. An effective toolbox for mapping these mental models now exists (Sinclair and Walker 1998, Walker and Sinclair 1998, Walker et al. 1999). Farmers' ecological knowledge often complements current ecological science in interesting ways, and contributes to decision rules for management, along with many non-ecological factors.

## THE NR OF INRM: AT WHICH SCALE CAN THE VARIOUS RESOURCES BE MANAGED?

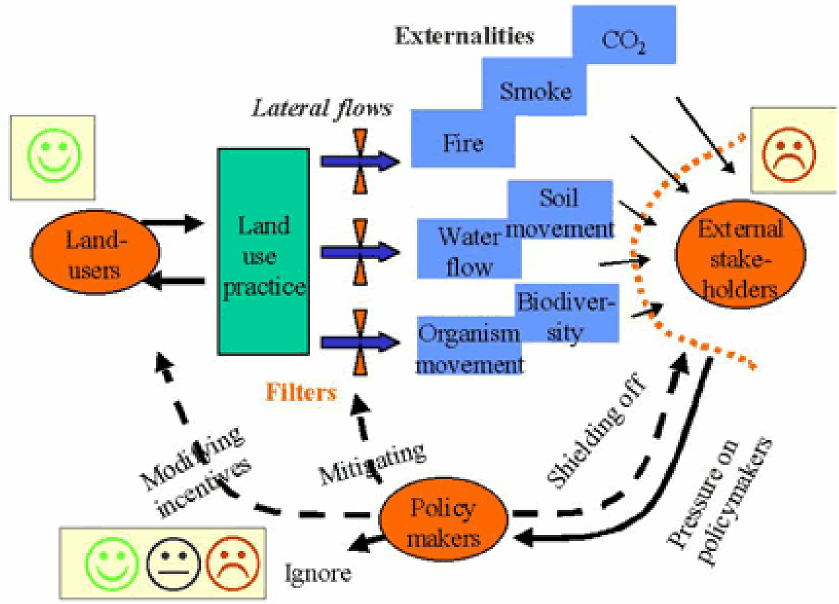
Natural capital consists of many resources, each with its own renewability, dynamics, and movement. Where management refers to a specific spatial domain, movements of resources in and out of this domain set boundary conditions for management. If "scaling up" implies the consideration of larger spatial domains, it is likely that changes in management will be needed at scale transitions. Each type of natural resource may have a typical scale at which it can be meaningfully managed, depending on the patterns of lateral flow relative to the local stocks of the resource. This scale, however, depends not only on the resource, but also on the situation. Groundwater may be a resource that is used, replenished, and thus managed at village scale (as in the Zimbabwe example of Lovell et al. 2002), or it may be part of aquifers that span hundreds of kilometers and may have the management complexity of large surface streams and rivers. The spatial correlation of rainfall is relevant for the way in which risks are reduced by access to plots some distance apart (van Noordwijk and Ong 1999), and also for predicting surface run-off and its soil transport capacity at above-plot level (van de Giesen et al. 2000).

In much work on "scaling up" naïve extrapolations of measurements and management recommendations are made on an area basis. For example, plot-level measurements of sediment loss are translated to statements that "erosion is one of the main causes of nutrient loss from Africa," whereas, in fact, very little sediment reaches the seas or oceans in African rivers. Plot-level erosion leads to a considerable lateral flow, impoverishing soil in one place and enriching it in another (van Noordwijk et al. 1998*b*). Scaling issues, in this sense, critically depend on lateral flows of entities such as organisms, fire, smoke, water, sediment, nutrients, people, money, and ideas, and determine the degree to which the overall scaling relationship differs from area-based ones (van Noordwijk 1999*b*, *c*). Many external effects of land-use change are based on modifications of lateral flows of soil, water, air, fire, or organisms (van Noordwijk et al. in press). To this list we can add people, money, and ideas. Lateral flows imply that area-based scaling is not appropriate. For example, if human migration is defined as people crossing boundaries at village, district, national, or continental scale, the number of migrants, or proportion in the total population, will decline strongly with increasing scale of consideration. At the global scale, migration is zero, just as is net loss of sediment by erosion.

Biodiversity is also a concept with a complex scaling relationship, because the richness of taxonomic or genetic entities at any scale depends both on the richness at a smaller scale and on the degree of similarity between these units (Douglas 1999). The time dimension causes an additional complexity because the objective of long-term survival of populations cannot be directly observed, and has to be inferred from current size of the populations and their internal genetic diversity.

The term "filter" is used here in a generic sense to mean anything that can intercept a lateral resource flow (Fig. 3). Typically, filters occupy a small fraction of the total area and have a large impact per unit area occupied. They can thus be regarded as “keystone” elements of a landscape. Closely coupled to the issue of filters and flows is the question of whether spatial pattern matters for natural resource management. When external impacts of land-use practices derive from lateral flows, the causality of impacts on external stakeholders of plot-level land-use decisions is complicated. Conserving or establishing filters to intervene in such lateral flows may provide attractive options to mitigate the impacts, compared with elimination of the “root cause.”

**Fig. 3.** Schematic representation of how lateral flows and filters complicate the cause–effect relationships between plot-level activities (managed by land users on the basis of their objectives) and external stakeholders. There are many options for reducing the impacts on external stakeholders.




Examples of this type of “mitigation” can be found in the filtering and temporary storage of $CO_2$ in terrestrial ecosystems that slows the rate of increase of the atmospheric concentration due to fossil-fuel use. It is also seen in the impact of riparian filter strips that mop up the flows of excess nutrients from intensively used agricultural land and reduce their “downstream” impact.

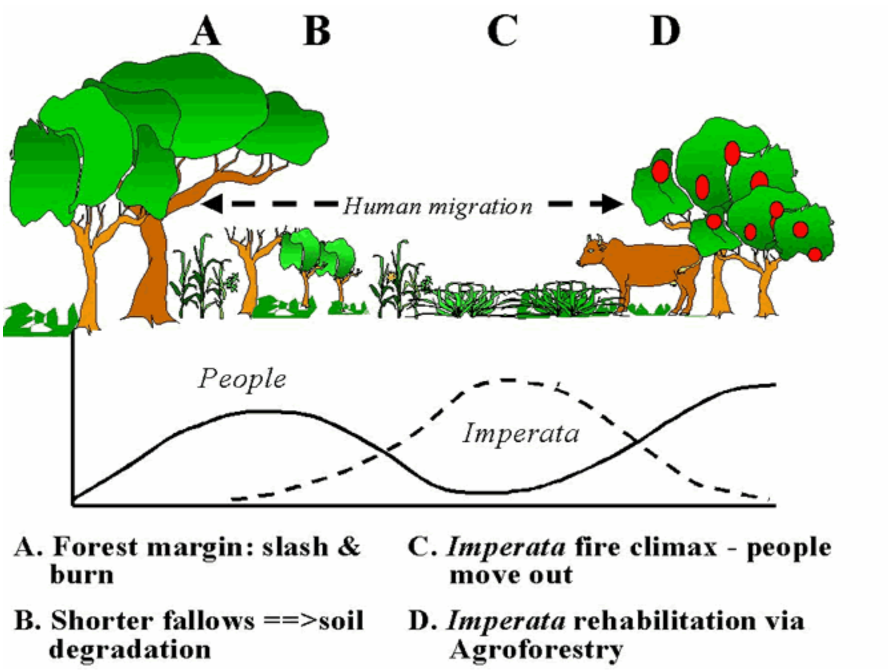
Key questions on the way filters function in natural resource management are:

1. How effective are different types of filters for intercepting flows?
2. How quickly will they saturate under high inflows?
3. How fast can the filters regenerate between events?
4. Do filters have a direct value and can they be treated as a separate “land use practice”?

Institutionally, landscape filters may require special attention in natural resource management. Private resource access is hard to secure for linear elements in the landscape far from home and potentially external to the enterprise. Nobody will plant fruit trees in vegetative filter strips along streams, even if they contain fertile soil and have a favorable water supply, unless local institutions secure access to the fruits of those trees.

The lateral flow, or migration, of people is one of the main conditioning factors in natural resource management at scales relevant for policy. People moving into and extending the forest margin are a major source of land-use change, with potentially desirable political and economic connotations for a central government, but may also lead to rapid loss of environmental service functions from a national, regional, or global perspective. Generally, four phases can be recognized in the changes of forests, through a degradation stage to a rehabilitated landscape where planted trees reappear (Fig. 4). Rules, such as taxes and administrative restrictions on the sale of logs and wood, aimed to reduce the forest degradation stage, may be a major constraint in the rehabilitation stage, as they reduce the incentives to plant trees. Unfortunately, this relationship applies particularly to indigenous trees, rather than to introduced species. There has been much debate on the conditions under which the availability of options for more intensive use of agricultural or degraded lands can reduce the pressures on forest conversion (Jepma 1995, Kaimowitz and Angelsen 1998, Tomich et al. 2001). The "Alternatives to Slash-and-Burn" program was built on the expectation that such a relation indeed exists.

**Fig. 4.** Schematic land-use transformations from forests ("more people, fewer forest") via *Imperata cylindrica* grasslands to rehabilitated lands with various agroforestry options ("more people, more trees") [After van Noordwijk (1994).]



## THE I OF INRM: INTEGRATE OR SPATIALLY SEGREGATE FUNCTIONS?

For most land-use and natural resource-management problems, both “integrated” and “spatially segregated” solutions exist, and each may have appeal to different stakeholders (van Noordwijk et al. 1997*a*). Although “integration” has a general appeal, similar to that of “agroforestry,” critical analysis is needed to decide whether it is really superior to segregated solutions. Similarly, agroforestry as a science has its roots in the often naïve expectations that close associations between trees and crops can not only serve multiple functions, but also serve these functions better than can a spatial segregation of agriculture and forestry. With an increased understanding of competition that typifies many of these intimate mixtures (Sanchez 1995), the definition of agroforestry and the focus in agroforestry research have evolved from plot-level interactions between trees, soils, crops, and animals, to the way in which landscape elements, including trees and forest patches, interact to produce local as well as external “environmental service functions.”

For some of these environmental service functions, however, a spatially segregated approach may be better (van Noordwijk et al. 1995). Again, lateral flows and filters are the key to recognizing the options for landscape-level integration of functions that are not compatible at plot level (van Noordwijk and Ong 1999). For example, where high nutrient supply to agricultural crops is not compatible with quality standards for surface or groundwater, a nutrient filter of vegetation around streams and ditches may lead to an acceptable solution. Where crops use less water than the natural vegetation they replaced, and where increased groundwater flows create problems of salinization, as in Western Australia, introduction of trees in specific zones may help (Lefroy and Stirzaker 1999). However, parts of the “charismatic megafauna” of tropical forests, such as tigers or elephants, are not compatible with human objectives in agroforestry, and a clearer spatial segregation is necessary for combining agriculture and biodiversity conservation (Nyhus and Tilson in press).

The first step in the segregate-or-integrate analysis is to define the trade-off function between the degree to which the various pairs of objectives can be met, similar to the practice in analysis of intercropping systems. Concave curves on such a biplot always lead to the conclusion that it is better to segregate the components; convex curves suggest that a combination of functions can indeed be attractive (van Noordwijk et al. 1995, van Noordwijk and Ong 1999). Where the two functions compared have different scale relationships, the shape of the trade-off curve will change. The relative merit of integrated vs. spatially segregated land-use options is essentially a question of scale.

## INRM RESEARCH ON ALTERNATIVES TO SLASH-AND-BURN IN INDONESIA: AN EXAMPLE

The original Alternatives to Slash-and-Burn (ASB) perception of the problems in the tropical forest margins was that “poverty causes people to migrate to the forests, but they don’t know how to manage the soils and are forced to move on to open new forest, leaving a trail of degraded lands behind.” This perception of the problems led to the “Phase 1 hypothesis” that “intensifying land use as an alternative to slash-and-burn can reduce deforestation and poverty.” This hypothesis has a local variant in the forest margin. Here, the “more people, less forest” trend can be modified by more intensive forms of agriculture and a landscape-wide action, where stimulating the “more people, more trees” stage may reduce the migration flows into the forest margin and thus contribute to forest conservation (Fig. 4).

The main conclusions of the research in Indonesia (van Noordwijk et al. 1995, Tomich et al. 2001) have been:

1. There is little evidence that the original perception holds true; unsustainable systems used by recent migrants are mostly found under the government-sponsored transmigration programs, which are planned at government level, rather than growing from spontaneous poverty-driven, land-use practices.

2. Farmers have developed agroforests, based on rubber, resin, and other local or introduced trees, as sustainable and profitable alternatives to food-crop production based on slash-and-burn techniques.

3. This opportunity, however, has stimulated rather than slowed down forest conversion in the absence of active boundary enforcement mechanisms for natural areas.

4. In mountain zones, opportunities for migrant farmers to privately plant profitable tree crops such as coffee and cinnamon have hastened forest conversion, with variable effects on forest functions.

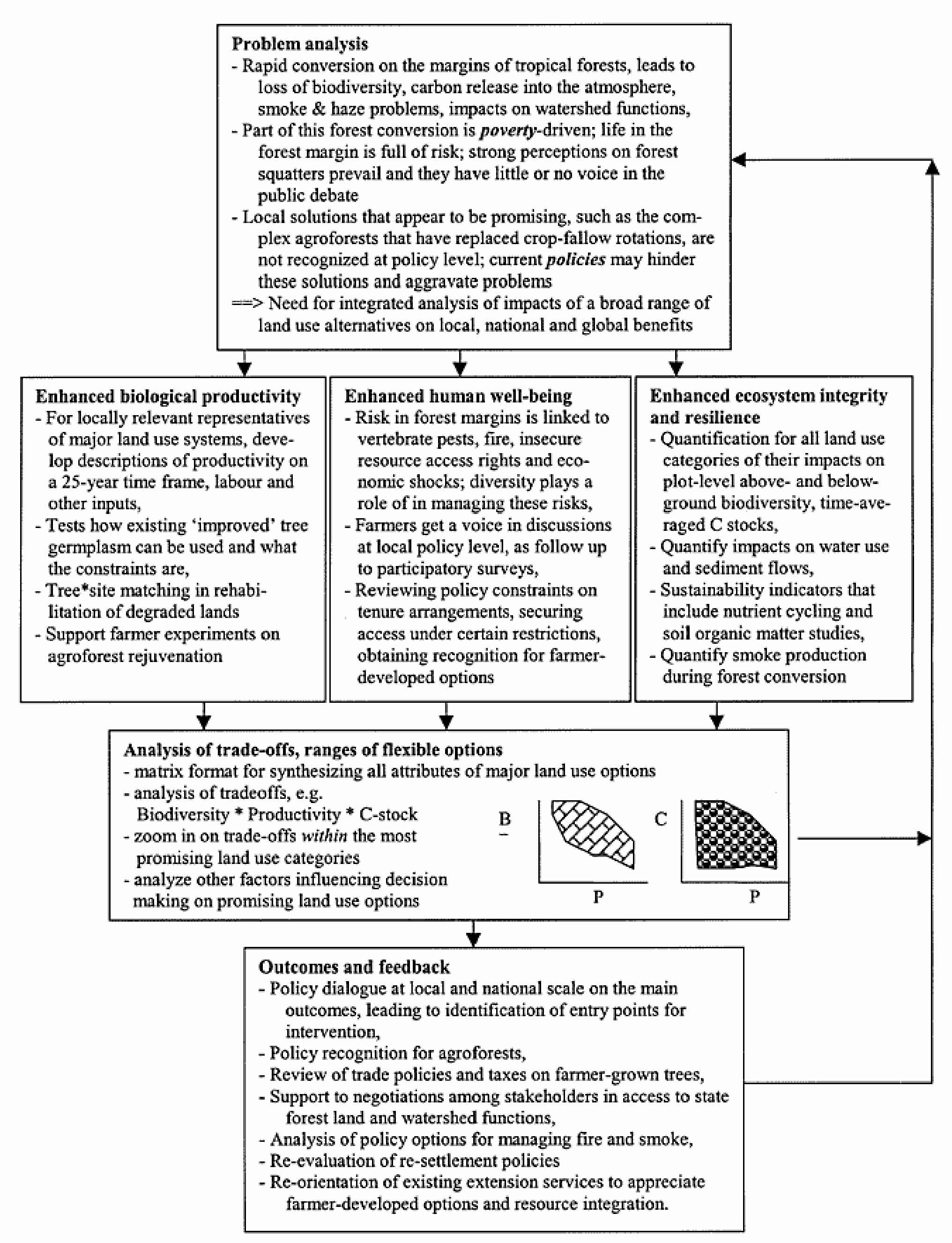
5. Current forest conversion is a combination of logging, large plantation-style projects, government-sponsored migration, and activities of both local and recent migrant smallholders. Much of the conversion is planned and sanctioned by government and is encouraged by public policy; small remnants of “shifting cultivation” remain in Sumatra, but largely in the form of settled fallow rotation, and these do not lead to significant land degradation and people moving onto new forest margins.

6. The land-use systems that follow forest conversion differ significantly in their sustainability, profitability, and impacts on carbon stocks, greenhouse gas emissions, and biodiversity.

7. Although agroforests can maintain part of the biodiversity of the original forests, they are clearly no substitute for full protection of biodiversity in dedicated natural areas and conservation reserves.

The main activities can be summarized (Fig. 5) in the general framework of natural resource management research (Izac 1998, Izac and Sanchez 2001). After quantifying the way in which various land-use alternatives can meet a wide range of criteria that reflect local, regional, national, and global interests, the analysis of trade-offs helped to identify a number of natural resource management conflicts that will require negotiation between stakeholders.

**Fig. 5.** Schematic representation of steps in “integrated natural resource management” taken by the “Alternatives to Slash-and-Burn” (ASB) program in its Indonesian benchmark sites.




## CONFLICTS AND THE NEED FOR NEGOTIATIONS

Conflict management entails clarifying the options from all perspectives, searching for mutually acceptable options or negotiating compromises, monitoring the outcomes, and enforcing compliance. Three types of natural resource management problems can be identified in the margins of tropical forests.

*Problems at local level (upland/lowland): watershed and landscape ecological services*

Conflicts between local and downstream stakeholders following forest conversion are evident throughout Southeast Asia. Yet some forms of spatial integration of "forest" and "agricultural" functions may fulfill the needs of downstream land use. The conflicts may be based, in part, on misperceptions of forest hydrological functions (Calder 1999) that lead to enforcing rules for "watershed protection forest" outside the domain where it is truly functional. Our key hypothesis in this category of problems is that complex tree-based, integrated systems, at plot or landscape level, provide an opportunity to minimize conflicts between private interests (in production/profitability of land use) and public interests in local environmental services (hydrology, ecology, air quality).

*Global–local conflicts of interest in biodiversity conservation*

Our key hypotheses in this domain are as follows. For core biodiversity values (including charismatic megafauna), spatial segregation of functions is an imperative, requiring socially acceptable ways of protecting conservation areas. For local biodiversity functions, a medium-intensity "integrate" option, such as agroforests, may be superior in terms of resilience and risk management.

Because there is indeed no substitute for spatial segregation of many endangered species and people, socially integrated mechanisms are needed for stabilizing boundaries of conservation areas. These would include tools for conflict management and actual compensation mechanisms based on agreed performance criteria. Stabilizing physical boundaries of protected and reserved areas implies providing farmers, extractivists, and hunters elsewhere with livelihoods at least as good as they could expect in their current situation, or providing shifting incentives toward sustainable use. There is a lack of proven means for either approach.

Major unresolved issues also remain in the relationship between species richness and ecosystem function from a local perspective. Farmers are most likely to perceive reasons to maintain complex and species-rich agro-ecosystems if the direct use value of each element per unit of resource use is approximately the same.

Where past germplasm development efforts focused attention on "priority" elements, they are likely to have increased the contrast in value among the components of the system, and thus to have undermined the rationale for maintaining agrodiversity (van Noordwijk and Ong 1999).

*Global–local conflicts between global interests in carbon stocks and local interest in conversion of forest for more profitable land uses*

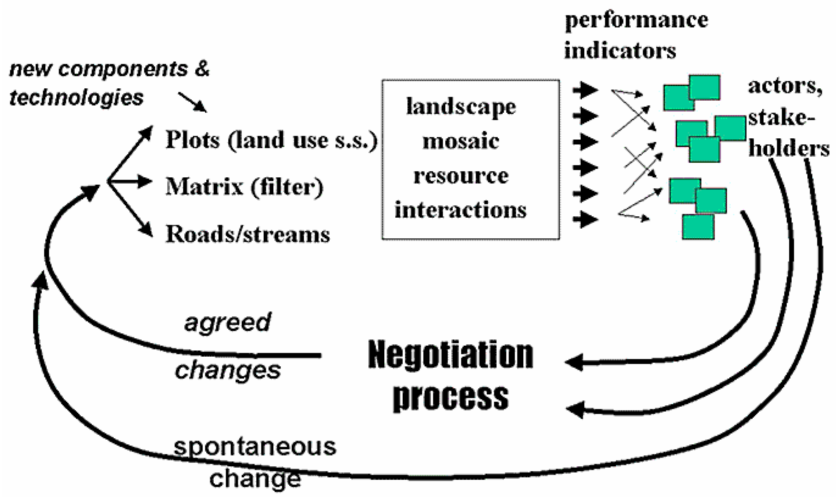
Evidence from ASB suggests that, for the combined objectives of increasing carbon stocks and annual food-crop production, a "segregate" option is superior if it allows for maintaining high carbon stock areas (including peat swamp forests) intact, and intensifying production elsewhere (van Noordwijk et al. 1997*b*). For the combined objectives of farm profitability and carbon stocks, however, production systems based on tree crops provide a sensible "integrate" option. The key hypothesis is that major options exist for increasing carbon stocks by expanding tree-based production systems on grasslands and in degraded watersheds through a coherent approach to the land tenure, market, policy, and institutional bottlenecks to the application of existing rehabilitation technologies.

This type of INRM issue implies (1) a need for institutional and policy reform to eliminate existing disincentives for planting trees, and (2) a need for compensation mechanisms or other means to increase incentives for planting trees.

## HOW DECISION SUPPORT EVOLVES INTO NEGOTIATION SUPPORT

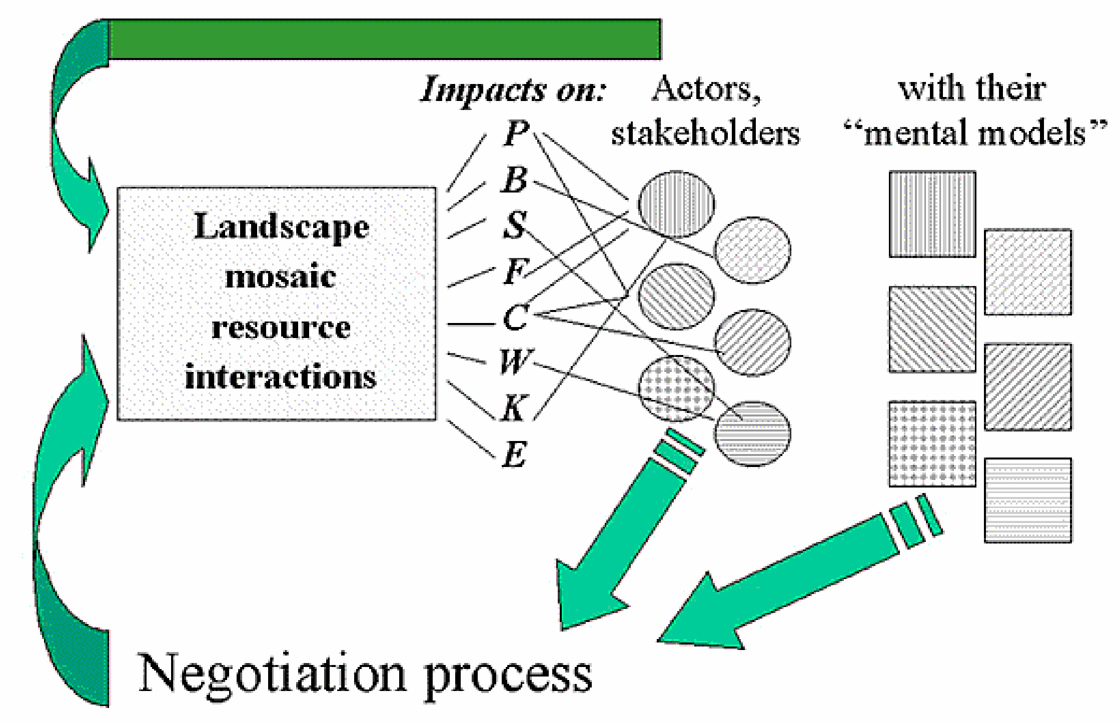
The real-world human impact on natural resources derives from a large number of individual decisions, made with different access to sources of knowledge and information, with different technical means to organize exploitation, and with different objectives, constraints, priorities, and strategies. The best we can hope for is a process of negotiations among stakeholders that leads to modification of the individual decisions to produce superior outcomes from the broader social perspective (Fig. 6).

**Fig. 6.** Schematic representation of the main elements of natural resource management "action research." This approach relates the predicted impacts of landscape-level changes in land use, channels, and/or filters to the range of performance indicators that is considered to be relevant by the actors and other stakeholders of this landscape. It facilitates a process of negotiation that may lead to changes in the way actors manage various parts of the landscape.




The term "decision support model" may suggest that a single management entity will seek a solution that optimizes the way in which multiple objectives can be achieved, and then will make decisions to be imposed on the various actors and stakeholders. We prefer the term "negotiation support models" for constructs that help to obtain a common perspective on the "if this, then that" relationships for a range of possible future landscapes. To function adequately, the "negotiation support model" itself will have to be the subject of negotiation and shared development efforts among stakeholders (Fig. 7). In this view, the main role of research and development organizations is to help in developing the tool as a predictive system, as well as in the process of stakeholder consultations and negotiation, acknowledging the existing inequity in access to resources and information, wealth, political power, and social status.

**Fig. 7.** Modified scheme (compare with Fig. 6) indicating that all stakeholders, including the researchers, will enter the negotiations with their own mental models of the real world and the impacts of activities on the performance indicators in which they are interested. These indicators include: *P*, productivity or profitability; *B*, biotic interactions or biodiversity; *S*, sustainability; *F*, fire or smoke; *C*, carbon stocks and net emissions of other greenhouse gasses; *W*, watershed functions or the regular supply of clean water; *K*, knowledge that can be used to update the various mental models; and *E*, ethical or aesthetic values.




## INTEGRATED MODELS

During the first two phases of the ASB project, it became clear that "watershed protection functions" of forests and the way in which they change after forest conversion are a major source of conflict in Southeast Asia (Tomich et al. 1999). Because these issues are based on the lateral flow of water and sediment, they have challenging scale relationships and involve distances beyond those at which local institutions can be expected to cope. Because several hierarchical layers of stakeholders are involved, a complex negotiation process is likely to be necessary, and a model of how the real-world landscape functions may be a helpful tool in this process.

Integrated system models can first serve as a common framework of analysis that clarifies the type of information required from the various participants of the research program. Second, and perhaps more important for the implementation phase, is the function as a discussion tool. Different scenarios outlined by the various stakeholders can be clarified qualitatively in a first approach. Possible future changes can be examined and discussed, possibly generating the basis for overcoming present conflicting interests to obtain a better collective future. Disciplinary research can offer the necessary "building blocks" to make quantitative simulations with a certain probability and precision. In the development of simulation models, a "top-down" approach that starts with the overall problem and gradually adds detail as required can be distinguished from a "bottom-up" approach that starts with available knowledge and insights on component behavior and seeks integration and "emergent properties" at a higher level of integration.

Some progress has been made, e.g., by the FLORES group using a "bottom-up" approach to model development (Vanclay 1995). A village-level model of shifting cultivation (FALLOW; van Noordwijk 1999*a*, in press) also builds up landscape-level predictions from the way in which households are supposed to manage the various plots within the simulation domain. Explicit scaling relationships can be built into such an approach. Many issues remain unresolved, however, especially regarding the amount of detail required to simulate individual decision-making processes and the collective action within and among rural communities. A diversity of approaches may also be needed to provide options for location-specific attempts to develop a support model for locally relevant natural resource management negotiations.

A top-down approach using a system description, which still allows for the incorporation of individual stakeholders' interests, was taken for the development of a modeling framework for coastal zone management near Ujung Padang, Sulawesi, Indonesia. The RAMCO-model (Rapid assessment for management of coastal zones; de Kok and Wind 1999) is based on conceptual guidelines provided by Randers (1980), Miser and Quade (1985), and de Kok and Wind (1999). It recognizes eight distinct steps for the design and use of integrated models for policy analysis.

1. Problem formulation, which should include at least one problem definition, its boundaries and constraints, and the various values and criteria used by respective stakeholders.

2. Generation of alternatives.

3. Qualitative system design, which involves the development of a causal relationship diagram or system diagram (see Fig. 8).

4. Quantitative modeling.

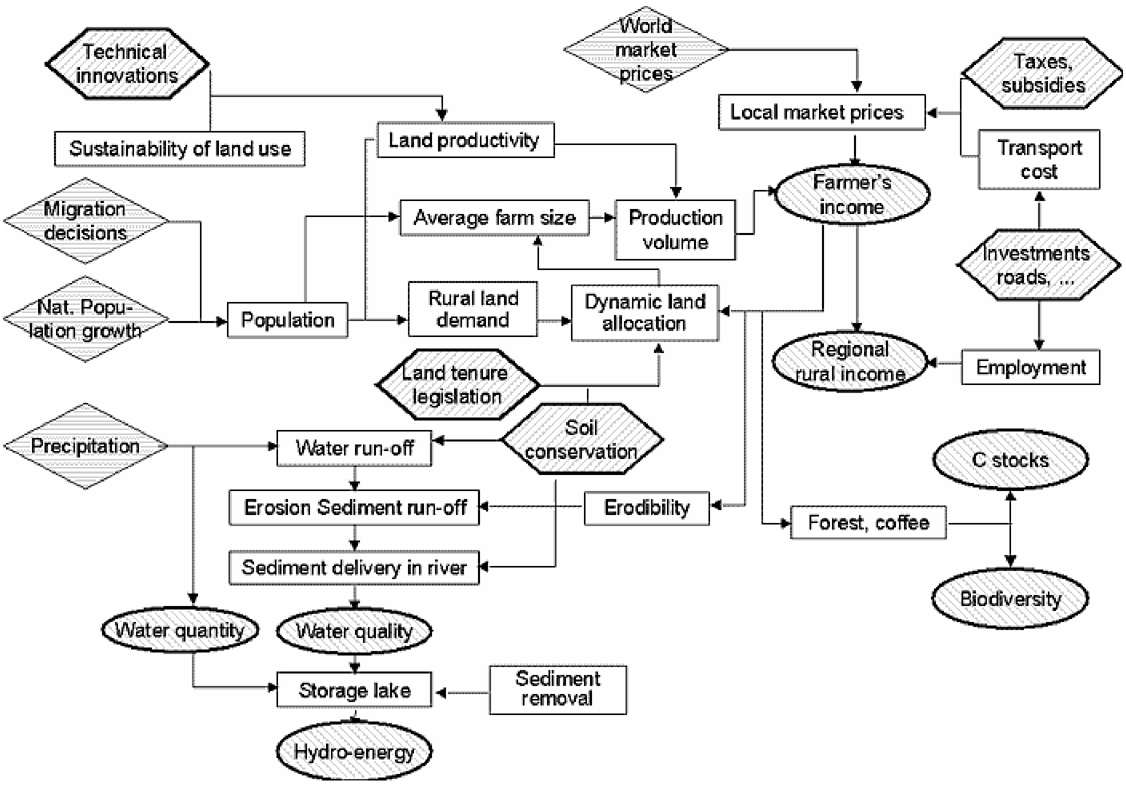
5. Model implementation.

6. Model validation (return to steps 3, 4, or 5, as needed).

7. Ranking of alternatives from various stakeholder perspectives.

8. Stakeholder negotiations on the consequences of the various alternatives (return to step 2, if new ideas arise).

**Fig. 8.** Initial system diagram of relations in the Sumber Jaya ASB benchmark area in Indonesia; shaded diamonds indicate external variables; shaded hexagons indicate management options for some of the stakeholders; shaded ovals represent key impacts. This qualitative diagram will have to be verified with the various stakeholders. The next steps are the quantitative modeling and a strength–weakness analysis of the various processes.




The general problem in the new ASB benchmark area in Sumber Jaya, the upper Tulang Bawang watershed in Lampung (Sumatra, Indonesia) can be defined as the perception of unsustainable use of natural resources, leading to conflicts over land use and access rights. A stakeholder analysis is being carried out to confirm or discard some of the initially identified issues and thus to frame the questions that the negotiation support model should try to answer. The apparently contradictory objectives of the stakeholders in this conflict can be formulated in terms of the values that are considered relevant for watershed management. On the basis of these values and criteria, a more concrete problem definition, and the boundaries and constraints of various alternatives, can be generated, including an initial compilation of the perceived causal relationships. Research to map the "mental models" of all participants in the negotiations, as illustrated in Fig. 7, can help to clarify the service that each stakeholder can actually expect from the watershed. The mental model of a model-builder (an example is given in Fig. 8) needs to be completed and verified with the mental models of the various other stakeholders.

Different "what if" scenarios, based on stakeholder inputs and feedback, will allow an exploration of various possible options. Scenarios need to be developed for fewer or uncontrollable, external parameters such as migration, world market prices, or precipitation. The main objective of this model building is to put stakeholders on a more equal footing and thus help them in negotiating an agreement over future resource use and access rights. The social process to achieve this objective requires a series of confidence-building experiences and a political climate of openness that only recently has developed in Indonesia. The modeling and social interaction will have to be iterative and parallel (not serial), adaptive-learning processes, contributing to the stages of problem definition, evaluation of options, negotiation, and implementation and monitoring of agreed-upon solutions.

## CONCLUDING REMARKS

Integrated natural resource management research and development efforts should lead to tangible impacts on the ground. If, however, we continue to evaluate the "impact" of our research and development involvement simply on the basis of the spread of specific technologies, we are likely to misdirect our efforts. Supporting farmers as managers may mean that informed non-adoption or adaptation-beyond-recognition may be better signs of success than adoption of well-defined practices in a context in which social pressure plays a role. If improving the ability of natural resource managers at all hierarchical scales is our target, we should measure our success and failure accordingly, based on the adaptive learning capacity and the way in which we can help to expand this.

The Sumber Jaya case study is still in an early stage and will form a laboratory for INRM research and development efforts. Ultimately, we subscribe to the naïve, positivist view that the quality of decisions and negotiations can be improved by providing better, not necessarily more, information to the various stakeholders so that more alternatives can be generated and evaluated. This optimistic view may not be supported by reality, where, too often, solutions are selected that bear no relation to the officially stated objectives or to the problem. More equal access to information for the various stakeholders and a process in which transparency becomes a requirement in public debate, are essential if the information that we contribute is to be of actual value in the negotiation process.

## RESPONSES TO THIS ARTICLE

Responses to this article are invited. If accepted for publication, your response will be hyperlinked to the article. To submit a comment, follow this link. To read comments already accepted, follow this link.

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