

# Chapter 12

## Systems Integration and Innovation

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**T**his transdisciplinary book has been designed as a foundation for a second Green Revolution driven by smallholders and their development facilitators. It can be summarized in six messages grouped under three themes. The first theme is food security, poverty, and environmental degradation as linked problems. These problems and their solutions are emergent from the complex adaptive systems of which they are a part. The Sustainable Agriculture and Natural Resource Management (SANREM) landscape systems framework provides a way to organize this complexity to learn from it and identify viable management options. Thus, the first two messages are as follows:

- Each SANREM landscape system is a scientifically documented coherent whole with its own terminology, dynamics, and drivers.
- Individual systems do not function in isolation; the cross-scale effects of one system on another may lead to abrupt shifts in individual and overall system impacts.

The second theme is problem management as an adaptive learning process. Adaptive management provides development practitioners with a learning-by-doing methodology. The second two messages are as follows:

- Adaptive management is a knowledge- and management-intensive learning process.
- The learning experience is not just a matter of one-time adoption but an iterative process of decision making, action, and evaluation.

The third theme is successful adaptive management as a team effort. It is not an individual activity, nor can it be implemented in a simple top-down fashion. Producers, conservation and development agents, and market and policy actors are all tightly interwoven in the complex adaptive systems they are trying to manage. Coordinated behaviors are necessary for successful management and effective learning. The last two messages are as follows:

- Effective management of complex adaptive systems requires the leadership and collaboration of multiple stakeholders across system levels from the field and farm household to the government and markets.
- Successful comanagement of complex adaptive systems involves institutionalized mechanisms for multi-stakeholder communication and governance.

## Adaptive Management

The chapters in this book teach us that adaptive management is a way of life. It constitutes a matter of day-to-day routines: listening, observing, and documenting results as the growing season advances. These routines are punctuated periodically with the reevaluation of goals and objectives, and subsequently, modification or reinforcement of behaviors and practices. Adaptive management must operate at multiple system levels, providing options and alternatives adapted to decision-maker circumstances.

Listening to these various authors, we learn that adaptive management begins with problem definition, goal setting, and planning. Problems are frequently defined with respect to soil quality, but their resolution requires higher system-level responses. Several authors mention the importance of conservation agriculture strategies to reduce or eliminate the disruption of natural soil processes, maintain soil cover, and rotate crops. Adopting conservation agricultural practices involves a series of adaptations across system levels.

Adaptation implies making changes in the way we do things. A certain amount of risk and uncertainty is to be expected. As Wyeth (chapter 3) points out, risk is a critical element shaping farmer assessments of their production possibilities. These risks need to be shared and a consciousness developed that we are in a process of learning together how to reduce or mitigate them. Buck and Scherr (chapter 8) emphasize the collaborative dimension of adaptive management as critical to the successful development of local innovations systems. Improvements in the production system at the farm level are mirrored in improvements across the rural economy. The lessons learned contribute to transdisciplinary and locally adapted knowledge bases or, as Alwang et al. (chapter 10) suggest, with an eye to operational implementation—“transfunctional” knowledge. This holistic, transdisciplinary knowledge founded on a base of solid scientific research at various system levels is needed to change the farm household livelihood opportunity sets. Making that knowledge useful in the daily lives of rural communities requires adaptation from the behavioral practices of those livelihoods.

## Complex Adaptive Systems

If this book had been written by a single author, the transitions from chapter to chapter would have been smoother. However, there would have been a tendency to maintain the same tone, language, and terminology. Consequently, recognition of different perspectives across systems, scales, and disciplinary approaches would have been lost. Each system has its own terminology and key concepts that provide its scientific insights. Through reading these chapters one comes to recognize the differences between the mindsets of the scientists working within each system. Nevertheless, there is a great similarity of messages from one system level to another. The authors approach the integration of various system levels diversely, but all recognize the significance of cross-scale interactions and effects, demonstrating the necessity of the landscape systems approach for sustainable agriculture and natural resource management. Given the diversity of factors involved at various system levels, recognizing the site and time specificity of a management problem is critical to the identification of potentially viable adaptive management options. Specific technological interventions will be embedded in the broader socio-ecological context, requiring both an understanding of watershed and ecosystem dynamics and a supportive local community and government environment. Let us review the basic system drivers, components,

and principles of the complex adaptive landscape systems and their cross-scale interactions; then consider a set of tools and techniques for their adaptive management.

## Boundaries of Nested Landscape Systems

Field systems (Mueller et al., chapter 2) are the primary units of managed space in which the biophysical components of the productive process come together: soil, water, microorganisms, and energy. Through a series of bio-geochemical processes, microorganisms cycle carbon, nutrients, water, and energy through the soil, creating the soil organic matter that preserves those same components for the nourishment of plant and animal life. In their turn, the fruits of the plant life are harvested and exported to other system levels.

Farm household/enterprise systems (Wyeth, chapter 3) are the interface between field systems and input and output markets, ecosystem services, and policies. These farm systems are managed by primary producers who organize the land, labor, and capital resources shaping their production possibilities. The focal point for production and innovation decision making is found within this system level. Smallholder choices are also shaped by risks and opportunities for sustained and culturally meaningful livelihoods. While the degree to which decision making operates in a unified fashion varies culturally and historically, some form of kinship unity and reciprocity operates and is mediated by local norms and practices regarding age and gender.

The watershed system (Walker and Mostaghimi, chapter 4) is defined by the land that drains to a particular point or outlet. While the corresponding governance boundaries may not exactly coincide, community watersheds aggregate and unify the biophysical and socioeconomic dynamics of the field and farm systems and pose questions of collective, community-based governance and decision making. Water is the critical element driving this system and linking it across systems. Variability in system dynamics is a function of rainfall events and the soil and topographical features shaping the water's consequent infiltration, percolation, and evaporation or transpiration. Management relies as much on successful negotiation of stakeholder priorities as on the coordinated implementation of specific field system practices.

Ecosystems (Haas et al., chapter 6) are defined similarly to field systems in that energy, nutrient and water cycles are the underlying features. However, ecosystems as discussed here are delimited by the foraging range of the particular species of interest—in this case, humans in communities. With increasing globalization these boundaries are expanding with the associated system threats. Management focuses on those cycles that provide communities with food, water, fiber, and fuel; regulate polluting practices; and offer aesthetic and spiritual nourishment while constantly attending to the foundation of soil formation and nutrient cycling.

The policy-market system (Shively and Birur, chapter 7) is driven by incentive and constraint signals in the form of prices. These signals communicate the choices and tradeoffs to consider in securing livelihoods and in conducting productive activities. Institutions at the local, national, and international levels establish the rules and norms for legitimate behavior shaping those incentives and constraints. Policymakers negotiate the rules established by these institutions. The resulting compromises may hamper or facilitate the communication of market signals as a function of market competition, information, and knowledge transfer. Innovative behaviors can be enhanced through careful designation of incentives and constraints.

## Cross-Scale Interactions

Cross-scale interactions are remarkably common, and their impacts need to be considered as an integral component of adaptive management decision making. Field practices that open the soil and leave it exposed to wind and water erosion can lead to losses of pollutants and sediment, which affect aquatic biodiversity, water availability, and drinking water quality throughout the watershed. Field practices, in turn, may be affected by input or crop price-support subsidies, which promote monocropping or excessive application of fertilizer or pesticides. On the other hand, policy and/or price supports may create conditions for local innovation. Input subsidies can stimulate positive adaptation and growth in the small-farm sector.

Governance systems that shape and enforce policies at the local and national levels can improve or constrain effective management of field, farm, watershed, ecosystem, and policy/market systems. Collaboration and co-learning at the community level can have a significant effect on innovations that improve productivity and/or conservation within field systems and livelihood outcomes at the farm household level.

Functioning input and output markets shape the conditions under which farm households manage their resources. Cross-scale effects are not fixed; these complex interactions require analysis and modeling where possible. For example, policies supporting biofuel development may reduce net greenhouse gas emissions compared with fossil fuel, but they may simultaneously increase greenhouse gas emission through deforestation and conversion of grasslands to biofuels production. While biofuel support policies may increase farm incomes for some, others may be left food insecure when food crops are used to produce biofuels. Off-farm employment opportunities affect the availability of labor for productive activities on the farm. Trade policies condition practices at the field level, such as whether to plant cacao or maize. Credit availability provides increased potential for investing in more profitable farming technology or for overusing chemical inputs.

Long-term sustainability depends on practices of multiple smallholders across the landscape. For instance, the “tyranny of small decisions” can lead to either increased forest cover, reducing stream water temperatures and improving rainwater infiltration and groundwater supplies; or forest clearing can yield fresh fields for agricultural production and improved farm incomes. In either case, land tenure arrangements may or may not support a suitable environment for developing carbon-trading schemes for carbon sequestration. Further, overspraying pesticides may induce pesticide resistance and consequent harvest losses, which at a sufficient scale may lead to famine. Various combinations of these management options can facilitate or inhibit wildlife buffers, habitat, and migration corridors that provide field systems with a source of pollination and beneficial insects for pest control. A careful balance needs to be collectively maintained.

## Principles and Tools for Adaptive Management at the System Level

The essence of adaptive management is for all stakeholders to assume their stewardship responsibilities at the system level in which they reside and to support others within their respective systems. Just as each system has its own distinctive characteristics and dynamics, each has its priority concerns too.

At the field level, regenerative practices should enhance soil organic matter, assure clean and abundant water supplies, protect biodiversity, particularly of soil resources, and reduce dependence on external energy inputs.

Smallholder innovation can be enhanced by focusing on those practices that have both short- and long-term benefits, are supported by viable input and output markets and policies,

accommodate and reduce risk, and are supported by patient, collaborative, and inclusive efforts of external agents.

Those sharing landscapes at the community level should develop cordial relations and positive synergy among themselves for watershed management to be successfully organized and implemented through an inclusive process that allows them to identify common problems and their likely causes, agree on reasonable goals and determine the levels of action required to achieve them, evaluate solutions in terms of their effectiveness in meeting common goals, interaction with other resources, economic feasibility, and site suitability, implement agreed-on solutions, and monitor results and evaluate the effectiveness of solutions.

At the ecosystem level a broader perspective is required for sustainability that focuses on long-term and large-scale consequences, maintains local diversity and recycles local materials, and works with the natural environment.

These actions can be enhanced through maintaining a policy/market environment that generates smallholder production incentives signaled by market prices, establishes norms and rules of behavior favoring those incentives, establishes norms and rules of behavior discouraging resource degradation, secures enforceable property rights, and facilitates the development and introduction of innovative technologies.

Complex adaptive system management is both knowledge and practice intensive. It is also locally specific. The following list of tools, technologies, and practices is indicative of the types of options stakeholders should consider and, if agreed, test and evaluate. The items are grouped by system but, as one can see, because of their cross-scale nature many would be easily categorized otherwise.

## **Partial list of tools, technologies, and practices for adaptive management**

### **Field**

- Mulch
- Cover crops
- Hedgerows
- Compost and other organic amendments
- Reduced tillage
- Conservation agriculture
- Fallowing
- Water conservation
- Drip irrigation
- Treadle pump
- Reduced external inputs and contaminants
- Integrated pest management
- Crop rotations/crop diversity
- Intercropping
- Promotion of soil biodiversity

### **Farm**

- Integrated crops and livestock
- Controlled grazing
- Credit (micro and alternatives)
- Adaptation of tasks to available labor

## Community

- Bringing stakeholder groups together
- Being inclusive and cognizant of differences
- Facilitating respectful social interaction
- Finding common ground and language
- Building congenial and trusting relationships
- Acting transparently and accountably
- Establishing platforms and networks for communication and action

## Watershed

- Soil and hydrologic data collection
- Group goal setting and problem solving
- Use of geographic information systems
- Watershed modeling

## Ecosystem

- Understanding local ecosystem
- Planting trees
- Agroforestry
- Wildlife corridors and riparian buffers
- Biocontrol of pests
- Sustainable harvesting (of trees and wildlife)
- Non-timber forest products
- Designation of natural parks and reserves
- Payments for ecosystem services

## Policy/Market

- Removing or initiating input subsidies
- Encouraging perennial crops
- Promoting resource conserving practices
- Introducing risk-reducing innovations
- Strengthening local institutions
- Supporting secure property rights
- Improving smallholder market linkages
- Coordinating national agencies
- Building human, social, and physical assets

## Building Transdisciplinary Teams

One of the primary points of this book is that we must work together. No one discipline, institution, farmer, entrepreneur, or government agency has everything needed to manage the emergent properties of these complex adaptive systems. In fact, one of the lessons of the systems approach is that the whole is truly greater than the sum of its parts.

## Establishing Institutional Arrangements

Innovation for adaptive management involves the mobilization of individual actors and groups across the landscape. Care must be taken in bringing these individual actors and groups together. This care is double faceted. Bringing people together across the landscape and with non-local

stakeholders involves organizational skills (Buck and Scherr, chapter 8) as well as basic etiquette and civility (Flora and Thiboumery, chapter 5). On one level, the landscape may include individuals and groups who have never even met. They may very well have different customs, norms, and language, and come from different social classes or status levels. Furthermore, their knowledge and frames of reference are likely to differ significantly. While fostering technological change in complex adaptive systems is enriched with knowledge across a wide range of local and scientific perspectives, it also requires the skills of facilitating communication between and among local and technical knowledge producers and users. Mutual respect must be established for both local and scientific knowledge and its caretakers.

Being cordial and open to learning from one another is not enough. Knowledge and information need to be proactively shared among those faced with similar sets of opportunities and constraints. Building networks of these individuals and groups strengthens the social learning process and assures that knowledge development is adapted to local settings. The sharing of experiences and information helps to create lasting relationships on which adaptive management practices can be built. Taking action on those understandings requires more formalized platforms or forums for discussion, debate, learning, negotiation, and decision making. Platforms help to gather the relevant actors to focus on specific issues or problems for which action needs to be taken. They provide a framework for linking with and bringing in non-local stakeholders such as policymakers, entrepreneurs, government agencies, or other scientists or advisors. Through these platforms awareness can be built, goals specified, resources negotiated, and joint actions taken.

While activities that develop social relationships are critical for building social capital and mobilizing other community or non-local resources, human capital development is also required. Adaptive management of complex adaptive systems is knowledge intensive, involving new and often more complex skills. This is not a matter simply of social learning but of training in and development of new technical and management skills among the local partners. One of the most critical elements is the realm of leadership training and development.

## Creating Leadership

There is a real need for leadership. Leaders come in many forms depending on the specific knowledge and skills to be mobilized at a particular moment. The key leader is the overall facilitator for adaptive management of the landscape. This leader may be from a government or non-governmental agency or from a farmers' organization, that is, someone with the power to bring diverse groups together in the first instance. Whatever the source of leadership, leaders should be perceived as neutral, adept in promoting experiential learning—to guide without leading—and able to motivate others, putting them at ease during the process of problem identification or when negotiating a solution compatible with all stakeholder concerns. Skills of the facilitator should be supplemented with knowledge of group management, learning processes, and facilitation tools (see Buck and Scherr, chapter 8).

But leadership involves a variety of stakeholders and scientific subject matter specialists (research and extension). Adaptive management is an ongoing process; local champions are critical to maintaining the momentum that leads to the success of adaptive management projects. A constant supply of leaders is needed. At any one time, there may be a series of tasks to be accomplished. As time goes on, the endurance of some leaders will fade, and others will have to carry on. Consequently, there is a constant demand for new leaders and leadership training.

## Fostering Communication for Learning and Innovation

Communication, learning, and innovation don't just happen; they must be cultivated. While extension agents are often tasked with the responsibility for communicating, they are not the only ones involved in promoting and communicating. As Buck and Scherr (chapter 8) note concerning the management of complex adaptive systems, the "boundaries between generators and users of knowledge are blurred." Consequently, all stakeholders need to be communicators. It is the role of the facilitator(s) to ensure that the connections are made among this diversity of partners. Networks provide the framework within which routine information exchange can flourish. Community knowledge exchange is vital to planning and feedback for timely and relevant decision making. Establishing a shared framework or vision about landscape functions is both an end and a means.

Communication needs to be directed. Communication should be encouraged and transformed into creative problem solving. Once the foundation for communication is established (Flora and Thiboumery, chapter 5), social learning can occur. Facilitators should engage groups in conscious, self-directed learning and problem solving. Although experiential or inquiry-based learning is most apparent in the evaluation phase of adaptive management, it begins with the process of problem identification and goal setting, and it continues throughout implementation. This learning should encourage active engagement, motivating community members to exhibit responsibility and independence as well as develop creativity and problem-solving skills. However, it should not be presumed that community interaction will be without conflict. Shaping landscapes is a process of negotiation.

Communication is not simply a matter of words. Maps, photographs, and other visual aids facilitate the development of the spatial literacy necessary for the discussion of complex landscape issues. Geographic information systems, along with watershed and other models, increase the precision and value of information for decision making. However, these methods are not always easily understood by local decision makers. Communicating across disciplinary boundaries and introducing cross-scale information to local authorities can be challenging. Often, systems thinking is not apparent to single-issue stakeholders. Simple tools and/or models need to be used for transmitting scientific messages and findings.

## Enrolling All Stakeholders in the Process

Inclusion of all voices is also required. However, empowering the poor is a challenge. There are difficulties in enrolling women and minorities in project or group activities (Flora and Thiboumery, chapter 5; Bell, chapter 9; Bertelsen et al., chapter 11). Lower-status individuals are often ignored, with meetings scheduled when they are otherwise occupied or located where they cannot attend. The costs of ignoring any stakeholders can compromise successful implementation. Both the weak and the strong can subvert collective endeavors. The poorest, women, and other minorities will require special efforts, but so too will powerful elites, government officers, and critical partners along the input and output value chains.

## Implementation

The three case studies indicate a generic model for the implementation of adaptive management for complex adaptive systems. The process begins with problem diagnosis and moves on to building consensus around how to solve it. Innovation systems grow out of these locally



expressed needs. Two of the case studies focus on community/watershed-level management and the other on household-level decision making as it affects higher levels of management. Clearly more resources were expended in the Bangladeshi development project, and a broader dispersion of impacts consequently occurred. Nevertheless, both development and research projects can provide the conditions for social learning and adaptive management. Each case study identifies the problem to be resolved concerning soil or water management, yet each one puts considerable emphasis on institutional and governance relations to accomplish the identified production and conservation goals. Issues of governance appear to emerge with the implementation of improved practices.

## Problem Diagnosis

For researchers and development professionals alike, problem diagnosis begins with a review of local development experiences and priorities, an exploration of current findings and best practices relevant to potential behavioral changes, and collection of secondary data on the targeted area. Before trying to narrow problem diagnosis, it is important to gauge the context within which production or conservation improvements are expected. In Ecuador, Alwang et al. (chapter 10) began by conducting discussions with local officials integrating science and local knowledge to describe and evaluate economic, social, and environmental problems in the watershed. Bell (chapter 9) reviewed the lessons learned from previous projects in Bangladesh (no local participation, lack of local government/elite participation). Further, given the focus on poverty and the environment, the Management of Aquatic Ecosystems through Community Husbandry (MACH) project addressed revival of local fisheries but recognized the importance of focusing on the ecosystem as a whole. Incorporating existing institutional arrangements was critical to designing a sustainable supporting environment for adaptive management. Bertelsen et al. (chapter 11) framed their relationship with the local community in the new policy context of Malian government decentralization. The formation of the Natural Resource Management Advisory Committee (NRMAC) mobilized new leaders in the interstices between traditional and modern institutions and set the research and development agenda.

Dialogue with those directly involved in production processes is critical to understanding current management practices and to developing the rapport needed to build teams of local and nonlocal participants. Alwang et al. (chapter 10) note the importance of sustained contacts (through previous projects) between outside research agencies and local producers for building the confidence to collaborate effectively. Bertelsen et al. (chapter 11) applied the participatory landscape/lifescape appraisal methodology to provide a mechanism not only to learn about local biophysical, socioeconomic, and institutional conditions but also to build the collective team effort combining representatives from several local institutions with other community members. Workshops were used by the MACH project to bring stakeholders together and collectively identify key problems to be addressed. The interaction among stakeholders and the recording of their collective perceptions and priorities is a critical first step in building local involvement. Not only do outside agency representatives come to an increased understanding of the problems and potential solutions, but the exchange that develops among locals who seldom speak with one another provides the critical learning experience.

## Consensus, Goal Setting, and Planning

Both Bertelsen et al. (chapter 11) and Bell (chapter 9) discuss action-plan development as a multistage process involving stakeholders discussing and developing alternatives in small groups before consolidating them in plenary sessions. Consensus building is actively sought at the primary-level village user groups (chapter 11) and resource user groups (chapter 9) who report to larger groups that involve local government partners and elites. The purpose of these groups is not only to set goals and plan collective interventions and research programs but also to institutionalize a process that shares information and lessons learned. As new needs become apparent, these relationships are in place to take new actions.

Having conducted earlier discussions with knowledgeable local agents, Alwang et al. (chapter 10) describe a process by which scientific information is introduced from the start into a participatory process of problem evaluation, goal setting, and planning. As a consequence, the scientific models were reformulated with improved local data, analysis, and evaluation. The approaches of both Bertelsen et al. and Alwang et al. frame the primary issue of decision making at the farm household level as it shapes the options for livelihood diversification and a diversity of household strategies.

## Institutional Relations for Sustained Adaptive Management

In Bangladesh, the MACH project was organized around comanagement of the water-based ecosystem and involved many community-based organizations and their local councils. The research-developed NRMAC in Mali was more limited in scope and focused on community level conflict management and adaptation of technologies. However, each assured that an institutionalized platform for debate and action was being established. Alwang et al. (chapter 10) used a series of workshops to develop a platform for discussion of watershed issues within the two Ecuadorian communities in which they were working. In all cases, links with existing government and local institutions were made. Full participation of all stakeholders (the poor householders, local elites, government officials, and development agents) was critical to long-term success. This participation assures the legitimacy of the collective efforts. It also provides locals with the conditions and opportunities to become leaders. Local champions are an essential feature of sustainable local efforts.

Capacity building is critical to ensuring that local organizations and government units can develop and maintain an active role in adaptive management. Capacity building has two dimensions. In the first, institutional skills and behaviors are needed to assure that these organizations are well governed and effectively managed. Bell (chapter 9) and Bertelsen et al. (chapter 11) describe considerable efforts to accomplish this. Skills are needed in proper governance practices, literacy and accounting practices as well as more advanced business management skills. Learning for institutional development is time consuming and requires that all relations be adequately cultivated. Communication must continually move back and forth from user groups to local leaders.

Capacity to incorporate scientific and technical knowledge is the second dimension. Alwang et al. (chapter 10) and Bertelsen et al. (chapter 11) emphasized the active engagement of farmers and local officials in field research on new technologies and practices that may be put to use in adaptive management programs. Alwang et al. (chapter 10) found that initial skepticism over the value of models led to increased precision of models as stakeholders became more familiar with them. However, it was often necessary to use simpler techniques such as maps to communicate the results of these models in a form useable by local leaders. Involving farmers and local officials

in the conduct of scientific studies and analyses led to improved understanding of cause-and-effect relationships and of the alternatives that were generated for potential implementation by all stakeholders. While training was useful for transmitting much of this new information, it was the learning-by-doing approach that assured the commitment of local leaders.

## Take Risks, Monitor, and Adjust

All of these cases identified and implemented innovative practices. Mistakes were made, or lessons were learned, leading to management adaptations. By setting in place user groups and their supporting institutional infrastructure, a framework for learning (monitoring and adapting) evolved. Maintaining inclusive practices was emphasized in Bangladesh. The resource management organizations needed to retain a majority of poor resource users throughout the process. The NRMAC in Mali routinely brought issues of minority herders to the table, and pasture management became a key research focus.

Reviewing implementation, evaluating outcomes, and updating plans is an ongoing process. Models were helpful in facilitating this task to the extent that local leaders were involved in initial model adaptations (earlier learning). Models reflect cross-scale linkages and other decision-making domains. The NRMAC learned in its second year to manage research trials with farmers, identifying those cooperators most likely to fulfill their obligations and provide feedback across the community. The local review and evaluation of quantitative data in the Ecuadorian watersheds was complemented by qualitative data provided by locals concerning idiosyncratic local conditions or operational issues of implementation. This feedback, in turn, increased the analytic precision and research value to both researchers and local participants.

## End of an Iteration

Writing this book was a collective effort in adaptive management; some likened it to herding cats. The various authors, trained as disciplinary scientists, acted and reacted as components of complex adaptive systems, elaborating their systems and crossing scales as these chapters of complexity emerged. Building on their diverse array of experiences from around the world, we negotiated each of their contributions in providing this collective product. However, this book is not designed for specialists; it is designed for transdisciplinary adaptive management facilitators.

The purpose of this book is to inform development practitioners about the range of expertise available for addressing the wide range of adaptive management options. In this iteration we attempted to provide the basic knowledge, terminology, understandings, and tools at each system level to improve the capacity of smallholders to better manage their assets. Chapters from the book can be used individually as needed to address a specific problem or collectively to help guide the coordination of team efforts. There is no single answer. Successful and sustainable solutions must be negotiated to deal with each specific time and place and must be agreed to by the range of current stakeholders.

A second Green Revolution is on the horizon, this one for smallholders. As we learn through the application of these system concepts and adaptive management principles, we can continue to communicate and adaptively revise our notions of how best to move forward.