Delivering the Goods: Scaling out Results of Natural Resource Management Research

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ABSTRACT

To help integrated natural resource management (INRM) research "deliver the goods" for many of the world's poor over a large area and in a timely manner, the authors suggest a problem-solving approach that facilitates the scaling out of relevant agricultural practices. They propose seven ways to foster scaling out: (1) develop more attractive practices and technologies through participatory research (2) balance supply-driven approaches with resource user demands, (3) use feedback to redefine the research agenda, (4) encourage support groups and networks for information sharing, (5) facilitate negotiation among stakeholders, (6) inform policy change and institutional development, and (7) make sensible use of information management tools, including models and geographic information systems (GIS). They also draw on experiences in Mesoamerica, South Asia, and southern Africa to describe useful information management tools, including site similarity analyses, the linking of simulation models with GIS, and the use of farmer and land type categories.

KEY WORDS: Mexico, South Asia, Southern Africa, conservation tillage, diffusion of research, environments, geographic information systems, natural resource management, participatory research, scaling out, simulation models, technology transfer.

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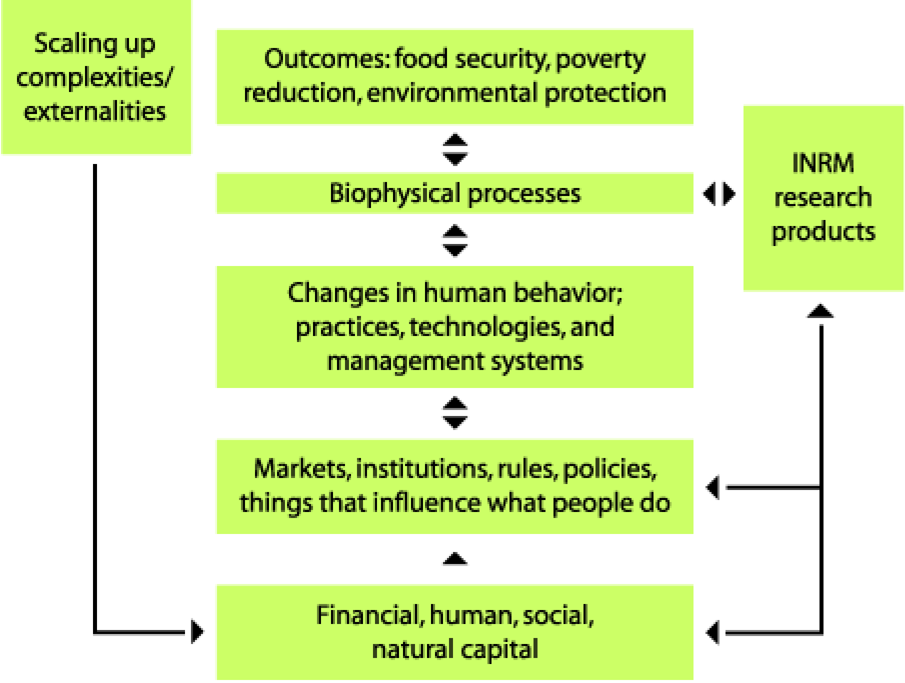
THE CHALLENGE

Support for research on natural resource management appears to be approaching a crisis. Increasingly, questions are being raised as to whether this research can deliver the goods. Some feel that it is more concerned with definitions and purity of process than with results. Research on natural resource management must demonstrate its ability to benefit large numbers of poor people across large areas within sensible time frames. The easy assumption that such work is inherently site specific must be overturned. Put simply, we must meet the challenge of accelerating the use of natural resource management practices that improve human well-being.

Integrated natural resource management (INRM) research can meet this challenge. Decentralized initiatives, supported by effective institutions and guided by suitable information management tools, can lead to the widespread use of suitable management options from INRM research. This, in turn, can improve agroecosystem productivity and resilience, thereby helping achieve the goals of poverty alleviation, food security, and environmental protection. Behind this is the realization that policies, people's behavior, natural resource management practices, biophysical processes, and system outcomes are linked in cause-and-effect relationships (Fig. 1). Specifically:

- policies, organizations, institutions, and rules affect the behavior of communities and individual farm families;
- people's behavior includes the selection and adoption of natural resource management practices;
- these practices affect plant and animal growth and biophysical processes; and
- biophysical processes result in outcomes that have consequences for incomes, food security, and resource conservation.

Fig. 1. Integrated natural resource management research furthers the goals of the Consultative Group on International Agricultural Research (CGIAR): food security, poverty reduction, and environmental protection.



This paper discusses some of the concepts involved in and procedures for generalizing and propagating the results of natural resource management research ("scaling out"), with a few forays into the area of externalities and scale of analysis ("scaling up"). It features examples of several methods and tools for accelerating the scale of geographical coverage and impact of INRM practices. Most examples are drawn from collaboration between the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), known in English as the International Maize and Wheat Improvement Center, and research partners in South Asia, southern Africa, and Mesoamerica. Methods and tools illustrated include site similarity analysis through geographic information systems (GIS), the linking of simulation models with GIS, and farmer and land type categories. The selection of examples is illustrative and does not aim to be comprehensive.

These examples show the tools being used in the context of a problem-solving process that harnesses cause-effect links among policies and institutions, farm-level practices, plant and animal growth, biophysical processes, and impacts and outcomes. Strengths and weaknesses of the different methods and tools are discussed.

Finally, it is argued that these tools are most useful when they provide information in the context of a bottom-up learning process to a wide range of stakeholders who need this information to make decisions. They should never be used for the mere mechanical extrapolation or replication of particular practices.

A PROBLEM-SOLVING APPROACH

Research on integrated natural resource management (INRM) must be capable of solving problems (or seizing opportunities) in ways that improve livelihoods for the poor while conserving resource quality and protecting the environment. Understandably, INRM researchers may wish to apply a problem-solving approach (Tripp 1991). Within a problem-solving process, we can distinguish among problem sets, causes, intervention points, and measurement tools.

Problem sets are situations in which agroecosystem performance, i.e., the processes that affect the resource quality or the environment, is unsatisfactory. Examples include low agroecosystem productivity, excessive resource degradation and environmental pollution, low levels of environmental services, low agroecosystem biodiversity, reductions in soil fertility, unsatisfactory water quality for consumers, and excessive greenhouse gas emissions. These problems can be characterized in terms of their costs and consequences, spatial and temporal incidence, and pace of change. They can be recognized and defined by farmers, communities, nongovernmental organizations (NGOs), scientists, and/or policy makers.

Causes are the factors that drive or contribute to problem sets. Typically, many causes at several levels are at work. Causal chains can be long and complex, linking policies, institutions, farmer or community behavior, biophysical processes, and their consequences for livelihoods and the environment. In other words, policies and institutional arrangements affect people's behavior, people's behavior affects plant and animal growth and biophysical processes, and biophysical processes result in outcomes that cause changes in system productivity and resource and environmental quality.

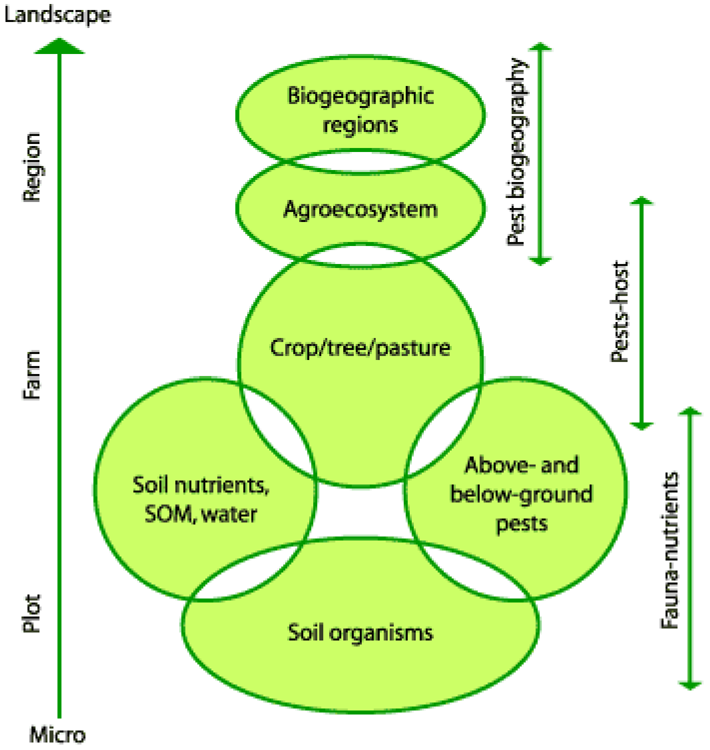
Chains of cause and effect typically link different scales of analysis. For example, regional policies on the burning of crop residues may influence mulch management at the farm level, affecting soil water and organic matter levels and fractions and rates of erosion at the plot level, with consequences for water quality in the watershed as well as for crop yields and family incomes at the farm level.

Intervention points are opportunities for addressing the problem set. They are not restricted to new farm-level technologies; they may also include changes in policies and institutional arrangements, e.g., rules governing community forest management. However, policy change as an intervention is most effective when cause-and-effect relationships are clear, that is, when there is a reasonable likelihood that a change in policies or institutions will modify farmer or community behavior in ways that lead to desired changes in biophysical processes, system productivity, and environmental and resource quality. Interventions, then, can be at any level of analysis: plot, farm, community, watershed, or region. They may be developed by farmers via farmer experimentation, by scientists, by policy makers, or by the private sector. Early successful interventions have been referred to as "sparks" (Consultative Group on International Agricultural Research 2000).

For example, a problem set may revolve around the siltation of the lowland irrigation infrastructure, leading to substantial productivity losses and heavy public investment in renovation. Causes may include heavy erosion from upland areas driven by policies that encourage communal livestock grazing of crop residues, thus reducing incentives to use these residues as a soil cover. An intervention point might feature policy changes to foster modifications in grazing practices that encourage the use of crop residues as a soil cover mulch to reduce erosion and ameliorate the original problem of siltation.

Finally, measurement tools allow us to understand cause-and-effect links, trace and even anticipate the consequences of interventions, and understand biophysical processes at any scale of analysis. Indicators of sustainability fall into this area, as do most modeling approaches. In this vein, ecosystems analysis provides an analytical framework that makes it easier to understand the consequences of changes in both short- and long-term states at a range of scales. The processes can be linked conceptually within a framework (see Fig. 2), and the effects of given scenarios can be quantified using simulation models linked to spatial and temporal databases through GIS.

Fig. 2. Biophysical processes at different scales of analysis. SOM stands for "soil organic matter."



Of course, most models still need to be refined in the critical areas of edaphic and pest (insects, pathogens, and weeds) interactions and constraints. Ecosystems analysis can provide two critical services at relatively minor cost: (1) assessment of both genetic and environmental productivity and sustainability and (2) a framework for impact assessment and the definition of problem-cause relationships, especially those involving biophysical processes, and how those relationships affect system productivity and sustainability. INRM will fail if we do not have a problem focus and include plenty of work to identify intervention points; we cannot simply conduct academic work on measurement tools.

SIMPLE INTERVENTIONS IN COMPLEX SYSTEMS

Natural resource management practices as implemented by resource managers such as farmers, communities, fishers, and forest dwellers are typically complex. Rules governing the use of land and water resources or forest or fishery stocks are usually complicated and difficult for outsiders to understand. However, intervention points, including new technologies or practices for resource use, can be relatively simple. Interventions are usefully seen as options or alternatives for exploration by resource users, who can best judge the attractiveness of an option by testing it under local circumstances.

However, even for simple interventions the consequences of widespread adoption can be hugely complicated. The introduction of relatively simple options can significantly change farming or resource management systems and their accompanying biophysical processes and system outcomes.

For example, farmers who deal with irrigated crop systems use complex practices to manage soil fertility and water quantity and quality. These include managing crop residues, fertilizers, and farmyard manure; arranging for biomass transfer from outside the farm; choosing alternative fuels for household use; deciding among alternative uses for canal and tubewell water; making decisions related to the timing and frequency of irrigation; and selecting crops for well-drained vs. poorly drained areas, among other things (Fujisaka et al. 1994). However, the introduction of a relatively simple practice such as zero-tillage crop establishment can improve the timeliness of sowing, increase the efficiency of water and nutrient use, reduce water pumping, stop groundwater depletion, reduce fuel use, drastically lower carbon emissions, change crop rotations to take advantage of the earlier grain-crop sowing, and change soil chemistry and soil health via new rotations (Hobbs and Morris 1996). Some of these consequences, e.g., changes in the quality and quantity of groundwater, may become apparent only at higher scales of analysis.

A good understanding of ecological, biophysical, economic, and social processes is needed to anticipate, model, assess, and manage such changes. Otherwise, farmers and scientists alike can only react to changes as they unfold.

THE NOTION OF SCALE

The role of integrated natural resource management (INRM) in "delivering the goods," that is, in fostering improvements in the livelihoods of large numbers of the poor, is often referred to as scaling out. This phrase conceals as much as it clarifies, because the notion of "scale" is perceived in many different ways, among them:

- scale of analysis: from plant to plot to farm to watershed to region;
- scale of intervention point: high-level interventions such as policy changes, adjustments in institutional arrangements or property rights, and the fostering of collective action vs. lower-level interventions such as farmer experimentation or extension for specific practices;
- scale of investment in intervention strategies: small vs. large investments in extension, farmer experimentation programs, or efforts to provide information to policy makers;
- scale of community empowerment: the number of communities able to undertake their own research and adaptation through processes for local learning;
- scale of geographical coverage of an INRM practice: whether it is limited to a village or watershed or has attained regional or national relevance;
- scale of impact: for example, the extent to which desirable outcomes, e.g., improved system productivity and resource quality, have been achieved through INRM research.

In principle, these scales are linked. Greater impacts are generated from higher levels of investment in suitable intervention strategies, or from more efficient use of these investments through greater reliance on community empowerment, leading to expanded geographical coverage of suitable practices.

This paper focuses on ways to augment and accelerate the scale of geographical coverage and impact of INRM research. It emphasizes efficiency and effectiveness in generalizing and propagating research results through the replication, dissemination, and adaptation of technologies or practices. These technologies may comprise plausible promises, malleable prototypes, or well-defined practices. If INRM research products are not scaled out, we will have failed in our goal of contributing to poverty alleviation, food security, and environmental protection.

Sometimes, though, to augment and accelerate INRM research impacts, we must also assess and manage positive or negative externalities, unexpected complexities, or unintended consequences that emerge at higher scales of analysis from the widespread adoption of new resource management practices. This is because consequences that emerge only at higher scales of analysis may either reinforce or undermine the desired outcomes. For example:

- improved efficiency of water use at the plot level may not, in fact, lead to improved water use at the level of the whole irrigation system;
- changes in land use or crop management on hillsides may improve or possibly downgrade the quantity and quality of water available to downstream users;
- more efficient fishing practices used by one person may destroy fish stocks if used by everyone;
- local rules and incentives may be undermined by regional or national policies; and
- institutions that seek to control rather than manage biophysical processes may not foster adaptive capacity, possibly exacerbating rather than solving problems.

Effective scaling out, then, also requires attention to the other notions of scale: scale of analysis, scale of intervention point, and scale of community empowerment.

SCALING OUT AND COMMUNITY EMPOWERMENT

Much current thinking on scaling out integrated natural resource management (INRM) research steers clear of the notion of spatial extrapolation of specific practices. Rather, the emphasis is on community empowerment and scaling out as a learning process. A recent workshop report (Consultative Group on International Agricultural Research 2000) describes this well:

> *It is not technologies that are scaled up, but processes and principles behind the technologies/ innovations. This is consistent with the belief that scaling out is not just replication but adaptation and learning that is flexible and interactive ... Scaling out is really about people—of communicating options to people, of a balance between introducing options and involving farmers' ability to adapt to changing contexts ... Scaling out as a development process rejects the cookie cutter approach. [It] ... achieves large numbers and wide area coverage through multiplication with adaptation ...*

We agree with these conclusions. Bottom-up farmer experimentation and community empowerment are fundamental to scaling out INRM practices. However, these bottom-up approaches will be more effective when their outcomes are widely shared. Surely farmer experimenters are likely to be interested in trying out exciting practices developed in similar communities facing similar problems.

Although scaling out is largely a bottom-up process whereby research outcomes are widely shared, our experience suggests that the use of information technologies such as the methods and tools described below can help "smarten" and focus the process.

ELEMENTS OF SCALING OUT

What can be done to foster the effective scaling out of suitable natural resource management practices? We suggest some activities below, several of which involve improvements in human and social capital.

- *Generate more attractive products.* Regardless of how it is done, scaling out is easier when practices are less risky and more profitable, and meet other resource management objectives. Participatory research increases the chance of identifying attractive options.

- *Balance supply-driven approaches with resource-user demands.* Demands from resource users must influence the kinds of resource management options developed through research and the kinds of options to be scaled out. However, they cannot express a demand for practices with which they are unfamiliar. Scaling out, then, must include ways for users to become familiar enough with new options to judge their attractiveness under local conditions.
- *Use feedback to redefine the research agenda.* As information accumulates on technology performance and attractiveness and how policies and institutions influence them, integrated natural resource management research can and should be adjusted accordingly.
- *Encourage support groups and networks for information sharing.* Community groups, cross-community networks, alliances of networks, study tours, and scientific exchanges can all can help resource users as well as scientists better understand the performance of alternatives and options under different conditions.
- *Facilitate negotiation among stakeholders.* With multiple-function, multiple-user resources, trade-offs in resource use may lead to conflicts among stakeholders. Negotiation and conflict management among stakeholders may be helpful in resolving conflicts and encouraging the use of suitable practices.
- *Provide information of use to those who are establishing policies and developing institutions.* Scientists can provide helpful information for policy formulation and institutional development. For example, if adaptable institutions are needed to review new resource management practices, this should be made clear. Policy makers may welcome new information on how resource management practices can help them meet economic and social goals. New policies and institutions can influence human behavior, including technology adoption.
- *Make sensible use of information management tools such as GIS and modeling.* When practices that raise agroecosystem productivity, improve resource quality, and ameliorate environmental consequences are discovered or developed, there is an understandable interest in seeing that these practices or their adaptations are used more widely. Adding a spatial dimension to the problem-solving process can help make this happen. This results from the simple recognition that practices may be equally attractive to different farmers or farming communities that face similar problem sets, are driven by similar causes, and are governed by similar factors with regard to adoption behavior. This is not a plea for top-down mechanical extrapolation of technology; rather, it is the recognition that stakeholders can use the information provided by spatial analysis when making decisions.

For example, in a certain community, a green manure cover crop may smother weeds, free up labor, improve water use efficiency, reduce the need for external inputs, raise yields, and improve farm family livelihoods. Research may suggest that this practice is most attractive in locations where the cover crop is climatically adapted, soil fertility is within a certain range, land use intensity is low (allowing a cover crop/grain crop rotation), and marketing margins are high (making external input use unprofitable). Spatial analysis that combines data on the climate, soils, population density, crop distribution, and transport infrastructure can identify large areas in other communities that might benefit from this practice. This outcome can be shared with NGOs, research and extension institutions, farmer groups, and policy makers for use as they see fit. This may encourage NGOs or farmer groups to experiment with and adapt the practice, or at least to evaluate its attractiveness under local conditions.

INFORMATION MANAGEMENT TOOLS FOR SCALING OUT: EXAMPLES

The following sections provide examples of information management tools of potential use in scaling out integrated natural resource management (INRM) practices. Most examples are drawn from CIMMYT's collaboration with a range of partners in South Asia, southern Africa, and Mesoamerica. The selection of examples is illustrative, not comprehensive. The methods and tools discussed include site similarity analysis through GIS, the linking of simulation models with GIS, and the use of farmer and land type categories. Although, in most instances, the tools and methods show considerable promise for use in scaling out INRM practices, on-the-ground experience remains insufficient. The strengths and weaknesses of these methods and tools are presented in Table 1.

Table 1. Relative strengths and weaknesses of tools and methods for scaling out.

Tool or method	Strengths	Weaknesses
Site similarity analysis	Simple tools available Conceptually accessible	May oversimplify Criteria for similarity often subjective
Interfacing GIS with models	Allows examination of time trends, including climatic risk Can express outputs in terms of specific variables of interest to stakeholders	Dependent on quality of model Requires specialists to implement
Land type and farmer categories	Outputs conceptually accessible Outputs suitable for use by extension workers and farmer experimenters	Outputs possibly too subjective Labor-intensive data acquisition May ignore interactions across land types within a household
Participatory extension, e.g., whole family training	Outputs readily accessible to farm families Can be scaled up in terms of organizational capacity required for implementation	Deals only with the family as a unit, does not extend to collective action at the community level Does not have an explicit spatial dimension

Site similarity analysis through GIS

A recurring question in efforts to scale out promising interventions is how a practice developed at one location will perform over a broader range of environments. Geographic information systems (GIS) can address such concerns, allowing scientists to share relevant results with colleagues elsewhere, to find new sites for testing and adapting discoveries, and to design more effective research programs. One simple GIS-based approach is to identify areas that are similar to a given location, using criteria relevant to the problem at hand (Corbett et al. 1999).

To identify regions suitable for the introduction and adaptation of wheat production practices that might show promise for conditions in Bolivia, a GIS was used to identify sites similar to key research locations in the country's two major wheat system environments (Hodson et al. 1998). In the highlands, wheat is grown on summer rains in numerous valleys and small plateaus. In the eastern lowlands, the crop is sown on residual soil moisture as temperatures drop and become more favorable for wheat. Zones of similarity were defined using the GIS-based Spatial Characterization Tool (Corbett and O'Brien 1997) by specifying the latitude and longitude of a given research site and then selecting criteria for similarity based on ranges of precipitation, potential evapotranspiration, and temperature. For the highlands, zones were based on the favorable 5-month growing period, and for the lowlands, the coolest quarter was used.

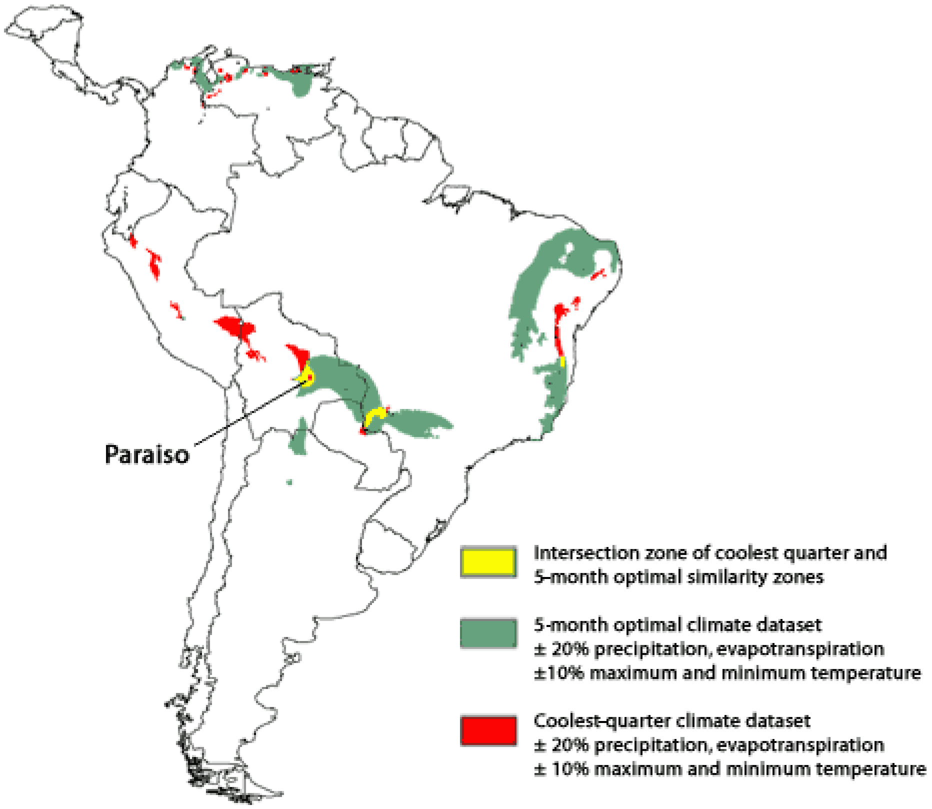
There were scattered zones of similarity in the highlands of Bolivia, Peru, Colombia, and Venezuela. Extending the analysis to Mexico, Central America, and Africa resulted in the identification of additional areas with similar climates, notably in Mexico and Ethiopia (Fig. 3). For lowland sites, the largest regions outside of Bolivia were in two substantial but disjunct areas of eastern and southwestern Brazil. To extend the analysis to a complete farming system scenario, similarity zones for the rainy season were identified to account for the times when crops such as maize, cotton, and soybean were normally sown and harvested. This allowed researchers to narrow regions of similarity to a single area in eastern Brazil (Fig. 4).

Fig. 3. Zones of Bolivia, Peru, Colombia, and Venezuela that are climatically similar to two Bolivian highland wheat production sites for the 5-month optimal crop growth period (± 20% similarity for precipitation and evapotranspiration, ± 10% similarity for maximum and minimum temperature).

a. Tarata, Bolivia.

b. Tarabuco, Bolivia.

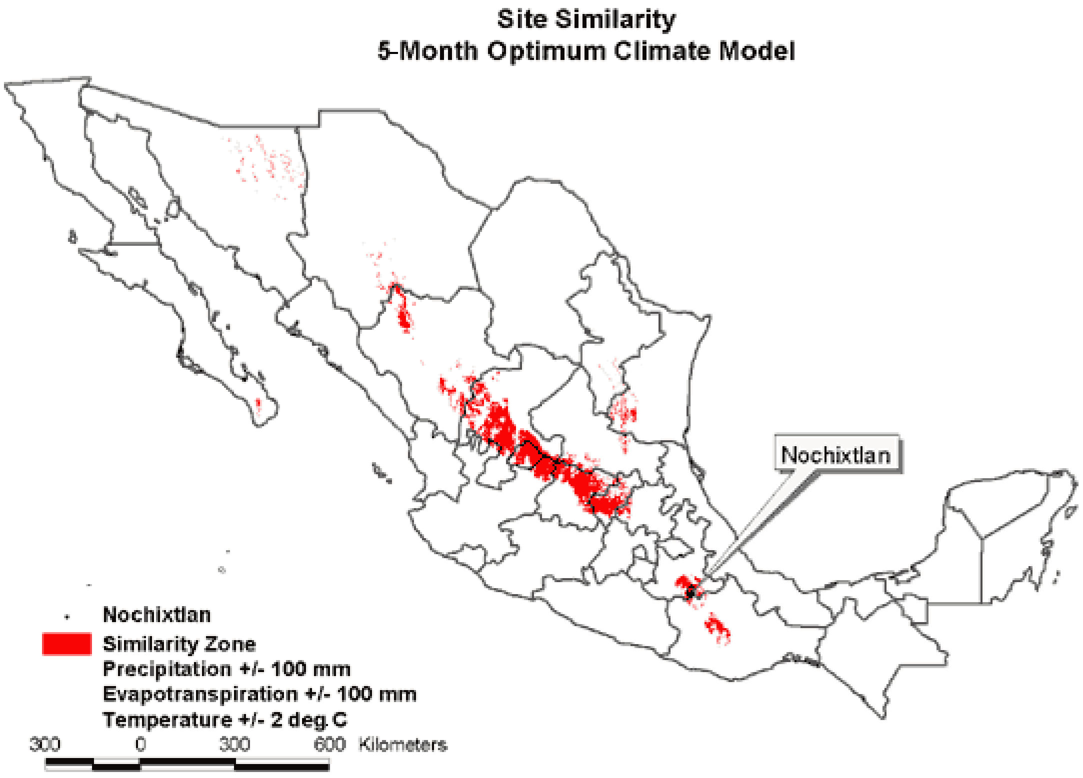
Fig. 4. Zones that are climatically similar to the lowland wheat production site, Paraiso, Bolivia, for the coolest quarter of the year, the 5-month optimal crop growth period, and the intersection zone of both.



This specific analysis has yet to be tapped to scale out INRM practices. However, it has now become clear that researchers and farmer experimenters in the defined areas of Bolivia, Brazil, Mexico, and Ethiopia are addressing similar problem sets with similar interventions, and would benefit from sharing research information and results.

In a different application and on a different scale, farmer experimenters in the Mixteca region of southern Mexico, one of the country's poorest areas, used site similarity analysis to identify locations elsewhere in Mexico with climate and soil conditions similar to their own (Fig. 5). This information was then used to plan a study tour of research and farmer experimentation in these similarity areas. The farmers returned home with several ideas that they have begun to test, among them the use of crop residue mulches and drip irrigation for fruits and vegetables (J. C. Velásquez, 2000, *unpublished manuscript*).

Fig. 5. Areas throughout Mexico that possess climate and soil conditions similar to those of Nochixtlan, a village in the Mixteca region.



Interfacing models with GIS

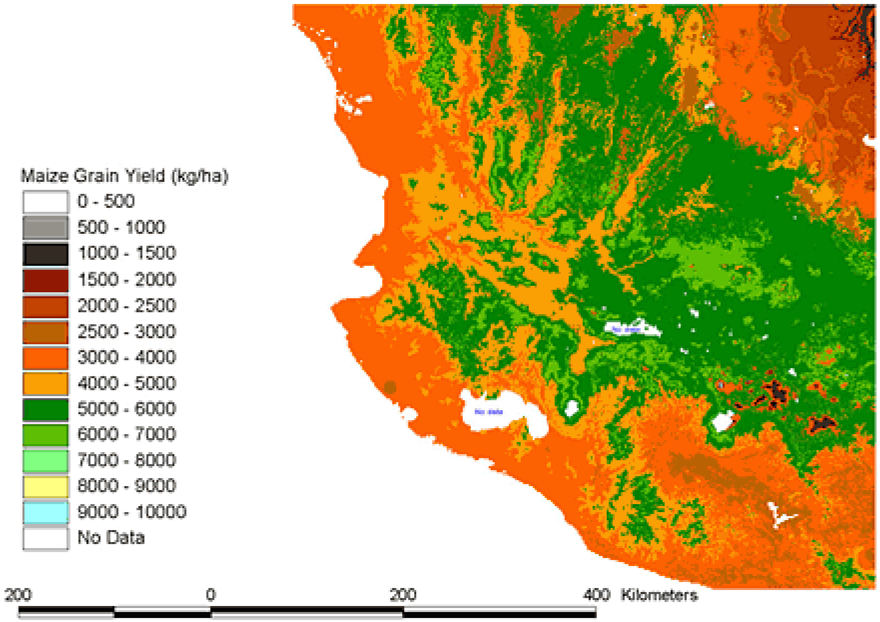
More complex comparisons may be beneficial to address some situations. Stakeholders may want to examine trade-offs for different scenarios. For example, are the productivity gains from conservation tillage likely to entirely offset the value of crop residues for animal feed? How will system performance vary over time, particularly in extremely dry or wet years?

Process-based simulation models can "grow" a virtual cropping system over many seasons, quickly and inexpensively. The output, in effect, extends the reach of science beyond the practicable time horizons of most research programs, while making it possible to examine variables that are difficult or costly to monitor at the field level (e.g., nitrogen leaching and volatilization). By interfacing GIS with simulation models, researchers can develop simulated performance surfaces that portray the likely biophysical consequences of a technology over space and over time (Hartkamp et al. 1999).

Using this approach, CIMMYT scientists examined how the performance of conservation tillage with residue retention might vary over space and time in western Mexico (Hartkamp 2000). Two key factors in the simulations were weather and soil type. Through collaboration with the International Fertilizer Development Center, a residue retention module was added to the Decision Support System for Agrotechnology Transfer suite of crop models (Tsuji et al. 1994).

Outputs from simulations (Fig. 6) were compared with experimental results and with the researchers' own experiences. Using the resulting maps, researchers and decision makers were able to assess the simulated effects of conservation tillage on run-off and erosion, organic matter, soil structure, and moisture conservation. For each soil type, maps produced using the simulations show differences across the region in the biophysical performance of the practice. Impacts can be expressed in terms of various factors, including yield, stability, biomass, and the organic carbon and nitrogen use efficiency of the soil. The methodology thus shows promise for providing information for a range of stakeholders; the maps and other outputs can help NGOs, farmer groups, and researchers determine where conservation tillage may be most appropriate for farmer experimentation and adaptation.

Fig. 6. Simulated 12-yr average for maize grain yields under a conservation tillage system (maize-fallow with 33% residue retention) in the state of Jalisco, western Mexico, produced using Decision Support System for Agrotechnology Transfer models linked to geographic information system databases.



Land type and farmer categories

The GIS-based applications described above emphasize regional, national, or international comparisons that can be used to guide scaling out. However, more modest tools and methods that feature comparisons across farms can serve the same purpose. It has long been known that many farmers recognize different land types within a farm. These land types frequently follow the toposequence. When problems, causes, and intervention points are specific to land types, scaling out activities can be guided by the typology. When land types are replicated across large areas of the landscape, efficiencies in scaling out can be considerable. Often, of course, farmers with different resource endowments use different management practices for the same land type. Consequently, measures to foster scaling out must also consider farmer categories and cross-land type interactions within farms.

In the rice-wheat systems of the Indo-gangetic Plains, rainfall, water control, and soil texture tend to follow an east-west gradient. However, water control and soil texture in specific locations are also influenced by land type, i.e., lower, middle, and upper terraces, within a toposequence. Even though a land type may be known by different local names in different parts of the Indo-gangetic Plains, its characteristics, uses, and management are often similar (Harrington et al. 1993). Lower terraces are characterized by heavier soils and relatively poor drainage and are more likely to be devoted to long-duration, traditional rice cultivars. Middle terraces have somewhat lighter soils and fewer drainage problems and are typically sown to modern rice and wheat varieties, at times mixed with other crops. Upper terraces have the lightest soils of all and tend to have greater agroecosystem species diversity. Here rice and wheat are sown, as well as pigeonpea, sugarcane, and vegetables.

The usual problems of rice-wheat rotations in the Indo-gangetic Plains, in particular, late sowing, high costs for tillage and establishment, low water and nutrient use efficiency, soil fertility decline, reduced agroecosystem species diversity, salinity and sodicity, waterlogging, and excessive water pumping leading to groundwater depletion, unfold differently in each land type. Similarly, intervention points change across land types but also by farmer category.

To give one simple example, it has become clear that the establishment of wheat after rice is best performed by inverted-T, zero-till seed drills drawn by four-wheel tractors for larger-scale farmers and on upper terraces. However, for smaller-scale farmers on middle and lower terraces, wheat establishment typically is best performed by surface seeding (Hobbs et al. 1998). In this practice, presoaked, pregerminated wheat seed is broadcast into a standing rice crop as water is being drained off. The presoak is a manure slurry that makes the seed unappetizing to birds. If the timing is right, soil moisture substitutes for tillage in reducing soil strength, so that roots follow the water down the profile. In both zero-till and surface seeding, there is considerable room for farmer testing and local adaptation.

In another example, farmers in southern Zimbabwe distinguish among "vlei" bottoms (wetter areas where rainfall accumulates through natural drainage), homestead gardens (with soils that benefit from crop residues, leaf litter, household waste, and farmyard manure), and toplands (with soils of low fertility and low water-holding capacity, relatively distant from the household). These different land types are managed very differently with respect to crop selection and rotations, the application of organic and inorganic fertilizers, soil fertility management, and so on (Z. Shamudzarira and C. Vaughan, 2000, *unpublished manuscript*). In addition, farmers with many draft animals manage land types differently from farmers with few draft animals. Nevertheless, these land types and farmer categories are replicated across much of southern Zimbabwe and adjoining areas of South Africa and Mozambique.

Exciting practices for addressing important problems, once characterized in terms of land type and farmer category, can be shared widely with farmer groups, NGOs, researchers, and other stakeholders in areas where these same land types and farmer categories prevail. Once again, the intent is to make the exciting practices available as new options to be mixed into local learning processes, not just for "cookie-cutter replication."

A FEW WORDS ON EXTERNALITIES

The heart of scaling up is anticipating, modeling, monitoring, and assessing positive or negative externalities, unconsidered complexities, or unintended consequences that emerge at higher scales of analysis from widespread scaling out, and then contributing to the management of these factors. This may require the use of implicit, explicit, or even mathematical models and an understanding of the interactions among humans, institutions, and ecological processes. In a very real sense, an understanding of consequences "at scale" can be used as feedback to redefine the elements of scaling out to minimize undesirable externalities.

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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