14 The Concept of Integrated Natural Resource Management (INRM) and its Implications for Developing Evaluation Methods

Boru Douthwaite[1], Javier M. Ekboir[2], Steve Twomlow[3] and J.D.H. Keatinge[4]

[1] *Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia*
[2] *Food and Agriculture Organization of the United Nations (FAO), Rome, Italy*
[3] *International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Bulawayo, Zimbabwe*
[4] *ICRISAT, Patancheru, Andhra Pradesh, India*

Introduction

Agriculture in developing countries faces a huge challenge. In the next 50 years the number of people living in the world's poorer countries will increase from 5 billion to nearly 8 billion (Population Reference Bureau, 2001). Moreover, per capita food consumption needs to increase to adequately feed the 1.1 billion underfed people in the world (Gardner and Halweil, 2000). This means that in 2050 farmers will need to produce at least 50% more food from a natural resource base that is already damaged by human activity to the point where further degradation could have devastating implications for human development and the welfare of all species (World Bank, 2000).

The Green Revolution is widely credited with having averted a similar crisis when large-scale famines were predicted to threaten Asia in the 1970s and 1980s. The research component of the Green Revolution was largely based on the genetic improvement of a few commodity crops to enhance their productivity and improve their resistance to pests and diseases. The gains were largely confined to areas of high agricultural potential, and they often benefited the more prosperous farmers. In many cases, this research yielded large production gains at the expense of soil degradation, water, biodiversity, and non-cultivated land (Sayer and Campbell, 2001).

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A second Green Revolution is now needed. However, the situation today is dramatically different from when the first Green Revolution began and different research and development approaches are required. Old, top-down ways of working, in which international agricultural research centres (IARCs) see themselves as the main sources of agricultural innovations that are transferred to national agricultural research and extension systems (NARES) and downward to farmers, are no longer valid (Biggs, 1990; Clark, 1995). There is now a much more sophisticated understanding of how rural development occurs, which recognises that innovation has multiple sources and results from the action of a broad network of actors, of which IARCs and NARES are just a part (Hall *et al.,* 2003a). Research is now seen as part of a collective effort to create new technical and social options that rely more on local knowledge and less on a 'one size fits all' application of simple technologies and chemical inputs. Hence, working in partnerships has become much more important, as has grassroots participation of farmers and their organisations (Hall *et al.,* 2002). A second important area of change is that farmers are increasingly exposed to global markets, and while the information and communication revolution offers exciting opportunities for them to benefit, it also threatens to create a 'digital divide' between rural and urban areas (Malecki, 2003). Over all, IARCs and NARES need to become much more nimble and responsive in the face of an ever-faster rate of change (Watts *et al.,* 2003).

Integrated natural resource management (INRM)[1] is an attempt to build a new agricultural research and development paradigm to meet the challenges and opportunities outlined above. Campbell *et al.* (2001) define INRM as "a conscious process of incorporating the multiple aspects of natural resource use (be they bio-physical, socio-political or economic) into a system of sustainable management to meet the production goals of farmers and other direct users (food security, profitability, risk aversion) as well as the goals of the wider community (poverty alleviation, welfare of future generations, environmental conservation)". Campbell *et al.* (2001) go on to say that evaluation has a crucial role in helping to build and support INRM. The objective of this chapter is to investigate the types of evaluation that are needed to build and support INRM.

Integrated Natural Resource Management (INRM)

INRM has grown out of farming systems research (FSR), which had its heyday in the mid-1980s and then all but disappeared from the list of research programmes by the early 1990s (Ravnborg, 1992). This was because FSR attempted, just as INRM is attempting today, to carry out research with complicated technologies in complex settings. Research on complex agricultural systems is difficult because of the multiple scales of interaction and response within and between physical and social subsystems, uncertainty, long time lags, and multiple stakeholders who often have contrasting objectives and activities (Campbell *et al.,* 2001).

Early FSR failed because by engaging with this complexity it was criticised for generating excessive amounts of data, being very costly to conduct, and yielding few results of immediate practical value. The other major cause of the failure of FSR was a lack of understanding of the role of farmers and other stakeholders in technology development (Röling, 1988; McCown, 2001). In many instances, researchers conducted their experiments in farmers' fields but failed to interact sufficiently with the farmers themselves; in other words, they continued their traditional research methods only this time outside the experimental station. The participation of private firms, consumers and farmer associations in the planning and execution of research was almost nil.

Early FSR learnt from its mistakes, evolved, and INRM is a result of this process. The term INRM was first coined in 1996 by the Consultative Group on International Agricultural Research (CGIAR) system, a coalition of 15 international research centres (CGIAR/TAC, 1998). INRM moved to centre stage in the CGIAR as a result of the 3rd CGIAR Systemwide External Review (CGIAR/TAC, 1998) recognising that a paradigm shift had occurred in 'best practice' NRM, in which 'hard' reductionist science was being tempered by 'softer' more holistic approaches. Specifically, the review identified a move from classical agronomy to ecological sciences, from the static analysis of isolated issues to systems' dynamics, from top-down to participatory approaches, and from factor-oriented management to integrated management. The CGIAR subsequently set up a task force to coordinate work on INRM (CIFOR, 1999 [The Bilderberg Consensus]).

One of the major outputs of the INRM initiative has been a special edition of the electronic journal *Conservation Ecology,* describing INRM concepts and practice. In a synthesis paper, Sayer and Campbell (2001) flesh out the definition given above, which emerges as a road map of how institutions might modify their way of doing business rather than by a set of tried and trusted approaches already in use. The guiding perspective of 'best practice' INRM is that standardised, generally applicable technologies or truths are unlikely because small-scale producers generally have multiple objectives, and achieving change involves the interplay of multiple stakeholders. Rather, research efforts should be directed at improving the capacity of agroecological systems to adapt to changes and to continuously supply a flow of products and services on which poor people depend, i.e. to improve systems' 'adaptive capacities'. In practice this means helping farmers and other managers of natural resources to acquire the skills and technologies to better control their resources, i.e. improving their 'adaptive management' abilities (Holling *et al.,* 1998; Hagmann and Chuma, 2002). INRM's way of working is to develop practical, local solutions in partnership with farmers together with an array of local and international partners. In deriving the solutions the best science is blended with local and specialised technological knowledge. The underlying principles learned in the local process can then be an ingredient used to develop solutions for similar conditions in different locations and environments. Sayer and Campbell (2001) describe five key elements of INRM.

Learning together for change

INRM must be based upon a continuous dialogue, negotiation and deliberation amongst stakeholders. Like jazz – NRM needs constant improvisation, so that each band member knows the weaknesses and strengths of the other players and that they all learn how to play together. Researchers cannot therefore remain exclusively outside: they need to engage themselves in action research to develop appropriate solutions together with resource users. In this process researchers and resource users: 1. define subsystems; 2. reflect and negotiate on future scenarios; 3. take action; and 4. evaluate and adapt attitudes, processes, technologies and practices. This learning cycle is the basis of resource management that can evolve.

Multiple scales of analysis

INRM attempts to integrate research efforts across spatial and temporal scales. This is because ecological and social processes are taking place over different time scales ranging from minutes to decades (Fresco and Kroonenberg, 1992). Slow-changing variables operate as restrictions to the dynamics of more rapidly-cycling processes. At the same time, fast changing variables affect the dynamics of the slow changing processes. As the system evolves, the dynamics of the different variables may experience sudden changes that reorganise the system. Usually these changes arise when the system reaches specific thresholds. In these reorganisation points, it is impossible to predict how the system will self-organise (Nicolis and Prigogine, 1989). Understanding a system, rather than just describing it, usually requires studying that system together with the other systems with which it interacts. Systems modelling is a practical approach to deal with variables that change more slowly than the length of a project. Modelling can also help farmers and other natural resource managers explore different scenarios, identify preferred ones, and then negotiate how to achieve them (van Noordwijk *et al.*, 2001).

Plausible promises

INRM needs to maintain a practical problem-solving approach that delivers tangible outputs. There needs to be some motivation for farmers to want to work together with researchers to develop technologies and processes. This motivation comes from ideas and technologies that make a 'plausible promise' to farmers of being of benefit to them. Working together builds trust and leads to further learning, from which other possibilities flow. Monitoring and evaluation and impact assessment can help identify and improve what is working effectively.

Scaling out and up

INRM runs the risk of being criticised for only producing local solutions. However, if natural resource systems are characterised adequately, for example, according to exogenous drivers as in the IITA Benchmark Area Approach,[2] then INRM can yield results that have application across broad ecoregional domains. While most INRM technologies cannot be scaled-out, INRM technologies together with the learning processes that allow rural people to identify and adapt new opportunities to their environments can be scaled-out. INRM recognises a difference between scaling-out where an innovation spreads from farmer to farmer, community to community, within the same stakeholder groups, and scaling-up which is an institutional expansion from grassroots organisations to policy makers, donors, development institutions, and other stakeholders key to building an enabling environment for change (Douthwaite *et al.,* 2003a). The two are linked: scaling-out occurs faster if INRM projects plan and invest in engaging with stakeholders who can help promote project outputs and create an enabling environment for them. Iterative learning cycles that take place in participatory technology development processes can also help create an enabling environment through interaction, negotiation and co-learning amongst different stakeholders.

Evaluation

Evaluation is key to adaptive management because it provides the real-time feedback necessary for constant improvisation in implementing INRM projects, and for learning and improving the performance of those involved. Evaluation also provides data for further negotiation between stakeholders, and for resource-allocation decisions. Stakeholders should agree on plausible strategies on how research will contribute to developmental change and then undertake regular monitoring of the implementation of these strategies to feed into the learning cycle. Success criteria and indicators, agreed early on in a project, are the basis for impact assessment and negotiation amongst stakeholders for resource-allocation decisions.

The discussion so far shows that INRM is based on a paradigm that is better able to cope with complexity than the top-down conceptual framework which underpinned much of the IARCs and NARES earlier successes with plant breeding.[3] New paradigms require new ways of looking at the world and new conceptual models for understanding it. These conceptual frameworks are important because they influence the ways that research and development interventions are conceptualised, planned and implemented. The authors contend that INRM would be well served by adopting an Innovation Systems (ISs) perspective, and that this perspective will help clarify the needs and roles for evaluation in INRM. The ISs framework has a long track record, has been widely adopted outside of agriculture, and is based on evolutionary economics (Nelson and Winter, 1983), institutional economics (Freeman, 1987), and stochastic processes and theories of complexity (Rycroft and Kash, 1999; Ekboir, 2003). The ISs framework has also been employed successfully in the analysis of post-harvest systems in South Asia (e.g. Hall *et al.,* 2003b) and is providing the conceptual framework for the emergent Institutional Learning and Change (ILAC) Initiative in the CGIAR (Watts *et al.,* 2003). The ILAC Initiative is being supported by the International Fund for Agricultural Development (IFAD), the Rockefeller Foundation and the German Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) and Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ). It was born out of a frustration that conventional evaluation methods used in the CGIAR were not supporting the learning and change needed for the CGIAR centres to adapt to an ever-faster changing world. In explaining Rockefeller's support for the ILAC Initiative, Peter Matlon of the Rockefeller Foundation said: "There is an urgent need for impact assessment and evaluation to play more self-critical learning roles. Impact assessment studies need to begin to address more systematically and rigourously the – 'why?' questions – that is, not only what works, but also what doesn't, under what circumstances and, most importantly, what are the drivers that determine success or failure" (Mackay and Horton, 2003).

The types of development practice, including evaluation practice, being proposed by the ILAC Initiative (Watts *et al.,* 2003) are fully consistent with those required by INRM, as shown in Table 14.1.

At its simplest, an innovation system has three elements (Watts *et al.,* 2003): 1. the groups of organisations and individuals involved in the generation, diffusion, adaptation and use of new knowledge; 2. the interactive learning that occurs when organisations engage in generation, diffusion, adaptation and use of new knowledge, and the way this leads to new products and processes – i.e. innovation; and 3. the institutions that govern how these interactions and processes take place. The reason it is believed that the framework is relevant to INRM is that both see innovation as an inherently complex process undertaken by a network of actors. Both also recognise innovation as a social process, involving interactive 'learning by doing' in which innovations and the institutions (norms, expectations, ways of organising) co-evolve. As a result innovation, including rural innovation, is an inherently unpredictable, non-linear process. This conclusion has profound implications for all types of evaluation, considered below.

Evaluation Appropriate for INRM

The term evaluation covers a huge area of enquiry and can fulfil many purposes. Patton (1997) identifies three main uses for evaluation findings which are: 1. judge merit or worth; 2. generate knowledge; and 3. improve projects and programs. Traditionally, evaluation carried out in both national and international agricultural research has focussed on 1 and 2, that is judging merit and generating knowledge. Cost–benefit analysis, audits, showing accountability to donors and quality control are all activities that fall under the

Table 14.1. The shifts and expanded options in development practice, including evaluation practice, implied by an Innovation Systems perspective (Watts *et al.,* 2003).

Evaluation	From	Expanded to include
Paradigm of and for	• Things	• People
Orientation and power	• Top-down	• Bottom-up
Key words	• Planning	• Participation
Modes/approaches	• Standardised	• Diverse
	• Linear	• Complex
	• Reductionist	• Systems
Conditions	• Controlled	• Uncontrolled (able)
	• Stable	• Dynamic
	• Predictable	• Unpredictable
Research mode	• Experimental	• Constructivist
Learning	• *Ex-post*	• Continuous
Roles	• Teacher	• Facilitator
	• Supervisor	• Coach
	• External evaluator	• Evaluation facilitator
Outcomes	• Products and infrastructure	• Processes and capability
Valued behaviours	• Rigourous/objective	• Critical self-reflection.
Dominant professions	• Agricultural scientists and economists	• All
Patterns of change	• Predetermined/prescriptive	• Evolutionary
Characteristic management tools	• Logframes and external review	• Action research, participatory review and reflection
Main purpose of evaluation	• Accountability and control	• Learning and improvement
Accountability to	• Donors and peers	• All stakeholders, especially the poor
Vision of capacity development	• Build capacity of others	• Develop own capacity
Treatment of failure opportunity	• Buried or punished	• Valued as a learning
Consequences of failure readjustment	• Cataclysmic	• Continuous programme

former while extrapolating principles about what work, theory building and policy making all result from the latter. While these types of evaluation are still necessary for INRM, much more emphasis needs to be placed on evaluation aimed at improving projects and programs. This type of evaluation focuses on stimulating learning about what is working and what is not, and as a result helps improve the management of projects and programs. In INRM, this evaluation needs to serve the learning needs of all the stakeholders involved, from farmers to researchers. Traditionally, the learning from evaluations has been assimilated by the agricultural economists who made these evaluations, and the information written up in journals that are inaccessible to non-specialists.

As well as having many uses, evaluation can occur at different stages in the project cycle, and beyond. In the past, evaluation in agricultural research has focussed on *ex-ante* impact assessment to set priorities, and *ex-post* impact assessment to attribute and quantify impacts. Little emphasis has been put on the evaluation that INRM most needs, which is within project cycles supporting the learning of all stakeholders and supporting adaptive project management. This is also the type of evaluation that the ILAC Initiative is urging the CGIAR to adopt in order to support the institutional learning and change necessary for CGIAR centres to adapt to the changing environments in which they work (Watts *et al.,* 2003). Evaluation carried out within the project cycle is examined followed by the types of *ex-ante* and *ex-post* evaluations and evaluation of scientists needed for successful INRM.

Evaluation that supports learning

Evaluation that occurs within the project cycle is usually called monitoring and evaluation (M&E). For INRM M&E is not only the method of generating this data, but it also includes the processes by which stakeholders learn and negotiate based on evaluation findings. There is a growing consensus in the literature that the M&E needed to fulfil this need should be derived from an agreed vision of the large-scale development goals to which the project intends to contribute, and the outcomes the project can help achieve. Outcomes are desired changes that indicate progress towards achieving the development goals, in other words, smaller-scale goals towards which a project can contribute. While outcomes are within the sphere of influence of a project they nearly always depend on the contributions of other actors and may be influenced by unexpected or uncontrollable factors (Campbell *et al.,* 2001; Earl *et al.,* 2001; Douthwaite *et al.,* 2003a; Sayer and Campbell, 2001; Springer-Heinze *et al.,* 2003).

Douthwaite *et al.* (2003a) have developed an approach to M&E which uses these ideas, and is called Impact Pathway Evaluation (IPE). IPE builds on GTZ's experience in project M&E. Another development agency and donor, the British Department for International Development (DFID) has recently requested some of its research programmes to provide impact pathways (Christopher Floyd, December 2003, personal communication). In this approach the stakeholders involved in a project agree on an impact pathway, which is a hierarchy of outcomes that contribute to a development goal, or goals. IPE borrows heavily from Program Theory Evaluation from the field of Evaluation (Funnel, 2000). Figure 14.1 shows an example of an impact pathway for an integrated weed control project in northern Nigeria. Shaded boxes in the figure represent outcomes that are within the sphere of influence of the project, although that influence decreases as the corresponding numbers increase. The impact pathway shows how these outcomes are expected to contribute to attaining the large-scale development goal of improved livelihoods. M&E in the project was done to determine attainment of the outcomes in the shaded boxes using the Sustainable Livelihoods Framework (SLF) (Scoones, 1998). The impact pathway helped guide and frame the M&E, and helped in the selection of success criteria and indicators. For example, for the intended outcome 'farmers modify and innovate', one of

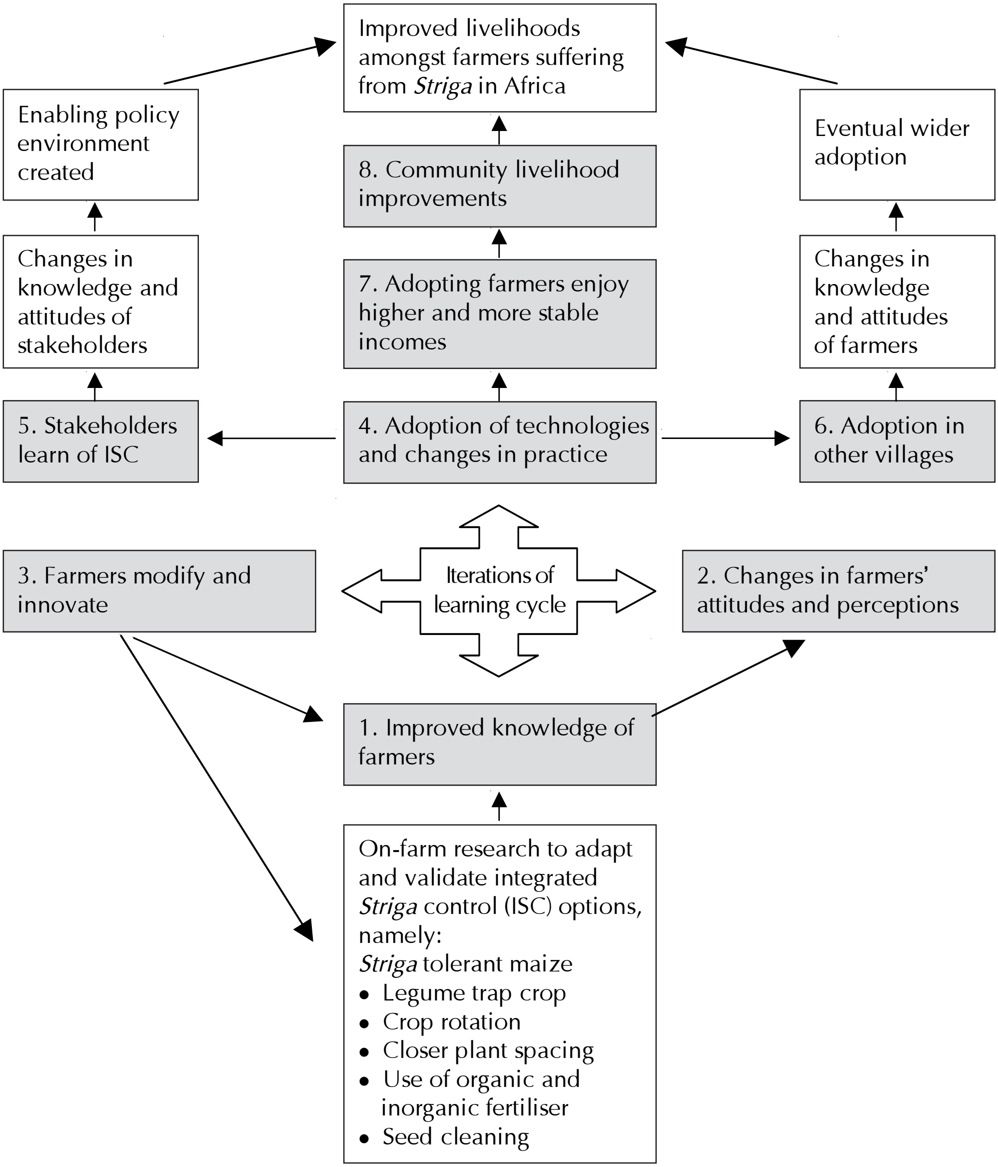

Fig. 14.1. Example of an impact pathway for an integrated weed *(Striga hermonthica)* control (ISC) project in northern Nigeria. The impact pathway is potentially applicable for other INRM research projects.

Source: Douthwaite *et al.*, 2003

the success criteria chosen was 'participating farmers make changes that improve the technology for them, they continue with these improvements and promote and pass them on to others'. The indicators included percentages of: 1. farmers who had made modifications; 2. had kept them; and 3. had passed them on to others.

In general, criteria, indicators and the impact pathway itself can change during a project, based on learning. Getting stakeholders together to agree on the impact pathway helps create a common understanding of what the project is trying to achieve, and this makes achieving impact more likely. All stakeholders should also be involved in designing the monitoring system and collecting data that serves their information needs. However, all information required cannot be collected through participatory approaches (Campbell *et al.,* 2001) and other extractive methods, such as structured questionnaires, are sometimes needed.

IPE shares many similarities with Outcome Mapping, developed over the last 5 years by the Canadian International Development Research Centre (IDRC) (Earl *et al.,* 2001). In Outcome Mapping, the outcomes are changes in people's behaviour. Outcome Mapping is based on individual projects and organisations documenting their contribution to developmental change, rather than attempting to quantify their impact in terms of rate of return to investment. IDRC sees the quantification of impact as detrimental to learning and adaptive management because the drive to claim credit interferes with the creation of knowledge. Instead, Outcome Mapping argues that donors should make recipients accountable for demonstrating that they are progressing towards impact and improving effectiveness, not for developmental impact itself, which in any case nearly always occurs well after a project has finished. Hence, in Outcome Mapping there is a change in emphasis in evaluation on helping to improve, rather than prove, on helping to understand rather than to report, and on creating knowledge rather than taking credit. In this shift to accountability for learning, impact assessment ceases to be an attempt to attribute and quantify based on often inappropriate economic models, and becomes more like making a legal case, built on evidence from many sources. Douthwaite *et al.* (2003a) make a similar argument, which, interestingly draws on the experience of GTZ in Germany, who, like IDRC in Canada, is a project implementer. Douthwaite *et al.* (2003a) argue that plausible *ex-post* impact assessment needs to describe the innovation processes that took place and therefore good M&E information is a pre-requisite.

Ex-post impact assessment

Based on the arguments in the last section it is believed that the emphasis for *ex-post* impact assessment should be placed on: 1. the processes of knowledge generation and diffusion; 2. the creation of organisational capabilities, i.e. the collective ability to develop appropriate solutions to identified problems; and 3. the emergence and evolution of innovation networks (Guba and Lincoln, 1989). However, donors will still need to demonstrate to their own constituencies that money spent has contributed to development. It is argued that *ex-post* impact assessment for INRM needs to be different from conventional impact assessment of agricultural research that is largely based on the use of inappropriate economic models (Hall *et al.,* 2002). These approaches attempt to relate changes in impact indicators to research investments. Ekboir (2003) states that this is valid only if an implicit assumption is true: that the link between indicators and investments dominates all other relationships that influence the impact indicators. Ekboir (2003) goes on to say that this is only true for minor improvements along stable technological paths, such as breeding improved germplasm for commercial irrigated production systems. Such an assumption is not likely to be valid for much of INRM research. Hence, rather than try to attribute impact using 'heroic' assumptions, *ex-post* impact assessment in INRM should focus on establishing which development changes (e.g. poverty alleviation) have taken place, and building a case based on a variety of different information sources which show that the project made a contribution. Box 14.1 gives an example of the unpredictability, time-lags and interactions of stakeholders in a rural innovation process. In this example, because zero tillage interacted with traditional seed improvement research, macroeconomic policies, commercial policies of herbicide producers and an institutional innovation (the farmers' associations), it is impossible to say what percentage of the impact can be attributed to research, which is what conventional impact assessment attempts to do.

Box 14.1. Real-life problems in attribution of impact (from Ekboir and Parellada, 2002).

Argentina, Brazil, Paraguay and Uruguay have enjoyed a six-fold increase in the production of grains since the 1970s. This increase came about as a result of farmers adopting three different technologies: soyabeans in the late-1960s, zero tillage in the 1990s, and improved cereals and oilseeds germplasm since the early 1970s. The adoption was triggered not only by the availability of new technologies but also by public policy changes and private firms' commercial strategies. The impact of technologies, policies and commercial strategies cannot be separated because without zero tillage, the impact of improved germplasm would have been very small, since zero tillage was necessary to stop soil erosion and improve water management. At the same time, new and improved germplasm increased the profitability of zero tillage, fostering adoption. But adoption of zero tillage only became technically feasible with the development of glyphosate and economically feasible when it became substantially cheaper in the early 1990s.[4] Finally, the liberalisation policies introduced in the late 1980s and early 1990s forced farmers to look for new technologies in order to reduce costs.

The zero tillage innovation itself was developed despite terracing being identified by the overwhelming majority of researchers in the late 1960s as the most promising solution to the problems of soil erosion caused by soyabean cultivation. Zero-tillage systems were eventually developed by a network of agents. This included agrochemical companies, a few public-sector researchers, farmers and agricultural machinery manufacturers. A key component of zero tillage's success was promotion by associations of farmers that also included researchers and private companies. These associations were created in the late 1980s with support from agrochemical companies.

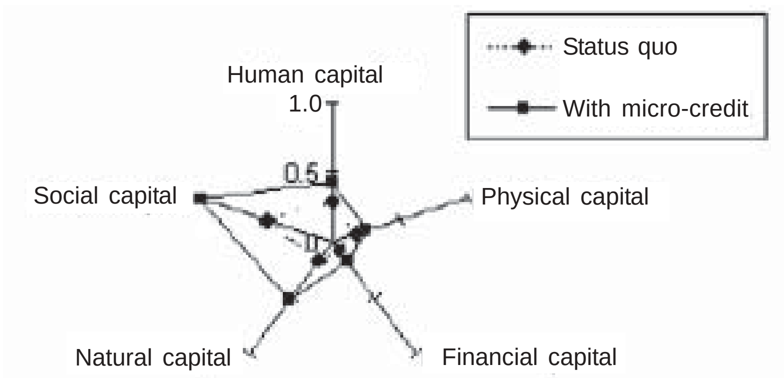

Fig. 14.2. A radar plot showing the effect of a micro-credit scheme on the five livelihood capitals in Chivi, Zimbabwe (Campbell *et al.,* 2001).

To build plausible impact cases, INRM needs to quantify and describe verifiable developmental changes to which it has contributed. These impacts can occur at a variety of spatial and temporal scales and can be context-specific. Campbell *et al.* (2001) suggest an approach based on the use of criteria and indicators, which can be selected with the help of the 'impact pathway' or 'outcome map'. Campbell *et al.* (2001) suggest that the SLF can also guide indicator selection because with the recognition of five capital asset types SLF helps avoid disciplinary bias. Moreover, SLF has been vigorously debated in the literature and is widely understood. However, each of these capital assets may require measurement of several variables, which makes it difficult in practice to identify few proxies that can be monitored over time.

Campbell *et al.* (2001) suggest five different approaches to amalgamating indicators to give an integrated account of change. These are: 1. simple additive indices; 2. combining indicators derived using principal component analysis; 3. two-dimensional plots of variables derived by principal component analysis; 4. radar plots of changes in the five livelihood capitals; and 5. the use of canonical correlation to combine indicators across scales. Depending on the approach used, combining indicators within and across each of the capital assets can create several practical problems. Campbell *et al.* (2001) discuss the pros and cons in the application of the different approaches for aggregating indicators and give examples for each of these approaches. We illustrate here only the application of the radar diagram approach. Figure 14.2 shows a radar plot of the impact of micro-credit schemes on the five capitals in Chivi district in South Zimbabwe. Campbell et al. (2001) indicate that the data was generated from a decision support system where the impacts seem to have been simulated with and without the micro-credit scheme. For each of the capital assets, a proxy variable was selected: 1. *physical capital,* percentage of households with `improved roofing' (income generated from activities sponsored by the micro-credit scheme are often used to improve household assets); 2. *financial capital,* percentage of households achieving a `high' level of savings; 3. *natural capital,* percentage of households taking measures to improve the fertility of their fields; 4. *social capital,* percentage of households adhering to community-based rules and 5. *human capital,* percentage of committees exposed to, and practicing, improved methods of organisation. The radar plot is very effective at quickly communicating that micro-credit is strongly correlated with improvements in social capital, followed by natural capital, and rather less on financial, physical and human capital. Clearly, an assessment that looked only at the effect of micro credit on financial capital, which on the face of it would appear reasonable, would miss a large part of the impact. However, it will be useful to note that attribution of the changes shown in the radar diagram to the credit intervention cannot be made unless the experiment has a proper counterfactual. Simulation models (as was done for this example) or statistical techniques can be used to test the attribution problem.

Campbell *et al.* (2001) state that simulation modelling is a particularly important tool for impact assessment in INRM because it can help predict outcomes in the complex systems in which INRM works. Complex adaptive systems theory helps to put some bounds on the predictive powers of simulation modelling in INRM by establishing that complex adaptive processes evolve by the interaction of trends and random events, subject to the initial conditions. Processes evolve through a succession of many small variations interrupted by rare catastrophic mutations. The mutations can be triggered by small changes in any variable and then spread through the system. Even though it is possible to model the probability distribution of the changes, it is impossible to predict whether the next change will be small or catastrophic. Even though limited predictability of major trends is possible, random events may derail these predictions. Additional information can reduce, but not eliminate, the uncertainty which increases with the time horizon considered (Dixit and Pindyck, 1994).

However, irrespective of the accuracy of predictions made, simulation modelling is an important learning tool (Twomlow *et al.,* 2003). It provides a suitable framework by which to understand the consequences of changes in the components of a system in both the long and short terms, on a range of scales. Moreover, simulation modelling can be applied in a participatory mode by using it to generate a number of likely scenarios that can provide useful discussion points between researchers and farmers. Simulation modelling can also provide an effective and efficient framework for extrapolating research findings and the understanding of system processes to other sites and management conditions (Foti *et al.,* 2002).

Ex-ante impact assessment and priority setting

One of the main reasons for carrying out *ex-ante* impact assessment has been to guide priority setting. The ISs recognition of the indeterminate and complex nature of innovation suggests that *ex-ante* impact assessment can only recognise technological trends once they have emerged (Rycroft and Kash, 1999). While most of the returns to research will come from research on existing technological trends, these returns will eventually fall unless new trends emerge. *Ex-ante* impact assessment can only give some estimates for simple projects along established research and market lines. But even in these cases, the intrinsically random nature of the process means that *ex-ante* projections of impact will probably be wrong and should only be used for priority setting with caution. Greater emphasis should be given to two complementary approaches. Firstly, researchers must be allowed to spend some of their time exploring new areas and ideas beyond those prescribed by *ex-ante* impact assessment. Knowledge-management literature suggests this should be as much as 20% (von Kreog *et al.,* 2000). Secondly, a research institution can build a consensus with its major stakeholders on strategic areas where its resources should be concentrated using technology foresight methods. According to Georghiou (1996) technology foresight involves "systematic attempts to look into the longer-term future of science, the economy, the environment and society with a view to identifying the emerging generic technologies and underpinning areas of strategic research likely to yield the greatest economic and social benefits". Technology foresight approaches include the Delphi method and scenario building. The Delphi method is a technique used to arrive at a group position on an issue under investigation and consists of a series of repeated interrogations, usually by means of questionnaires, of a group of individuals whose opinions or judgments are of interest. After the initial interrogation of each individual, each subsequent interrogation is accompanied by information usually presented anonymously about the preceding round of replies. The individual is thus encouraged to reconsider and, if appropriate, to change his/her previous reply in the light of replies provided by other members of the group. After two or three rounds, the group position is determined by averaging (Ziglio, 1996). Scenario building is often used in industry by companies like Shell to develop a number of possible situations and then work back from those futures to establish how credible they are, and how the organisation would respond or change if they came true (van der Heijden, 1996).

Even though particular outcomes cannot be predicted with certainty, it is possible to identify factors that will, with high probability, affect the chances of success or failure. Among these factors, probably the three most important are: 1. the information flows within individual institutions; 2. information flows within the innovation network; and 3. the patterns of collaboration among agents. Institutions with more horizontal information flows are able to adapt faster to changing environments and to identify earlier emerging commercial and technological opportunities (von Kreog *et al.,* 2000). Strong information flows enable each agent to understand the capabilities and needs of other agents and what they are doing. Collaboration patterns determine the collective capabilities of the network (Dosi *et al.,* 2000). Close collaboration brings together the capabilities of the individual agents and helps to fuse them into collective capabilities. In this way, the network can undertake more complex and extensive activities.

Once research projects have begun, the M&E described above can help to modify priorities and identify new areas of research. Early identification of farmer adoption/non-adoption and modification allows the research process to be adapted and allows new priority areas for research to be set. For example, M&E carried out by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Malawi and Zimbabwe found that limited access to inorganic fertilisers and improved legume seeds meant that there was little adoption/adaptation of soil fertility management interventions (Dimes *et al.,* 2004; Twomlow *et al.,* 2004). This helped to focus research onto short-term solutions that carry little risk or require only limited investment, and those that require enabling environments to be developed, thus encouraging households to make a major change in the way they allocate the resources they are willing to invest.

Evaluation of scientists

The INRM paradigm and ISs view have profound implications for the evaluation of NRM scientists. Given the dynamic and unpredictable nature of innovation and the difficulties of attributing impact, scientist evaluation should focus on their contribution to achieving the outcomes specified in Outcome Mapping or Impact Pathway Analysis rather than on achieving development impact itself. The production of research outputs, such as publications, varietal releases, methodologies and tools, are necessary but not sufficient for achieving research outcomes. Researchers should also be assessed in relation to external qualitative assessments of research programmes. A third area of assessment should be in relation to behaviour known to foster innovation, such as participation in innovation networks, collaboration with colleagues, and knowledge sharing (Huffman and Just, 2000). These assessments should form part of an incentive scheme that also includes enforcement of quality standards and adequate salaries and funding.

Conclusions

In this chapter it has been shown that INRM is the result of an evolution of learning from experience that began with FSR in the early 1970s. INRM is an approach to research and development that builds the capacity of farmers and other natural resource managers to manage change in sustainable ways. The evolution of thinking in INRM has mirrored similar advances in the understanding of research, development and innovation processes, one of which is the ISs framework from the fields of evolutionary and institutional economics. Both INRM and the ISs view acknowledge that rural innovation is an inherently indeterminate and complex process, involving the interactions and co-learning of a network of actors, of which farmers and researchers are just two. The ISs view has some important implications for the evaluation for INRM. The focus of evaluation needs to shift from being about accountability and public awareness to supporting learning and adaptive management of all the stakeholders involved in a project. Specifically, more emphasis should be placed in the use of evaluation to improve, rather than prove, on helping to understand rather than to report, and on creating knowledge rather than taking credit. In this shift towards accountability for learning, *ex-post* impact assessment ceases to be an attempt to quantify an intervention's impact based on inappropriate economic models. Instead it becomes a rational argument, built like a legal case using evidence from many sources that an intervention contributed to developmental impact. The overall developmental impacts, for example, reduction in poverty, should be quantified but not as an intervention's contribution to that impact, unless the link between the intervention and the impact dominates all others.

In this chapter it is argued that a key source of the evidence needed for impact assessment is the monitoring and evaluation carried out within the project cycle, which also provides the real-time information necessary to facilitate the adaptive management of all stakeholders necessary for successful INRM. To be most effective M&E should be based on a shared view amongst the stakeholders of the outcomes they expect the project to contribute, and how these outcomes contribute to larger-scale developmental impact. This shared view should be recorded as an 'outcome map' or 'impact pathway' that then helps frame the M&E, and the selection of criteria and indicators. Good M&E will identify and describe incipient processes of knowledge generation and diffusion, the emergence and evolution of innovation networks, and the creation of organisational capabilities. The job of the impact assessor at some time in the future is to convincingly show how these incipient processes and capabilities grew and contributed to wider-scale development changes that occurred in the project area. In this chapter a number of methods of measuring, describing and understanding these development changes including the SLF, simulation modelling and various approaches of combining indicators to give an integrative picture have been reviewed.

Finally, evaluation appropriate for INRM is very different from the conventional evaluation practice in many IARCs and NARES. Whether INRM-type evaluation becomes more common will depend largely on donors making IARCs and NARES accountable, not for impact in unrealistically short time-periods, but accountable for learning, adapting and achieving outcomes that are known to contribute to development. The signs are positive. IDRC, GTZ and DFID have started to make the change, not just for INRM but for all types of integrated development projects. The CGIAR Institutional Learning and Change Initiative, supported by IFAD, The Rockefeller Foundation and GTZ and BMZ, is recommending evaluation techniques that support learning and change, and are fully consistent with those outlined in this chapter.

Endnotes

1 INRM is assumed to include all efforts in integrated genetic resource management. As such, at ICRISAT, INRM is now referred to as IGNRM to make this linkage more explicit.

2 The IITA Benchmark Approach conducts research in a characterized benchmark area that contains within it farming system dynamics and diversity that is representative of a portion of a wider agroecological zone. The benchmark areas are characterized in terms of population density and access to markets (Douthwaite *et al.,* 2003b).

[3] Often called the Transfer of Technology model (Chambers and Jiggins, 1986) or the Pipeline model (Clark, 1995).

[4] Glyphosate is a broad-spectrum herbicide released commercially by Monsanto in the early 1970s.

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