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Participatory Technology Development in the Context of Integrated Natural Resource Management

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ABSTRACT

Technological change tends to occur as a non-linear process, driven by needs that derive from the lack of sustainability of current resource use systems. Technology that was adapted to one setting may provide inspiration for similar local adaptation elsewhere, but the risks and pitfalls of 'scaling up' farmer-developed technologies are not essentially different from those for 'researcher-initiated' technologies. Current focus in the international agricultural research arena is shifting from commodities and technologies to a broader view on integrated natural resource management (INRM). INRM involves multiple scales and multiple stakeholders, and often leads to a strong policy or institutional focus, as the way local institutions can adapt and respond to new challenges underlies many aspects of poverty that do remain in this new millennium.

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1 INTRODUCTION

Poor people live without fundamental freedoms of action and choice that the better-off take for granted (World Bank, 2001). While the harshest aspects of poverty, including lack of food, can be covered up, especially in emergency situations, 'lack of voice' and 'lack of empowerment' remain a daily truth for large numbers of people in Southeast Asia, both rural and urban. Participatory technology development (PTD) with rural communities can lead to forms of recognition and empowerment that are valuable, but otherwise this undertaking builds on the premise that 'lack of technology' is a major aspect of poverty. There is remarkably little direct evidence for this assumption, and thus the basis for any 'impact analysis' of PTD is weak. PTD, can, however, also address other aspects of poverty: the 'lack of voice', the 'lack of empowerment' and the feeling of not being able to take events into ones' own hands. This aspect of poverty is difficult to quantify as yet, but is easy to recognize as an important element in the debate on rural poor, deforestation and other natural resource management.

Crises may be the mother of all invention, but many rural poor in Asia remain in a situation of crisis, as their current 'livelihood' means may be hardly worth the name. The solutions they seek, however, are often an escape to urban jobs or employment within the rural landscape but outside of agriculture. Other solutions address a major aspect of their poverty by seeking access to land, establishing *de facto* use rights that over time may become formally recognized. Participatory technology development does not relate to any of these problem-solving strategies, but it can play a role in changes to the commodity basis of the farm (introducing new annual crops, trees or animals), or in the use of external inputs or labour. Given these restrictions, does 'participatory technology development' contribute to poverty alleviation? Or are aspects other than technologies the main bottleneck to be addressed? Can 'participatory' approaches lead to empowerment? Do they achieve this through the way they are currently practised? Is technology development a generic objective, or a means to solve specific problems? In this contribution to the debate I want to explore the role of PTD in the broader framework of integrated natural resource management as it currently emerges in the Consultative Group of International Agricultural Research (CGIAR) centres as a paradigm of adaptive learning. After developing the concept of episodic technological change, driven by internal or externally determined need, I will focus on three examples from the Southeast Asia regional research program of the International Centre for Research in Agroforestry (ICRAF): getting out of the food-crop based poverty trap on degraded lands, extrapolating locally successful institutional and technology change in such environments, and making use of the diversity in forest margin agroforests.

2 EPISODIC TECHNOLOGICAL CHANGE AND LOCAL KNOWLEDGE

Technological change, like biological evolution, may from a distance appear as a continuous, gradual process. On close inspection, however, it may consist of episodes of radical changes over a short time period, alternating with periods of a fine-tuning of existing models and patterns. Rapid change may be spurred by internally induced 'crisis' that undermines the 'fitness' of existing life forms or life styles, or by the sudden change of the boundaries of 'the system' through the disappearance of barriers that separate local life from elsewhere. At a general 'systems' level, from biological and ecological to business, economic and political systems, a common pattern has been recognized that describes life cycles in terms of growth, decline and re-organization (Figure. 22.1).

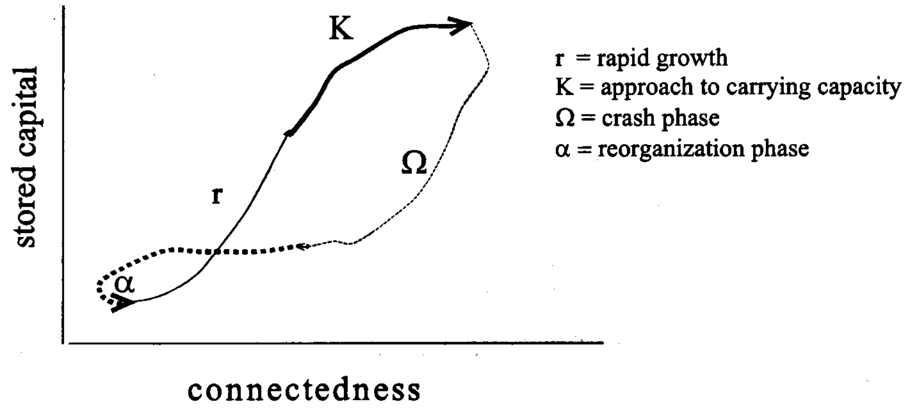


Figure 22.1
Four stages in the life cycle of a system
Source: after http://www.resalliance.org/

The four phases in this system present very different options for both 'management' and 'technology development'. ***r*** phase management tries to increase the growth rate and may lead to the largest production outputs; ***K*** phase management aims at increasing the carrying capacity by filling in under-exploited niches and may maximize 'environmental services'; the ***Ω*** phase manager will try to obtain a soft landing during a crash and reduce the loss of capital; and the ***α*** phase manager has the best options for real innovation as the system reorganizes itself. There is at least a suggestion that the longer the K phase, the deeper the subsequent crash may be. Participatory technology development may function best in a K phase, where targets appear to be clearly defined.

Human societies that have been stable and successful in dealing with the challenges of the local environment (remaining in K-phase mode, with only small perturbations, while maintaining a nutrient balance (Van Noordwijk, 1999), market access, and avoiding major pest and disease build-ups, generally embody a strong sense of identity, self-esteem and 'culture'. They often have a system of knowledge and values that is sufficient for the transfer of lifestyles and coping strategies to future generations. Most 'wild ideas' do not lead to improvements of the livelihood system, and the society has effective ways of dealing with deviations from the 'norm'. Further innovations have the character of 'fine tuning' of existing technologies, not of radical change. Radical changes are often triggered by contact with outside groups, coming in to trade and exchange, or to occupy the area and impose their will based on military superiority.

If a 'new' society thus takes over, the old system of norms, knowledge and values loses (some of) its immediate relevance for the individuals in the society and tends to become ignored. Worse, it may become seen as an obstacle for progress and a politically subversive element that is to be eradicated by the powers that be. While new religions initially may blend in with local value and belief systems, subsequent 'purification' movements may lead to strong negative perceptions of the preceding culture. Education systems are built on new paradigms of the 'modern', superior culture and lead to neglect or explicit defiance of 'traditional' knowledge, views and values. Top-down transfer of wisdom from the 'educated' to the 'uneducated' is still the predominant mode of rural extension and development. Client conservatism is often blamed for lack of technology adoption. The way the 'old' society dealt with innovations is now seen as an obstacle to progress. 'Shifting cultivation' is a typical example of a system that becomes seen as backwards, something of the past that should be stopped.

Current land use change in the Jambi benchmark areas of the Alternatives to Slash and Burn project in Sumatra is extremely rapid, and may be even more drastic than change in the 1910-1930 period when rubber agroforestry became firmly rooted in a landscape of 'shifting cultivation' or long fallow rotations. Recent change was induced by a change in accessibility (Trans Sumatra Highway), increase in population density (Tramnsmigration resettlement schemes), logging concessions and government support for large-scale oil palm plantation development.

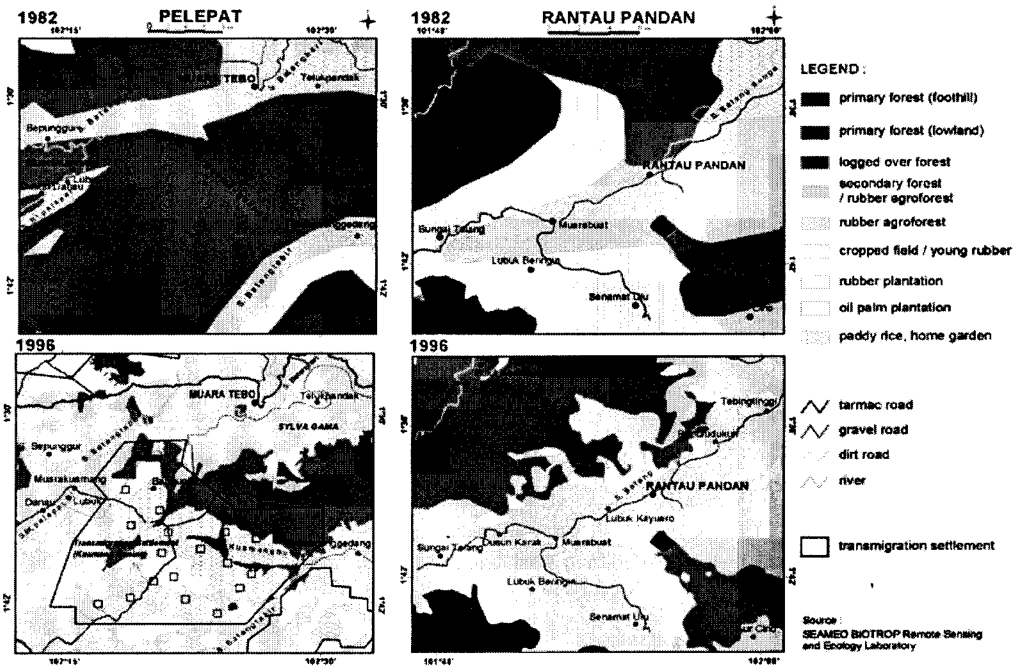


Figure 22.2. Land use change in the 1982–1996 period in two of the benchmark areas of the Alternatives to Slash and Burn project in Jambi (Sumatra, Indonesia).

Box 22.1

Lowland peneplains of Sumatra in a Ω- α reorganization phase?

After a while, however, the balance may swing. Individuals in the 'new' society discover traditional wisdom among traditional societies and recognize that some of the current problems did not exist in the past, or that effective ways to deal with them were once part of culture. Where these insights develop, the balance may easily swing to a romantic view of the 'rustic' past that is idealized and seen not just as a source of inspiration, but as a norm and standard. The initial stages of this debate may do little to give the people concerned and their priorities a real voice, as it tends to assume that they want to stick to the old ways and not find their own blend of old and new.

Strongly simplified, we can distinguish between farming systems that have annual food crops (C), animal products (A), tree crops (T) or forest products (F) as their main component. We can visualize these four broad groups of land use systems as a 'tree', with a common stem and 'branches' reaching out in different directions (Figure 22.3). Within each 'meta' land use system a number of sub-classes are found. The link between the branches and the stem of the tree can be illustrated as follows: forests managed for local forest products, F_m, can be thought of as a starting point of the agroforest-tree-crop gradient, but can also be the long-fallow point of an intensification gradient based on annual crops.

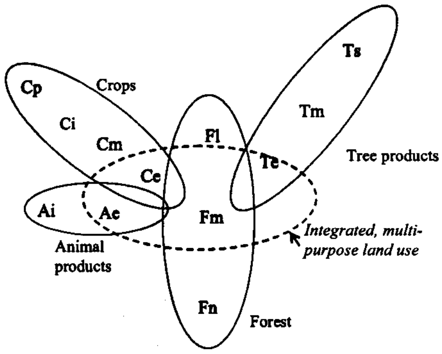
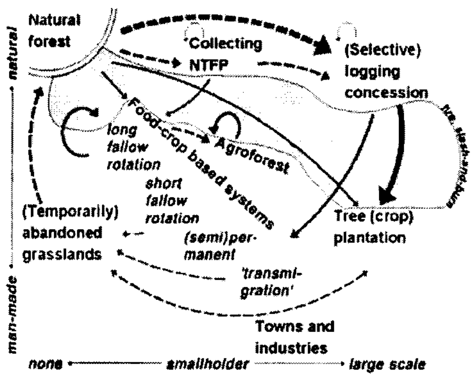


Figure 22.3. Four 'meta' land use systems based on forest (F), tree crop (T), crop (C) or animal production (A) systems

Within each of these classes a gradient in intensity of the use of labour and/or external inputs can be distinguished. In much of the humid tropics of Southeast Asia tree-based systems dominate the landscape, while the annual food crop component is concentrated on a relatively small area of intensively used paddy rice fields. The transition of most extensive upland food crop systems ('shifting cultivation') to the extensive tree-based production systems ('agroforests') has been little studied. What we do know of the rise of the rubber (and damar) agroforests in Sumatra and Kalimantan at the beginning of the 19th century points to a success story in farmer led technology development and spontaneous adoption of a radically different farming style. This transition to trees as a main livelihood resource fully depended on access to export markets for the latex (rubber) or resin (damar), and the availability of the staple food (rice) in trade with lowland areas that could produce a surplus. Technology development in paddy rice thus created an opportunity for a radical shift in upland farms, not by spreading the technology, but by allowing them to start on a very different trajectory, in a phase of rapid change. The changes that occurred in the development of agroforests, can be understood as changes in the degree of human control over natural processes, as well as in the privatization of formerly common village resources (Figure B). Planting a few rubber trees in a swidden was sufficient to establish private claims of formerly communal land, creating an incentive for extensive agroforests as dominant feature of the landscape.

Figure 22.4. Two-dimensional classification of land use systems based on the type of human control (no claims, community-level claims, smallholder private claims and large scale private claims), and relative strength of natural processes in determining the land cover (from completely 'natural' to fully 'man-made'). All transformations in the shaded areas use ***'slash-and-burn'*** as a method for land clearing; the ***'agroforests'*** are the major farmer-developed alternatives to slash-and-burn based food crop production systems. (Van Noordwijk et al., 1998)



Box 22.2
Intensification within, and switches between, land use categories

A more balanced view, however, can emerge from this debate. This can lead to a serious attempt to articulate farmers' ecological knowledge, their norms and values and coping strategies. It can also lead to an analysis of how this knowledge system complements currently dominant paradigms, where it concords (but simply uses other words or terms), where the two views contradict each other and provides challenges to further research, and where 'local' knowledge can indeed benefit from and be complemented by 'modern' ideas. The first step in this process is an attempt to overcome the language barrier and explore what local knowledge has to offer. Two aspects of such knowledge are the recognition of components of the landscape, climate, soil, vegetation and fauna, and the knowledge of dynamic relationships between these elements, including the response to human management efforts. The next step is to appreciate the dynamic character of local knowledge, and the basis that it provides for learning or innovation by experimentation and selection of components and technologies with superior 'fitness', evaluated on the basis of local criteria. This may become the basis for 'participatory technology development (PTD).

3 PARTICIPATORY TECHNOLOGY DEVELOPMENT AND DISSEMINATION FOR 'ACCELERATED IMPACT'

Interest in agricultural PTD arose a few decades ago in response to a view that the agricultural technology primarily developed by specialized researchers with little interaction with the intended clients had a poor track record of subsequent adoption ('impact').

The term 'participation' covers a substantial range of relations: from researcher managed on-farm trials with or without direct evaluation by farmers as representatives of the intended 'clientele', to researcher attempts to participate in and contribute in a meaningful way to technology development by farmers themselves. Franzel and Van Houten (1992) have distinguished three main types of trials on the basis of where they take place: in the protected environment of a research station; on farmer's fields with all their variability and lack of 'control'; and on the basis of who is in charge, the researcher, the farmer or a combination of both. Their classification of researcher and farmer planted and managed trials was originally linked to 'exploratory', 'determinative' and 'verification' stages of technology development, with a generally increasing number of 'sites', less variables in the trial, less replications per site, larger plots and increasing farmer involvement. The three-fold typology (Table 22.1) is not complete, however, and may need to be expanded to include farmer participation in on-station trials, and the real world situation of farmer experimentation without direct 'researcher' involvement. The latter may depend on how we define 'researcher', as a functional role or in the conventional way of referring to a formal (academic) training. Farmer-led on-station research appears to be an empty cell, but this may depend on one's definition of 'farmer'.

	On a research station	On farm/farmer fields
Researcher-led	Type I	Type II
Participatory	farmer evaluation of trials	Type III
Farmer-led	non-existent?	Real world

Table 22.1
Terminology for types of experiments
Source: after Franzel and Van Houten, 1992

Although it is difficult to quantify, it seems likely that most innovations on which current agricultural practices are based originated in farmer heads, without direct involvement of 'researchers'. Again this depends on one's definition of farmers and of researchers. The main role of researchers has been, and probably still is, to document, analyse, test and extrapolate locally developed innovations to potential application domains elsewhere. International agricultural research aims at international public goods, knowledge and technology that can be of widespread usefulness and that can be brought to and kept in the public domain to prevent others from claiming restrictive intellectual property rights. From this perspective, is there any inherent reason to assume that participatory technology development is more effective and efficient than technology developed in isolation from farmers practice? Of course there is, but it may be relevant to review the arguments and reasons.

New technology is	On site of initial development	Elsewhere
Not better than what exists		
Neutral		
Real improvement over what exists		

Table 22.2
Relevance of the participatory process versus the technology produced

Once new ways of managing local resources ('technologies') have been developed in a specific situation, by or together with farmers, the technology is evaluated locally against current land use practices and existing alternatives (Hoang Fagerström et al., 2001). If it is found to be superior in 'fitness', information on the technology will spread to neighbours and farmers elsewhere. The new technology may be seen as an improvement over what already exists for farmers in similar conditions, or it may form a source of inspiration for further innovation and adaptation.

A major issue that remains is whether dissemination of results of PTD should focus on the products (the technologies as such), on the process (the way the PTD process worked, implying continued outside involvement), or on the ideas and broad concepts with their likely boundaries as themes that invite variations to be made. If we do not choose a narrowly defined technology package as our 'product', we forgo the opportunity of simple impact assessment. With a product such as IR36, for example, we can count the number of farmers adopting and compare their current yields with what they obtained before. Alternatively, with a generic understanding of bottlenecks in tree domestication and ways to overcome them, we may be able to unleash local initiative, but we don't have an easily quantifiable indicator. Yet, current extension material is focused on clarifying principles and providing examples, rather than recipes (IFAD et al., 2001; Dierolf et al., 2001).

Table 22.2 focused on farmers as major stakeholders, taking decisions on the adoption or non-adoption of new technological options. Most changes, however, have impacts beyond the farm, and the evaluation of new technologies should involve other stakeholders (Table 22.3). Whether or not the views of other stakeholders matter in farmer decisions on adoption depends on the degree to which of-farm concerns are reflected in mechanisms that affect the sustainability of farming practices.

New technology is	From national development and social perspective	From private perspective of farmer	From perspective of regional/global environment
Not better than what exists			
Neutral			
Real improvement over what exists			

Table 22.3.
Perspectives on evaluation of technologies

4 SUSTAINABILITY AND THE NEED FOR TECHNOLOGY DEVELOPMENT

Sustainability of farming depends on the ability of farmers to overcome current and future threats to a continuation of their enterprise. These threats can derive from on-site productivity (especially if the soil is not maintained in a productive state with adequate resistance to soil-borne and other diseases and pests); from 'angry neighbours' who no longer accept the lateral flows through air or water of elements and pesticides coming from the farm; from dissatisfied customers; or from a policy frame that tries to regulate the activity of farmers. Sustainability criteria and indicators usually refer to the 'persistence' aspects (can one continue with the current set of activities), while it is likely that a 'lack of options' and inability to change is a more important aspect of non-sustainability. Of particular interest for the current debate on element balances is whether regulation of activities aimed at controlling negative environmental impacts, can be done in such a way that it does not unduly restrict the agility of farmers to innovate on their farms.

5 INRM, OR HOW CAN REAL-WORLD NATURAL RESOURCE MANAGEMENT BE IMPROVED?

Natural resources are influenced by day-to-day management decisions of large numbers of actors – both small and large in scale (Van Noordwijk et al., in press). Each decision influences the interests of a manager but also the environment of all other managers, both now and in the future. Many of the institutions aimed at balancing different stakeholder interests are of limited effectiveness.

A conceptual diagram (Figure 22.5) shows how farmers' choices to 'use, extract and exploit' and/or to 'care for and plant' influence the landscape, with consequences for profitability as well as biodiversity, C-stocks and watershed functions. Farmers' choices are themselves under the influence of available knowledge, market supply and demand, push and pull factors for migration, and the positive and negative incentives that are provided through the institutional framework in which farmers operate. The overall impact of all institutions may be sub-optimal, to put it mildly, as there are many conflicting and overlapping elements in this framework. In the diagram, four types of feedback loops are indicated that may influence farmer's decisions. The opportunities for 'use' and for 'local environmental functions' depends on the efforts to 'care and plant', and these feedback loops, along with the knowledge that they generate and that is passed on in the local community, may qualify together as a 'land use system' for an outside observer. The fourth feedback loop, via stakeholder actions leading to modification of institutions represents a higher level 'system', that may be indicated as 'natural resource management system'.

In the Alternatives to Slash and Burn Project (Izac and Sanchez, 2001), attempts have been made to substantially broaden the assessment of land-use options for the margins of tropical forests. The approach has been to include the perspectives of farmers (direct returns to labour, sustainability of the production system), the government (returns to land, the population density that can find employment at or above a minimum wage level), and external environmental stakeholders (C stocks, biodiversity conservation, watershed functions). In the lowland peneplain of Sumatra (Table 22.4), for example, we found that the land-use systems with nearly the highest returns to labour are based on community-based forest management for the collection of 'non-timber forest products'. These have little negative environmental impacts, but are only feasible for very few people (population density equivalent to full-year employment is less than one person km^{-2}). The logging industry, supposing they follow the Indonesian selective logging system, and bush fallow/rice rotations could provide for population densities in the 10-20 km^{-2} range; logging may pay above the minimum wage rate but food crop production systems are at the minimum level, at most. Intensive food crop production in the form of the cassava, alternated with *Imperata* dominated fallow years, can provide for a minimum wage for about 50 people km^{-2}. The tree-crop based systems can provide for slightly higher population densities, and may lead to higher returns to labour. Note, however, that the assessment of 'rubber agroforests with clonal planting material' is an *ex-ante* estimate at the start of real on farm trials. Although in this assessment oil palm plantations do not stand out in terms of higher returns to land or labour, they have been favoured by government concession schemes to support external investors.

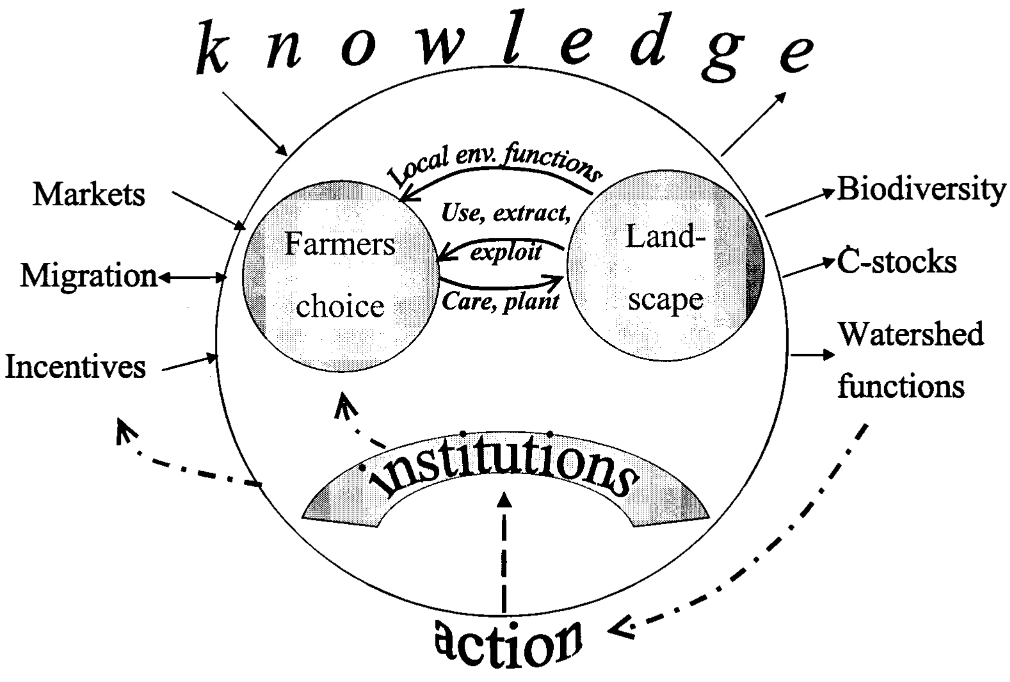


Figure 22.5
Schematic view on farmers' decisions about the landscape, the factors influencing these decisions and the consequences they have.

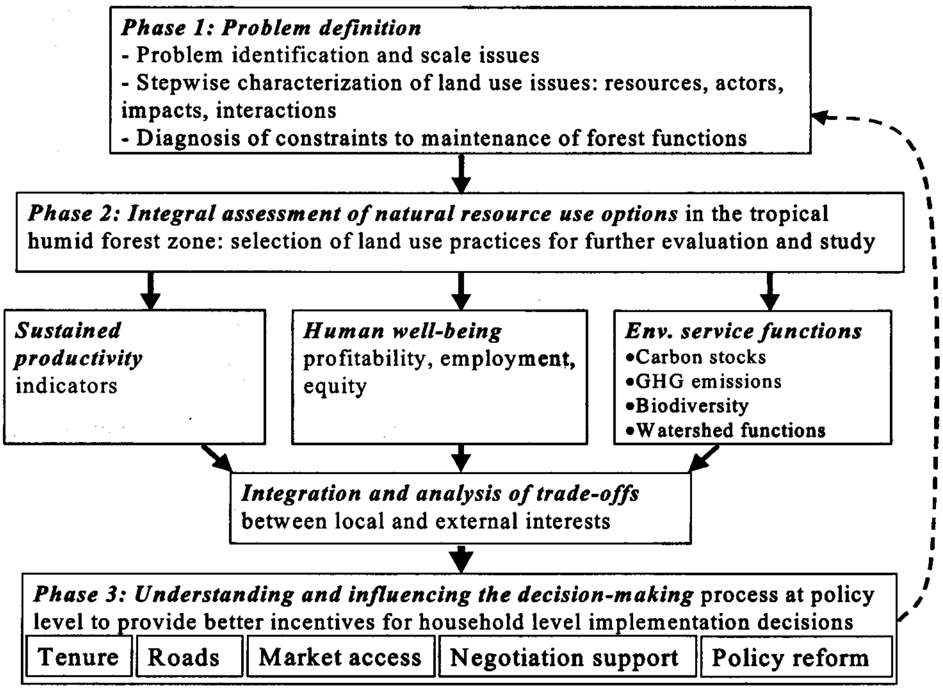


Figure 22.6

Steps taken in the Alternatives to Slash and Burn program to achieve integrated natural resource management in forest margins of the humid tropics

(Van Noordwijk et al., *in press).*

Land Use Type	Sustainability of production system[1]	Human well being			Environ- mental Service Functions			Institutional change requirment
		M Rupiah ha^{-1}	Returns to labour, relative to minimum wage	Employ-able popu-lation density, km^{-2}	C sto rage, Mg ha^{-1}	Biodi-versity conser-vation	Water-shed func-tions[2]	
F_n Natural forest	0	0	0	0	250	+++	0	****
F_m, Community-based forest management	0	0.02	2.8	0.2	175	++	0	*
F_l, Commercial logging	-0.5	-0.4	2-7.8	17	150	++	-0.5	**
T_e, Rubber agroforests with seedlings	-0.5	1.6	1	59	116	++	0	
T_m, Rubber agroforests with clonal planting material	-0.5	0-2.2?	1.1–1.9	80	103	+	-0.5	*
T_{s_rubber}, Rubber monoculture	-0.5	-0.2	0.7	71	97	0	-0.5	**
$T_{s\_oilpalm}$, Oil palm monoculture	-0.5	0.3	2.5	58	91	0	-0.5	**
C_e/ C_m, Upland rice/ bush fallow rotation	-0.5	-0.1	0.95	11	74	+	-0.5	
C_i/A_e, Cassava/*Imperata* rotation	-1	0.1	1.05	54	39	0	-1	

1) 0 = no problems outside of normal farmer management domain,
0.5 = problem that may challenge farmers' adaptive capacity,
-1 = serious problem, probably beyond farmers' ability to respond to

2) 0 little change relative to natural forest
-0.5 some concern justified
-1 serious concern justified

Table 22.4

Integral assessment of land use options as 'Alternatives to Slash and Burn'

The Jambi case study (Figure 22.6 and Table 22.4), and similar studies elsewhere, has increased our understanding of real-world natural resource management problems as they relate to the situation in the margins of tropical forests. But how can we translate that understanding of the problems into action that leads to a real improvement? Returning to Figure 22.5, this question can be phrased as 'how can we get a smile on the face of the image that describes the way farmers, the landscape and the local and national institutions interact?

Five type of answers to this question are commonly provided:

1. We need technologies (options) that provide a basis for better NRM at the local scale;
2. We need a more conducive policy environment that stimulates options for improvement to be realized by providing positive incentives to change;
3. We need a more holistic understanding of how the whole socio-political-agro-ecosystem works, with all its feedback loops, so as to identify the weakest parts in the overall chain for any specific situation and get the priorities right for any change;
4. We need a better functioning of 'civil society', with all its feedback loops, to derive a dynamic and responsive system that continuously monitors the system as well as the persons and mechanisms entrusted with providing the 'public goods' required for improvement. We also need a 'learning culture' built into all aspects of 'civil society'; and,
5. We have to acknowledge that the concerns of 'external' stakeholders will not be taken into account unless they are linked to transfers of benefits to local communities. We cannot expect the rural poor in the tropics to continue to provide the 'environmental benefits' of biodiversity conservation to the global community, for example, without being paid for it. We thus need an effective and efficient method for 'environmental service transfers'.

6 THREE EXAMPLES FROM THE SE ASIA REGIONAL PROGRAM OF ICRAF

6.1 The Inverse 'J' Curve

Since its beginning in 1992, ICRAF's Southeast Asia program has focused on two major issues that link poverty and natural resource use: alternative land use options for forest margins, and options for the rehabilitation of degraded, under-utilized lands. Both of these efforts may contribute, under very specific conditions that we've gradually come to understand (Tomich and van Noordwijk, 1996; Tomich et al., 2001; Angelsen and Kaimowitz, 2001) to the maintenance of forests and/or 'forest functions'.

When we try to interpret the 'stored capital' of Figure 22.1, we may consider carbon stocks or total biodiversity (the former for which we have much better operational definitions that allow measurement). A time course (Figure 22.7) of this property though a deforestation-degradation-rehabilitation cycle may have an 'inverse J' shape. While the loss of stored carbon and biodiversity in forest vegetation under intensifying land use is universal, the subsequent changes in carbon stocks or biodiversity of a unit of land area can vary widely between land use types. C stocks can continue to decline slowly, they can stabilize at a low level where a new equilibrium between organic inputs to the soil and release of soil C is reached, or they can start to increase again, especially if tree density in the area increases. Such a trajectory has been described for many areas in the tropics, including those that were at some point in time considered to be the worst examples of land degradation (including Machakos in Kenya, Gunung Kidul in Java, areas in Lampung in Sumatra). These examples differ in the initial C stocks of the forest/natural vegetation (about 100, 200 or 250 Mg C ha-1), the duration of the period at low C stocks (several to 1 decade) and the likely C stock reached in the up-swing (25-50 % of the original). What they have in common is that the recovery of C stocks was the consequence of many smallholders finding the time ripe for planting trees on their lands. No or very limited outside assistance was needed to induce farmers to make this transition.

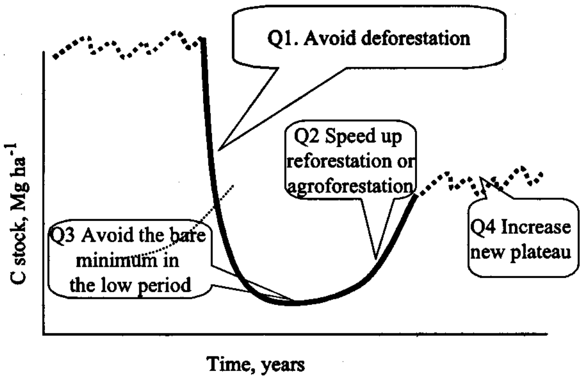


Figure 22.7.
The 'Inverse J' shaped baseline of terrestrial C stocks as indicator of environmental quality of land cover or land use types, and four questions that may guide outside interventions

We can focus on four aspects of this curve:

1. Delaying/arresting the initial decrease of C stocks due to forest conversion or destocking and degradation of forests (avoiding 'deforestation');
2. Stimulating the early start and or rate of increase of C stocks ('reforestation' or 'afforestation, depending of the length of time elapsed since 'deforestation' took place);
3. Reducing the length of time and intensity of the low C stock phase; and,
4. Increasing the 'time-averaged' C stock of the emerging new land use practice (at the scale of a landscape mosaic, so allowing for individual trees and forest patches to be harvested and replanted).

6.2 SAFODS: Getting Out of the Food-Crop Based Poverty Trap on Degraded Lands

Smallholder agroforestry options for degraded soils may provide a way out of the poverty trap of cassava/Imperata cycles on degraded soils, if a number of conditions are met:

1. Tenure security;
2. Community-level fire control;
3. Access to markets for tree products; and,
4. Viable technological options for the transition phase.

Our general hypothesis is that on poor soils the long-term prospects of systems purely based on annual food crops are bleak and a transition into tree-based farming offers better prospects.

In the ASB benchmark areas in North Lampung (Sumatra, Indonesia) and North Mindanao (Philippines), ICRAF and its partners are researching the socio-economic and biophysical aspects of farmers who have to balance short term profitability and a medium term escape from further soil degradation occurring under pure crop-based land use systems. The overall objective is to help close the knowledge gaps that constrain the on-set and success of this agroforestation phase by providing site-specific knowledge of socio-economic and biophysical constraints, as well as a generic method (improved agroforestry model) for extrapolating to other sites, other components and other management practices. Profitability and risk (biophysical and economic) analysis for realistic farm situations will hopefully provide a solid basis for complementing the 'participatory technology development' approach. The research involves five aspects:

1. Establishing a farmer typology for tree-crop management priorities through in-depth surveys to evaluate:
   - farmers interest and knowledge in trees and market potentials;
   - what indigenous or new tree and management options do farmers prefer; and,
   - what bottlenecks exist through existing policies.

2. Identifying site by tree species matching to better recognize and utilize landscape *niches* by evaluating existing on farm trials to:
   - test a simple set of indicators of suitable site quality (landscape position, soil quality) for the trees; and,
   - evaluate the range of farmers management intensities.

3. Quantification of tree-soil-crop interactions on new and existing on-farm trials under a range of soil and farmer management conditions to:
   - measure yields of sole/intercropped crops and trees;
   - monitor tree canopy shape and light competition;
   - evaluate water and nutrient competition between trees and crops using advanced ^{15}N, ^{18}O stable isotope methodologies;
   - determine the contribution of trees to soil fertility; and,
   - develop a database of tree parameters required for model extrapolation

4. Developing an improved array of management options for transition years by improving an existing agroforestry model to:
   - explore tree-soil-crop interactions;

- derive improved options for adjusting tree spacing and intercropping patterns to the conflicting demands of maintaining soil cover and weed control; and,
- extend to wider application domains.

5. Analysing risk and farm profitability and developing recommendations by:

- cost-benefit analysis of agroforestry options, including the likely biophysical and economic risks;
- identification of macro-economic policies and of local socio-economic circumstances that constrain or favour adoption and discuss at policy level; and,
- definition of information dissemination and adoption pathways.

6.3 Landcare: Experiments in Extrapolation of Local Solutions

The Landcare movement in the Philippines began in Claveria, Mindanao, in 1996, based on the successes farmers had experienced in developing a low cost soil conservation strategy ('naturally vegetated strips' or NVS), with participation of researchers in the process. The NVS technology set the scene for further development of tree-based farming practices. Currently, about 200 village-based Landcare groups are working in Claveria and other municipalities in northern, central, southern and eastern Mindanao, with a membership of several thousand households. NVS practices have been adopted on more than 1500 farms and more than 200 community and household nurseries have been set up to produce hundreds of thousands of fruit and timber tree seedlings, mostly with local resources (Catacutan and Mercado, 2001).

Landcare provides important opportunities for improving the way farmer participatory research is done. Landcare groups can manage such research, enabling them to diversify their experimentation, ensuring a better understanding of the performance and recommendation domains of technical innovations, and offering more effective and less expensive alternatives to technology-transfer approaches. The farmer-field-school approach, as was first developed for 'integrated pest management' in rice fields, is currently being explored for conservation farming, with the establishment of Landcare groups as a possible outcome to broaden thè local agenda and provide a more sustainable institutional framework.

Some distinguishing features of Landcare groups are:

1. They develop their own agenda and tackle the range of sustainability issues considered important to the group;
2. They tend to be based on neighbourhoods or small watersheds;
3. The impetus for formation comes from the community, although explicit support from outside may be obtained; and,
4. The momentum and ownership of the group's program is with the community.

ICRAF and partners have provided positive, but critical support to the Philippine Landcare movement. They are especially interested in whether such a movement can be sustained beyond the normal 'project' lifespan and how it can expand rapidly to reach all potential beneficiaries. The sustainability of the Landcare movement gives rise to six significant concerns that ICRAF is currently trying to address. First, given its growing popularity, the movement runs the risk of 'projectising', that is, attracting the support of projects that do not understand the concept, and that provide funds in a top-down, target-driven mode defeating the whole basis of a farmer-led movement. Second is the issue of long-term sustainability. Networking and the stimulation from outside contacts are considered to be crucial for long-term success. This can be achieved through Landcare Federations, as has evolved locally in Claveria, and through provincial and national federations, which are currently being explored in the Philippines. Third, group leadership is a time-consuming and exhausting task, particularly when undertaken on a voluntary basis. Landcare is still young in both the Philippines and Australia but leadership "burn-out" has already raised concerns. Fourth, local initiative to achieve 'Landcare' targets can lead to less democratic forms being used, or to pure coercion. At one stage a school in Claveria proposed that children could only graduate from primary school if their parents had adopted a soil conservation practice promoted by Landcare. Fifth, local government may perceive the Landcare formula as a way of achieving targets that are not necessarily in the best interest of all farmers. Where conflicts over land tenure and the presence of recent migrant farmers dominate the local agenda, a different type of organization may be better in channelling local aspirations. Sixth, the application of Landcare in differing conditions and at wider geographic scales may corrupt the process, thereby losing the basic elements where it has been successful. The challenge for scaling-up Landcare remains in the maintenance of its voluntary nature and, therefore, mainstreaming Landcare in government programs should approached with caution.

In the daily interactions between ICRAF field staff and Landcare farmers this critical dialogue is maintained. Ironically, it seems that the 'Landcare' movement can only remain a 'success story' if it is not treated as such, but seen as a source of 'inspiration', not something to be 'replicated'.

6.4 Rubber Agroforestry in Forest Margins

As demonstrated in Box 22.1, the history of episodic loss of forest functions in Sumatra has entered an active phase, which is likely to result in the near-complete loss of lowland rain forests within a decade. While it seems too late to stop this trend, we may at least hope to derive important lessons for the forest frontiers of the future, elsewhere in Southeast Asia. While the forest as such will be gone, important aspects of 'forest functions' can remain, including parts of the biodiversity values. Their fate is in the hands of a large number of land users and governments will have to learn to interact with them in view of the multiplicity of stakeholder interests.

Raising the productivity of rubber agroforests, which involves millions of hectares, offers a promising, sustainable, economic pathway in Sumatra. There appears to be great potential for raising profitability in these systems though adaptation of existing higher-yielding clones within existing smallholder systems. This would also enhance household food security and expand employment opportunities. It may be possible to combine these potential benefits from the perspective of smallholders and national policymakers with significant biodiversity conservation because the mix of planted species is augmented by natural regeneration of forest species (Michon and de Foresta, 1995; van Noordwijk et al., 1995). Indeed, these agroforests may approximate a number of natural forest functions, thereby providing the technical foundation for sustainable community-based forest and watershed management. Thus far, efforts to introduce higher-yielding rubber germplasm into these extensively managed agroforests in Jambi have had only partial success (Williams et al., 2001). The chapter by Laxman Joshi et al. (Chapter 23, this volume) will provide further elaboration of the way we are trying to combine an understanding of the local ecological knowledge of farmers of this system, with attempts to increase profitability of the system, to keep it in the race with oil palm.

7 CONCLUDING REMARKS

In this contribution to the debate on PTD as a way to reduce rural poverty and achieve better and more integrated natural resource management we haven't produced clear answers. A continuous re-assessment of the questions and objectives may indeed be integral part of the adaptive management cycle. The majority of today's rural poor will have to find a living outside of agriculture, and much of the education system is geared to that goal. PTD can support the continuous process of change, not so much through the technologies it develops, but also through the process of stimulating learning styles that bridge the distance between local and external knowledge and concepts.

REFERENCES

Angelsen, A. and Kaimowitz, D., (2001) *Agricultural Technologies and Tropical Deforestation.* CAB International, Wallingford, UK.

Catacutan, D.C. and Mercado, A.R. (2001) *Technical innovations and institution-building for sustainable upland development: Landcare in the Philippines.* Paper presented to the START-SARC Regional Science and Policy Conference, Chiang Mai, Thailand, 17-19 February 2001.

CGIAR (2000) *Integrated Natural Resource Management Research in the CGIAR.* CGIAR, Bogor, Indonesia.

Dierolf, T, Fairhurst T and Mutert E., (2001) *Soil Fertility Kit: a Toolkit for Acid, Upland Soil Fertility Management in Southeast Asia.* Potash and Phosphate Institute, Singapore.

Franzel, S. and Van Houten, H. (1992) *Research with Farmers, Lessons from Ethiopia.* CAB International, Wallingford, UK.

Hoang Fagerström, M.H., van Noordwijk M., Thai Phien and Nguyen Cong Vinh, (2001) Innovations within upland rice-based systems in northern Vietnam with *Tephrosia candida* as fallow species, hedgerow, or mulch – Net returns and farmers' response. *Agriculture Ecosystems and Environment* 86: 23-37.

IFAD, IDRC, CIIFAD, ICRAF and IIRR (2001) *Shifting Cultivation: Towards Sustainability and Resource Conservation in Asia.* International Institute of Rural Reconstruction, Cavite, Philippines.

Izac, A.M.N. and Sanchez, P.A. (2001) Towards a natural resource management paradigm for international agriculture: the example of agroforestry research. *Agricultural Systems* 69: 5-25.

Joshi, L., van Noordwijk, M, Sinclair, F. L. (2001) *Bringing local knowledge into perspective – a case of sustainable technology development in jungle rubber agroforests in Jambi.* (chapter 23, this volume).

Michon, G. and de Foresta, H. (1995) The Indonesian agroforest model. Forest resource management and biodiversity conservation. In: P Halladay & DA Gilmour (eds) *Conserving Biodiversity Outside Protected Areas: The role of traditional agro-ecosystems*. IUCN, Gland, Switzerland.

Tomich, T.P. and van Noordwijk, M. (1996) What drives deforestation in Sumatra? In: Benjaven Rerkasem (ed) *Montane Mainland Southeast Asia in Transition*. Chiang Mai University, Chiang Mai, Thailand.

Tomich, T.P., Van Noordwijk, M., Budidarseno, S., Gillison, A., Kusumanto T., Murdiyarso, D. Stolle, F. and Fagi, A.M. (2001) Agricultural intensification, deforestation, and the environment: assessing tradeoffs in Sumatra, Indonesia. In: Lee D.R. and Barrett, C.B. (eds) *Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment*. CAB-International, Wallingford.

Van Noordwijk, M., T.P. Tomich, R. Winahyu, D. Murdiyarso, S. Partoharjono and Fagi, A.M. (eds) (1995) *Alternatives to Slash-and-Burn in Indonesia: Summary Report of Phase 1*. ASB-Indonesia Report Number 4, Bogor, Indonesia.

Van Noordwijk, M., Murdiyarso. D. K., Hairiah, Wasrin, U.R., Rachman, A. and Tomich, T.P. (1998) Forest soils under alternatives to slash-and-burn agriculture in Sumatra, Indonesia. In: A. Schulte and D. Ruhiyat (eds) *Soils of Tropical Forest Ecosystems: Characteristics, Ecology and management*. Springer-Verlag, Berlin.

Van Noordwijk, M. (1999) Nutrient cycling in ecosystems versus nutrient budgets of agricultural systems. In: Smaling, E., O. Oenema and L. Fresco (eds) *Nutrient Cycles and Nutrient Budgets in Global Agro-ecosystems*. CAB-International, Wallingford, UK.

Van Noordwijk, M, Tomich, T.P. and Verbist, B. (2001) Negotiation support models for integrated natural resource management in tropical forest margins. *Conservation Ecology*, (forthcoming).

Williams, S.E., Van Noordwijk, M., Penot, E., Healey, J.R., Sinclair F.L. and Wibawa, G. (2001) On-farm evaluation of the establishment of clonal planting stock in multistrata rubber agroforests. *Agroforestry Systems* (forthcoming).

World Bank (2000) *Attacking Poverty: World Development Report 2000/2001*. Oxford University Press, Oxford.