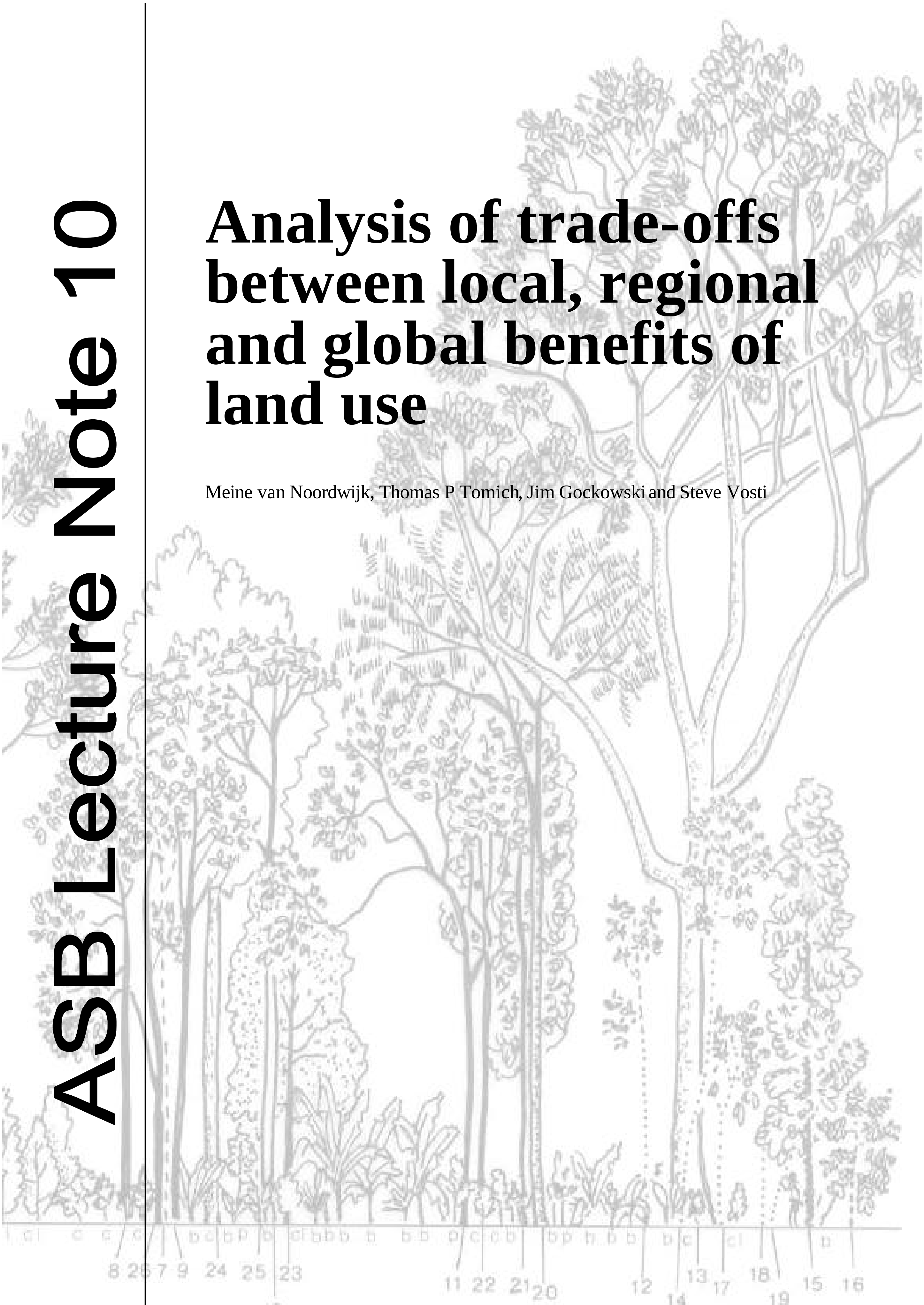
ASB Lecture Note 10

Analysis of trade-offs between local, regional and global benefits of land use

Meine van Noordwijk, Thomas P Tomich, Jim Gockowski and Steve Vosti



INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY

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Towards integrated natural resource management in forest margins of the humid tropics: local action and global concerns

Meine van Noordwijk, Sandy Williams and Bruno Verbist (Editors)

> Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being. However, integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own; but together we can - in a global partnership for sustainable development. (Preamble to the United Nations' Agenda21 on Sustainable Development; http://www.un.org/esa/sustdev/agenda21chapter1.htm).

Background to this series of lecture notes

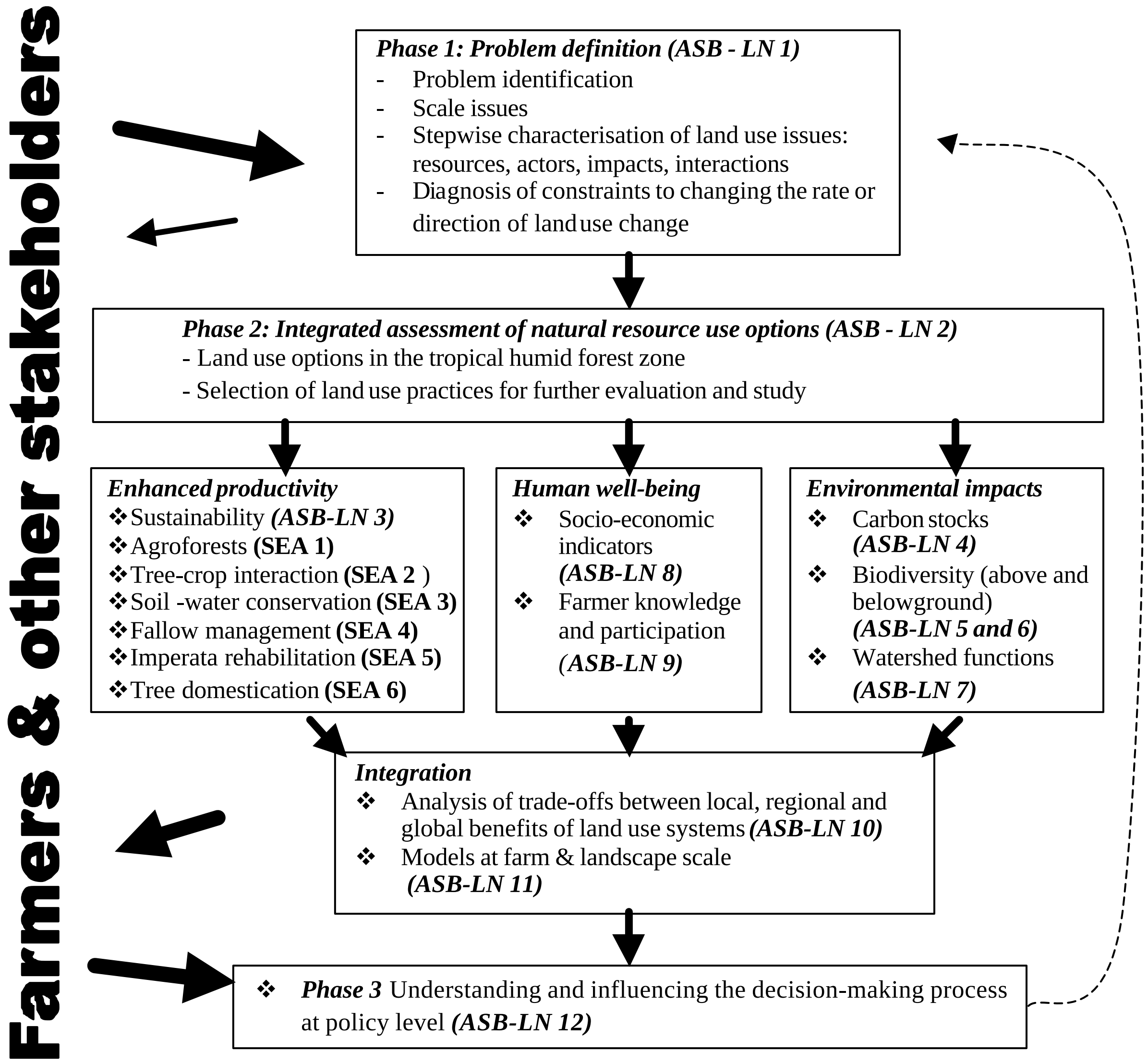
Much of the international debate on natural resource management in the humid tropics revolves around forests, deforestation or forest conversion, the consequences it has and the way the process of change can be managed. These issues involve many actors and aspects, and thus can benefit from many disciplinary perspectives. Yet, no single discipline can provide all the insights necessary to fully understand the problem as a first step towards finding solutions that can work in the real world. Professional and academic education is still largely based on disciplines – and a solid background in the intellectual capital accumulated in any of the disciplines is of great value. If one wants to make a real contribution to natural resource management issues, however, one should at least have some basic understanding of the contributions other disciplines can make as well. Increasingly, universities are recognising the need for the next generation of scientists and policymakers to be prepared for interdisciplinary approaches. Thus, this series of lecture notes on integrated natural resource management in the humid tropics was developed.

The lecture notes were developed on the basis of the experiences of the Alternatives to Slash and Burn (ASB) consortium. This consortium was set up to gain a better understanding of the current land use decisions that lead to ***rapid*** conversion of tropical forests, shifting the forest margin, and of the ***slow*** process of rehabilitation and development of sustainable land use practices on lands deforested in the past. The consortium aims to relate local activities as they currently exist to the global concerns that they raise, and to explore ways by which these global concerns can be more effectively reflected in attempts to modify local activities that stabilise forest margins.

The Rio de Janeiro Environment Conference of 1992 identified deforestation, desertification, ozone depletion, atmospheric CO_2 emissions and biodiversity as the major global environmental issues of concern. In response to these concerns, the ASB consortium was formed as a system-wide initiative of the Consultative Group on International Agricultural Research (CGIAR), involving national and international research institutes. ASB's objectives are the development of improved land-use systems and policy recommendations capable of alleviating the pressures on forest resources that are associated with slash-and-burn agricultural techniques. Research has been mainly concentrated on the western Amazon (Brazil and Peru), the humid dipterocarp forests of Sumatra in Indonesia, the drier dipterocarp forests of northern Thailand in mainland

Southeast Asia, the formerly forested island of Mindanao (the Philippines) and the Atlantic Congolese forests of southern Cameroon.

The general structure of this series is



This latest series of ASB Lecture Notes (**ASB-LN 1 to 12**) enlarges the scope and embeddes the earlier developed ICRAF-SEA lecture notes (**SEA 1-6**) in a larger framework. These lecture notes are already accessible on the website of ICRAF in Southeast Asia: http://www.icraf.cgiar.org/sea

In this series of lecture notes we want to help young researchers and students, via the lecturers and professors that facilitate their education and training, to grasp natural resource management issues as complex as that of land use change in the margins of tropical forests. We believe that the issues, approaches, concepts and methods of the ASB program will be relevant to a wider audience. We have tried to repackage our research results in the form of these lecture notes, including non-ASB material where we thought this might be relevant. The series of lecture notes can be used as a basis for a full course, but the various parts can also ‘stand alone’ in the context of more specialised courses.

Acknowledgements

A range of investors (or 'donors') have made the work of the ASB consortium possible over the past years, some by supporting specific parts of the program, others by providing core support to the program as a whole. These lecture notes build on all these investments, but were specifically supported by the ASB Global Steering Group, with funds provided by the Asian Development Bank, the World Bank via the CGIAR, by ICRAF core funds, by the Netherlands' Government through the Direct Support to Training Institutions in Developing Countries Programme (DSO)-project and by the Flemish Office for Development Cooperation and Technical Assistance (VVOB). Both biophysical and policy research was supported bu a Regional Assistance Grant from the Asian Development Bank. Many researchers and organisations have contributed to the development of ideas, collection and synthesis of data, and otherwise making the program what it is today. A team at the International Centre for Research in Agroforestry (ICRAF), consisting of Kurniatun Hairiah, Pendo Maro Susswein, Sandy Williams, SM Sitompul, Marieke Kragten, Bruno Verbist and Meine van Noordwijk developed these lecture notes. A first test of their suitability was provided by a course on 'Ecology for Economists' organised by the Economy and Environment Program for Southeast Asia (EEPSEA) program – we thank David Glover, Hermi Francisco and all participants to that course for their suggestions. Key researchers within the consortium provided support and agreed to act as co-authors on the various chapters. Editorial comments on draft forms of the various lecture notes were obtained from Fahmuddin Agus, Georg Cadisch, Min Ha Fagerström, Merle Faminow, Roeland Kindt, Chun Lai, Ard Lengkeek, Jessa Lewis, Chin Ong, Per Rudebjer, Goetz Schroth, Douglas Sheil, Fergus Sinclair, Sven Wunder and others. Overall responsibility for any shortcomings in the lecture notes remains with the editorial team.

ASB-consortium members

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Lecture Note 10

ANALYSIS OF TRADE-OFFS BETWEEN LOCAL, REGIONAL AND GLOBAL BENEFITS OF LAND USE

By Meine van Noordwijk, Thomas P. Tomich, Jim Gockowski and Steve Vosti

Contents

I. Objectives

- To explore relationships between local and global benefits of tropical land use categories
- To quantify trade-offs in these relations and discuss how they can be interpreted

II. Lecture

1. Introduction: taking stock

In the series of lecture notes so far (Figure 1), we have defined problems of tropical land use that involve forest conversion (#1) and set up a scheme to evaluate categories of land use (#2) on the basis of a range of criteria derived from local (Profitability #8, Sustainability #3), regional (Watershed functions #7) and global (C stocks #4, Biodiversity #5, #6) benefits.

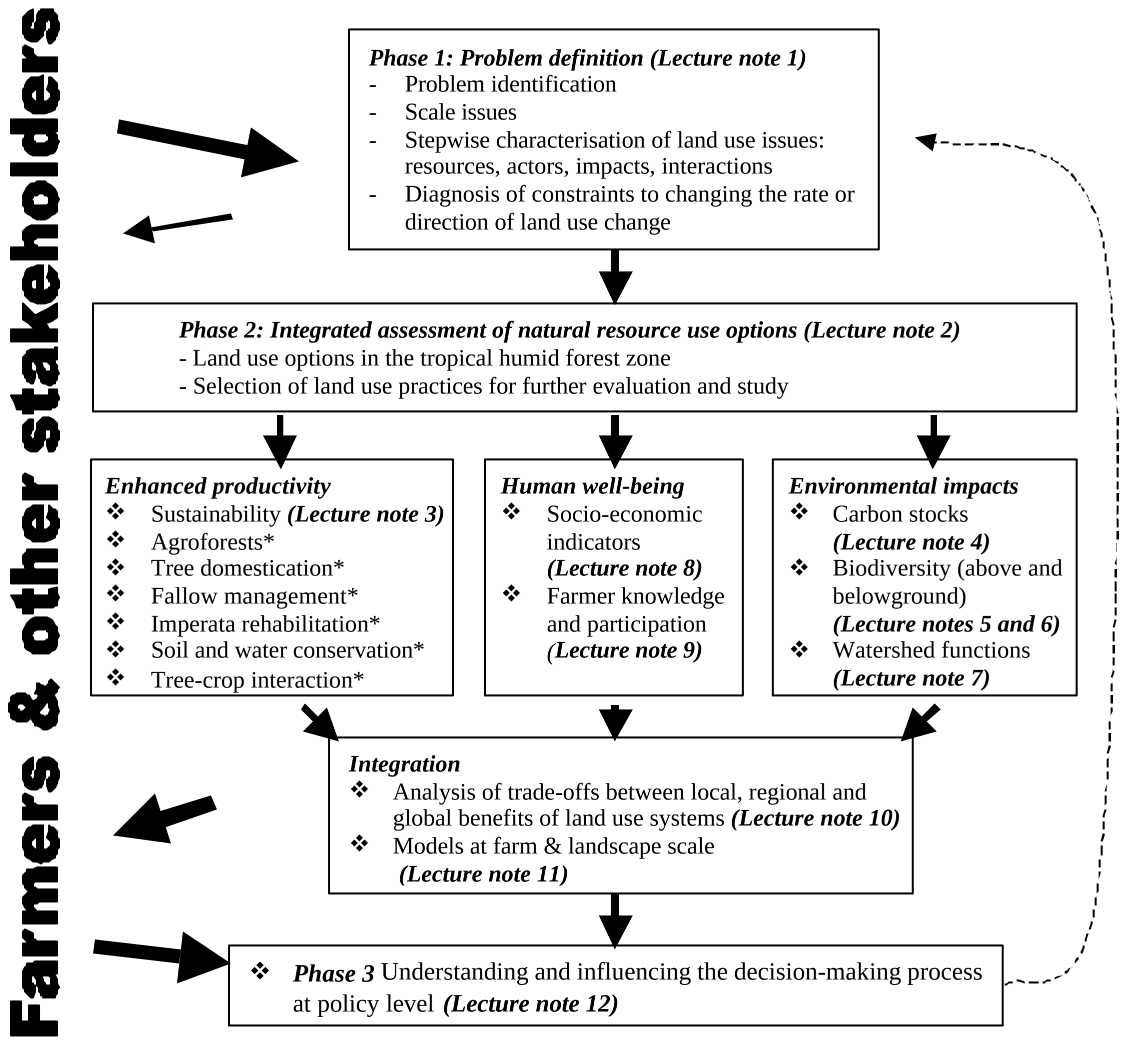

Figure 1. Towards integrated natural resource management (NRM) in the humid tropics: three main phases considered within this series of lecture notes.

We will now consider the first steps towards a synthesis of such data, drawing heavily on the data sets obtained in the Alternatives to Slash and Burn project. As these data were collected on the basis of a common methodology, they offer a unique opportunity to compare results both within the countries or benchmark areas, and across the three tropical continents.

2. Multiple objectives: identifying 'best bets' or clarifying trade-offs

Decision making is normally based on narrowing down the number of available options and condensing the expected outcome of the various choices into simple indicators. In theory, if it were possible to synthesise such indicators into a single overall value, then it may seem that decision making could be stripped of its emotions and subjectivity and become simply a matter of selecting the option with the highest overall value associated with it. In reality, however, things are rarely that simple!

A first step, however, now that we have evaluated the performance of many land use options on a broad range of criteria, is that we try to derive a set of weights for these indicators and develop an index to rank alternatives. In particular, we attempted to value all indicators in terms of a financial currency, to make the final analysis one of simple arithmetic to derive the 'optimum' solution, or 'best bet'.

In practice, however, the basic values for the various criteria are weighted very differently by the range of stakeholders involved. Rather than pretending that there is an overall, intrinsically benign decision-making level where such an optimum choice is of interest, every stakeholder will have their own opinion on what is best and will act accordingly. So, the information and data we have summarised so far can help in negotiations among stakeholders, even if there is no agreement on 'best bet' solutions.

For now we may be content to analyse the trade-offs between the ways the various objectives can be met, and their stakeholders satisfied, by each type of land use considered. A matrix of land use alternatives (Table 1 provides an example for Sumatra) is a pragmatic attempt to circumvent the valuation problem and to organise information that incorporates competing objectives. Every group of stakeholders can assign their own relative weights to these criteria -- they may be able to agree on the data in such a table, but draw different conclusions from it about what land use practices are desirable.

With this array of indicators, it is possible to examine trade-offs and complementarities across the various criteria. Are environmental benefits compatible with sustainable agricultural development? Which environmental functions are the least compatible with productive use of the lands? How much would the private benefits of less environmentally benign land use practices have to be compensated before private decision making would shift away from them? For all such questions we do not need a single overall value for the land use options, but we do need clarity in what the trade-offs are.

As was mentioned in lecture notes 1 and 2 the different evaluation criteria have different scaling rules. Whereas properties such as time-averaged C stock or returns to land can be expressed on a per unit area basis, relatively independent of the extent over which the systems actually occur, for properties such as biodiversity or watershed functions this is certainly not the case. The data collected by ASB, as explained in the preceding lecture notes, primarily apply to plot-level characteristics, but are integrated over a typical rotation length. The environmental data primarily refer to (a combination of) land cover types, the profitability data to land use types (see lecture note 2). The type of integration that is required between land cover and land use may be conceptually easier if we refer to a spatial mosaic rather than a sequence in time (see Figure 1 in lecture note 2...).

2.1 Trade-offs between plot-level indicators in Sumatra, Indonesia: biodiversity, carbon stocks, profitability and employment

The first step is the analysis of trade-offs between the various indicators within this matrix (Table 1). Figure 2 gives examples. In some of the comparisons there may be ‘win-win’ solutions, where both indicators are high (reflected by data points in the upper right corner). For example, plant species richness is high in the community-managed forests where NTFP collection leads to high returns to labour, as well as in the rubber agroforests that give high returns to land. In other comparisons, however, the upper right corner is empty and there are no win-win solutions. This occurs, for example for the C stocks, which drop substantially as soon as forests are logged or utilised.

A point to note here is that these measured attributes may not be necessarily ‘caused’ by the current land use. For example, the reduction in C stocks of the community-managed NTFP collection system is probably due to logging activities in the past.

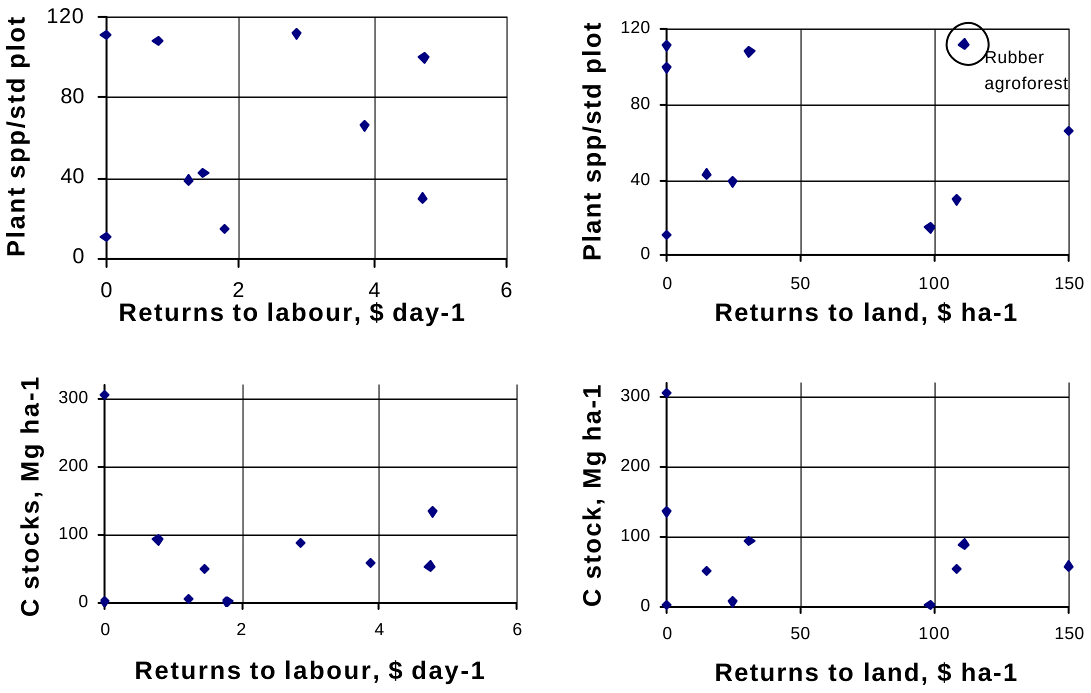

Figure 2. Trade-offs between plot-level environmental indicators (C stocks and plant species richness) and profitability (returns to land (NPVs[1]) and returns to labour) for the land uses studied in the Sumatra benchmark area.

[1] NPV: Net Present Value. NPVs include future costs and benefits ‘discounted’ to the current time, so they do not have a time dimension (this is explained in lecture note 8).

Table 1. ASB matrix for the forest margins of Sumatra

Land use		Global environment		Agronomic sustainability		National policymakers' concerns		Adoptability by smallholders			
Description	Scale of operation / evaluation	Carbon sequestra-tion	Biodiversity	Plot-level production sustainability		Potential profitability	Employment	Production incentives	House-hold food security	Institutional & policy issues	
		Time averaged C (Mg/ha)	*Plant species/ standard plot*	*Overall rating*	*Main sustain-ability issues*[a]	*Returns to land (Rp 1000 / ha) at social prices*	*Time averaged labor input (days/ha/yr)*	*Returns to Labor (Rp /day) at private prices*	*Food entitle-ment via:*	*Market imper-fections*[b]	*Other institutional problems*[c]
Natural forest	25 ha fragment / 1 ha	254	120	1		0	0	0	n.a.		
Community-based forest management	35,000 ha common forest / 1 ha	176	100	1		9.4 to 18	0.2 to 0.4	11,000 to 12,000	own prod'n & exchang e	o	N, R, P, C
Commercial logging	35,000 ha concession / 1 ha	150	90	0.5	C	(32) to 2102	31	(17,349) to 2008	Wages	O, K	N, R, E, P, B, C
Rubber agroforest	1-5 ha plots / 1 ha	116	90	0.5	C	73	111	4000	Exchang e		P, b, c
Rubber agroforest w/ clonal planting material	1-5 ha plots / 1 ha	103	60	0.5	C,K,W,P	234 to 3622	150	3900 to 6900	Exchang e	I, k	N, P, b, c
Rubber monoculture	1-5 ha plots / 1 ha	97	25	0.5	C,W,P	(993)	133	3683	Exchang e	I, k	N, P, b, c
Oil palm monoculture	35,000 ha estate/ 1 ha	91	25	0.5	C,Fert	1480	108	5797	Wages	I, o, K	N, R, e, P, B, c

Land use		Global environment		Agronomic sustainability		National policymakers' concerns		Adoptability by smallholders			
Description	Scale of operation / evaluation	Carbon sequestra-tion	Biodiversity	Plot-level production sustainability		Potential profitability	Employment	Production incentives	House-hold food security	Institutional & policy issues	
		Time averaged C (Mg/ha)	*Plant species/ standard plot*	*Overall rating*	*Main sustain-ability issues*[a]	*Returns to land (Rp 1000 / ha) at social prices*	*Time averaged labor input (days/ha/yr)*	*Returns to Labor (Rp /day) at private prices*	*Food entitle-ment via:*	*Market imper-fections*[b]	*Other institutional problems*[c]
Upland rice / bush fallow rotation	1-2 ha plots / 1 ha	74	45	0.5	Fert,P	(180) to 53	15 to 25	2700 to 3300	own productio n		n, P, c
Continuous cassava degrading to *Imperata*	1-2 ha plots within settlement project/ 1 ha	39	15	0	C,Fert,W	(315) to 603	98 to 104	3895 to 4515	own prod'n & exchang e	o, K	n, E, p, c

Notes: [a] Plot-level production sustainability: C = soil compaction; K = potassium balance; Fert = fertilizer cost; P = pest or disease problem.
[b] Market imperfections: I = input market problem; O = output market problem; K = capital market problem.
[c] Other institutional problems: N = non-market information problem; R = regulatory problem; E = local environmental problem; B = equity biases; P = insecure property rights;
C = social cooperation required.
For market imperfections and other institutional problems: upper case letters indicate more serious problems.

An interesting comparison is the one between the returns to land and returns to labour. NTFP collection stands out in this comparison, as it leads to high returns to labour but a low value per unit land. So, it is suited to low population densities, but not to higher ones. If we treat this as an 'outlier', the other land uses show a positive relationship between the number of persons that can find 'employment' in a system and the returns to labour they can obtain (Figure 3). Essentially this relation is caused by the labour-intensive tree crop systems rubber and oil palm, that give attractive returns. Within these tree crop systems, the extensive rubber agroforests are clearly superior in environmental indicators.

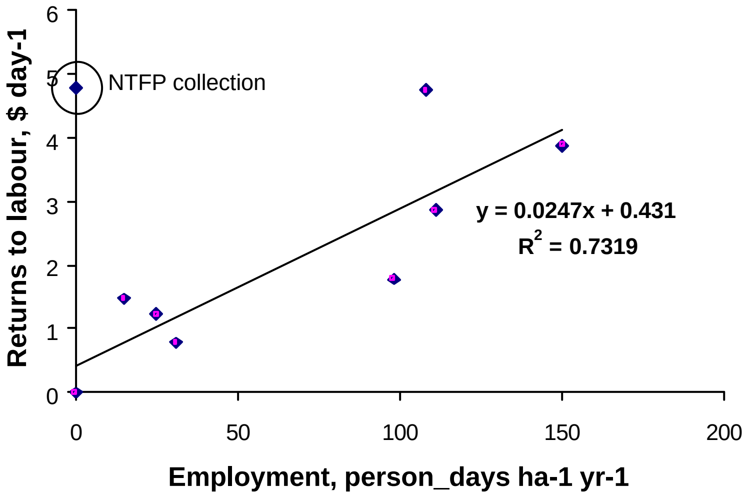

Figure 3. Relation between labour use intensity (number of person days per ha per year) and the returns to labour for all land uses in the matrix comparison for Sumatra. NB NTFP collection is excluded from the regression as it has a very small value for 'employment', because it is a very extensive form of land use.

2.2 Global comparison of trade-offs

Some of these trends for Sumatra are confirmed when we consider ASB data for Cameroon and Brazil, grouping land uses under the following headings: forest, tree crops, fallow/crop systems and permanent crops or pasture.

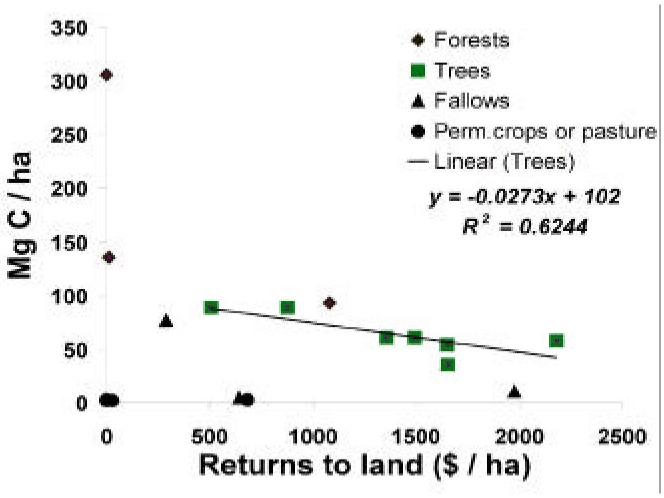

Figure 4. Relationship between time-averaged C stocks and the returns to land (net present value) for forest-derived land use systems in benchmark areas in the three tropical continents.

2.2.1 C stocks versus returns to land

In the trade-off between C and returns to land, the natural forest clearly stands out as having the highest value (Figure 4). Otherwise the big difference is that between systems based on tree crops (with time-averaged C stocks of 50 - 150 Mg ha^{-1}) and those based on annual food crops or pasture (with time-averaged C stocks of < 20 Mg ha^{-1}). Within the tree crop systems, a slight negative trade-off can now be seen, where the more profitable tree crop systems have a slightly lower time-averaged C stock. From these data we can calculate how large the differences in returns to land are between forests and tree-crop systems ($/ Mg C) (Figure 5). This can be interpreted as a first indication of how much one would have to pay a tree-crop farmer to leave the forest untouched. The outcomes vary from 2 - 25 $/Mg C.

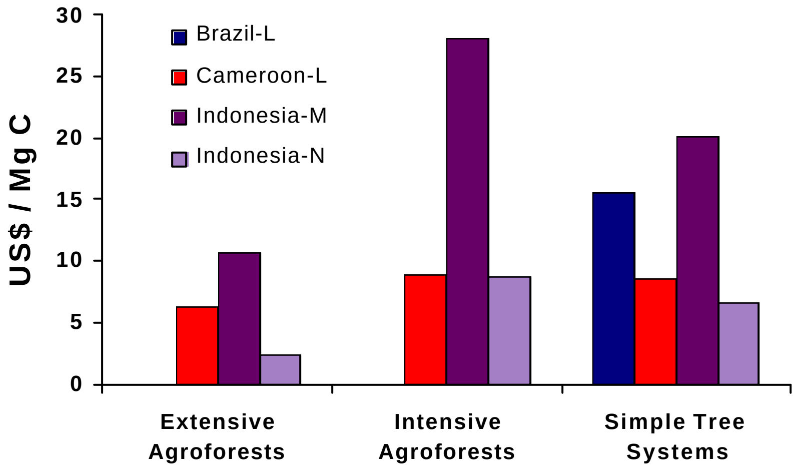

Figure 5. Differences in returns to land between tree crop systems and forest, per unit difference in time-averaged C stock between forests and these systems. L=logged-over forest; M=community-managed forest; N=Natural/undisturbed forest).

2.2.2 Plant species richness and profitability

In the global comparison of plant species richness and returns to land (Figure 6), the first thing to note again is that the tree-crop based systems are far richer in plant species than the systems based on annual food crops. Yet, within these tree crop systems and forests, a negative trade-off exists between plant species richness and returns to land. So, a shift from annual food crops or pasture and tree crops may lead to gains in environmental benefits as well as profitability. However, within the tree crop systems, more intensively managed systems give higher returns to land but at a lower plant species richness.

Relationship between plant species richness and C stocks

Across all these systems we can compare the relative loss of plot-level plant species richness and loss of time-averaged C stock if we compare the forest-derived land use systems with the forests that they replaced. Data from the three continents suggest that the loss of C stock is faster than the loss of plant species richness (Figure 7).

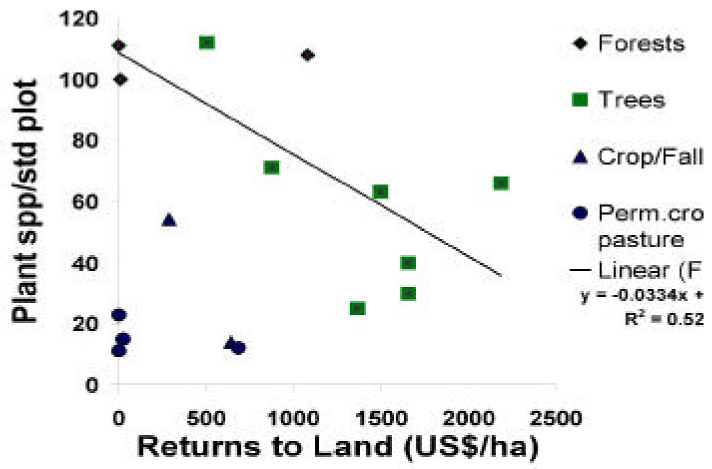

Figure 6. Relationship between plant species richness (number of plant species per standard 40 m x 5 m plot) and returns to land (net present value) for forest-derived land use systems in benchmark areas in the three tropical continents.

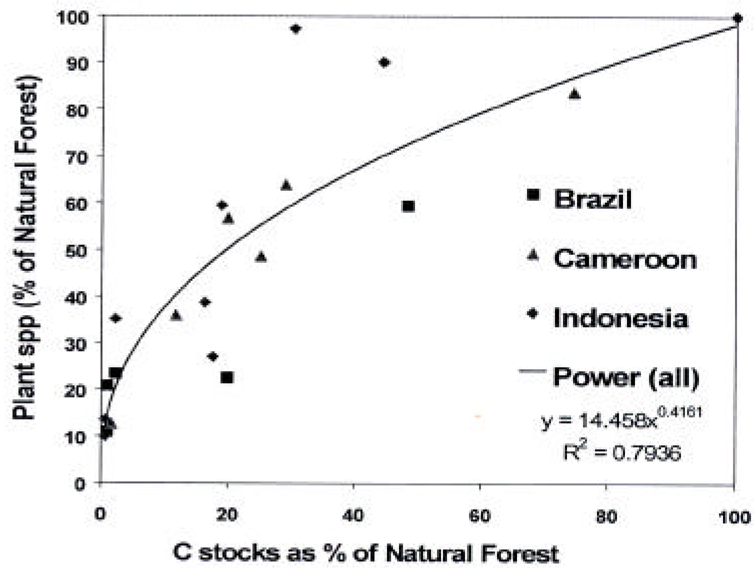

Figure 7. Relative loss of C stocks and plant species richness for forest-derived land use practices in the three tropical continents.

3. So what? What do these trade-offs mean?

3.1 Social win-win solutions where conflicts currently lead to lose-lose

Recognition of the trade-offs and the scarcity of 'win-win' solutions where both environmental and developmental objectives are at their maximum, may help the various stakeholders to understand the options they have. In a relative sense, 'win-win' situations may still be possible where currently conflicts mean that all parties involved lose out. For example, current enforcement of 'watershed protection forest' rules by eviction of villages that have 'encroached' into forest areas, does not actually restore the watershed functions and leads to large losses for the farmers evicted. A reconsideration of the options may lead to a 'relative win-win' situation, where local and external stakeholders are better off than in the current conflict, even though neither side may get exactly what they wanted. In interpreting the plot-level data, however, we have to realise the limitations they have and not go beyond their range of validity.

3.2 Understanding the limitations of current plot-level assessments

Scaling up is a real challenge (see lecture note 1) and the current plot-level indicators cannot be directly extrapolated to a landscape scale. For example, the plot-level richness in plant species can not be used to make statements about landscape-level richness. It is likely that in forests, the beta and gamma diversity (measures of differences in diversity between plots and at the landscape scale, respectively; also see lecture note 5) is higher than in the agroforests and tree crop systems. Therefore, a landscape scale comparison will be less favourable than plot-level data suggest. But we don't yet know the degree to which this occurs.

3.3 Appreciate the best of what we currently have

The overall conclusion that forest-derived systems based on profitable tree crops are 'win-win' solutions in comparisons with attempts to produce annual food crops or pasture, is probably not sensitive to these scale relations. Within these systems the more extensive forms (jungle rubber in Sumatra, jungle cacao in Cameroon) are superior in environmental terms, but not in profitability. Yet, these systems have been barely visible in development and land use plans, which are typically focused on more intensive systems.

3.4 Search for win-win situations where they do not yet exist

Where win-win situations do not yet exist, we can try to search for them. For example, introducing tree germplasm with a higher value per tree, may (at least in theory) increase the profitability of extensive rubber agroforests at little loss to biodiversity indicators. Different management practices within a system may also increase time-averaged C stocks without reducing profitability.

4. To segregate or integrate land uses within the landscape?

In the preceding lecture notes we looked at a number of arguments for either favouring spatially-segregated (natural forest + intensive agriculture) or integrated, multifunctional landscapes (Figure 8). Table 2 summarises these perspectives and shows the different preferences for the different environmental functions. Clearly-segregated areas of natural forest with minimum human disturbance are essential for part of the biodiversity conservation agenda – in this sense none of the 'integrated' land uses can be a substitute for national parks. Purely agricultural areas, however, are likely to be undesirable on sloping land where at least some form of 'integration' with other land cover elements is required to provide the vegetative filter functions necessary for 'watershed functions'. When we bring a 'human perspective' into the evaluation, we will see that borders of segregated national parks are unlikely to be respected by local communities or newcomers (migrants) unless there are clear benefits associated with such respect for boundaries, or disincentives linked to disrespect. Some form of 'integration' is needed to achieve such incentives, for example through bufferzone constructions.

Table 2. Summary of conclusions with regards to the segregate-integrate debate in the preceding lecture notes and in Figure 8.

	Sustainability #3	C stocks #4	Biodiversity #5,#6	Watershed functions #7	Soil conservation #7	Profitability #8
Segregated - Agriculture	Highest internal risks for low value, bulk production	Aboveground C stocks low (< 5 Mg C ha^{-1}); soil management can restore up to 20 Mg C ha^{-1}	Agro-biodiversity mainly relevant for pest and weed control	High water yield but infiltration capacity tends to decline, so more run-off	Problematic on sloping land, but no problems if intensive agriculture is concentrated in flat lands	Potentially high
Segregated - Natural forest	Main threats from outside: continued conversion into agriculture and degradation by logging	C stocks high (100 - 350 Mg C ha^{-1})	Large reserves desirable to reduce edge and island effects	Ideal where clean water is desired; total water yield relatively low, base-flow component high	No problems (but logging can be very damaging)	Low direct returns, option and ex situ use values
Interme-diate solutions	The forest boundary is likely to be under continuous threat	If forest fraction > 25%, C stocks can be 25 - 100 Mg C ha^{-1}	Sharp (fenced) boundary reduces conflict but increases island effect; 'integrated' areas can act as a buffer zone and help dispersal of organisms	Limited options for correcting subsurface lateral flows	Problematic, but strategically located riparian forests can act as sediment filter	Potentially OK – but profitability difference between the Agriculture and Forest parts encourages forest conversion; many options in portfolio to reduce overall risk
Integrated - Agroforestry mosaic	Competition between components is a major 'threat', but the multiple components also provide opportunities for adaptive response	C stocks medium (25-100 Mg C ha^{-1})	Agro-diversity with direct value + which provides survival options for a certain proportion of the forest flora & fauna	Many options for lateral flow interac-tions in fine-grained mosaics	Many options for local sedimentation	Multi-functionality can lead to high overall value and hedging of risk

Exercise

Divide the group (or classroom) in two parts and give each group 20 minutes to prepare the arguments for defending a) a spatially-segregated, or b) an integrated solution to land use in a specified part of your country. Then have a public debate and compare the strength of the arguments. Is there room for compromise and intermediate solutions? Does the final 'vote' of the group differ from the perceptions expressed at the start of the course (in lecture note 1)?

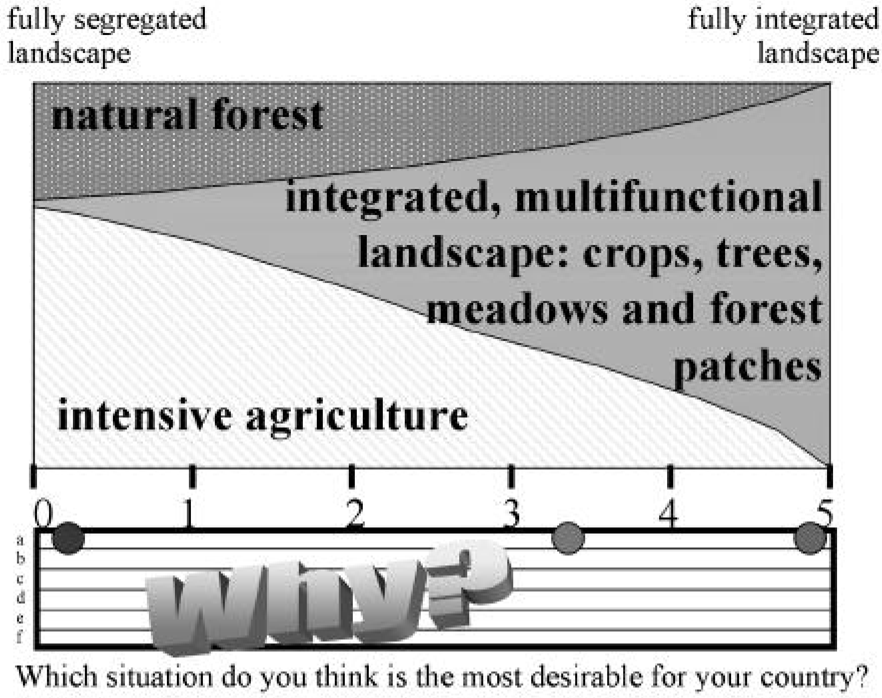

Figure 8. What are the benefits of spatially-segregated or integrated land uses at the landscape level?

5. How can real-world Natural Resource Management be improved?

By now we may have achieved a pretty good understanding of some 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 actions that lead to real improvements? Referring to Figure 9, 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 types 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 realised by providing positive incentives for change;

3. we need a more holistic understanding of how the whole socio-political-agro-ecosystem works, including all its feedback loops, so as to identify the weakest parts in the overall chain for any specific situation and to make sure our priorities are right before making any change;

4. we need a better functioning of 'civil society' with all *its* feedback loops, to ensure a dynamic and responsive system that continuously monitors itself as well as the persons and mechanisms entrusted with providing the 'public goods' required for improvement; we need a 'learning culture' built into all aspects of 'civil society';

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, for example, biodiversity conservation to the global community, without being paid for it. We thus need an effective and efficient method for 'environmental service transfers'.

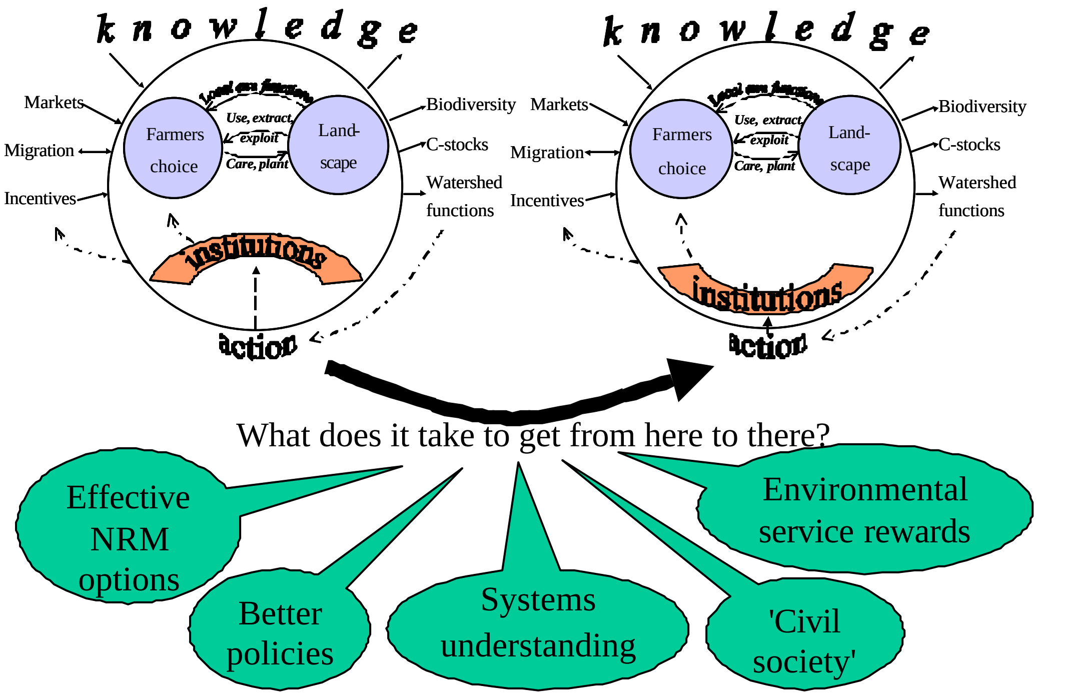

Figure 9. The objective of 'natural resource management' interventions is to achieve a better functioning of the way farmers, the landscape, external stakeholders and local institutions interact – the lower part of the diagram illustrates the five type of 'interventions' that are often proposed to achieve better NRM (compare CGIAR 2000).

Exercise

Can you give example of what each of the five types of interventions of Figure 9 would try to achieve in a situation at the margins of tropical forests with which you are familiar? Which approach may be the easiest to implement? For which one could you expect to obtain funding? Which one would you expect to be the most effective in the long run? Do you want to change discipline, or is your current (planned) disciplinary background in line with what you think is the priority issue?

III. Reading Materials

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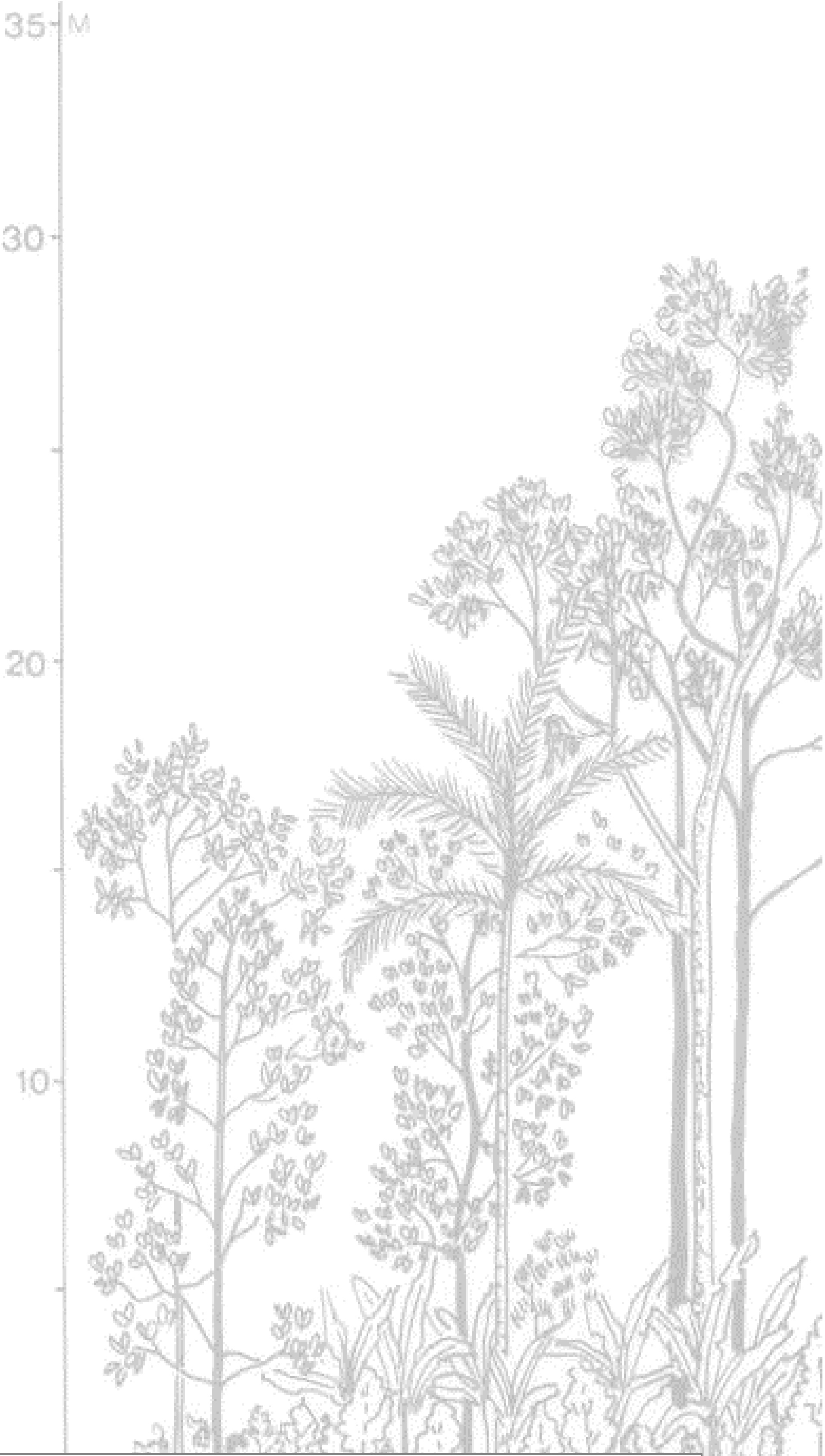

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