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CRITERIA AND INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT: NEW FINDINGS FROM CIFOR'S FOREST MANAGEMENT UNIT LEVEL RESEARCH

Ravi Prabhu, Carol Colfer and Gill Shepherd

SUMMARY

This paper traces the growing interest in the development of Criteria and Indicators for sustainable forest management since the declaration of the 'Forest Principles at the Rio Conference in 1992. Several processes are underway in different regions of the world to define sets of criteria and indicators that can be used to assess the social, economic and ecological sustainability of forest management. Some have focused more at national level, while others have emphasised information needs at the forest management unit level. In an attempt to produce a generic 'master set', the Center for International Forestry Research (CIFOR) has carried out several tests to compare the different sets of criteria and indicators currently in existence. At the forest level, ecological criteria have been found much easier to apply than social ones as the latter often require an in-depth understanding of areas beyond the immediate boundaries of the forest management unit. In addition to social issues, other areas that still need further work include biodiversity, the development of criteria and indicators for plantations, and a means of linking information from the local to the national level. In an attempt to help people in different areas adapt the generic hierarchy of criteria and indicators to their own conditions, CIFOR is developing a computer programme, CIMAT, which allows for the addition of local knowledge and an iterative development of locally-specific criteria and indicators. In spite of the work still needed, the importance of defining a comprehensive but practical set of criteria and indicators lies in the fact that such a measurable and comparable methodology would build public confidence on the issue of forest sustainability.

INTRODUCTION[1]

The United Nations Conference on Environment and Development held in Rio in 1992 – and subsequently known as the Earth Summit – was set up to review progress made since The Brundtland Report, *Our Common Future*, had been published in 1987. While the earlier event had stressed sustainable development, the Earth Summit went further to assert that sustainable development and sustainable management of the environment went hand in hand.

Among the outcomes from the Conference were the 'Forest Principles' – a non-legally binding alternative to the forest convention which could not be agreed upon at the time.

[1] This section draws on Shattock (1997) and Wijewardena (1998).

The 'Forest Principles' moved goals forward where it was possible to do so, and were the first global attempt to arrive at criteria for consensus on the management, conservation and sustainable development of forests.

Thus, attempts to define what sustainable forest management ought to consist of developed out of the Forest Principles, and led directly to the most interesting attempt of all, the definition of Criteria and Indicators (C&I). C&I are tools for assessing trends in forest condition and forest management. They go well beyond an assessment of sustained yield for timber, to an assessment of forests as ecosystems with environmental and social as well as economic functions. C&I provide a common framework for describing, monitoring and evaluating progress towards sustainable forest management, and implicitly define it.

The International Tropical Timber Organisation (ITTO) introduced the Criteria and Indicators concept and terminology in 1992. Since then several regional groupings of countries have worked together upon the process of generating and testing appropriate C&I to suit their own conditions. In 1994 thirty-eight European countries signed on to the temperate forest 'Helsinki process' and twelve non-European countries, also with temperate forests, followed suit through the 'Montreal process'. In 1995, eight Amazonian countries began work on the 'Tarapoto process' and more recently twenty-seven sub-Saharan African countries have been working on C&I for dry zones. Processes are under way in the near East and Central America, and most recently of all the African Timber Organisation has been testing C&I for the rainforest zones of Central and West Africa. The countries most actively reaching for ways of defining and assessing progress towards sustainable forest management have driven these processes, and the result has been that, six years later, over a hundred countries are taking part in one or another regional process.

In all these regions, the focus has been mainly on the generation of C&I at the national level. Useful feedback has been provided to ITTO itself, and the process over recent years has seen the development of much more all-encompassing C&I, taking into account a fuller range of forest goods and services including environmental services and biological diversity. ITTO has recently (Wijewardena, 1998) issued a new broader set of C&I as a result, which are summarised in Table 1.

THE CONTRIBUTION OF CIFOR

CIFOR's approach has been to complement these regional and national-level processes by the field-testing of Criteria and Indicators at the Forest Management Unit (FMU) level. At this level measurements can be more precise, and the impact of forest management practices on the forest itself and on local populations are more evident. It has also been possible to eliminate difficult-to-use Criteria and Indicators, combine the more powerful and useable C&I from different sets and to generate new ones where there were key gaps. The work began in 1994, with Phase 1 running until 1996. Phase 2 is still ongoing.

The objectives at each site were to

- develop a methodology to evaluate and generate C&I;
- generate a minimum number of cost-effective and reliable C&I for each site, based on iterative and comparative field evaluations of selected sets;
- initiate work on a system to evaluate the sustainability of forest management as a whole, based on the recommended criteria and indicators.

Table 1 ITTO's new criteria for sustainable forest management (revised 1998)

CRITERION 1	Enabling Conditions for Sustainable Forest Management
CRITERION 2	Forest Resource Security
CRITERION 3	Forest Ecosystem, Health and Condition
CRITERION 4	Flow of forest produce
CRITERION 5	Biological Diversity
CRITERION 6	Soil and Water
CRITERION 7	Economic, Social and Cultural Aspects

Source: Wijewardena (1998)

The ultimate goals were twofold. Firstly, of course, to develop tools for the unbiased and objective on-site assessment of the quality, performance and systems of forest management. Secondly, to speed the process for those wishing to develop or improve their own C&I.

The work is aimed at certification bodies, government officials, donors, forest managers, project managers and scientists.

METHODOLOGY

In each test, a multi-disciplinary team of foresters, ecologists and social scientists worked to test sets of C&I in a variety of sites. Initially, these included Germany, Austria, Indonesia, Côte d'Ivoire and Brazil. Sets of C&I tested were those which were deemed, at the time, to represent the most advanced generic or site-specific sets. They included those from Smartwood, USA; Initiative Tropenwald, Germany; Woodmark, UK; the Dutch Working Group of Experts (DDB), Netherlands; and Lembaga Ekolabel Indonesia (LEI), Indonesia.

At each test-site, teams selected for their disciplinary and location-specific expertise participated in a month-long exercise. In a pre-fieldwork phase, they examined all the C&I available to them in all the sets under consideration, and made preliminary decisions about which were most likely to be useful. The second phase involved an iterative fieldwork process, testing selected C&I (abandoning some, incorporating others and generating new ones where essential), and exchanging perceptions between disciplines about usefulness and information generated. Each field exercise concluded with a workshop at which knowledgeable representatives from government, industry, academia and NGOs were invited to discuss the selected C&I in small working groups. Many further refinements could then be

incorporated before the final sets of C&I were generated in each case.

In a further test, in Cameroon, CIFOR invited several teams at once to participate in a test on the Wijma concession near Kribi. With the presence, for the first time, of several teams simultaneously, it was possible to gain further insights. The ideal length of time for a test was assessed by giving three teams seven days for their test, and three teams fourteen days. Here, too, with six teams, each composed of a forester, an ecologist and a social scientist, it was possible to gain further insights into the disciplinary complexities of testing C&I.

MAIN OUTCOMES

The nature of good quality criteria and indicators

From early tests, the attributes of C&I that were likely to be useable gradually became clearer, and many could be discarded. (The original master list, from all the sets being tested, had contained well over 1,000.) The Criteria and Indicators which were retained as most valuable scored highly because they were:

- relevant;
- unambiguously related to the assessment goal;
- precisely defined;
- diagnostically specific;
- easy to detect, record and interpret;
- reliable, as indicated by the replicability of results;
- sensitive to stress on the forest management, ecological or social systems;
- providing a measure over space/time;
- appealing to users.

Generic testing problems and responses to them

The tests demonstrated that it was easiest to find commonality among ecology criteria and indicators (there was an average of 72-78% commonality between all the sites). Policy and forest management sets showed a commonality of 57-60%. Social C&I, unsurprisingly, exhibited a much lower commonality, ranging from 27-34%.

The Cameroon test, with a far larger number of participants and more comparative data for examination in the workshop after the test, shed additional light on two important issues. Firstly, the test made it abundantly clear that at least fourteen days were needed for an effective test. The teams who had been given seven could not complete the task usefully. Secondly, it became clearer why foresters and ecologists found C&Is far easier to apply than social scientists. This was mainly because while the bulk of physical criteria examined in the test could be assessed within the Forest Management Unit, a high proportion of the social and economic criteria and indicators required national and regional level knowledge, detailed and more time-consuming interviewing, and decision-taking about inevitable conflicts between national and local-level understandings of tenure, and land and forest use-rights.

Because of these problems, much additional detailed work has been undertaken on social C&I. A wide variety of methods has been tested and a series of C&I 'best bets' has been developed as a result and incorporated into the CIFOR Master List (see Table 3 , Principles 3, 4 and 5 and all their accompanying Criteria and Indicators).

CIFOR has recently produced drafts of its social C&I manuals, the 'Basic Assessment Guide' or 'BAG' (Colfer *et al.*, 1998a); 'The Grab Bag: Supplementary Methods for Assessing Human Well-Being' (Colfer *et al.*, 1998b); and the 'Scoring Guide for Assessing Human Well-Being' (Colfer and McDougall, 1998): the first of their kind. An example of how 'access to resources' might be scored in different conditions is given in Table 2. While it will be essential to exercise caution in developing scoring systems, since people's livelihoods depend on the outcome of assessments, the beginnings of the development of a methodology usable by non-specialists is very important. The manuals perhaps need to be combined and further stream-lined, and the goal of further simplification when possible maintained.

CIFOR has also been working to investigate the potential role of traditional management as part of forest conservation. Tests took place in lowland tropical forest, among communities still exhibiting a strong traditional commitment to forests, but also where there were significant threats. Work included developing C&I that establish a historical

Table 2 Scoring 'Access to Resources'

(1 = maximally unsustainable; 10 = sustainable)	
1	A community scheduled for resettlement; victims of war; a community where no accessible resource base remains (e.g. parts of the Sahel).
2	A community being invaded by victims of war or other in-migrants, with resulting competition and over-use of resources (e.g. parts of Côte d'Ivoire, Brazil).
3	A community whose natural population growth and resource use patterns are threatening their own future access to resources (e.g. parts of Côte d'Ivoire).
4	A community where neither local nor national law and practice are adequate to ensure access to resources by community members.
5	A community where individuals select elements from both local and national law and practice in their own respective interests (e.g. parts of Cameroon).
6	A community with its rights of access protected by *local* law and practice, which is in conflict with *national* law and practice (e.g. Borneo).
7	A community with its rights of access protected by all relevant law and practice, but where sustainability of the resource and biodiversity is in question (e.g. Quilcene, Washington, USA).
8	A community with its rights of access protected by all relevant law and practice, with resources so abundant that biodiversity is maintained, though there are no mechanisms in place to ensure sustainability of the resource (e.g. parts of British Columbia).
9	A community with its rights of access protected by all relevant law and practice, and with mechanisms in place to ensure sustainability of the resource (e.g.Finland?).
10	-

Source: Colfer et al. (1998a), p.41

baseline, stability or flux, and the underlying causes of trends and changes. Each test site focused on two neighbouring communities, in order to examine the relationship between these villages and its impact on sustainability. Local participants felt that C&I could be used to recognise, document and communicate community forest management systems, to promote devolution, to develop policy, and to promote conservation and stewardship agreements for special protected areas.

Further recent work concerns the feeding of better economic indicators into the Policy and Management indicators in the master set. Work on this undertaken by Ruitenbeek and Cartier (1998) has concentrated on avoiding inappropriate economic indicators for the Forest Management Unit level, and developing positive and useful indicators. The authors recommend the exclusion of Internal Rate of Return as an indicator, since it does not properly account for alternative investments, is often miscalculated, and is less useful than, for instance, rent margins, to highlight a firm's economic efficiency or sustainability. They suggest avoiding economic valuation of global or regional functions such as biodiversity maintenance or carbon sequestration at FMU level. Rather, simpler and less costly-to-monitor measures of stand size and integrity should be used. Finally, they advise against the use of measures of equity such as economic distribution indices, recommending instead the use of simpler measures that are easier to estimate, such as forest rents accruing to local populations. Positive economic C&I from Ruitenbeek and Cartier have entered the Master set (Criteria 1.2-1.6 inclusive) and are currently undergoing further testing.

Approaching a master set of C&I

Although CIFOR rightly stress that C&I will always need to be adapted to local conditions, their tests made it possible to arrive at a set of Principles, Criteria and Indicators which are not too cumbersome, and which can form a common starting point for all sites. By testing so many C&I for user-friendliness, reliability and ability to monitor change, they have saved other potential users many hundreds of hours of work. Table 3 (overleaf) outlines the generic list of Principles, Criteria and Indicators, put together by CIFOR.

MAKING THE C&I MASTER SET MORE USER-FRIENDLY

Refinements to this master set will continue to be made as new opportunities present themselves. But the main challenge now is to make it more field-friendly, so that new users do not find it too daunting to manipulate. One way forward being tried by CIFOR is the development of a computer programme – CIMAT (Criteria and Indicators Modification and Adaptation Tool) – to help those who wish to adapt the generic hierarchy of principles, criteria, indicators (and verifiers – not listed here) to meet local needs, expectations and conditions.

The aim of the system is to rearrange the knowledge of experts in forest disciplines and in the concept of sustainable forest management into a computer format which can be adjusted to any forest area, and which can then be used by people with less expertise to test, in a relatively simple manner, whether forest management in a certain area is sustainable or not.

CIFOR has already developed a 'toolbox' for producing criteria and indicators for sustainable forest management, its core being the generic hierarchy of principles, criteria and indicators which provide a template for harnessing local expertise about standards for forest management in particular ecological regions or for particular forestry regimes.

However, CIFOR research shows that it will not be possible for a single set of C&I, however well developed, to be equally applicable across the globe. At the same time most research effort has been devoted to developing scientifically sound and cost-effective C&I that are applicable across large areas. This implies that there will be a need for local adaptation or customisation of 'generic' C&I. The goal of the research on the Criteria and Indicators Modification and Adaptation Tool (CIMAT) is thus to facilitate the adaptation of the generic hierarchy to meet local needs, expectations and conditions.

Modifications to the hierarchy are always required for the following reasons:

- filling specific knowledge gaps (for example, about local species important for biodiversity assessment),
- modifying indicators to local conditions (for example, to reflect local social or cultural considerations),
- adding indicators where extra information is deemed important, and
- rejecting them if they are redundant for assessment of sustainability in the local context.

A computer-based tool which supports such modifications can do three things:

- Firstly, and most pragmatically, it makes the clerical job of keeping track of changes to the C&I more straightforward than it currently is, thereby increasing the efficiency of modification.
- Secondly, it enhances the quality of modifications by encouraging people to think hard about the changes they make, encouraging them to record justifications for their changes, enabling cross-referencing of related C&I in different parts of the hierarchy and providing access to other people's experience in doing the modification task.
- Finally, and most idealistically, a computer tool helps with the evolution of C&I amongst the global community, by providing a resource for interdisciplinary teamwork and an electronic forum for sharing C&I knowledge across locations and disciplines.

CIMAT is a tentative step towards this tool. A first version is currently under development at CIFOR. It builds both on the experience of the last two years in which the CIMAT project team has carried out research into various GIS and Artificial Intelligence technologies; and on the four years of research by the CIFOR C&I team on the management of large scale natural forests for commercial purposes in the tropics.

CIMAT DEVELOPMENT

The building of CIMAT was preceded by investigation of its potential users, so that it was possible to design a genuinely useful system making their job quicker, easier, more manageable, cheaper or of better quality. Three groups of potential users, and their requirements were investigated:

Table 3 CIFOR'S generic list of Principles, Criteria and Indicators (as of May 1998)
(Note that the Verifiers, the fourth level of the hierarchy, have been omitted in the interests of saving space)

Key: **P=PRINCIPLE**
C=Criterion
I=Indicator

POLICY

P 1. POLICY, PLANNING AND INSTITUTIONAL FRAMEWORK ARE CONDUCIVE TO SUSTAINABLE FOREST MANAGEMENT (from Prabhu *et al.*, 1996)

C 1.1 There is sustained and adequate funding for the management of forests[1]
I 1.1.1 Policy and planning are based on recent and accurate information
I 1.1.2 Effective instruments for inter-sectoral coordination on land use and land management exist
I 1.1.3 There is a Permanent Forest Estate (PFE), adequately protected by law, which is the basis for sustainable management, including both protection and production forest
I 1.1.4 There is a regional land use plan or PFE which reflects the different forested land uses, including attention to such matters as population, agricultural uses, conservation, environmental, economics and cultural values
I 1.1.5 Institutions responsible for forest management and research are adequately funded and staffed

C 1.2 Precautionary economics policy in place[2]
I 1.2.1 Reserve funds available for damage (performance bond)
I 1.2.2 Anti-corruption provisions in place

C 1.3 Non-forestry policies do not distort forest management[2]
I 1.3.1 Absence of agricultural sector incentives for production expansion
I 1.3.2 Absence of price controls on domestic food production
I 1.3.3 Presence of alternative fuel oils in forest boundary areas
I 1.3.4 Absence of price controls on fuel oils
I 1.3.5 Absence of distorting resettlement policies
I 1.3.6 Absence of distorting exchange rate over or under-valuation

C 1.4 The existence of a functioning buffer zone[2]
I 1.4.1 Low level of conflict at FMU boundary
I 1.4.2 Existence of economic development authority in buffer zone
I 1.4.3 Local respect for FMU boundary
I 1.4.3 Concessionnaires' efforts to protect FMU boundaries

C 1.5 Legal framework protects forest resources and access[2]
I 1.5.1 Security of tenure (includes status of length, exclusivity, enforceability, and transferability)
I 1.5.2 Existence of non-confiscatory land use policy
I 1.5.3 Existence of property rights for exploited non-timber forest products (e.g. fuelwood)
I 1.5.4 Land tenurial prerequisite policy does not discriminate against forestry
I 1.5.5 Efficient equivalence of domestic log price/export log price
I 1.5.6 Transparent system of concession allocation

C 1.6 Demonstrated reinvestment in forest-use options[2]
I 1.6.1 Absence of excessive capital mobility (promoting cut and run) (cont'd)

ECOLOGY

P 2. MAINTENANCE OF ECOSYSTEM INTEGRITY (from Boyle *et al.*, 1998)

C 2.1 The processes that maintain biodiversity in managed forests are conserved

I 2.1.1 Landscape pattern is maintained
I 2.1.2 Change in diversity of habitat as a result of human interventions should be maintained within critical limits
I 2.1.3 Community guild structures do not show significant changes in the representation of especially sensitive guilds, pollinator and disperser guilds
I 2.1.4 The richness/diversity of selected groups show no significant change
I 2.1.5 Population sizes and demographic structures of selected species do not show significant change, and demographically and ecologically critical life-cycle stages continue to be presented
I 2.1.6 The status of decomposition and nutrient cycling shows no significant change
I 2.1.7 There is no significant change in the quality and quantity of water from the catchment
I 2.1.8 Enrichment planting, if carried out, should be based on indigenous locally adapted species

C 2.2 Ecosystem function is maintained

I 2.2.1 No chemical contamination to food chains and ecosystem
I.2.2.2 Ecologically sensitive areas, especially buffer zones along watercourses, are protected
I.2.2.3 Representative areas, especially sites of ecological importance, are protected and appropriately managed
I.2.2.4 Rare or endangered species are protected
I.2.2.5 Erosion and other forms of soil degradation are minimized

C 2.3 Conservation of the processes that maintain genetic variation

I.2.3.1 Levels of genetic diversity are maintained within critical limits
I.2.3.2 There is no directional change in genotypic frequencies
I.2.3.3 There are no significant changes in gene flow/migration
I.2.3.4 There are no significant changes in the mating system

SOCIAL

P 3. FOREST MANAGEMENT MAINTAINS OR ENHANCES FAIR INTERGENERATIONAL ACCESS TO RESOURCES AND ECONOMIC BENEFIT (from Colfer *et al.*, 1998a)

C 3.1 Local management is effective in controlling maintenance of and access to the resources

I 3.1.1 Ownership and use rights to resources (inter and intra-generational) are clear and respect preexisting claims
I 3.1.2 Rules and norms of resources use are monitored and enforced
I 3.1.3 Means of conflict resolution function without violence
I 3.1.4 Access to forest resources is perceived locally to be fair
I 3.1.5 Local people feel secure about access to resources

C 3.2 Forest actors have a reasonable share in the economic benefits derived from forest use

I 3.2.1 Mechanisms for sharing benefits are seen as fair by local communities
I 3.2.2 Opportunities exist for local and forest-dependent people to receive employment and training from forest companies
I 3.2.3 Wages and other benefits conform to national and/or ILO standards
I 3.2.4 Damages are compensated in a fair manner
I 3.2.5 Product mix is optimal and equitable
I 3.2.6 Diversification of total forest product utilization (products used/known potential products)

C 3.3 People link their and their children's future with management of forest resources

I 3.3.1 People invest in their surroundings
I 3.3.2 Out-migration levels are low
I 3.3.3 People recognize the need to balance number of people with natural resources use
I 3.3.4 Children are educated (formally and informally) about natural resource management
I 3.3.5 Destruction of natural resources by local communities is rare
I 3.3.6 People maintain spiritual links to the land

(cont'd)

P 4. CONCERNED STAKEHOLDERS HAVE AN ACKNOWLEDGED RIGHT AND MEANS TO CO-MANAGE FOREST EQUITABLY

C 4.1 Effective mechanisms exist for two-way communication related to forest management among stakeholders

I 4.1.1 > 50% of timber company personnel and forestry officials speak one or more local language, or > 50% local women speak the national language

I 4.1.2 Local stakeholders meet with satisfactory frequency, representation of local diversity, and quality of interaction

I 4.1.3 The contribution of all stakeholders is mutually respected and valued at the generally satisfactory level

C 4.2 Local stakeholders have detailed, reciprocal knowledge pertaining to forest resources use (including user groups and gender roles), as well as forest management plans prior to implementation

I 4.2.1 Plans/maps showing integration of uses by different stakeholders

I 4.2.2 Updated plans, baseline studies and maps are widely available, outlining logging details like cutting areas and road construction, with timing

I 4.2.3 Baseline studies of local human systems are available and consulted

I 4.2.4 Management staff recognize the legitimate interests and rights of other stakeholders

I 4.2.5 Management of non timber forest products reflects the interests and right of local stakeholders

C 4.3 Agreement exists on rights and responsibilities of relevant stakeholders

I 4.3.1 Level of conflict is acceptable to stakeholders

P 5. THE HEALTH OF THE FOREST ACTORS, CULTURES AND THE FOREST IS ACCEPTABLE TO ALL STAKEHOLDERS

C 5.1 There is a recognizable balance between human activities and environmental conditions

I 5.1.1 Environmental conditions affected by human uses are stable or improving

I 5.1.2 In-migration and/or natural population increases are in harmony with maintaining the forest

C 5.2 The relationship between forest management and human health is recognized

I 5.2.1 Forest managers cooperate with public health authorities regarding illnesses related to forest management

I 5.2.2 Nutritional status is adequate among local populations

I 5.2.3 Forest employers follow ILO working and safety conditions and take responsibility for the forest-related health risks of workers

C 5.3 The relationship between forest maintenance and human culture is acknowledged as important

I 5.3.1 Forest managers can explain links between relevant human cultures and the local forest

I 5.3.2 Forest management plans reflect care in handling human cultural issues

I 5.3.3 There is no significant increase in signs of cultural disintegration

PRODUCTION OF GOODS AND SERVICES

P 6. YIELD AND QUALITY OF FOREST GOODS AND SERVICES SUSTAINABLE[3]

C 6.1 Forest management unit is implemented on the basis of legal title on the land, recognized customary rights or clear lease agreements

C 6.2 Management objectives clearly and precisely described and documented

I 6.2.1 Objectives are clearly stated in terms of the major functions of the forests, with due respect to their spatial distribution

C 6.3 A comprehensive forest management plan is available

I 6.3.1 The management plan looks beyond the second cutting cycle

I 6.3.2 Yield regulation by area and/or volume prescribed

I 6.3.3 Harvesting systems and equipment are prescribed to match forest conditions in order to reduce impact (cont'd)

I 6.3.4 Management planning involves all stakeholders and takes into account all the components and functions of the forest such as timber production, non timber forest products, ecology and well-being of local population
I 6.3.5 Silvicultural systems prescribed and appropriate to forest type and produce grown
I 6.3.6 Management plan is periodically submitted to revision
I 6.3.7 Maps of resources, management, ownership and inventories available

C 6.4 The implementation of management plan is effective
I 6.4.1 Inventory of all forest uses and forest product is available
I 6.4.2 Infrastructure is laid out prior to harvesting and in accordance with prescription
I 6.4.3 Low residual stand damage
I 6.4.4 The forest unit is zoned into areas to be managed for various objectives

I 6.4.5 Boundaries are marked on the field
I 6.4.6 Rehabilitation of degraded and impacted forest is undertaken in accordance with a code of practice
I 6.4.7 Workers and staff of economic operator have adequate training to implement management
I 6.4.8 Efficiency of systems of production and transformation of forest products
I 6.4.9 Externalities of forestry practices are minimized

C 6.5 An effective monitoring and control system audits management's conformity with planning
I 6.5.1 Continuous Forest Inventory (CFI) plots established and measured regularly
I 6.5.2 Documentation and record of all forest management activities are kept in a form that makes it possible for monitoring to occur
I 6.5.3 Worked coupes are protected (e.g. from fire, encroachment and premature re-entry)
I 6.5.4 Tree marking of seed stock and potential crop trees
I 6.5.5 Result from monitoring and research and other new scientific and technical information are incorporated into the implementation and revision of the management plan

C 6.6 Equitable distribution and presence of economic rent
I 6.6.1 Total harvesting revenues exceed harvesting costs
I 6.6.2 Estimated government rent capture
I 6.6.3 Estimated operator (manager) rent capture
I 6.6.4 Estimated forest local dwellers' rent capture

[1] This criterion and its indicators are taken from the Phase I Report by Prabhu *et al.* (1996).
[2] This criterion and its indicators are taken from the paper of J. Ruitenbeek and C. Cartier (1998) and are still being field-tested.
[3] Criteria, and indicators in this section are taken from three different sources; Prabhu *et al.* (1996); the Cameroon test; and the paper of J. Ruitenbeek and C. Cartier, (1998).

- In-house and in-country experts who have been involved in the evolution of the current C&I sets;
- International C&I stakeholders;
- Assessors/certifiers.

Needs of users were investigated through informal questioning; in person and by email; by seeking feedback on fictional 'scenarios' for the use of CIMAT; and by an analysis of protocols obtained during a pseudo-forest certification exercise by Smart Wood and SGS, both accredited certification organisations. Based on this information, an analysis of common user needs and constraints was made to inform system design.

CIMAT is not designed to be an expert system, in the sense that it will not make decisions, nor will it act as an expert guiding a user through an assessment of sustainability. It will be a tool for knowledge management, rather than a decision-making system. The CIMAT design and technical specification of functionality was developed from the results of the trials and interviews with potential users, and it was decided what exactly to build only once these needs were known.

CIMAT will contain a knowledge base of C&I for sustainable forest management. This knowledge base will be essentially incomplete, and contain lots of 'hooks' upon which users can hang knowledge which is relevant to sustainability of forest management in the particular context they are interested in. CIMAT will invite the user to bring their knowledge to the system, in order to enhance and build upon the knowledge within it.

The core of CIMAT will be the current knowledge base of C&I. This is the template set of C&I which users will be able to modify by bringing their own and other people's local or specialist knowledge to the system. Each criterion, indicator or verifier in the hierarchy will be an 'object', which can be changed, deleted, added or moved. It will be possible to create links between indicator objects that have things in common, or which are related in some way. Each object will remember the sequence of modifications that it undergoes, so each indicator will end up with its own 'history' of how it has been adapted to meet local conditions.

In addition, CIMAT will include knowledge about how and why the C&I objectives can be modified. This knowledge will enable CIMAT to suggest possible modifications to the user, and also to encourage users to think about why they are making modifications and to provide justifications for their changes. By recording not only changes to indicators, but also some of the reasoning leading to these changes, it is hoped CIMAT will be a useful tool for teams who are involved in the ongoing process of developing and adapting sets of C&I for local forest management.

Finally CIMAT will also include guidance for how the C&I can be applied, though not in interactive form. It is helpful to think of a sustainability assessment as a process of argumentation, in which the user's data and the knowledge base are used in combination to provide arguments for and against an assessment of sustainable management. In this way it may be possible to be sensitive to cases where, for example, the broad sweep of an assessment points to sustainable management but a few negative indicators provide critical counter-arguments pointing to specific areas which require attention. There exist probabilistic and quantitative approaches to handling risk, as opposed to uncertainty, which is by definition not quantifiable. However, due to the great variety of ways in which uncertainty can be introduced in a C&I assessment, it may be more informative to a user if they are provided with information about the possible *sources* of uncertainty in a final assessment.

Thus CIMAT might be thought of as a medium within which a hierarchically ordered network of C&I 'items' are subjected to evolutionary pressure by external users of the system. Each of these will 'remember' its history, and none will actually disappear out of the system. 'Deleted' items remain within CIMAT as 'ghosts' to be revived at the user's will. CIMAT will thus allow the development of a living, and locally relevant, definition of sustainability in operational terms.

A functioning version of CIMAT will be tested with users and evaluated by the end of 1998, and a full demonstration version will be available shortly afterwards.

WHERE NEXT FOR C&I?

Finally, CIFOR and others are at work on a further set of problems which will require resolution before C&Is can fully enter the market.

Biological Diversity Issues

Forest management contributes to biological diversity insofar as it serves to maintain forests. Sustainably managed forests should do so even more effectively. However, in the case of biodiversity, there is a need to include considerations of scale. There has to be a system for the aggregation of information from the Forest Management Unit (FMU) level to higher levels, so that the full spectrum of forest impacts on biodiversity can be properly assessed. The best approach is probably not to aim to conserve particular species, but to preserve most species by preserving processes. This approach assumes that rates of extinction will not rise if processes are conserved, and that, while rarity is important in the assessment of susceptibility, it is not a value to be maintained in itself.

Nevertheless, these processes need time, space, and monitoring. FMUs do not follow natural boundaries, and thus the processes that need monitoring may be spread beyond the FMU boundary. Similarly, some landscape level processes cannot be monitored in small FMUs, because the scale would be greater than the accountability of the managers concerned. Another difficulty is that socio-economic scales of operation are not the same as biophysical ones.

A point that has not yet received the prominence it deserves, is the need to research the differing perceptions of different stakeholders of biological diversity. All forms of biodiversity assessment involve the making of choices, since an analysis of the entire range of biodiversity is impossibly expensive and time-consuming. The choice of the selection from the whole which will represent the whole is currently made in diverse ways, each inevitably favouring or disfavouring different components of the whole. Over and above

methodology, the range of biodiversity present depends on whether the forest is used or not, how, by whom, and for what.

Social Issues

Issues for further work include careful comparisons between social C&I developed within timber concession areas and those developed in forests managed primarily by communities. Another area of work will focus on more refined identification of important sub-groups within stakeholder categories. The issue of representation of different elements in local communities (such as age, gender, ethnicity, caste) is an important one in conducting accurate assessments of human well-being. Given the divergences among social C&I developed in different contexts – much more dramatic than divergences in ecology or conventional forest management – the process of adapting CIFOR's master C&I to local conditions, in cooperation with local stakeholders needs attention, some of which CIMAT will provide. We anticipate developing guidelines for use by others in adapting these C&I. Finally, as with the other C&I, additional work on verifiers and thresholds is desirable.

Plantation Issues

C+I for plantations are at an early stage of development. Plantations are required to meet all the standards that are required of natural forests, and any specific additions relevant only to plantations. Testers need to consider how biodiversity can be enhanced in a plantation context. Use of plantation C&I will inevitably spread from plantations for timber to involve other plantation areas, such as oil palm. In the case of plantations, the issue of scale is a key one, for two reasons. Firstly, it is only on a large scale that it is possible to investigate all related impacts resulting from plantation activities. Secondly, the issue of the national-level integration of all C&I components, including plantations, is brought into sharp focus, for only at this level can national levels of sustainability, biological diversity, etc., be resolved.

The link from the local to the national level

It has become clear that there is a need, not only to integrate C&I from the standpoint of biophysical, social, and economic disciplines, but also, at national level, to integrate the results of C&I monitoring in different production systems, (natural forests, community-managed forests, and plantations). So many issues are raised by the artificial compartmentalisation of these production systems, that it is clear that a unified approach to all such production systems is required, even though it may be complex and expensive. However, under conditions of falling market prices, the costs of sustainability assessment will be the first to be dropped, unless assessment costs can be built in as some proportion of total management costs.

CONCLUSION

C&I are one part of a market/public environment which encourages and reinforces sustainability. They are also a tool – a means of verification of forest management. C&I also create a basis for discussion and dialogue – and public discussion of what sustainability is, and how it is to be achieved, may be as important as the process itself. A problem that forestry currently faces in many countries, is that foresters may be perceived by the general public as failing to do the best job possible. C&I potentially provide a measurable, comparable methodology – and thus a system which builds public confidence on the issue of forest sustainability.

Can C&I play such a role? If they are to do so, they need to consider not only scientific issues, but also issues perceived to be important by the public, such as endangered species. For, while C&I are potentially important tools for the communication of what good forest management is, many of those who place most faith in C&I may not have a scientific background, and may be frightened by highly sophisticated documents and products. The need is for 'best-bets' that can be refined later, incorporating feedback from the field. Finding a midpoint between simplicity and solid science will always be complex, and the solution may well be to find a way of combining a full scientific justification for actions (available in background documents), with simple-to-use implementation guidance. The hope is that CIMAT will be able to provide this.

Finally, if CIMAT succeeds in tackling the task of simplifying FMU-level analysis, it may in due course provide one of the tools which will be needed in order to move on to the much more challenging, but ultimately equally important task, of finding integrative mechanisms for the incorporation of diverse FMU-level blocks of knowledge into a national level picture.

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ACRONYMS

C&I	Criteria and Indicators
CIFOR	Center for International Forestry Research
CIMAT	C&I Modification and Adaptation Tool
FMU	Forest Management Unit
GIS	Geographic Information System
ILO	International Labour Organisation
ITTO	International Tropical Timber Organisation
PFE	Permanent Forest Estate

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