RENEWABLE NATURAL RESOURCES KNOWLEDGE STRATEGY

FORESTRY RESEARCH PROGRAMME

# IMPACT ASSESSMENT STUDY

Final Technical Report : Project R7079

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# EXECUTIVE SUMMARY

## Report structure

*To contribute to the development of improved monitoring and evaluation of uptake and impact of FRP research*

**Executive Summary**

- Overview;
- Conclusions/Proposals;

*Output 4*

**Section 1**

General evaluation issues:
- Principles guiding the study;
- Key factors influencing evaluation design;
- Potential problems posed by forestry research for evaluation

*Output 1*

**Section 2**

Review of forestry research evaluation literature:
- Characteristics of research evaluated;
- Methods employed;
- Relevance to FRP and conclusions.

*Output 1 /cont…*

**Section 3**

Summary discussion of economic evaluation techniques:
- Framework;
- Non-econometric techniques;
- Econometric techniques
- Preliminary conclusions

**Section 4**

Practical case study # 1: DFID/OFI research into the utilisation and improvement of tropical pines
- Challenges posed for evaluation;
- Applicability of economic evaluation techniques;
- Conclusions regarding evaluation requirements

*Output 2*

**Section 5**

Institutional review:
- Examine extent to which public and private sector research organisations have resolved evaluation challenges in practice;
- Conclusions regarding relevance for FRP;
- Basis for a "modified" framework for FRP evaluation

*Output 1 /cont…*

**Section 6**

Practical case study # 2: FRP support to Sustainable co-management of *miombo* woodlands in Malawi.
- Development and application of a "modified" evaluation framework
- Advantages, disadvantages and outstanding issues

*Output 3*

## Overview

The study is concerned with *methodologies* to assess the *economic impact* of forestry research and is written primarily for FRP's Programme Manager. It is, therefore, concerned with what is practicable rather than possible within the context of FRP.

Evaluation design is case specific and is dependent on the type of research to be evaluated, the resources available and the objectives of the evaluation exercise itself. As such, this study does not attempt to design an evaluation "blueprint" for FRP but rather considers the methodological and practical issues faced by FRP and provides suggestions to inform the development of FRP's own evaluation strategy.

In terms of the challenges posed for research evaluation, forestry research *per se* is not unique. Economic evaluation can be, indeed has been, carried out for a range of forestry research types. However, where perhaps it is different is in terms of the frequency and severity of the problems faced. These arise from the characteristics of the forestry sector in general and of forestry research in particular and can be summarised as (section 1):

- multiple objectives
- timeframe
- data and measurement constraints
- valuation issues
- social/institutional characteristics

The fact that such characteristics exist does not provide justification for ignoring "economic evaluation" as an issue. Economic impact represents a key standard against which forestry research should be measured. However, these characteristics are likely to increase the level of uncertainty involved in any analysis and may preclude precise estimates of economic impact. This general issue of uncertainty, and how FRP's evaluation strategy can address it, form recurring themes throughout the study.

Examination of the forestry research evaluation literature (section 2) indicates that economic assessment is possible, where economic efficiency gains represent the primary objective of research. However, it is recognised that FRP research may also include a range of other objectives that fall outside simple efficiency gains (e.g. social, institutional, environmental aims) and these are not easily addressed within conventional economic evaluation frameworks. Furthermore, the nature of the research itself (in particular, the associated lags), data availability and the timing of evaluation can all be expected to affect the type of analysis possible. These factors in turn affect the credibility of results when attempting to arrive at definitive/ absolute estimates of impact. *Ex post* econometric studies, in principle, offer the most appropriate means of meeting this objective. However, use of these techniques is constrained, outside of industrial forest products research – a sub-sector with little or no relevance to FRP's current portfolio.

For forest-level research, a combination of *ex post* and *ex ante* or fully *ex ante* analyses are more common primarily because of the lags involved. Where such evaluations are conducted as "stand alone" efforts to estimate (potential) economic impact, they may be of limited value in terms of the precision with which impact can be estimated. Their full value may only be realised if results are used more "dynamically", during the course of research, to review and revise assumptions and inform research management decision-making. This requires, however, that evaluation be built more explicitly into research planning and implementation procedures.

The discussion of existing approaches to economic evaluation (section 3) suggests that in spite of the advantages of econometric analyses, practical constraints are likely to limit the application of these methods within FRP. Alternatively, models that do not rely on econometric estimation techniques appear more flexible in dealing with these constraints but at the same time results can be expected to be less reliable. To a large extent, the degree to which precise estimates of impact are considered necessary will depend on the purpose for which results are to be used.

The case study of long-term research into the utilisation and improvement of tropical pines (section 4) serves to highlight (a) the analytical complexities involved when attempting to "model" realistically the economic effects of research; and (b) in face of such complexity, the insurmountable constraints posed by data shortages. While the case study does not attempt to formally evaluate the tropical pines research programme, it is clear that any attempt to do so would struggle even with significantly greater resources at its disposal. Thus, more than 30 years after the start of programme, understanding regarding the successes and weakness of this research remains largely anecdotal. The limited evidence available to the case study, however, indicates the need for caution in making simple assumptions regarding uptake and impact.

If the objective of FRP's evaluation strategy is to *measure* economic impact, significantly greater effort will be required during the course of research to collect the necessary data. More fundamentally, however, the question may be asked as to the value of results obtained so long after the event. *Achieving* economic impact is the key point. FRP's evaluation efforts therefore should seek to facilitate this process while research is still on-going.

As such, the study examines experiences from a range of public and private sector institutions (section 5) involved in research to determine how, in practice, such strategic evaluation objectives are operationalised. Key characteristics of interest include a focus on more intermediate (but real-time) measures of progress, recognition of the role of intended users in determining "success" and *on-going* assessment of research prospects, (defined from a multi-disciplinary perspective). However, there is no single, "off-the-peg" model that would fit FRP. Just as the design of particular evaluation studies is case specific, so evaluation strategies are determined by resources, the nature of the research funded and institutional arrangements and the objectives of the strategy itself.

The final case study examines an example of on-going FRP support to the development and promotion of "co-management" of *miombo* woodlands in Malawi (section 6). Again, the objective was not to evaluate formally this research, which is both long-term and has yet to be fully implemented. Instead, the example is used to test an alternative evaluation framework that is intended:

(a) to have wider applicability within FRP's portfolio
(b) to address as far as possible the evaluation dilemma posed by long research lags
(c) to incorporate more dynamically the uncertainty surrounding longer term impact
(d) to facilitate aggregate report across a number of different research projects

Within the scope of this study, not all methodological issues could be resolved. If all or part of the modified framework is felt to have merit, these could be further explored.

## Conclusions/Proposals

- *FRP research should include a clearer specification of intended economic impact.*

Economic benefits of forestry research may be direct or indirect, may be realised on- or off-site and may be achieved in the short or longer term. Clarification of where intended research effects lie on these different axes is a prerequisite of any effective evaluation strategy.

- *The nature and role of "non-efficiency" objectives of FRP research should be more explicit*

Economic efficiency gains (e.g. increased yield, unit-cost reductions) represent a primary justification for research. However, FRP research can be expected to include objectives that lie beyond these (e.g. social/equity objectives, global environmental aims). The validity of these objectives is not questioned, but such research may fall short of "acceptable" performance targets when assessed within a conventional economic framework for research evaluation. Even relatively crude evaluation of performance against non-efficiency objectives is hindered by (a) a lack of clarity at the project-level regarding the precise objectives being addressed; and (b) a lack of clarity at the programme-level regarding the relative importance of different objectives (both non-efficiency and efficiency orientated).

- *FRP research should include clearer predictions of the timeframe for research, adoption and benefit realisation*

The timeframe of research has major implications for research planning, the timing and scope of evaluation and the results of economic assessment. While it may be accepted that production cycles in forestry will increase associated lags, it cannot be ignored. In many cases, minimum lags can be predicted at the outset of research, from intended duration of trials, the number of PSP measurements required, anticipated growth rates and so on. Where minimum research lags extend beyond the life of a project, it is clear that a log-frame Purpose that is cast in developmental impact terms has only strategic relevance. Use of an "intermediate" purpose within project log-frames might be considered, that could more clearly define what delivery of project outputs is intended will achieve by the end of the project.

- *Uncertainty surrounding future impact requires more explicit treatment*

The results of long-term forestry research and in particular natural forest management research are uncertain. This is a result of many factors that extend beyond the issue of "technical" success of research. While greater uncertainty should not *a priori* preclude research investment, it does imply the need for greater management input. More explicit treatment of uncertainty would enable FRP to develop a portfolio that balances shorter term, lower impact but less "risky" research with longer term, more uncertain but ultimately more significant research.

Critical success factors (CSFs) that reflect technical and non-technical (economic, social, policy, and so on) issues should be identified in advance and during research. While such issues may already be included in log-frame assumptions, these are rarely monitored, their relationship to research outputs is not explicit and there is no requirement for the degree of risk to be assessed. In short, the right-hand column of the log-frame needs to be expanded to accommodate more active management of CSFs. The proposed "uptake network" (section 6) offers a means to do this.

- *An "evaluation strategy" should be identified for FRP research projects at design/initiation*

The evaluation requirements for particular FRP projects will be more readily apparent if objectives, timeframe and factors affecting uncertainty are more clearly specified. At the same time, evaluation will be constrained if relevant data are not collected during the course of research. The extent to which formal economic evaluation is possible depends on available data. The trade-off between imposing higher data burdens on projects and the depth of analysis possible at evaluation should be considered explicitly. The optimal compromise will reflect strategic decisions taken by FRP regarding the objectives of the evaluation exercise.

- *FRP should consider using more generic, intermediate performance measures as basis for its evaluation strategy*

The objectives of an evaluation strategy commonly include (a) support to internal management decision-making, and (b) support to managers in meeting external reporting obligations. The exact weight given to these objectives affects the design of a strategy. Where FRP considers objective (a) to be of primary concern, the following recommendation should be considered.

At a minimum, FRP's evaluation strategy should indicate whether research is meeting/has met partner/beneficiary expectations and whether prospects for wider uptake and impact are positive. Such indicators are discussed within the context of the framework proposed in section 6. It is recognised that these will not, by themselves, provide estimates of economic impact. However, they are likely to be measurable across a wider range of research types and as intermediate, real-time measures may be more meaningful.

The validity of an evaluation strategy that uses such "minimum" tests as its basis requires "ground-truthing" with occasional economic impact assessment studies that could also contribute to objective (b). FRP should identify appropriate examples when planning medium-term activities under its evaluation strategy but responsibility for their implementation (funding) should lie within DFID's periodic review process for all RNRKS programmes.

- *Implications for research duration and institutional relationships should be considered.*

Much of the research supported by FRP is long-term in nature and benefit realisation may require continued local efforts after the conclusion of FRP support. Where intermediate indicators are considered acceptable measures of FRP performance, significant problems are not anticipated. Where this is not the case, FRP should consider two options. The first would involve extending FRP's involvement in (promising) research in order to permit continued access for evaluation purposes. Three-year project cycles could be maintained but firmer commitment to follow-on research projects might be provided from the start. Second, FRP could seek to strengthen its relationship with overseas collaborators at the programme-level (as opposed to project-level). FRP could support local capacity development to enable collaborators to continue evaluating progress periodically even after completion of a given FRP project.

## Abbreviations/Acronyms

| | |
|---|---|
| ACIAR | Australian Centre for International Agricultural Research |
| BASE | Banco de Semillas Forestales (Honduras) |
| BCR | Benefit cost ratio |
| BSC | Balanced scorecard |
| BSO | Breeding seed orchard |
| CAMCORE | Central American and Mexico Coniferous Resources Co-operative |
| CBA | Cost benefit analysis |
| CGIAR | Consultative Group on International Research |
| CIFOR | Centre for International Forestry Research |
| CIMMYT | International Maize and Wheat Improvement Centre |
| CS | Consumer surplus |
| CSF | Critical success factor |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CTN | Canadian Technology Network |
| DFID | Department For International Development |
| DFSC | DANIDA Forest Seed Centre |
| EMP | World Bank Environment Management Project |
| EEU | Economic Evaluation Unit (ACIAR) |
| FAO | Food and Agriculture Organisation |
| FD | Forestry Department |
| FR | Forest reserve |
| FRC | Forestry Research Centre (Zimbabwe Forestry Research Commission) |
| FRIM | Forestry Research Institute of Malawi |
| FRP | Forestry Research Programme (RNRKS) |
| FRU | Forestry Research Unit (SIR) |
| GOM | Government of Malawi |
| IAEG | Impact Assessment and Evaluation Group |
| ICRAF | International Centre for Research in Agroforestry |
| INIF | Instituto Nacional de Investigaciones Forestales (Mexico) |
| IRR | Internal rate of return |
| LEV | Land expectation value |
| M&E | Monitoring and Evaluation |
| MPBS | Multiple population breeding strategy |
| N-E | Non-econometric |
| NEP | National Environment Policy (Malawi) |
| NFM | Natural forest management |
| NLCE | Non-linear constant elasticity |
| NPV | Net present value |
| NRC | National Research Council (Canada) |
| NRI | Natural Resources Institute |
| NTFPs | Non-timber forest products |
| OFI | Oxford Forestry Institute |
| OVI | Objectively verifiable indicator |
| PF | Production function |
| PS | Producer surplus |
| PSP | Permanent sample plot |
| QFRI | Queensland Forestry Research Institute |
| R&D | Research and development |
| RNR | Renewable natural resources |
| RNRKS | Renewable Natural Resources Knowledge Strategy |
| RRA | Rapid rural appraisal |
| RSA | Republic of South Africa |
| SAFCOL | South African Forestry Company Limited |
| SETRO | Semillas Tropicales (Honduras) |
| SIR | Shell International Renewables |
| SL | Sustainable livelihoods |
| SSC | Statistical Services Centre (Univ of Reading) |
| TES | Total economic surplus |
| TFP | Total factor productivity |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| VFA | Village forest area |
| $\varepsilon$ | Own price elasticity of supply |
| $\eta$ | Own price elasticity of demand |

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# 1. Introduction

## 1.1 Background to the study

The Forestry Research Programme (FRP) is one of 11 research programmes funded by the UK's Department for International Development (DFID) under the Renewable Natural Resources Knowledge Strategy (RNRKS). FRP supports strategic and applied/adaptive research designed to address identified constraints in DFID's forestry partner countries (FRP target countries). It provides funds for about 40 research projects in any given year from an annual expenditure of around £2 million. Projects are typically three years in duration, with an average budget of about £175,000

Since mid-1997, FRP has been reviewing its strategic priorities and the processes by which research projects are identified and implemented. The aims are to reorientate portfolio expenditure in line with updated priorities (while at the same time minimising disruption to the existing programme) and to actively incorporate demand expressed by target countries when identifying new research. This exercise has coincided with DFID's efforts to review and "revalidate" all RNRKS programmes, in part prompted by the start of a new funding cycle (in late 1988) but also driven by a wider interest in assessing and demonstrating the developmental impact of research investments.

Periodic external reviews are implemented by DFID (the last one being in 1994) but FRP, in common with all other RNRKS programmes, has not yet developed a systematic approach to evaluation *within* the research portfolio. With this in mind, FRP commissioned this study.

## 1.2 Objectives of the study

The results of the study are intended to contribute to the development and implementation of methodologies for improved monitoring and evaluation of uptake and impact of FRP research (i.e. the purpose of the study). To this end, the study attempts to deliver the following outputs:

Output 1: Literature and institutional review of what has been and what is being done in the field of forestry research evaluation in order to assess relevance for FRP.

Output 2: Case study of completed DFID-funded research into the improvement and utilisation of tropical pines to test the practicability of conventional economic evaluation techniques.

Output 3: Case study of an existing FRP project in applied natural forest management research to consider options and test an approach for on-going research evaluation.

Output 4: Conclusions and recommendations.

It should be clearly understood from the start that this study is NOT an evaluation report. Thus, the primary aim when reviewing previous and current evaluation efforts was not to assess the quality of these but to identify relevant lessons for FRP. Similarly, the research projects included as case studies were selected as vehicles to explore the application and development of methodologies. Although relevant conclusions arising from the experiences of these are highlighted, it was not the intention to formally evaluate the economic impact of these projects and results should be interpreted with this in mind.

The remainder of the introductory section sets out some of the basic assumptions underlying the study. Section 2 examines evidence available in the forestry research evaluation literature, identifies common approaches and issues and considers implications for FRP (Output 1). Section 3 outlines a number of approaches commonly applied to assess the economic impact of research. In section 4, the practical application of conventional economic evaluation techniques is considered in the context of the challenges posed by the first of the case studies (Output 2). Section 5 then reviews the evaluation approaches within a range of organisations to determine how such challenges are resolved in practice (Output 1 continued).

On the basis of the findings of earlier sections, section 6 presents a modified approach to evaluation for FRP to consider, developed within the context of the second of the case studies (Output 3). The approach adapts a performance assessment framework currently in use in the private sector and proposes a mix of indicators to facilitate *on-going* evaluation of forestry research. Final conclusions and recommendations (Output 4) have been summarised in the executive summary at the front of this report.

## 1.3 Principles guiding the study approach

While it is possible to develop a broad strategic framework for evaluation that is consistent across an institution or programme, the design of any particular evaluation study is determined by three main factors (see USDA Forest Service, 1986):

1. *The type and characteristics of the research being assessed.*
2. *The objective of the evaluation exercise itself.*
3. *The resources available to carry out evaluation.*

With respect to the first of these, FRP operates, at any given time, a range of projects that differ in terms of the sub-field of forestry addressed, the researchable constraints identified, the research objectives and the location of the research in the strategic-adaptive continuum. These differences shape both the questions that can asked by evaluation and methodologies that can be used to provide answers.

Concerning the second factor, evaluation activities within a research programme commonly seek to address one or both of the following objectives: (a) external management requirements: reporting obligations, securing funds, advocacy, etc.; and (b) internal management requirements: decision-making (e.g. resource allocation) and lesson learning. While both rely on the use of credible criteria and methods, the type of information and the manner in which it is collected may differ according to the requirement being addressed. Thus, evaluation design will also be influenced by the objectives of the exercise and, in particular, the needs/interests of the intended audience.

Finally, institutional constraints faced by FRP (and indeed its collaborators) are as significant as methodological issues in determining evaluation methods. Even in cases where the first two factors permit/require in-depth evaluation, resources may ultimately constrain the options available. This is particularly true for evaluation within a programme, where a range of research projects must be assessed during a given period and the process repeated in subsequent periods.

Given these influencing factors, the study does not attempt to develop an evaluation "blueprint" for FRP. Instead, it examines the major issues posed by forestry research evaluation and the practicalities of implementing evaluation within FRP. The intention is to inform future efforts by the Programme to develop a strategic approach to evaluation.

Given this objective, it should be clear that the FRP Programme Manager represents the intended audience for this report. As such, the study focuses on the practicable rather than the (theoretically) possible.

The study is interested primarily in "impact" and "uptake[1]" (in so far as the latter is a prerequisite for the former) and defines impact in terms of the objective of economic efficiency. That is, the extent to which research leads to an increase in the welfare of target beneficiaries sufficient to justify the investment. This focus is relatively narrow, compared with broader definitions of evaluation which may include the assessment of "relevance, performance, efficiency and impact" (Casley and Kumar, 1987). As a starting point, the focus is thought reasonable though later discussions highlight the need to consider intermediate measures of impact and other research objectives that are not fully addressed by this framework.

In keeping with this "impact focus", monitoring *per se* is considered to lie outside the interest of the study[2]. Thus, FRP's systems for monitoring the physical and financial progress of research have not been examined. In the discussion that follows, use of the term "monitoring" refers to "monitoring of progress towards impact" and is more usefully described as "on-going evaluation".

For reasons of time and space, the study does examine in depth the assumptions underlying the economic techniques discussed. Similarly, the study does not explicitly consider detailed developments in the sphere of environmental and natural resource economics. That is not to say that these are unimportant; improved techniques to value the environmental goods and services derived from forests may be important tools in the evaluation of particular forestry research projects. However, the wider debate concerning conceptual and practical developments in this regard lies outside the remit of this report.

## 1.4 Problems posed by forestry research

The fact that this study has been commissioned at all implies an *a priori* assumption that FRP research projects in some way pose greater challenges for evaluation than other RNR fields of research. This difficulty might be attributed to one or more of the following:

- Existing evaluation methodologies are inadequate for the purpose of assessing the uptake and economic impact of FRP-funded forestry research.
- Existing evaluation techniques are adequate but the practical constraints faced by FRP limit their application.
- The characteristics of forestry research make "failure" almost inevitable when assessed against conventional criteria of economic efficiency, even for research projects widely perceived as "successful".

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[1] Uptake, as it suggests, relates to the adoption and application of research recommendations.
[2] Monitoring is concerned with the "functioning of project activities" (Casley and Kumar, 1987)

The study contends that while none of the above presents an overriding constraint in each and every circumstance, there is a grain of truth in all of them. This section considers a number of features of forestry research that may account for the assumption outlined above. Although rather lengthy, up-front discussion of these issues is unavoidable given that it provides the backdrop for much of the subsequent sections. While the interest here is in those issues specific to forestry research evaluation, it should be borne in mind that these reflect the characteristics of forestry more generally and thus may impinge on any analysis of forestry issues, be it policy-orientated, a project appraisal or indeed research-related.

The discussion is not specific to any particular type of forestry research, though genuinely strategic/basic research has not been explicitly considered, and in the main the discussion reflects the orientation of FRP's current portfolio (presented in table 1.1 below). Natural forests/woodlands and "trees on farms" represent the main focus of FRP's activities. Within these categories, social/economic and environmental issues receive as much attention as the technical aspects conventionally associated with forestry research[1]. In contrast, plantations and (industrial) wood products research receive considerably less support, reflecting changes in DFID/FRP policy over the last 20-30 years.

Table 1.1: FRP portfolio 1997/98

| | Natural forests | Trees & farming systems | Plantations | Total |
|---|---|---|---|---|
| Growth and yield | 1 | 3 | - | 4 |
| Tree improvement | 1 | 3 | - | 4 |
| Silviculture/management | 5 | 7 | - | 12 |
| Protection (pest/disease/fire) | 1 | - | 3 | 4 |
| Forest products/marketing | $1_1$ | - | 1 | 2 |
| Conservation/biodiversity | 5 | - | - | 5 |
| Socio-economic research | $7_2$ | 1 | - | 8 |
| TOTAL | $21_3$ | 14 | 4 | 39 |

Note: Subscripts indicate the number of projects with a specific focus on non-timber forest products in the natural forest category

Jakes and Risbrudt (1988) identify five characteristics of forestry research that complicate the task of impact evaluation:

(i) It is often difficult to establish direct links between change in the resource with the adoption of research innovations because of long production periods and the influence of other interacting factors that affect the production of forest resources.

(ii) A research innovation may affect outputs or resources in addition to the one intended because forests produce multiple outputs.

(iii) It can often be difficult to value the effects of adoption because many forest outputs lack direct consumer markets.

[1] NB: almost all research under "Trees and farming systems" includes a significant social/economic dimension.

(iv) Much forestry research [in the U.S.A.] is productivity-sustaining rather than productivity-increasing (i.e. maintenance research).

(v) Forecasting rates and the extent of adoption presents major methodological challenges.

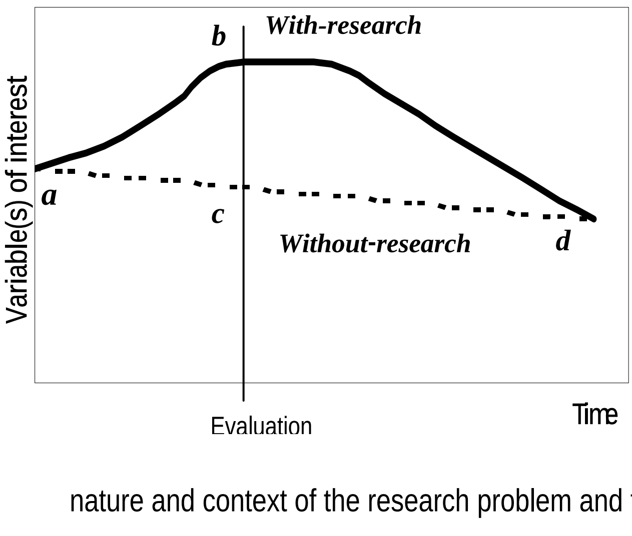
The above is a useful summary of the major technical constraints facing the economic evaluation of forestry research, though institutional constraints might also be included when moving from the level of an occasional evaluation study to a programme-wide evaluation strategy. However, this study holds that there is nothing unique about forestry research *per se* for evaluation purposes. Other RNR fields under certain circumstances face similar challenges. Similarly, given sufficient time and resources, existing tools of economic analysis and those being developed in the area of natural resource/environmental valuation can be applied. However, where forestry research evaluation is perhaps different is in the frequency and extent to which these challenges are encountered.

The following pages recast and expand on the constraints identified above. It should be remembered that not all the issues discussed apply equally to all types of forestry research or indeed all FRP projects.

### 1.4.1 Defining objectives and effects

Even when there is widespread recognition of the problem context and general support for the chosen intervention strategy, it is not uncommon for FRP research to lack a clear statement of intended economic impact. Higher order objectives may refer to aims such as "sustainable utilisation for the benefit poor communities" but intended changes and the manner in which research will deliver these are often not explicit. This is a basic weakness from the point of view of economic evaluation.

The diagram below presents a basic conceptual framework for evaluation. Point ***a*** represents baseline conditions, point ***b*** represents conditions at evaluation following adoption of research recommendations and point ***c*** represents the conditions that would have obtained at the time of evaluation in the absence of research (i.e. counterfactual conditions). Area ***abc*** represents the effect of research calculated at the time of an evaluation, while area ***bdc*** represents the projected effect of research. Total impact is represented by area ***abdc***. The shape and slopes of the ***with-*** and ***without-research*** curves both pre- and post-evaluation are dependent on the nature and context of the research problem and the solution provided.




In order to define these curves, it is necessary to determine the variable(s) affected by research (i.e. the y-axis). Historically, economic evaluations of RNR research have focused on technologies that affect the production efficiency (yield-enhancing/cost-saving) of specific crops or aggregate output. In the case of natural forests, there is no single, homogeneous product but a range of goods and services that display varying degrees of substitution and complementarity. Furthermore, these multiple outputs differ in nature (public/private, non-marketed/marketed) and yield their benefits over different timeframes, for different consumers. Table 1.2 illustrates these points with some examples.

Table 1.2: Examples of outputs of natural forests

| Good/Service (G/S) | Use category | Type of G/S | Supply | Demand |
|---|---|---|---|---|
| Wood products & NTFPs | Direct | Private | Site-specific | Local |
| Cultural/spiritual | Direct | Public | Site-specific | Local |
| Soil fertility | Indirect | Public | Non-site specific | Local |
| Water quality/ flow | Indirect | Public | Non-site specific | Local/National |
| Erosion control | Indirect | Public | Non-site specific | Local/National |
| Tourism | Direct | Private | Site-specific | National/International |
| Climate change | Indirect | Public | Non-site specific | International |
| Biodiversity | Non-Use | Public | Site-specific | International |

*Adapted from Hyde* et al *(1991)*

Calibration of the y-axis, therefore, requires complex analysis to define first the physical relationships between the goods and services, and second to convert these into a comparable numeraire (most commonly a money-metric). Even if pricing these goods and services was straightforward, which it is not (see “Valuation Issues”), modelling the physical relationships between these outputs is likely to be either impossible or impracticable in most cases.

Evaluation, of course, is interested in *changes* brought about by research. In certain cases, it may be reasonable to assume that the research innovation will not substantially affect any “intangible” forest outputs, leaving evaluation free to focus on more measurable products. In the case of industrial plantations or forest products research, efficiency gains in production may be conceptually clearer and easier to measure, but such research may also include other economic objectives such as improving efficiency in consumption (e.g. longer-lasting products) or improving the quality of products. Such objectives, however, have received significantly less attention in the evaluation literature to date, largely because of the methodological difficulties posed (Bengston, in USDA Forest Service, 1986).

With regard to the economic effects of natural forest management (NFM) research, a number of other issues can be expected to arise. First, trees grow relatively slowly, productivity can be relatively low and management inputs tend to be extensive rather than intensive. Opportunities for research to achieve significant efficiency gains in production are, therefore, limited (see Hyde *et al* 1992). Second, much of FRP’s research (whether relating to natural forests or “trees on farm”) includes “sustainability” as a fundamental objective. This typically implies a long-term, “maintenance” objective in the research and may also be associated with no significant change (or even a reduction) in the harvesting of certain forest products in order to maintain productive potential in the longer term. Finally, adoption of forestry research innovations may be more variable than in agricultural research given the heterogeneous nature of producers/users, site-specificity of benefits and the length of the production cycle.

For NFM research, therefore, these points suggest that efficiency gains in the production of the main wood and non-wood products alone may often be insufficient to justify research investment when assessed using conventional cost-benefit criteria (and a positive discount rate). Yet such research continues to be funded. It is, therefore, clear that implicit assumptions are being made regarding the importance of other goods and services (indirect use, option and non-use values) and indeed other research objectives such as institutional (e.g. tenure) and policy-related (e.g. equity, international obligations) aims. Measurement and valuation issues constrain the extent to which the former can be directly incorporated into an analysis, while normative, distributional objectives, though not impossible to address, present more difficulties for an economic evaluation framework that is positive, efficiency-orientated in origin.

Few would dispute the importance of these outputs and objectives. From the perspective of evaluation, however, the design of forestry research is often unclear on both the relative priority given to each and the intended way in which research will add value to those considered most important.

### 1.4.2 Time

Evaluations of research impact typically assess not the knowledge created by research but the effect of this knowledge when it is embodied in "products". Where these products relate directly to the production cycle of trees, forestry research can take significantly longer than other RNR fields to reach a stage that allows impact to be evaluated. For example, silvicultural research may require ten or more years to yield the necessary data on which to base final recommendations (i.e. the research lag). At the same time, wider application of these recommendations may be constrained by the status of the existing resource (reflecting earlier management decisions) which in turn may lengthen the adoption lag and reduce the rate of adoption. Finally, unlike annual crops, long production cycles in forestry imply a "benefit lag" between application of research recommendations and final harvest of the results. Of course, the outputs of natural forests have varying production cycles, e.g. continuous (amenity, spiritual values), annual (certain NTFPs) and periodic (erosion control during rains). But even in these cases, it remains true that most forestry research is targeted at trees, for the wood products they yield and/or as a means of indirectly influencing these other outputs.

Time, therefore, plays a critical role in the analysis of most forestry research. One related factor above all generates enormous debate…the discount rate. The effect of discounting on benefits that occur a long time in the future is well known and it is an inescapable conclusion that any forestry research yielding tangible benefit only after an extended period will be penalised by high discount rates. Concerns for sustainability, inter-generational equity and so on have to led to calls for the use of lower discount rates when assessing environmental investments. More fundamentally, the premise of discounting at a societal level (in contrast to an individual firm) has been questioned. This study has neither the scope nor the remit to enter this debate. Instead, it contends that, in the absence of convincing evidence that positive discount rates should not apply to the forest sector, the significance of this factor should be taken into account when designing and appraising forestry research.

The longer the lags between research and benefits, the more difficult is the task of attributing change to research. Over long periods, other variables that are not affected by research but do affect production will change (e.g. the quality and quantity of other inputs, the policy environment, socio-economic factors affecting utilisation/production and consumption). Separating out the effects of these different variables from that of research either requires high quality time-series data over long periods or significant compromise in terms of what is actually measured. Where econometric techniques cannot be employed, the "without research" situation must be considered separately. However, developing a credible portrayal of counterfactual conditions over a period of 20 years or more is extremely demanding.

The timeframe associated with forestry research also raises a practical issue for evaluation. Impact assessment studies are faced with a trade-off between certainty of results (which increases as time passes) and timeliness of conclusions (which decreases as time passes). Ideally, the timing of an economic impact evaluation should be such as to allow meaningful comparison between research benefits and costs, as determined by the anticipated shapes of the with and without research curves. However, long production cycles in forestry make resolving this trade-off difficult, given their importance in determining lower limits for the research-adoption-benefit lags. A review of actual research lags in agriculture (Davis et al, 1987) identifies a timeframe ranging from three to 17 years. Given growth rates, much forestry research can be expected to entail lags that lie in the upper half of, if not beyond, this range. Furthermore, "sustainability" objectives by their very nature imply a long-term horizon for research (and therefore evaluation). It may be necessary to wait 20+ years before economic impact can be formally evaluated and therein lies FRP's dilemma; namely, the need of the Programme Manager to report today on impact that can only occur in the long term.

One possible solution is *ex ante* evaluation of potential impact, which is common in many fields of RNR research, often as a component of a priority-setting exercise (see Davis *et al*, 1987). It is important to note, however, that the assumptions and calculations used in such exercises tend to be approximate and gross when estimating potential "economic" impact; the analysis is normally comparative and measures of worth are relative rather than absolute.

For certain types of forestry research (e.g. introduction of new/improved fast growing species) estimates of potential impact are often based on a combination of *ex post* evaluation of research results (e.g. to ascertain unit productivity gains) and *ex ante* projections of the rate and ceiling level of adoption. However, this may be less practicable for NFM research. Future events are uncertain and uncertainty increases the further into the future one imagines. The management of natural forests is affected by complex social, economic and institutional factors and the challenge of predicting prices, utilisation patterns, the policy environment, and so on, over a period exceeding 20 years should not be underestimated. That is not to say that *ex ante* evaluation is impossible, indeed, the frameworks applied in such analyses provide a useful starting point for strategic appraisal of research options. However, formal *ex ante* study also requires significant resources. Given the extent of assumptions needed in the case of an individual NFM research project, it is unclear whether results would be particularly meaningful. Bengston notes that *ex post* evaluations of *ex ante* studies have typically revealed substantial differences between projected and actual costs and benefits (USDA Forest Service, 1986).

### 1.4.3 Data and measurement

Input and output data are required for evaluation. FRP research inputs are relatively easy to identify but data relating to the inputs of researchers and adopters in target countries is frequently unavailable. On the output side, even greater problems are encountered.

Hyde identifies three major differences between data in the agriculture and forestry sectors: quality, specificity and timeframe (in Risbrudt and Jakes, 1985). Even in the United States, forest inventory data exist for only around the last forty years based on approximately ten-yearly surveys. Elsewhere in the world, periodic inventories are not systematically conducted. Furthermore, the survey data that do exist often aggregate important species and age-classes and often represent biological rather than economic inventories (Hyde *et al*, 1991). In the case of non-industrial forests, data are even scarcer and estimates of standing inventory and growth rates little more than rule of thumb guesses.

Production data in the forestry sector are often similarly patchy and/or aggregate in nature. Unlike much agricultural research where adoption in one year can be clearly related to production in the same or next, forestry research recommendations may be applied to existing trees of different ages and different species that are harvested at different times. "Adopting" trees are also harvested simultaneously with "non-adopting" trees. Production data, however, if available, are normally only in aggregate form such as "industrial roundwood" or "softwood" but rarely at the level of species and sites.

In the case of natural forests in developing countries, the majority of private goods harvested are for domestic consumption and estimates of production/utilisation are based on crude assumptions. Frequently, national governments are the *de jure* owners of the resource and harvesting is in some degree restricted. Official records of utilisation are often incomplete while clandestine removals are by their very nature unknown. In the case of data relating to the production/consumption of *public* goods, estimates are normally made by recourse to very general assumptions (e.g. applying the results from a discrete study conducted in a different country).

In the case of NFM research, multiple outputs (private and public) of natural forests are mutually related, though the degree of substitution and complementarity is not known precisely. NFM research commonly seeks to influence a range of goods and services via control/ manipulation of the standing trees. The effects of research on non-wood outputs are often indirect and depend on relationships internal to the ecology of the resource. Data defining these relationships commonly do not exist.

Furthermore, as has been mentioned earlier, much FRP research includes a significant element of "maintenance" research, which in turn increases the importance of the without-research situation for evaluation. By definition, data do not exist for counterfactual conditions. A common approach is to extrapolate trend data but this can be risky given the general paucity of good quality data in the forestry sector. To illustrate, Hyde *et al* (1991) report that since 1817 the U.S. government has repeatedly expressed the belief that the nation was running out of timber, and that every US Forest Service projection since 1909 has anticipated a future timber shortage.

Where data are not available, direct measurement may be the only option, though this may raise further problems. First, primary data collection is expensive. Second, evaluation is concerned with relative changes brought about by research rather than absolute measures of physical output. The former cannot be observed directly and in order to isolate the proportion of total output that can be explained by a research intervention many observations may be necessary. Third, wide variations can occur naturally from year to year in the availability of certain forest products; if these are of interest to an evaluation, multiple observations may be needed to discern trends in availability.

Fourth, problems of site specificity both between and within sites may make for excessive measurement requirements. FRP is necessarily interested in impact on a regional, national and even international scale and unless the results of detailed measurements in a particular site can be generalised to a wider level, they may of questionable value. Whether or not simplifying assumptions can be made depends, in practice, on the nature of the research. The basic issue is whether the utility of the information justifies the cost/practicalities of collection. If data relevant to evaluation are also required for research implementation then the only issue may be both exercises' differing requirements for data rigour. Where research is required to collect evaluation-specific information for use some time in the future, however, the answer is less clear.

### 1.4.4 Valuation

Valuation is, of course, dependent on the availability of data regarding the physical inputs and outputs related to the research intervention. However, there are additional problems that stem from the characteristics of forestry research, forests and the forestry sector.

On the cost side, project expenditure data are relatively easy to obtain from records, though the real cost of research may be more difficult to ascertain. The activities of research institutions in target countries are rarely fully “projectised” and the division of fixed and variable costs between activities for accounting purposes may not reflect reality. Many research institutions in developing countries are still core funded (albeit erratically) by the Treasury. This both complicates identification of the full costs of research and calls for judgement in determining the extent to which items such as overheads should be attributed to the research effort of interest.

The timeframe of forestry research compounds the difficulties in identifying costs. Reliable cost data associated with relevant changes in research and production are rarely available over extended periods. In addition, defining a clear boundary around the costs of long-term research is normally more difficult than in the case of specific short-term initiatives.

On the benefit side, much FRP research is aimed at generating recommendations regarding the way resources are managed rather than production of new products (inputs or outputs). Furthermore, participatory NFM research more common today is often directed towards a redistribution of management responsibilities (from public to private groups). In both cases, cost changes resulting from adoption may not be readily apparent. For example, estimating the economic costs incurred by communities who take over forest management activities from the public sector may be difficult, while the assumption that there are no cost implications (i.e. a straight switch from public to private) may be unrealistic where government staff are not reassigned to alternative activities.

Valuation of benefits might be expected to be more straightforward for research directed towards more commercial operations in the forestry sector. This is certainly true where research intervenes at the level of the final good (e.g. woodfuel plantations, forest industries). However, often forestry research is targeted at wood as an intermediate good that is used by processing industries. The value of this wood is commonly estimated as a “residual” by subtracting the costs of felling, transportation, processing and marketing from the price of the final good. This approach is perfectly reasonable but does have implications for valuing the benefits of research. First, processing inefficiencies may “absorb” part of the value that might be attributed to say tree improvement research. At the same time, high degrees of vertical integration in forest industries within many developing countries mean that competitive markets for roundwood may not exist and, hence, the “real” value of the wood is not easily observable. Second, changes in market conditions for the final good can have significant implications for the residual value of the trees that embody the recommendations of research (and of course those that do not). For example, if the price of standing timber constitutes 20% of sawnwood price, a 10% fall in the sawnwood values on the world market (e.g. as a result of exchange rate movements) halves the residual value of the standing trees (Price, 1989).

In the case of forests that are not managed for industrial timber production, relatively simple analyses encounter valuation problems for even the most straightforward of forest goods, e.g. fuelwood, poles, rope fibres, thatch, foodstuffs. In many instances, production is primarily for domestic consumption and only limited amounts, if any, are traded in small, informal markets. For non-marketed products, value is often estimated based on either the opportunity cost of production or the price of a substitute product (a proxy value). In the case of the former, labour is the main input used in harvesting private forest goods and "price" is estimated on the basis of the time spent harvesting, and the value of labour in the next best alternative use. Estimating the opportunity cost of labour is by no means simple, particularly given that for certain non-perishable forest products most harvesting may occur during slack periods in the agricultural calendar. Furthermore, this method may well understate the real impact of research. For example, a study in Nepal (Kumer and Hotchkiss, in Hyde *et al*, 1991) found that reducing the women's firewood collection time led to greater gains in household nutrition as well as agricultural production. A more general criticism of this approach, however, is that firewood and materials for house construction are part of the basic essentials of life; a shadow wage rate, on the other hand, reflects only the limited economic opportunities available to rural populations.

Use of substitute products to value outputs also requires caution. First, even close substitutes have different characteristics, making a straight "swap" impossible. In the case of fuelwood, preferences even between species are evident. Second, choice of a substitute product is restricted by the realities facing consumers. Comparisons between the calorific values and thermal combustion efficiencies of kerosene and fuelwood may be irrelevant if the former is just not available in the area of study. Indeed, the substitute products used in practice may themselves be non-marketed goods (e.g. agricultural residues, animal dung), presenting the analyst with the challenge of estimating the "lost" value that has resulted from shifting use to inferior alternatives.

For products that are marketed locally in small volumes, prices obtaining in these markets may not be reliable measures for evaluation if the research is expected to increase significantly the availability of such products. In such cases, if demand is less than perfectly elastic, market price will fall as a result of research[1] but the extent will depend on the magnitude of the supply effect and the price elasticities of supply and demand. In practice, however, large gains in productivity are unlikely in NFM research. Where research leads to a small increase in the availability of certain goods, market prices may provide a reasonable approximation of unit value, assuming, of course, that the additional supply is actually consumed or sold.

The above refers to the flow of private goods obtained from natural forests. This is not unreasonable given that the objective of all economic activity is ultimately consumption[2]. However, certain types of forestry research may also affect the stock of products available. The "value" of products results from the fact that they have "place utility, time utility and form utility: they are valued for where and when, as well as what they are" (Price 1989). This implies the need for caution when evaluating changes in product stocks. In general terms, forest products that are located beyond the margins of intensive use may quickly become worthless under current supply and demand conditions (as a result of prohibitive harvesting costs). In the

[1] If the objective of an exercise is to value total *current* production (i.e. domestic consumption and sales), the reliability of market prices will depend on the competitiveness of the markets, and not the fact that there is a high degree of subsistence production. The argument that if all existing production entered the market, a significant fall in price would result ignores the fact that market demand would also expand.

[2] Consumption means "use of goods and services to promote happiness" (Price 1989).

future, as accessible stocks are exhausted, prices may rise sufficiently so as to bring more remote stocks into play. However, predicting the value of these stocks is not straightforward and requires assumptions to be made regarding other potential adjustments in the market. In conventional analysis, such future values must also be discounted to take into account the time utility of products.

Research that promotes greater local ownership and control of woodlands previously managed by government on a restricted access basis can generate stock-related benefits that are not easily captured in an economic evaluation. Assuming the resource in question is perceived by communities to be valuable, the benefits may include its value as insurance against future shortages in addition to the products that can be immediately harvested. Expanding the resource base to which people have legal access may within marginal communities go some way to ameliorating the risk of shocks to other parts of the local livelihoods system. Similarly, the "well-being" of local communities may be increased by involving them in resource management planning, implementation and enforcement. This may have tangible benefits such as more optimal resource management decisions (in contrast to the short-termism that may occur where tenurial arrangements are insecure). However, these efficiency effects can only be observed in the longer term while the more immediate benefits of "empowerment" cannot be assessed directly within the framework of an economic evaluation. Of course intangible benefits that arise from concepts such as ownership and empowerment are closely linked to the anticipation of tangible benefit in the future. It is less clear, however, whether their full effects are captured in the benefits streams conventionally estimated in cost-benefit analysis.

Next, like fisheries and livestock, trees comprise both capital and product; thus if for whatever reason available stocks are not harvested they will continue to grow and add value over a certain range. This does not present major problems for valuation in general but raises some practical issues in the context of certain forestry research projects. Where research is directed at only part of the forest resources available to users, (e.g. woodland on public land), any additional production resulting from research may augment local supplies but may also displace harvests from existing sources. For a perishable crop, the incremental value of production that displaces existing sources would be limited to the saved costs that prompted producers to switch. However, unharvested trees in general do not perish, indeed they continue to grow. Determining the division between additional and displaced production may be difficult in practice.

Furthermore, anticipating the future value of unharvested trees is complicated by the fact that they have the capacity to yield different and joint products. Smaller diameter poles suitable for fencing will, if left, grow into larger poles that can be used in house construction. At the same time, harvesting larger trees can be expected to generate greater volumes of fuelwood as a residue. It should be noted, however, that the relationships between joint products are not symmetric in the sense that trees managed for fuelwood will not yield large poles as a by-product.

Stocks of trees in natural forests also play a crucially important role in the generation of the indirect use and non-use goods and services consumed. Where research is thought to influence these outputs, valuation is hampered by the fact that public goods are unmarketed and are "consumed" by different groups in different locations over different timeframes.

These characteristics raise both practical and normative issues for evaluation. In spite of promising developments, widely applicable "prices" for biodiversity, carbon sink and so forth have yet to be developed and as such an evaluation may be limited to all but the most general conclusions regarding these functions. Furthermore, such general prices may never exist for certain of these functions. For example erosion control, which is non-site specific in supply, is nevertheless site-specific in demand, in the sense that the extent of negative impact caused by erosion will depend on the nature of the economic activities occurring "downstream".

In valuing the multiple outputs of a forest, trade-offs potentially exist between direct extractive use of wood products and indirect/non-use functions. At the local level these may be reasonably clear (e.g. harvesting of trees vs. water flow/quality in rivers) but where research increases [decreases] local levels of exploitation at the cost [to the benefit] of global public goods, the approach for evaluation is less clear. Traditionally, cost-benefit analysis is indifferent between beneficiaries at a national level; however, it is doubtful whether FRP-funded research would be considered "successful" if the most significant benefits were generated for consumers in Europe.

### 1.4.5 Institutional/social aspects

Many of the institutional and social aspects of forestry have already been alluded to above and have implications more for research design and appraisal than evaluation *per se.* However, the fact that they provide context for the implementation of research, it is worth discussing them briefly here. The first issue considered is the extent to which forest goods and services are "underpriced" by the societies in which FRP research occurs.

In the case of direct uses (i.e. harvested products), it is an empirical question whether markets can be considered "competitive" (and prices a true reflection of value). The claim of "underpricing", however, is often made because the prices of these products do not include the cost of replacing/renewing the resource. This argument needs to be treated cautiously. Many of the forest products of interest to FRP grow naturally and intervention (harvesting) can be expected, up to a point, to stimulate growth rates. Where a natural forest is brought under management, there will be a period of "draw down" from the natural capital as old-growth is cut to create the conditions necessary for the anticipated gains in productivity. It is unreasonable to ascribe replacement costs to products that are obtained during this conversion period. However, in other cases, the conversion period will have passed and production levels may continue to exceed the natural rate of regeneration. In these cases, the approach for evaluation is not clear-cut. Assessments are required regarding supply (including alternative sources) and demand conditions, future prices, availability of substitutes and so on. It can be anticipated, however, that naturally available products will continue to be harvested up to the point where production costs exceed the cost of alternatives e.g. substitute products or private planting initiatives, at which time markets will adjust and prices reflect this new equilibrium.

More generally, natural forests are said to be "underpriced" because the value of additional, non-marketed outputs is not included when management decisions are taken. Such cases of market failure can arise from decisions made at a local level, by communities living near to the resource, or nationally, by governments pursuing particular development policies. Where loss of relevant non-marketed outputs is not taken into account, then the resource can be considered "underpriced". Examples are not uncommon in developing countries, particularly with respect to government policies (see Repeto and Gillis, 1988). These can be intentional, (e.g. promoting clearance of natural forests), or unintentional, (e.g. supporting prices of food crops), but the effects “come to rest on the forest resource because forests are generally a residual land use” (Hyde *et al*, 1992). Evaluation may be able to assess the “real” value of research (if such values can be estimated) and the “real” costs associated with the chosen strategy. However, funding specific research to clarify the choices for decision-makers and to influence the policy environment *in advance of* “biologically-orientated” research would appear to be a more cost-effective means of addressing this constraint.

Tenure is another issue that has generated significant debate in the forestry sector. Insecure tenure may arise where *de facto* managers of the resource are not the *de jure* owners, though extent of insecurity in practice needs to be carefully assessed. Where it is significant, it represents a particular problem related to the policy environment and may have effects similar to those above. In certain circumstances, it may act as a disincentive for forest users to invest in longer-term management strategies (e.g. resource protection, controlled exploitation). Again, strategic, policy-orientated research is likely to be a more appropriate tool than research evaluation *per se* to assess the trade-offs involved.

The heterogeneous nature of local, small-scale forest producers/users also poses problems for evaluation. In contrast to industrial forestry operations or annual crop producers, local forest users are likely to have multiple management objectives. Evidence in USA from studies of non-industrial private forest owners suggest that market benefits are traded-off against non-market benefits (amenity/aesthetic values). Similar studies in Sweden have identified the potential for a backward bending supply curve to exist among smaller-scale private forest owners (the so-called “volvo effect”). Although formal evidence is less commonly available for developing countries, there is no reason to think that the basic conclusion will be substantially different, especially once these users attain a certain, minimum subsistence level of forest products. Local communities may attribute, rightly or wrongly, certain environmental benefits to forests. Individuals may view trees as a type of savings account which admittedly may offer even negative real rates of interest but which may be preferred to existing rural finance schemes, if such schemes exist. These characteristics pose problems for econometric models that impose the assumption of profit-maximisation when seeking to discern the effect of research but even for non-econometric estimation techniques, care must be exercised in interpreting current or predicting future behaviour.

## 2. Literature review

### 2.1 Background

Under Output 1 the study reviewed available literature on the economic evaluation of forestry research. The aims were to identify the types of forestry research and benefits addressed, the evaluation methods used and their relevance for the development of FRP's own evaluation strategy. The literature search was based primarily on library databases and references in the evaluation studies initially identified. A surprisingly small number of formal studies were found. Given the nature of the search, it is recognised that relevant "grey" literature available within institutions may have been overlooked. Although not expected to be large, the potential volume of informal literature cannot be estimated. With this issue in mind, the study also reviewed a variety of institutions (see section 5) to assess current practice.

It is stressed that the objective of the exercise was to identify literature relating to the economic evaluation of forestry research. Swinkels and Scherr (1991), for example, provide an annotated bibliography of 230 reports entitled "Economic analysis of agroforestry technologies". However, the majority of examples in that study focus on the (mainly) financial viability of the *technologies* and none report the returns to the project/research investment. For the vast majority, the focus is on effects at the research plot or farm level.

The bulk of the formal literature relating to forestry research evaluation has been generated by institutions in North America, with the USDA Forest Service occupying a leading role. The drive to identify more systematic approaches to research planning, selection and, in particular, impact assessment in the U.S.A. was provided in the mid- to late 1970s by increased scrutiny of public expenditure and tightening federal and state research budgets. Throughout the early to mid-1980s, the USDA Forest Service in conjunction with a number of universities debated and investigated these topics through a series of workshops and reports[1] and collaborative research projects[2].

This work took its methodological lead from the agricultural sector where a longer tradition of research evaluation exists. Methodological testing/development formed the rationale for some studies but in the main efforts were focused on increasing the body of evaluation case studies, given the limited number of examples available at that time. These studies appear to have been directed largely towards external, advocacy objectives, i.e. determining the benefits of forestry research investments for administrators and policy makers. Broader issues such as the role of evaluation in forestry research and the methodological challenges posed were considered in a number of papers (e.g. USDA, 1986, Jakes and Bengston, 1987) but the development of firm conclusions appears to have been limited by the preliminary nature of investigations.

For a number of reasons, the results of these and subsequent evaluation efforts are of only indirect value to this study. First, forestry research in North America provides the bulk of the examples, implying different resource and data constraints. Second, the case study approach means that the majority of examples focus on final results rather than methodological problems and solutions[3]. Third, research more typical of FRP's current portfolio, e.g. social/rural

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[1] e.g. Callaham (1981), Hyde (1983), Risbrudt and Jakes (1985), Fox (1986), Burns (1986), USDA Forest Service (1986)

[2] e.g. Bengston (1984), Haygreen *et al* (1986), Seldon and Newman (1987)

[3] Hyde *et al* (1992) and Seldon and Newman (1987) provide examples of the few exceptions.

development forestry and natural forest management, is poorly represented in the research evaluation literature. More recent attempts to update the debate regarding the evaluation of forestry projects to reflect the wider range of interventions common today do not specifically consider forestry *research*[1]. Finally, the objectives of the evaluation exercise itself are detailed in very few cases.

Before discussing the specific examples identified, it is useful to summarise some of the early conclusions arising from the publications that examined the issue of forestry research evaluation more generally. While papers such as *Forestry research evaluation: why and how"* (Jakes and Bengston, 1987) and *Alternative approaches to forestry research evaluation: an assessment* (USDA, 1986) fall significantly short of the practical guidance suggested in their titles, they do provide insight into the challenges posed and context for the more detailed discussions that follow.

These papers suggest that while efficiency-orientated, commodity-focused forestry research can be evaluated using conventional techniques, adequate methodologies do not exist for more systems-orientated research e.g. NFM or agroforestry research. The enduring validity of this conclusion appears to be supported by the lack of such examples in the literature.

The advantages of more complex methodologies, in particular aggregate-level econometric evaluation, were also recognised, particularly in terms of the greater confidence in results generated by such studies[2]. However, the literature search indicates that these approaches have been almost exclusively restricted to the wood products sector and their applicability to the evaluation of forest management research appears constrained by data and measurement problems.

That is not to conclude, however, that complex approaches are impossible. For example, in spite of "the spatial and temporal complexity of agroforestry systems, heterogeneous farm conditions…multiple inputs and outputs and the existence of several non-market costs and benefits", Pattanayak and Mercer, (1996) applied production function analysis to examine the relationship between agroforestry/soil conservation and changes in household production and income. Data collection involved a survey of 244 households to obtain information on a range of biological, social, economic and demographic data and in-depth weekly surveys of 37 households over a twelve-month period. Even so, the strength of final conclusions is tempered by the fact that results "do not account for several significant off-site and on-site benefits…In addition, all long run soil conservation benefits…may not have been realised in the short *ten year* period since the initiation of the agroforestry project" [emphasis added by this author].

Finally, early discussions of the challenges posed for evaluation identified the need to develop multiple criteria of worth for forestry research in order to capture the full range of possible effects. Again, the literature suggests limited progress has been recorded in this regard. In part, the continued reliance on NPV, IRR, etc. is evidence of the importance attached to these measures and, presumably, to the type of benefits that they measure. However, given that evaluation criteria are up to a point selected with the intended audience in mind, there is an element of circularity in this argument. Alternative measures are unlikely to be used widely until donors/managers indicate the acceptability of these alternatives.

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[1] For example, Gregersen et al (1993) provides a broad and comprehensive overview of the issues for development projects in general but, understandably given the objectives of the report, there is little in the way of practical guidance.
[2] Aggregate analyses avoid the criticism of selecting only examples of successful research.

## 2.2 Summary of literature identified

Basic characteristics of the examples identified in the literature search are presented in table 2.1 below. Appendix 2.1 provides detailed summaries for each example. Wood products research provides the largest number of examples (9), followed by silviculture (8), tree improvement (6) and "other" (4). This last category refers mainly to studies that examine multiple categories of research though an example of an evaluation of growth and yield research is also included. Unsurprisingly, silvicultural research covers the widest range of initiatives, including seedling production, weed and pest control and harvesting methods.

**Table 2.1:** Summary descriptions of studies included in the literature review

| Research category | # | Country-focus | Species/ products | Type of research | Evaluation objectives | Evaluation approach |
|---|---|---|---|---|---|---|
| TREE IMPROVEMENT | 1 | Canada | Black spruce (timber) | Clonal forestry and seed orchard | Potential returns to 2 approaches compared | *Ex ante*<br>Simple CBA |
| | 2 | Canada | Black spruce, jack pine (timber) | Seed orchard research | Potential returns for 2 species compared | *Ex ante*<br>Simple CBA |
| | 3 | U.S.A. | 19 timber spp., 4 Xmas tree spp., sugar maple | Coordinated program producing improved stock for applied breeding/production | Potential economic efficiency of program at aggregate and state/species level | *Ex ante*<br>Simple CBA |
| | 4 | China | *Eucalyptus, Acacia, Casuarina* (pulpwood, poles, fuelwood) | Species selection trials project | Potential impact and returns to research | *Ex ante* (benefits)<br>Non-econometric (N-E) economic surplus |
| | 5 | Kenya, Zimbabwe, Thailand | *Eucalyptus, Acacia, Casuarina* (fuelwood, other ind. roundwood) | Species selection trials projects | Potential impact and returns to research | *Ex ante* (benefits)<br>N-E economic surplus |
| | 6 | Vietnam, China, Australia | *Acacia* (fuelwood, tannin, pulpwood, timber) | Species selection trials projects | Potential impact and returns to research | *Ex ante*<br>N-E economic surplus |
| SILVICULTURE | 7 | Canada | Black spruce (timber) | Harvest methods for slow growing species experiment | Assessment of conditions required to justify research | *Ex ante*<br>Simple CBA |
| | 8 | Canada | White pine (sawlogs) | Improvement cut/ shelterwood mngt | Potential returns to technology | *Ex ante* (benefits)<br>Simple CBA |
| | 9 | U.S.A | General | Containerised seedling research | Returns to aggregate research | *Ex post* (+ projections)<br>N-E economic surplus |
| | 10 | U.S.A | Southern pine (roundwood) | Herbaceous weed control research | Returns to aggregate research | *Ex ante* (benefits)<br>Simple CBA |
| | 11 | U.S.A | Douglas-fir, western hemlock (roundwood) | Regional forest nutrition research | Potential returns to research program | *Ex ante* (benefits)<br>Simple CBA |
| | 12 | U.S.A. | Douglas-fir (timber) | Accelerated program of control for Tussock Moth | *Ex ante – Ex post* comparison of justification | *Ex post*<br>Cost-effectiveness analysis |
| | 13 | U.S.A | Southern pine (lumber/plywood, pulpwood) | Timber management research in twelve states | Productivity of, welfare effects of and returns to aggregate research | *Ex post*<br>Econometric (production function+ econ. surplus) |
| | 14 | Nepal | Various | Natural and planted forest management | *Ex post* performance & impact assessment | *Ex ante*<br>Break-even analysis |

**Table 2.1** /cont…

| Research category | # | Country-focus | Species/ products | Type of research | Evaluation objectives | Evaluation approach |
|---|---|---|---|---|---|---|
| FOREST PRODUCTS | 15 | U.S.A. | Structural particleboard | SPB as substitute for construction plywood | Aggregate returns to public/private research | *Ex post* (+ projections) N-E economic surplus |
| | 16 | U.S.A. | Softwood lumber | Truss-Framed System, Edge, Glue & Rip and Saw-Dry-Rip, and Best Opening Face | "Successes" vs. aggregate/specific research costs[1] | *Ex post* & *ex ante* mix Simple CBA |
| | 17 | U.S.A. | Softwood plywood | Powered back-up roll, structural particleboard | "Successes" vs. aggregate/specific research costs[1] | *Ex post* & *ex ante* mix Simple CBA |
| | 18 | U.S.A. | Softwood pulp and paper | Press-drying, increased hardwood utilisation | "Successes" vs. aggregate/specific research costs[1] | *Ex post* & *ex ante* mix Simple CBA |
| | 19 | U.S.A. | Lumber and wood products industry | Sector-wide | Comparison of aggregate productivity growth and research costs | *Ex post* Econometric (Index Number Approach) |
| | 20 | U.S.A. | Softwood plywood | Aggregate research for product | Marginal productivity of, and returns to public research | *Ex post* Econometric (dual of supply function+ economic surplus) |
| | 21 | U.S.A. | Sawmill industry | Aggregate research for industry | Marginal productivity of, and returns to public research | *Ex post* Econometric (dual of supply function) |
| | 22 | U.S.A. | Woodpulp industry | Aggregate research for industry | Marginal productivity of, and returns to public research | *Ex post* Econometric (dual of supply function) |
| | 23 | U.S.A. | Wood preservative industry | Aggregate research in industry | Marginal productivity of, and returns to public research | *Ex post* Econometric (dual of supply function) |
| | NOTE 1: Paper also combined results to compare with total forestry research costs and total forest utilisation research costs | | | | | |
| OTHER | 24 | U.S.A. | Oak | Growth and yield model | Potential impact of improved information | *Ex ante* Simple CBA |
| | 25 | Various | Various | Forestry research prioritisation, and comparison with agric. and fisheries research | Potential (gross) impact of 5% unit cost reduction across commodities | *Ex ante* N-E economic surplus |
| | 26 | U.S.A. | Various | 81 innovations arising from Forest Service Research | Comparison of costs and 1st year benefits, and factors influencing success | *Ex post* Hindsight analysis |
| | 27 | Kenya | Various spp. (fuel, fodder and poles in the main) | Species selection, nursery/establishment, NFM, on-farm trials | *Ex post* performance & impact assessment | *Ex ante* (benefits) Simple CBA |
| | 28 | Thailand | Various spp. (fuel, saw & veneer logs, pulpwood, poles) | Various (7 projects) | Preliminary evaluation (Phase I) | No economic assessment Output, training and potential users assessed |

The majority of examples are drawn from research conducted in North America. Of the studies examining research in developing countries, only Zimbabwe and Nepal are FRP target countries.

The benefits of research are assessed *ex ante* in half of the examples. It should be noted that in two of these, data relating to adoption levels were already available but because of the benefit lag (i.e. the production cycle) gains are estimated. *Ex post* studies effectively make up the other half of the examples, though two of these still include projections of future benefits. Unsurprisingly, *ex ante* analyses are mainly used for biological-related research where longer production cycles are the norm. *Ex post* evaluations in the main relate to the wood products sector, where production cycles are continuous.

Twelve of the examples assess (potential or actual) returns to specific research projects while thirteen evaluate aggregate research investments, though the degree of aggregation varies. In some of these, all public and private research expenditures relating to a specific product (e.g. containerised seedlings) are included for the period of analysis. In others all research expenditure for a particular sub-sector (e.g. timber utilisation research, forest management research) is compared with the output of that sub-sector. The results of aggregate analyses can be viewed as more "representative" in that they do not focus only on successful research. For the project-level evaluations, however, this implied criticism is somewhat offset by the fact that many are *ex ante* analyses. Such studies might be criticised for using over optimistic assumptions, but can hardly be accused of purposively selecting "winners".

In common with evaluation in the agricultural sector, the techniques most commonly used in the studies identified are: simple cost-benefit analysis or CBA (12), non-econometric economic surplus models (6) and econometric estimation (6). These approaches are described more fully in section 3, but a few points are worth stressing here. First, the terminology used to distinguish these approaches is for descriptive purposes only. All can be considered variants on the same theme, that is, they compare costs with benefits. All use the Marshallian concept of social welfare to assess benefits and apply discounted measures of worth (e.g. net present value, internal rate of return, benefit-cost ratio) to compare research (and in some cases adoption) costs with these benefits over time. Second, the term "simple CBA" does not imply "inferior" but rather refers to the assumptions/data requirements of this approach as applied in the literature[1].

It can be seen that econometric techniques that are more data demanding are almost exclusively reserved for the evaluation of wood products research. The fact that econometric techniques are not widely used in say the evaluation of forest management research is most likely explained by differences in the quality of data available regarding the production process and/or benefits in the different forestry sub-sectors.

Data needed to assess capital and labour inputs are available, certainly in North America, for the forest product industry, as are production and price data. The length of forest rotations, however, makes obtaining reliable input data at the forest-level difficult, while time-series measures of forest level output for industrial roundwood are influenced by changes in processing technology and the mix of final goods produced. Technology adoption by forest industries may also be more readily observable from output data than is the case for forest level operations where overlapping production runs confuse the picture. In addition,

[1] In fact, the CBA framework commonly applied in the appraisal of projects in developing countries allows for quite complex analysis to be incorporated; it is the shortage of data that accounts for any apparent simplicity.

behavioural assumptions (e.g. profit maximisation) that are imposed in certain econometric analyses may be more tenable at the industry level; at the forest level, producers are likely to exhibit a greater degree of variation in management objectives. All these problems are encountered in the only example (#13) found of econometric analysis of forest management research (Hyde *et al*, 1992).

## 2.3 Treatment of time

Given the importance of time in forestry research for both the implementation and results of evaluation, an attempt was made to summarise the research, adoption and benefit lags identified in the literature. In addition, the period of analysis was assessed, along with any explicit assumptions regarding supply and demand conditions and future costs and prices. Table 2.2 presents the results. The results and subsequent interpretation are largely governed by the nature of the studies. In the case of *ex post* analyses, lags are, in general, more clearly identified. Econometric evaluation techniques used in the examples of wood products research directly estimate the lag between research and production effects, while those studies using less demanding techniques benefit from hindsight and available information to arrive at reasonable *ad hoc* estimates. Similarly, by definition, *ex post* studies do not face the problem of modelling future supply and demand conditions and prices.

The study attempted to distinguish the time periods between: (a) Research-to-first adoption, (b) First-adoption-to-full adoption, and (c) Research-to-first-benefit. In principle, (a) + (b) indicates the length of the research and adoption lags, while (c) - (a) indicates the benefit lag. Thus, (b) + (c) provides a broad indication of the timeframe from the start of research to the maximum benefit level. In practice, it proved difficult to identify these periods (question marks in table 2.2 indicate uncertainty). For fully *ex ante* studies and those relying on long term projections to estimate overall returns, the absence of clear information on time-related factors is striking. In part, this reflects the limitations on the space available in journal papers/reports but, for *ex ante* studies in particular, such issues would appear to warrant explicit attention.

Comparison of the lags associated with different categories of forestry research must be treated cautiously, given data constraints. Similarly, some research targeted more than one product, (e.g. fuelwood, poles and timber) which in turn means there are a range of (minimum) benefit lags. In addition, the research and benefit lags vary between species. While it may appear intuitively correct that the lags on average decline as one moves from tree improvement, to silvicultural, to wood products research, individual research initiatives can easily buck this trend. For example, tree improvement research directed towards fast growing species for fuelwood production may involve a shorter research-to-benefit lag than silvicultural research directed at weed control.

In addition to the lags, the study examined the manner in which future projections are treated in the literature. The average period of analysis for *ex ante* studies is over sixty years (compared with around 28 for *ex post* studies). In spite of this timeframe, very few studies explicitly discuss the difficulties attendant with projections over such long periods. In the case of studies using simple CBA, constant costs and prices are in the majority of cases assumed, though explicit justification is not provided. Estimates of the price elasticities of demand ($\eta$) and supply ($\varepsilon$) used by studies employing the economic surplus approach were in the main informed by the results of previous studies. Nevertheless, the validity of these estimates over such extended periods of analysis are not explicitly discussed.

**Table 2.2:** Timeframe information from examples included in the literature review

| Research category | # | Research → 1st adoption | 1st adoption → Full adoption | Research → 1st benefits | Period of analysis | Supply & demand conditions | Future costs/ prices |
|---|---|---|---|---|---|---|---|
| TREE IMPROVEMENT | 1 | 8 yrs (min) | 33 yrs (approx)<br>Annual planting rate assumed | 48 yrs | ? 99 yrs | Not explicit | Constant costs; Govt stumpage charges varied |
| | 2 | 6-8 yrs (min) | 33-35 yrs (approx)<br>Annual planting rate assumed | ?48 yrs | ? 99 yrs | Not explicit | Constant costs; Govt stumpage charges varied |
| | 3 | 25 yrs (min)<br>Various | ? planting projected for 40 yrs | ?30-100+ yrs<br>Various | 40 yrs | Not detailed<br>Supply projections based 10 yr trend + additional Information | Constant costs; Constant stumpage |
| | 4 | 10 yrs (approx) | ?<br>Annual planting rate assumed | 17-24 yrs | ? | $\eta=\infty$<br>$\varepsilon$ not specified ($\varepsilon<\infty$) | Constant costs; Govt-set prices (no price effect) |
| | 5 | ? 6 yrs | ? 4 yrs | ? 12 yrs | 30 yrs | Fuelwood: $\eta$ = -0.4; $\varepsilon$ = 0.6<br>Roundwood: $\eta$ = -0.8; $\varepsilon$ = 0.3 | Constant costs; Future prices estimated by model |
| | 6 | ? 10 yrs | ? 10 yrs<br>Annual planting rate assumed | ? 10 yrs<br>"adoption"≡"benefit" | 30 yrs | Not explicit | Constant costs and prices |
| SILVICULTURE | 7 | ? 6 yrs (research lag not discussed) | 25 yrs | 6 + harvest every 25 yrs | 125 yrs | Not explicit | Constant costs; Govt stumpage charges varied |
| | 8 | ? not discussed | Experimental level only | ? 20 yrs approx | 115 yrs approx | Not explicit | Constant market prices |
| | 9 | ? 1 yr (implied from data) | ? 20 yrs approx until max production | 1 yr | 31 yrs | $\eta$ = -0.1<br>$\varepsilon = \infty$ | Constant market prices |
| | 10 | 3-yr research & adoption lag | 10 yrs approx<br>Actual/projected applications based on forest managers survey & annual area of regeneration | 16 yrs (min) 1st thin.<br>26 yrs (min) harvest | 20 yrs | Not explicit | Constant costs; Rising (real) stumpage values |
| | 11 | 5 yrs | Immediate<br>(different ceilings estimated) | 15 yrs | 47 yrs | Not explicit | Constant market prices |
| | 12 | *Accelerated research to provide controls 7 yrs earlier than base funding but adoption (at time of evaluation) effectively zero.* | | | 7 yrs | Not included | No detail |
| | 13 | Not included | Not applicable.<br>Aggregate costs v. aggregate productn. | 1 – 20 yrs tested in analysis | 45 yrs | Pulpwood: $\eta$ = -0.43 $\varepsilon$ = 0.23<br>Solidwood: $\eta$ = -0.57 $\varepsilon$ = 0.55 | Not applicable |
| | 14 | Not discussed | Not discussed | Not discussed | ? | Not explicit | Not explicit |

**Table 2.2** /cont…

| Research category | # | Research → 1st adoption | 1st adoption → Full adoption | Research → 1st benefits | Period of analysis | Supply & demand conditions | Future costs/ prices |
|---|---|---|---|---|---|---|---|
| FOREST PRODCUTS | 15 | 21yrs research costs | 20 yrs (approx) | Aggregate 21 yrs (general 8-10 yrs) | 50 yrs | $\eta$ = -0.5 & 1.0 $\varepsilon = \infty$ | Historic costs Constant prices |
| | 16 | 10yrs aggregate research costs | 19 yrs (assumed straight line) | 10 yrs | 28 yrs | Not detailed USDA demand projections | Historic costs Price projections |
| | 17 | 10yrs aggregate research costs | 19 yrs (assumed straight line) | 10 yrs | 28 yrs | Not detailed USDA demand projections | Historic costs Price projections |
| | 18 | 10yrs aggregate research costs | 19 yrs (assumed straight line) | 10 yrs | 28 yrs | Not detailed USDA demand projections | Historic costs Price projections |
| | 19 | 10 yrs assumed | Not applicable Sector analysis | 10 yrs | 31 yrs | Not applicable | Not applicable |
| | 20 | 2 yrs | Not applicable Industry-wide analysis | 2 yrs | 30 yrs | Not applicable ($\eta$ = -2.7 $\varepsilon$ = 0.5) | Not applicable |
| | 21 | 5 yrs | Not applicable Industry-wide analysis | 5 yrs | 30 yrs | Not applicable ($\eta$ = -0.6 $\varepsilon$ = 0.34) | Not applicable |
| | 22 | 3 yrs | Not applicable Industry-wide analysis | 3 yrs | 30 yrs | Not applicable ($\eta$ = 0 $\varepsilon$ = 1.1) | Not applicable |
| | 23 | 1 yr | Not applicable Industry-wide analysis | 1 yr | 30 yrs | Not applicable ($\eta$ = -1.6 $\varepsilon$ = 0.5) | Not applicable |
| OTHER | 24 | ? 3 yrs | ? Not specified | 45-95 yrs | ? 95 yrs | Not explicit | Constant costs and prices |
| | 25 | Not included | Not included | 11-45 yrs | 30 yrs | Various elasticity estimates used for different products | Constant costs and prices |
| | 26 | Research:15 yrs | Not included | Not explicit | ? 20+ yrs | Not applicable | Not applicable |
| | 27 | 14 yrs | 10 yrs | ? 20 yrs (min) | 30 yrs (approx) | Demand growth 4% p.a. | Constant costs and prices |
| | 28 | Preliminary analysis which does not attempt estimate of economic impact | | | 12 yrs | Not included | Not included |

## 2.4 Benefits, uncertainty and results

Finally, the study examined the type of benefits included in the examples, the basis on which these are estimated, the treatment of uncertainty and the final results (table 2.3). Quantified benefits included in the examples are almost exclusively restricted to efficiency gains. In the main these are realised in terms of either greater output (e.g. yield gains) or reduced costs (e.g. same output at lower unit costs). At the same time, around a third of the examples identify other benefits of research but no attempt is made to quantify these. Such benefits include multiple use benefits (e.g. environmental benefits, recreation), joint products (e.g. oils, pollen, fodder, seeds for human consumption), quality improvements, allocative efficiency gains (as a result of greater price stability, guaranteed sources of high quality seed), gene conservation, human capacity and infrastructure development, regional employment effects, publications. In an example that examines 81 innovations arising from forestry research in the U.S.A. (# 26), the author notes that monetary benefits could be easily identified for only 22 of these (Callaham, 1981). Only two examples attempt to quantify benefits arising from associated environmental effects (soil fertility, erosion control and carbon sequestration). The estimates of effects and value, however, are relatively crude and based on results from research in other countries rather than site-specific studies.

The distribution of benefits is given little or no consideration in the majority of studies; 19 of the examples do not examine this issue. This is largely explained by the particular evaluation model, where direct distributional analysis is precluded by use of a simple CBA[1]. In addition, it appears that *ex ante* analyses are much less likely to examine questions of who will benefit, perhaps because of the more general uncertainty surrounding such analyses. In general, treatment of distributional issues is relatively crude: "producers" and "consumers" tend to be defined in aggregate terms, while in other cases, the analysis is restricted to geographical distribution of benefits (between countries) resulting from price or technology "spill-overs" of research. Three studies examine the issue in-depth. One considers whether the distribution of benefits might justify research in spite of low or negative national (efficiency) returns. The other two are DFID evaluation reports, which include a separate analysis of "social impact".

In short, issues such as environmental externalities and/or the distribution of benefits can be addressed in economic evaluation, but in order to do so requires good quality data, most likely based on detailed in-country study. Such data may not be available for much FRP research or may not be collectable within the constraints imposed by FRP programme management resources.

More than half of all examples rely on researcher/expert opinion to estimate the productive effects of research, though a number of these use research data or results published elsewhere to inform judgements. In contrast, those studies using econometric techniques estimate research effects "directly". This reliance on subjective assessment is not surprising given timeframe and data/measurement constraints. It is noteworthy that in a number of these examples, the evaluation exercise was conducted near the end or at completion of research yet benefits were assessed *ex ante* because of the benefit lag. Where subjective assessment is used, credibility depends on a clear statement of underlying assumptions and adequate treatment of uncertainty.

Uncertainty is, of course, of greater significance for *ex ante* analyses than *ex post.* The majority of *ex ante* studies do consider uncertainty, most commonly by varying estimated effects of research (e.g. % yield gain) or anticipated adoption levels. A few of the examples that involve the longest lags also vary the price of the product affected (most commonly upwards) to examine the effect on final results. However, the majority of *ex ante* studies treat uncertainty largely as a "mechanical" process. Sensitivity analyses rarely examine possible outcomes of *non-research* factors that may influence final results (e.g. variation in field-level management skills, capacity of extension services), while the degree of variation tested is frequently determined by the same source providing the "base case" estimates. As such, there is an implicit assumption that research will be successful and only the degree of success is examined. Finally, variables are frequently treated as independent in sensitivity analyses, when quite clearly they are not (e.g. lower than anticipated yields, lower than anticipated adoption levels).

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[1] In contrast, these issues can be examined as a "by-product" of (non-econometric) economic surplus models and econometric estimation techniques (see section 3).

**Table 2.3:** Summary of research effects and results from examples in the literature review

| Research category | # | Type of benefit(s) | Estimates of research effect | Probability of success? | Discount rate(s) | Results |
|---|---|---|---|---|---|---|
| TREE IMPROVEMENT | 1 | Yield gains | Scientist estimates | Range of yield gains | 4-6% | Break-even stumpage charge<br>Seed orchard preferred<br>Real growth in stumpage charge needed |
| | 2 | Yield gains | Scientist estimates | Range of yield gains | 4-6% | Break-even stumpage charge<br>Jack pine preferred<br>Real growth in stumpage charge needed |
| | 3 | Yield gains | Scientist estimates,<br>Growth model | Not explicit | 4-6% | BCR:<br>Timber avg 2.8<br>Xmas trees. avg 383<br>Sugar maple 27.6 |
| | 4 | Yield gains | Early trial results | Range of yield gains | 10% | NPV: $A 109-115 M<br>IRR 33-34% |
| | 5 | Yield gains<br>Soil fertility & erosion<br>Carbon sequestration | Early trial results,<br>Scientist estimates<br>Third country studies | Range of yield gains | 8% | NPV $A27.3 M;<br>IRR 27% |
| | 6 | Cost savings, Soil fertility, Carbon seq. | Assumed cost reduction<br>Third country studies | Range of cost savings | 8% | NPV $A 9 M;<br>IRR 26% |
| SILVICULTURE | 7 | Yield gains | Early results,<br>Growth model | Stochastic technique for uncertain variables | 4% | Financial viability requires yield gains & rising (real) stumpage values |
| | 8 | Yield gains | Growth data over 20 yr period + projections | Not explicit | 3-5% | Technology financially viable |
| | 9 | Cost savings | Scientist and industry estimates | Not applicable | - | IRR 37-111% |
| | 10 | Yield gains | Trial data<br>Growth model | Survey of researchers / foresters<br>Actual @ 43%-77%<br>Future @ 80% | 7% | NPV $112 M - $143 M |
| | 11 | Yield gains | Research data | % adoption attributable to research varied | - | IRR 9-12% |
| | 12 | Losses avoided,<br>cost savings | *Ex ante* scientist estimates reassessed | Not included | ? 12% | Break-even uptake levels (BCR = 1). Accelerated program prob. not justified |
| | 13 | Yield gains | 10 yrly inventory data + econometric estimation | Not applicable | 0%-10% | NPV negative under most assumptions |
| | 14 | Production gains | Assumed by analyst | Not explicit | - | Qualitative judgement + break-even analysis for IRR of 10% |

**Table 2.3** /cont…

| Research category | # | Type of benefit(s) | Estimates of research effect | Probability of success? | Discount rate(s) | Results |
|---|---|---|---|---|---|---|
| FOREST PRODCUTS | 15 | Cost saving | Literature review, market data, industry experts | Not applicable | - | IRR 19%-22% |
| | 16 | Input/cost saving | Literature review, industry experts | Not applicable | - | IRR 36%[1] |
| | 17 | Input/cost saving | Literature review, industry experts | Not applicable | - | IRR 25%[1] |
| | 18 | Input/cost saving | Literature review, industry experts | Not applicable | - | IRR 14%[1] |
| | 19 | Productivity gains (inputs saved) | Econometric estimation | Not applicable | - | IRR 34% |
| | 20 | Productivity gains | Econometric estimation | Not applicable | - | IRR 260-460% |
| | 21 | Productivity gains | Econometric estimation | Not applicable | - | IRR 13%-57% |
| | 22 | Productivity gains | Econometric estimation | Not applicable | - | IRR 15%-33% |
| | 23 | Productivity gains | Econometric estimation | Not applicable | 4-10% | NPV $96-$384 M |
| | NOTE 1: Also compares returns to (a) total forest products research and (b) total timber utilisation research: | | | | | (a) IRR 18%; (b) IRR 26% |
| OTHER | 24 | Production/profitability gains | Scientist estimates | Not explicit | 6% | BCR: 16.3<br>LEV: $48.65/acre |
| | 25 | Cost saving | Assumed | Implicit. Assessment of research strengths & production environments | 12% | Break-even "relativities" for prioritisation of research |
| | 26 | Var. (efficiency gains) | Expert estimates | Not applicable | - | "Pay-back" period: ≤1 mth-5 yrs for innovations with easily quantifiable benefits (22 out of 81) |
| | 27 | Yield gains | Analyst assumption | 33%-100% assessed | - | IRR: 0.1-3.0% |
| | 28 | Preliminary analysis which does not attempt estimate of economic impact | | Not included | - | Publications, preliminary evidence of uptake, training activities |

As such, it is difficult to judge (a) the likelihood of variation from the base-case, and (b) whether the extent of variation tested is reasonable.

Assuming that the evaluation of most FRP research will include a significant *ex ante* element and assuming that uncertainty increases with the length of lags, the treatment of this issue would seem to warrant further attention in any evaluation approach. One example (# 7) addresses this by identifying standard deviations for all uncertain variables, the value of which reflects the degree of uncertainty. By running hundreds of simulations as per typical Monte Carlo techniques, an estimate of the present value of research is obtained that is normally distributed with a mean (expected value) and standard deviation. Minimum and maximum results can be observed along with an estimate of the probability of a positive result. Of course, this approach is less suited to situations where the variables themselves are difficult to quantify and it is also unclear whether the approach fully accounts for inter-relationships between variables.

In terms of final results, all bar two of the examples use capital budgeting techniques to assess the overall returns to research (e.g. Net Present Value, Internal Rate of Return, Benefit-Cost

Ratio)[1]. Of these, six can be broadly defined as assessing the conditions necessary to justify research, given assumptions regarding possible gains. In these particular cases, the assessments highlight the importance of assumptions regarding the scale of adoption/ application of results and the value (price) of wood at harvest. For the remaining 20, 18 of the studies concluded that the benefits justified the research investment.

One obvious conclusion is that the conventional techniques of economic evaluation can be applied to forestry research, at least in those cases where the major anticipated effect of research is either yield gains or cost savings (i.e. economic efficiency). From the *ex post* perspective, results are considered encouraging (given the greater confidence that can be placed in these analyses) but of limited relevance to FRP given that most of the examples are drawn from research and/or conditions unrepresentative of FRP projects. Nevertheless, in an era of increasing pressure on research budgets and growing demands for evidence of impact, the importance of *ex post* analyses should not be underestimated, though results may provide little more than general guidance on the potential of future research.

In the case of the *ex ante* studies, conclusions are necessarily less definitive. For the five developing country examples, projected results certainly paint a more mixed picture. Prospects for positive returns appear very limited in examples 14 and 27 while the positive return estimated in one of the three *ex ante* assessments of tree improvement research is heavily dependent on assumptions regarding environmental benefits (# 5).

More generally for *ex ante* analyses, it is legitimate to question just how valuable are single measures of worth for research managers? In the examples of conventional *ex ante* economic evaluations found in the literature, much detail is necessarily sacrificed in favour of simplifying assumptions that permit the estimation of a “final” NPV or IRR. As a consequence, information regarding more immediate factors that may influence future success tends to be lost or presented in insufficient detail for operational management purposes.

## 2.5 Conclusions

The above discussion implies a number of conclusions. First, economic evaluation is indeed possible for a wide range of forestry research types. At the same time, the representativeness of the examples identified may be questioned in the context of FRP. The geographical focus is heavily weighted towards North America and the types of research examined do not reflect the social/environmental interests of FRP.

Second, economic efficiency gains represent the evaluation yardstick, with little or no attention paid to non-efficiency objectives in the examples. Given that the examples bear only limited resemblance to “typical” FRP research, the temptation may exist to dismiss the almost exclusive efficiency focus as largely irrelevant. However, to do so would be to miss the point. The benefits related to efficiency gains *are* important and represent a good starting point for the justification of any research. Indeed, these benefits represent the standard against which all research can be assessed. Where possible, economic evaluation (*ex post* or *ex ante*) should be attempted in support of FRP’s internal and external requirements.

[1] The exceptions are: # 26 that examines the pay-back period for a range of research innovations; and # 28, a preliminary evaluation that does not seek to assess returns to research.

That is not to say, however, that research with primarily a non-efficiency focus should be excluded from FRP, only that in such cases there is an even greater need for these "other" objectives to be clearly articulated. In other cases, some FRP research projects may simply suffer from practical constraints (e.g. data/measurement or lag issues) that stretch the feasibility/credibility of *ex ante* economic evaluation or preclude timely *ex post* assessment. Regardless, all research can be subjected to a basic framework of questions that underpin more formal evaluations of efficiency-orientated research: what are the effects of research, in what way and over what period are these effects translated into results "on the ground", what are the benefits generated, and who is affected by this process. Costs can even be compared with benefits, in a qualitative/subjective sense.

It is of course recognised that variants of these questions are already included in the documentation required of all RNRKS research proposals, but it is held that poor specification of research objectives weakens the value of the information provided. In many cases, the objectives of research are described in general terms and/or confused with the problem context that provides the justification for research, while the link between research outputs and effects "on the ground" is often unclear. The use of cascading log-frames in the RNRKS was originally intended to ensure coherence between strategic objectives and research activities. However, the danger is that this approach may lead to an abnegation of responsibility for objective setting at the project level.

It is also recognised that at the programme level FRP itself has multiple objectives that span economic efficiency, environmental maintenance (including intergenerational issues), and social (e.g. distributional/equity issues) and institutional (e.g. policy reform) concerns. The balance between these objectives should be explicit for both evaluation and more general management purposes. In the same way that FRP's portfolio reflects an acceptable mix between strategic, applied and adaptive research, so the emphasis on different objectives within the Programme should be visible to facilitate research planning and decision-making.

Third, time is likely to be an important factor in much FRP research, with a number of associated implications. Long lags and positive discount rates can be expected to penalise forestry research at the evaluation stage. While this may be accepted, its importance cannot be ignored. Outside of the forest industry sector, the returns to research in many of the examples are low in comparison with agricultural research[1]. For planning, management and evaluation activities to be effective, explicit consideration of the research timeframe appears necessary at design and appraisal.

The lags involved in much FRP research suggest that *ex ante* type analyses will form an important part of any evaluation strategy. In such studies of potential impact, non-econometric (subjective) estimation techniques are likely to be more common, given the lack of observable data. For some research projects, it may be possible to conduct evaluation at or near completion but even if econometric estimation techniques are feasible, it can be expected that such "*ex post*" studies will still include significant elements of projection. Longer lags imply longer projection periods and greater uncertainty. While the chances of "technical" success may not be affected, non-research related factors (policy environment, rates of adoption, actual gains realised in practice, etc.) are likely to be more variable over extended timeframes. Under these circumstances, the simplifying assumptions necessary to arrive at a single measure of (potential) project worth may be of less use for management purposes. Instead, factors

[1] Many of the examples presents results in the form of "break-even" assumptions. At the same time, the implicit rates of return demonstrated by these studies are low.

affecting the initial and intermediate progress of research (i.e. up to and including adoption) and their likely influence on final impact should be identified more explicitly. These might then be used as *leading* indicators for on-going management and evaluation purposes (e.g. permitting comparison between *ex ante* assumptions and actual achievements/outcomes as research progresses).

## 3. Economic evaluation techniques

### 3.1 Introduction

The following section considers a number of approaches commonly used to assess the economic impact of research. In the discussion, attention is devoted to the manner in which each approach attempts to estimate research-induced benefits and the requirements of each. More familiar features of economic evaluation studies, e.g. estimation of the measures of worth (NPV, IRR, and so on) are not discussed. For those requiring more general information on such topics see, for example, "*Economic analysis of agricultural projects"* (J.P. Gittinger, 1982).

The review of the forestry research evaluation literature (see section 2.2) suggests that three broad approaches have been used to assess economic impact: simple cost-benefit analysis (CBA), economic surplus models and econometric techniques. However, it is important to stress that the analytical frameworks underlying each of these "approaches" are *not* significantly different from one another. All are forms of cost-benefit analysis where estimates of the benefits, discounted to allow for time lags, are set against the costs. Similarly, all are derived from the basic production relationship between outputs and inputs (i.e. the production function). The key distinction between approaches is in practice methodological, namely whether the productive effect of research is estimated econometrically or non-econometrically.

For the purposes of this discussion, however, the three approaches are discussed separately, for two main reasons: first, there are *practical* differences between them in terms of the quantity/quality of data required and the assumptions that are being made. Second, there are differences in terms of the way results are *perceived*. In short, the more complex the technique and the greater the reliance placed on objective measures of research benefit, the greater the confidence in the results.

Section 3.2 describes the basic analytical framework underlying conventional economic evaluation. Simple CBA and economic surplus models are then discussed under the category of non-econometric approaches (section 3.3). The decision to discuss economic surplus models here (rather than under econometric approaches) reflects only the weight of practical evidence from the literature review. However, such models can in practice be used in combination with either estimation technique.

Section 3.4 outlines some of the more common econometric approaches based on a collaborative input to this study by the Department of Agricultural and Food Economics (University of Reading)[1]. The details of this input are presented in appendix 3.1 for reference.

### 3.2 Economic surplus

Based on Marshallian concepts of social welfare and cost, the economic surplus framework has a long tradition in the evaluation of returns to agricultural research and development (R&D). While there is some debate concerning the validity of particular assumptions underlying its use in R&D evaluation, the approach is generally accepted and widely used. Examples and overviews of its application to agricultural R&D can be found in Arndt *et al* (1977) and Norton and Davis (1981).

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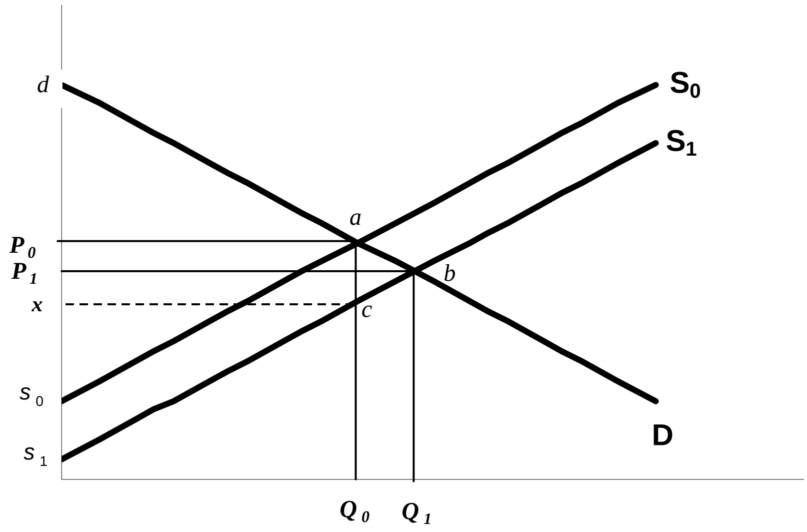
[1] The University of Reading also provided comments in subsequent sections regarding econometric techniques.

In basic terms, the "surplus" referred to is the difference between the market price for a commodity at equilibrium and the price that consumers and producers would be prepared to accept at all quantities up to market equilibrium. This is illustrated in figure 3.1 below.

**Figure 3.1: Basic economic surplus**




$S_0$ and D are the supply and demand functions for a commodity. The market is in equilibrium at $Q_0$, where the equilibrium price ($P_0$) represents the unit price paid by consumers and received by producers for $Q_0$ units of the commodity. It is clear from inspecting the supply and demand curves, however, that for quantities to the left of $Q_0$, producers would accept a lower price while consumers would pay a higher price for the commodity. Therefore, at equilibrium the area $daP_0$ represents a surplus to consumers while the area $P_0 as_0$ represents a surplus to producers[1].

Figure 3.1 also demonstrates the use of this framework to assess the effect of research. The introduction of technological innovation lowers the marginal cost of producing the commodity (by $ac$) and shifts the supply curve rightwards ($S_0 \rightarrow S_1$). A new market equilibrium is reached where $S_1$ and D intersect, at a higher level of production ($Q_1$) and lower market price ($P_1$). These effects cause a change in economic surplus that can be apportioned between producers and consumers, an obvious advantage when the issue of "who benefits" is also of interest. The changes in surplus are represented graphically as follows:

$\Delta$ consumer surplus (CS) = $(dbP_1 – daP_0) = P_0abP_1$
$\Delta$ producer surplus (PS) = $(P_1bs_1 - P_0as_0) = P_1bcx$ [2]
$\Delta$ total economic surplus (TES) = $\Delta$CS + $\Delta$PS = $s_0abs_1 = P_0abcx$ [3]

[1] In fact, producer surplus represents rents or quasi-rents to the owners of fixed (e.g. land) and quasi-fixed (e.g. labour) factors who may or may not be the "producers", as commonly defined.
[2] The change in producer surplus is equivalent to $P_1bcx$ in this particular case where S and D are linear and the supply curve shift ($S_0 \rightarrow S_1$) is parallel.
[3] The change in total economic surplus ($s_0abs_1$) is equivalent to $P_0abcx$ again for the same reasons outlined in the preceding footnote.

More formally, figure 3.1 portrays a partial-equilibrium model for a single homogenous product being sold in a single market (normally at the national level) in a closed economy (i.e. no trade). All curves and measures of surplus are defined as flows per unit of time (normally a year) and the net changes in welfare represent the (annual) economic benefits arising from R&D. In the case of the example presented in figure 3.1, valuing the change in economic surplus is straightforward, using the following formulae:

$$\Delta\textbf{CS} = P_0 Q_0 \left( \frac{K\varepsilon}{\varepsilon + \eta} \right) \left( 1 + 0.5 \frac{K\varepsilon\eta}{\varepsilon + \eta} \right)$$

$$\Delta\textbf{PS} = P_0 Q_0 \left( K - \frac{K\varepsilon}{\varepsilon + \eta} \right) \left( 1 + 0.5 \frac{K\varepsilon\eta}{\varepsilon + \eta} \right)$$

$$\Delta\textbf{TES} = P_0 Q_0 K \left( 1 + 0.5 \frac{K\varepsilon\eta}{\varepsilon + \eta} \right)$$

where $K$ is the vertical shift of the supply curve (i.e. $ac$ in Figure 3.1) resulting from the new technology, expressed as a proportion of the initial price $P_0$, $Q_0$ is the initial quantity supplied, $\eta$ is the absolute value of the elasticity of demand and $\varepsilon$ is the elasticity of supply. Information is required regarding market conditions and the effects of research on the industry supply curve (which in turn incorporates yield or unit cost effects and adoption/application of the technology over time). These are discussed further in section 3.3.2. At this point, however, it is worth highlighting some general issues raised in Figure 3.1 relating to the two assumptions of linear supply/demand functions and a parallel shift in supply.

The functional form of the supply and demand curves and in particular the nature of the supply-curve shift have generated significant debate e.g. Lindner and Jarret (1978), Rose (1980), Wise and Fell (1980), Lindner and Jarret (1980), Miller *et al* (1988), Voon and Edwards (1991). Assuming a parallel supply shift, in most cases the measures of total benefit and its distribution are relatively insensitive to functional form. However, it is quite possible that the supply shift may more closely approximate to a pivotal or alternatively a convergent shift rather than a parallel one. In the case of a pivotal shift, *infra-marginal* producers (i.e. those closer to the price axis) realise smaller absolute unit cost reductions than marginal producers. In the case of a convergent shift, the opposite is true. While in both cases, unit cost savings evaluated at the point of initial equilibrium may be the same as in a parallel shift, the magnitude of change in TES will be smaller if pivotal and greater if convergent. Furthermore, in the case of a pivotal shift, assumptions regarding functional form become more important. The increase in TES will be greater [lower] for linear compared with non-linear, constant elasticity (NLCE) supply curves when the elasticity of supply is less [greater] than one.

For a given set of market conditions, these assumptions to some extent pre-determine the results of any distributional analysis. For example, the change in both PS and CS for a parallel shift with linear curves is always positive/neutral but the change in PS will always be negative in the case of a pivotal shift (with linear curves) when demand is inelastic. Similarly, the change in PS will only be positive for a pivotal shift of NLCE supply curves when the (absolute) elasticity of demand is greater than one.

Defining the nature of the supply shift is therefore important but in practical terms impossible. Lindner and Jarret (1978) and Rose (1980), discuss the difficulties involved in locating specific types of producers (e.g. small or large, mechanised or non-mechanised) on the supply curve and associated problems in determining the nature of the shift. A solution suggested by Linder and Jarrett (1980), and further developed by Davis (1994) and Alston *et al* (1995), is to disaggregate the analysis horizontally (i.e. treating each producer/consumer group of interest separately) and assume a parallel shift in each of these sub-analyses. Results can then be aggregated to provide overall estimates of impact based on a more detailed understanding of the differential effects of research along horizontal market relationships. This solution is also relevant where the general categories of "producers" and "consumers" distinguished in a simple model are too crude for the purposes of distributional analysis. This horizontal disaggregation however, does require research-related and market-related data specific to each of the sub-analyses attempted.

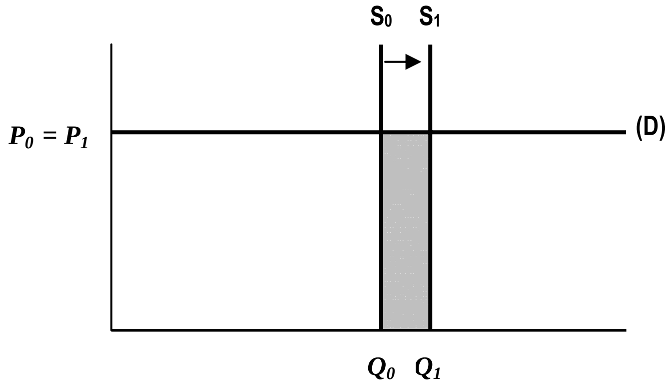
## 3.3 Non-econometric approaches

### 3.3.1 Simple CBA

Simple CBA is the most common approach encountered in the literature review (see Section 2.2) and the one with which the reader is probably most familiar. Typically, an estimate of the effect of research (e.g. a yield increase) is combined with actual and/or projected levels of adoption (i.e. area) over time to arrive at estimates of the additional production resulting from research (normally on an annual basis). In *ex post* analyses, historical price data can be used to value the estimated production gains. In forestry research, however, where *ex ante* analysis is common, constant market prices are commonly assumed in the "base case" scenario.

Figure 3.2 illustrates the above within a supply and demand framework. The application of a yield-enhancing innovation in a given year, over a given area results in a shift in the supply of the commodity in question, reflecting the increase in production resulting from research. Market price is assumed to be constant and the (annual) benefit resulting from research is represented by the shaded area, or $P_0(Q_1 - Q_0)$[1]. This approach was applied by OFI in 1982 when estimating the potential economic impact of the DFID/OFI tropical pines research (Plumptre and Barnes 1982, see section 4).

**Figure 3.2 : Simple CBA**




The figure demonstrates that the simple CBA approach in fact uses an economic surplus framework based on the same measures of welfare as discussed in section 3.2. However, the simple CBA approach imposes a number of assumptions. In the case of the example

[1] The assumption of a real increase in price over time equates with the assumption of exogenous growth in demand and can be incorporated by a corresponding (arbitrary) upwards shift of the demand curve.

presented in the above figure, it is implicitly assumed that demand is completely elastic ($\eta = \infty$) while supply is completely inelastic ($\varepsilon$ = 0), with the corollary that all benefits are obtained by producers. Whether or not this is reasonable for any particular case is not considered by the model. Similarly, possible "spill-over" effects of new technologies to other regions (either through the price mechanism or through technology adoption elsewhere) and issues of market structure are not addressed.

The advantage of simple CBAs, however, lies in the relatively limited data requirements. Production and price data can be easily combined with a simple estimate of the productive effect of research to arrive at an estimate of overall value. Furthermore, although not implicit in the approach itself, the simple CBAs encountered in the literature (including OFI's own analysis of the tropical pine research) translate the estimate of research-induced yield gains directly into a supply shift at the (aggregate) industry level. As is discussed below, this assumption may not always be valid.

### 3.3.2 Economic surplus models

In contrast to simple CBAs, economic surplus models attempt to capture more explicitly the underlying analytical framework discussed in section 3.2. For this reason, they are more flexible in representing actual market conditions: including aspects such as international/ regional trade and spill-over effects of research adoption in one country/region to others e.g. within a two country model (Edwards and Freebairn,1984), and within multi-regional model (Davis *et al,* 1994). Alston *et al* (1995) provides a comprehensive review of developments in the approach, which include incorporation of horizontal market relationships, vertical market relationships (between factor and product markets), demand shifts (as a result of income and population growth) and market distorting policies. In addition, some progress has been made, at least conceptually, in incorporating environmental externalities.

In the simplest case, the economic surplus model requires only limited additional data compared with simple CBA, i.e. estimates of the elasticities of supply and demand for the commodity being studied. Appendix 3.2 summarises elasticity estimates for various forest products obtained from a range of empirical studies. It should be noted, however, that such studies in the forestry sectors of developing countries are rare. Where data are unavailable, Alston *et al* (1995) discusses practical approaches to arrive at approximate estimates of elasticities based on economic theory and the characteristics of the commodity being examined. Of course, data requirements increase significantly as the analysis becomes more complex. However, the ability of surplus models to incorporate such "real-world" complexity is, if anything, an advantage. While simple CBAs may be easier, they may also involve unrealistic assumptions and produce inaccurate results.

Discussions up to this point have assumed that a particular research-induced shift in supply has occurred. However, accurate estimates of the magnitude of this shift and its path over time are crucial in obtaining reliable evaluation results. Eight of the examples identified in the literature review (see section 2.2) explicitly use some form of the economic surplus model, for either *ex ante*-type (4 examples) or *ex post*-type (4 examples) assessments of the welfare effects of research. Six of these apply this approach in conjunction with non-econometric estimation of the effect of research. Where an analysis is entirely *ex ante,* estimates are restricted largely to the subjective opinion of experts. In some cases, *ex ante* projections may be combined with *ex post* analysis of data from experimental trials, or indeed early industry-level yield data. However, the relationship between experimental data, changes in industrial yields and shifts in the (industry's) supply curve is not necessarily direct and caution is required when using non-econometric estimation methods.

First, there are well-known differences between experimental and commercial yields (i.e. the "yield-gap"). Second, when translating experimental yields into a commercial setting, any changes in inputs (and associated costs) resulting from optimisation under the new technology have to be taken into account. Third, there is the question of whether all inputs and prices, that are reasonably assumed as variable and exogenous for the farm/firm, can be considered so at the industry level. In short, the elasticity of supply of the commodity, the nature of technical change (i.e. whether it is "neutral" or "biased") and the elasticity of substitution among factors of production are important in determining how a research-induced yield gain affects supply at the industry-level. Only under particular circumstances will experimental or industry yield data provide a good measure of the increase in supply. These are discussed in Alston *et al* (1995).

The alternative is to estimate the supply effect of research directly, using econometric techniques. This and a number of other econometric approaches are discussed in the following section.

## 3.4 Econometric techniques

In contrast with the approaches already discussed, econometric techniques seek to identify and isolate the direct relationship between research and production over time. There are a variety of econometric approaches but all share a common characteristic: output is explained by inputs and R&D, either directly (e.g. production function approaches), indirectly ("dual" approaches) or in two stages (where the relationship between inputs and outputs is first expressed as a measure of productivity and then the effect of R&D identified).

Econometric approaches typically focus on measures of total factor productivity (TFP), that is, output divided by an appropriately weighted aggregate of *all* inputs. Partial productivity measures can be used (e.g. yield) but production is a multi-input process and such partial measures risk placing too great an emphasis on the average physical product of a single factor as a measure of overall productivity.

An associated feature is that the lags between research expenditures and benefits and the duration of these benefits (i.e. the rate of depreciation) can, in theory, be determined from objective data. Accurate estimation of these lags is important given the effect of discounting on future benefits when determining the rate of return to research investments. However, in practice, the research and adoption lags even in agriculture can be as long as thirty years. For this reason, a particular lag structure is often assumed. In RNR research this is typically an inverted-V or inverted-U shaped lag, reflecting the assumption of a gradual increase in benefits over time up to a peak, followed by a gradual decline.

In terms of the precision with which research impact can be estimated, econometric approaches have obvious advantages over non-econometric counterparts. However, this precision is obtained only at a relatively high cost in terms of the data required for evaluation purposes. Furthermore, this need for data in order to establish the relationship between research and subsequent changes in output explains why almost all econometric evaluations are based on *ex post* study.

The following sections attempt to outline briefly some of the more common econometric approaches. The discussion draws directly on appendix 3.1 provided by the University of Reading.

### 3.4.1 Econometric estimation of the supply function

As indicated in section 3.3.2, the majority of examples of the economic surplus approach identified in the literature estimate the research-induced supply shift using a mix of available data and judgement. An alternative to this approach in *ex post* analyses is direct estimation of the supply shift using econometric techniques.

Typically, the supply of any commodity is a function of the commodity's own price, the price of substitutes and complements, input prices, technology, institutional/infrastructural factors and the environment (including the weather). Where appropriate data are available for these different elements over time (including real R&D expenditures), a functional form for the supply curve can then be chosen and the supply curve estimated directly. In addition, a dynamic element can be incorporated in the estimation by allowing for the influence of price expectations and slow responses to price changes on supply. Both these factors may be considered important in forestry where production cycles are relatively long.

The results enable the supply shifts and the contribution of each explanatory variable to be identified over time. In common with other econometric approaches, other explanatory variables can then be held constant to isolate the specific effect of R&D in with/without scenarios. However, in addition to the exacting data requirements, selection of the appropriate variables to include in the analysis is important and requires considerable experience/judgement. Where crucial variables are omitted, their effects will tend to be attributed to those included. Thus, for example, if fertiliser and R&D both increase yields, omission of fertiliser prices in the supply function will lead to an upwards bias in the estimate of R&D effects.

### 3.4.2 Basic production function (PF) approach:

In contrast, PF approaches attempt to model the direct physical relationship between output and inputs, both conventional and non-conventional. The majority of PF evaluation studies use a Cobb-Douglas functional form to estimate this relationship. In econometric estimation, this standard form is transformed to a function that is linear in the logarithms of the variables, which enables the estimated coefficients to be interpreted as elasticities (i.e. unit free measures of the relationship between output and the input in question). Originally, a time trend was added to models to account for the productive effect of changes in technology over time (and indeed any other time-related changes). However, there has been steady progress in using variables that may be expected to account for actual technological change e.g. R&D expenditures, extension expenditures, education.

The PF approach requires data regarding the physical quantities of inputs (land, labour, capital, purchased inputs, R&D, and so on) and output produced over time. Regression techniques are used to establish the input-output relationship and the resulting estimate of the R&D coefficient indicates the percentage change in output in response to a 1% change in R&D expenditure.

Although useful, due to its simplicity the Cobb-Douglas function is very restrictive (e.g. it imposes a constant, unitary elasticity of substitution between inputs and constant output elasticities for all the variables). Its limitations have been overcome by the development of more general functional forms. These "flexible" production functions, (e.g. the translog), impose fewer *a priori* restrictions on production relationships than the Cobb-Douglas and allow the data to determine important relationships between inputs. The cost of increased flexibility, however, is greater difficulty in estimation.

The PF approach is conceptually straightforward in as much as the objective is to explain output in terms of the inputs used in the production process. However, obtaining estimates of the quantities of all inputs can be difficult, as can adjusting for changes in the quality of inputs over time. In addition, statistical problems can be encountered such as collinearity where a number of key inputs move in the same direction over time, complicating the task of separating out the effect of each input.

A version of the PF approach, using a Cobb-Douglas form, is used in the only example found of econometric assessment of *forest-level* research relating to timber management of southern pine in the United States (#13, Hyde *et al,* 1992). Significant constraints are encountered relating to the measurement of both output and inputs. In the case of the former, the length of the production cycle (up to 40 years), overlapping production runs and the lack of time series data mean that aggregate output data cannot clearly reflect the periodic effect of research (or any other input). For the latter, input data conventionally included in the PF approach are non-existent. A management-ownership index is used as proxy for variation in land, labour and capital inputs, while three biological factors (tree diameter, stocking and site quality) summarise the effect of direct external inputs such as weather, soil chemistry and stand age on the condition of the total resource. Because of data constraints, R&D expenditure estimates do not enter the regression analysis but rather time dummies are included to "explain" upward shifts in the production function over time. However, this approach does not permit a clear distinction to be made between movements along the production function and research-induced shifts of the function. As a result, the estimates of research effects are recognised as biased (most likely upwards).

### 3.4.3 Dual models:

The dual approach involves estimation of a profit or cost function and is based on the correspondence that exists between a firm's production function and its profit, cost, factor demand, and supply functions. Dual models assume profit maximisation [or cost minimising] behaviour on the part of producers. This behavioural model can be combined with the underlying physical model (i.e. the production function) to produce a profit [cost] function that relates maximised profits [minimised costs] to the prices of outputs, prices of inputs and "fixed factors" such as R&D. The process by which a simple production function model can be converted into a 'dual' cost or profit function model and used to estimate returns to R&D is briefly described below:

The production function is specified, i.e., output is described as a function of variable inputs, fixed inputs, and R&D and may be written: $\boldsymbol{Q = f(V, F, R\&D)}$, where $V$ denotes variable inputs, $F$ denotes fixed inputs and $R\&D$ denotes expenditures on R&D. By specifying such a function, it is assumed that there is a mathematical relationship that converts variable inputs, fixed inputs and R&D into output. Note that the production function is describing a purely *physical* relationship[1].

Behavioural assumptions are now introduced; most commonly, that producers choose variable inputs in such a way that profits are maximised. If $q$ denotes output price and $v$ denotes variable input price, profits are given by $qQ - vV$. Variable inputs are the only choice variables for the producers in the short term; even though fixed inputs and R&D affect output, the producers have no control over them. Output can be considered a choice variable, but note that once the variable inputs are chosen, output is automatically given by the production function relationship. Therefore, the behavioural profit maximisation problem can be presented as:

Maximise $(qQ - vV)$, by choosing $V$, given that $Q = f(V, F, R\&D)$.

Solving the maximisation problem produces the output supply function $Q = g(q, v, F, R\&D)$ and the variable input demand function, $V = h(q, v, F, R\&D)$. In other words, once the exact values of the 'uncontrollable factors' are known (variable input prices $v$, output price $q$, the level of fixed inputs, $F$ and R&D expenditure, and the nature of the production function), the profit maximisation model provides the exact value of the 'controllable factors', $V$ and (hence) $Q$. Further, the model enables estimation of the exact amount of profits earned by a producer once the values of the uncontrollable factors are known.

Denoting profits [$(qQ - vV)$] by $P$, we can use $Q = g(q, v, F, R\&D)$ and $V = h(q, v, F, R\&D)$ to write profits as $P = (q\, g(q, v, F, R\&D) - v\, h(q, v, F, R\&D))$. This is called the 'profit function' – i.e. maximised profits are completely determined by input and output prices, fixed factors, and R&D. Thus, by using the profit maximisation model, the exact relationship between 'uncontrollable' variables (including R&D) and input demands, output supplies and total profits are known. Given data on input and output prices, levels of fixed factors, expenditures on R&D, and total profits of the firm, the firm's profit function can be estimated econometrically to determine exactly how a given increase in R&D expenditures may affect the firm's profits.

One advantage that can be seen *vis-a-vis* the production function approach is that the profit function does not need data on input and output *quantities*. However, it is common practice to estimate the profit function *together* with the input demand function $V = h(q, v, F, R\&D)$ and the output supply function $Q = g(q, v, F, R\&D)$. Estimating these functions jointly is known to provide more reliable econometric estimates than estimating the profit function in isolation. However, joint estimation requires data on input quantities as well. A major disadvantage is that the results from profit function estimation are only as accurate as the profit maximisation assumption is tenable. The PF approach does not make any behavioural assumptions, and describes only a physical relationship. The profit maximisation assumption, however, is a strong one. At least in certain years, producers may instead be acting to say maximise the size of their businesses, or to minimise the risk of going out of business.

[1] The production function specified here is completely general. To be useful in empirical analysis, it has to be given a particular *functional* form, such as the Cobb-Douglas described in the previous section.

### 3.4.4 Total Factor Productivity (TFP) and the two-stage approach

The measures of technological change based on dual relationships between the production, profit and cost functions are equivalent to economic accounting measures, which, in turn, are based on index number theory. In the two-stage approach, stage one involves the construction of a TFP index whereby multiple inputs are aggregated into a single index of inputs, and multiple outputs are aggregated into a single index of outputs[1]. The required data are: quantities of inputs and outputs, shares of the cost of each input in the total variable input costs, and shares of revenues from each output in the total revenue. Divisia indices for inputs and outputs can then be calculated. The simple difference between these indices generates a TFP index (in logarithmic form).

The second stage of this approach involves regressing the TFP index upon factors other than the conventional inputs considered in constructing the input index. These may include R&D expenditures, the human capital of the producer as measured by his/her education, and so on. Since all variables are in logarithmic terms, the estimated coefficients for R&D expenditure can be interpreted as the percentage change in TFP in response to a 1% change in time specific R&D expenditures. The TFP method thus provides an estimate of the productivity effect of R&D *after the effects of other inputs have been accounted for*. If necessary, these estimates can be compared with R&D expenditures to arrive at an estimate of the return to research.

Two stage approaches have clear advantages over alternative techniques when data is available in cross-sectional form (i.e. between regions or countries). The disadvantages are mostly technical/theoretically in nature and beyond the scope of this paper.

## 3.5 Conclusions

Econometric analyses obviously have a major advantage in terms of the precision with which research effects are estimated. This, in turn, implies greater credibility of the results. That said, econometric techniques do require good quality data that can be expensive/impossible to collect if not readily available. Similarly, appropriate use of these approaches requires considerable experience and skill.

Even in commercial forestry, price and quantity data for outputs and inputs are relatively scarce in comparison with the agricultural sector. Simpler, econometric models may offer some compromise and one option is considered below (see section 4.4). At the same time, the length of the growing cycle both exacerbates the lags associated with research, adoption and benefit-realisation and increases the data burden associated with any econometric analysis. Even if such information is available, econometric models may struggle over long periods of analysis to distinguish the effects of research from the variety of management, institutional, biological and market factors that also affect production.

In practice, “real-world” constraints within the context of FRP suggest that less exacting evaluation standards, involving a trade-off between precision and cost/ease, are more likely to be applied. For example, while the case study discussed in section 4 involves research that

[1] TFP approaches can be used to evaluate a single technology. However, all other changes (other projects, for example) that might be affecting the TFP must be fully accounted for, before ascribing changes to a single technology.

began some 33 years ago, the majority of FRP evaluation efforts can be expected to focus on much more recent research. At the time of any evaluation, such examples may still have some way to go before the full economic impact (if any) is felt. Given difficulties imposed by lags and available data, non-econometric approaches may be more flexible in handling full or partial *ex ante*-type analyses. In principle, econometric models can be used to forecast future scenarios; however, the productive characteristics of the forestry sector coupled with data limitations may constrain the specification of such models.

That said, it must be accepted that non-econometric approaches can offer only imprecise estimates of impact. Furthermore, the simplifying assumptions commonly used and justified on cost/data grounds may yield extremely imprecise estimates. In the end, there is no single best-fit approach to evaluation and the choice will depend on the circumstances (including the factors identified in section 1.3). While there are good reasons for anticipating that the formal econometric approaches discussed will prove impractical for FRP, the results of simpler alternatives may ultimately be meaningless unless significant effort is made to ensure as close an approximation with reality as possible.

The practicality of evaluation approach is now considered in the context of the first of the case studies included in the report.

# 4. Case Study: Utilisation and improvement of tropical pines

## 4.1 Introduction

### 4.1.1 Objective of the case study

The objective of this section of the report is to examine the applicability of economic evaluation approaches to forestry research. For illustrative purposes, a case study of tree improvement research is used to explore this objective. While it is anticipated that many of the evaluation issues encountered will be relevant to FRP's current portfolio, the dangers associated with drawing "definitive" conclusions from one example are recognised. The relevance of the issues and/or constraints encountered to the evaluation of other FRP projects should, therefore, be considered on a case-by-case basis.

The case study example is provided by the programme of research into the utilisation and improvement of tropical pines, funded by DFID and implemented by the Oxford Forestry Institute (OFI)[1] over a period of 33 years (1963-96). The aim of the case study is not to formally evaluate this research but rather to use it as means to facilitate methodological assessment. The factors influencing the choice of example were: (a) the research had finished; (b) given a start year of 1963, sufficient time was expected to have passed to allow meaningful assessment; (c) the research focused on *productivity gains* in *industrial* forest plantations which should, in principle, be more easily addressed in an economic evaluation; and (d) the research is generally perceived to have been successful[2].

At the same time, it can be anticipated that this example would pose a number of challenges for evaluation, (not least the multi-country, multi-topic nature of the research). Furthermore, the value of the example in terms of providing lessons to inform future FRP projects is somewhat limited by the age of the research. Many of the design/implementation issues arising from research conducted during the 1960s-80s have already been addressed through structural changes to DFID's research programmes. Similarly, many others may simply be redundant as a result of changes in DFID's and FRP's priorities and objectives. For these reasons, the case study does not specifically examine issues of research relevance, performance or efficiency but instead focuses on the challenges posed for measuring economic impact.

### 4.1.2 Approach

Section 4.2 provides a summary of the DFID/OFI programme of research into the tropical pines. The main components of the DFID/OFI programme are considered separately and associated issues relating to the potential benefits of each are discussed. It is recognised that any attempt to summarise such a substantial body of research work will inevitably suffer from inadequacies/omissions; the implications of these shortcomings for this exercise, however, are thought to be limited given the relatively narrow objectives of the case study.

In order to assemble the necessary information for the programme, project files, reports and publications were examined and discussions held with current/previous OFI staff members and

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[1] Formerly the Commonwealth Forestry Institute. For clarity, the terms OFI (and, for that matter, DFID) are used throughout the report to represent all predecessor organisations.

[2] For example, "elements of the…seed and research work have…been applied in many countries throughout the tropics [*and*] the programme has generated numerous international benefits, both direct and indirect" (DFID 1998).

other organisations and individuals familiar with the research programme over time. A limited number of country visits were also undertaken to examine research outcomes among overseas collaborators and to collect data. The choice of visits was guided by OFI who identified a shortlist of countries where the research was felt to have had the greatest success; these were: Australia, Brazil, Fiji, Republic of South Africa (RSA) and Zimbabwe. In the end, RSA and Zimbabwe were selected for detailed study while a short consultancy visit to Brazil was funded in order to provide balance to the results obtained from southern Africa. However, the variety of institutions involved in Brazil, changes in personnel and institutions over time and the time available restricted this visit to largely an exploratory assessment.

The decision not to visit Australia was taken partly on the basis of costs and partly because the pine improvement programme in Queensland was for many years a world-leader. Given the extent of Australia's domestic research efforts, the contribution of the DFID/OFI programme was expected to be relatively small (and difficult to observe). Nevertheless, contact was made (via e-mail) with Queensland to obtain basic data and views on experiences with the DFID/OFI research. In the case of Fiji, it is understood that the pine improvement programme has been in decline in recent years due to funding difficulties and staff changes. As such, anticipated problems in obtaining even basic information explain its exclusion.

Section 4.3 considers the practical challenges posed for any evaluation of the DFID/OFI programme in the light of the findings from the case study countries. In keeping with the requirements of conventional economic evaluation, issues relating to the identification of costs and assessment of benefits are considered. Conclusions are presented in section 4.4.

## 4.2 Summary of the DFID/OFI programme of research into the tropical pines

### 4.2.1 Background

The programme of research was initiated following recommendations of the Eighth British Commonwealth Forestry Conference in 1962. The Conference identified the increasing importance of *P. caribaea* in tropical softwood plantations and highlighted the serious shortage of information about the species. A special study of its races and provenances was proposed and interested countries were called upon to make arrangements for co-ordinated seed collection and provenance trials. The Conference recommended that OFI should be responsible for the co-ordinating these efforts. As a result, DFID support began in 1963 to establish the Unit for Tropical Silviculture in OFI.

Early on, the research expanded both in terms of the number of species and research topics investigated. A total of 21 DFID-funded research projects, implemented by OFI during 1963-96, have been identified for inclusion in the case study. A timeline for the projects identified is provided in Appendix 4.1. Six species (including three varieties of *Pinus caribaea*) from Central America and south-east Asia accounted for the major part of the research and thus represent the focus of the case study. These were as follows[1]:

| Central American: | South-east Asian: |
|---|---|
| *Pinus caribaea* var. *hondurensis* | *Pinus kesiya* |
| *Pinus caribaea* var. *caribaea* | *Pinus merkusii* |
| *Pinus caribaea* var. *bahamensis* | |
| *Pinus oocarpa* | |
| *Pinus tecunumanii* | |
| *Pinus maximinoi* | |

Economic efficiency gains provided the primary justification for research. The aim was to facilitate the development of coniferous forests in the tropics for pulp and sawn timber schemes to contribute to economic development. While subsidiary objectives relating to conservation gained in prominence over time, economic objectives continued to provide the underlying rationale for research throughout the period. This was based on the premises that (a) tropical pines were capable of supplying the same type of long-fibre, general-purpose timber as temperate conifers and (b) they would be not only fast-growing on good sites but also capable of maintaining acceptable growth on infertile/degraded sites, unsuitable for sustained agriculture.

A wide range of research was undertaken in pursuit of this aim, covering the genetic, taxonomic, ecological and industrial characteristics of these pines. The activities can be grouped as follows[2]: Collection, distribution and assessment of tropical pine provenances (including wood properties assessment); tree improvement research; taxonomic investigation, and conservation-related activities. The following sections consider these components in turn, though, in practice, separate assessment is difficult. This is in part because many projects

[1] Of these, *P. caribaea* (in particular, var. *hondurensis*), *P. oocarpa* and *P. tecunumanii* received the greatest attention during the programme.

[2] DFID also funded a limited amount of OFI research into mychorrhizal functions and diseases in the tropical pines.

included multiple research topics but in the main because of the complementary linkages between components (for example, taxonomic and wood properties research that supported provenance collection and assessment activities).

While the justification for research was based largely on potential efficiency gains, it is recognised that the direct output of research is knowledge. Assessing research-generated "knowledge" is problematic and (conventional) economic impact is normally only measurable when such knowledge is converted into "technologies" (loosely defined) that in turn are used to affect production. Nevertheless, understanding about the distribution, taxonomy and commercial potential of the tropical pines increased enormously, as a direct consequence of the research. In addition, research and operational techniques were developed that have been subsequently applied to other species and genera (e.g. DFID-funded research into hardwood species).

As well as providing a basis for specific training activities undertaken by OFI, the results of the research generated a significant body of published literature. An attempt has been made to summarise the main dissemination products (by project) in Table 4.1. (Appendix 4.2 provides details).

Table 4.1: Summary of main dissemination products by project

| Project No. | Journal paper | Conference paper | Bulletin/ report[1] | Thesis |
|---|---|---|---|---|
| R1422[2] R1711[2] | 1 | 5 | 2 | |
| R2145[2] | 5 | 4 | | |
| R2607 | 2 | 4 | 3 | |
| R3070 | 1 | | | |
| R3157 | | 1 | 1 | |
| R3158 | 8 | 5 | 5 | |
| R3251 | 7 | 6 | 2 | 1 |
| R3493 | 2 | 1 | 1 | |
| R3642 | | | 1 | |
| R3644 | 7 | 3 | 1 | 1 |
| R3728 | 2 | | 1 | |
| R3809 | 5 | 1 | 1 | |
| R3881 | 19 | 13 | 3 | 2 |
| R3882 | | | | |
| R4346 | | 4 | | |
| R4347 | 2 | 1 | 1 | |
| R4437 | 1 | 1 | | |
| R4619 | | | 1 | |
| R4725 | 3 | 1 | | |
| R 5465 | 3 | | 3 | |
| TOTAL | 68 | 50 | 26 | 4 |

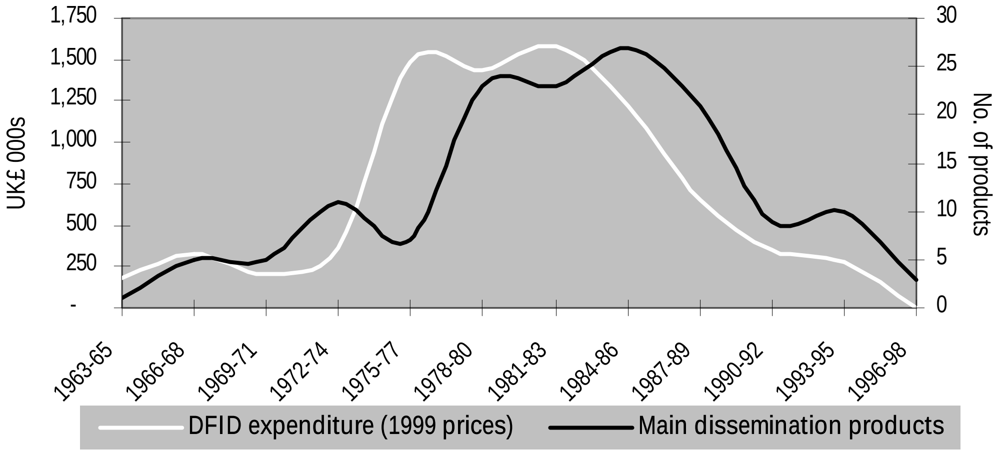
Sources: PROREC database (OFI); references included in publications

Notes: 1 – excludes project reports, includes chapters in books *etc*.
2 – incomplete records expected; includes references to publications for which details could not be located

Each project produced on average around seven major dissemination products (just over three journal articles). Figure 4.1 below compares DFID expenditure (see Section 4.3.1) and the flow of dissemination products over time. The graph suggests a strong relationship between expenditure and dissemination given a lag of around three years, which one might assume relates to the standard duration of research projects.

**Figure 4.1:** Expenditure & dissemination

(3 yearly grouped data)




## 4.2.2 Collection, distribution and assessment of tropical pines

### *Seed collection and distribution*

The collection and distribution of tropical pines seed for testing in recipient countries was of central importance in meeting the research's overall aim. This component delivered the new technology embodied in the seed of the species/provenances directly to collaborators where its potential could be assessed. It was implemented in two broad phases.

The first phase, from the early 1960s to the late 1970s, involved the collection and distribution of seed at a bulk provenance level for the establishment of trials to assess performance and in particular variation *between* provenances. Extensive collections were undertaken from previously untested and unexplored/inaccessible sites and distribution of this seed began in 1968 for the majority of the species of interest. Along with the seed, OFI provided advice on trial design and analysis to interested collaborators with the expectation that they in turn would submit results to OFI. By the mid-1970s, it was estimated that at least 160 separate but linked provenance trials of *P. caribaea* and *P. oocarpa* had been established in 33 countries (R2145).

During this period a number of other organisations were involved in the international programme. These included the Australian Forestry Research Institute and FAO, (who sponsored collections of *P. kesiya* from the Philippines and Zambia), Danida Forest Seed Centre (DFSC), and the Instituto Nacional de Investigaciones Forestales (INIF) in Mexico, (with whom OFI established a collaborative arrangement for the collection, distribution and testing of *P. oocarpa* provenances).

By the end of 1979, eleven years after the start of seed distribution, OFI had sent nearly 340 kg of seed or almost 60% (by weight) of all tropical pine seed distributed by the programme. *P. caribaea* var. *hondurensis*, *P. oocarpa, P. caribaea* var. *bahamensis* and *P. tecunumanii*[1] accounted for 94% of the distributions up to 1979, reflecting seed availability and conditions/ interest in recipient countries.

The second phase of this programme began in the late 1970s/early 1980s and involved repeat collections, managed at a family-level (i.e. individual trees), from among the best provenances identified. The impetus for this was provided by co-ordinated trial assessments undertaken by OFI in the early 1970s (see below) which indicated, (in conjunction with the results of biochemical analysis), a high degree of variation *within* provenances. The family-level seed was distributed for the establishment of combined provenance/progeny trials. The objectives of these trials were to: (a) to identify the most useful provenances under local conditions, (b) assess variation *within* provenances to aid in the identification of genetic parameters for the purposes of further improvement, and (c) provide material for the selection of individual trees in order to construct breeding populations. By combining testing and improvement objectives, the trial design was considered advantageous on both flexibility and time-saving grounds. Distribution of family-level seed of *P. caribaea* var. *hondurensis*, *P. oocarpa* and *P. tecunumanii* began in 1981.

Following OFI's review of phase one *P. kesiya* trials and an associated recommendation from the IUFRO Conference in Zimbabwe (both in 1984), OFI and DFSC initiated a collaborative effort to collect and distribute family-level seed of *P. kesiya*. By 1988 collections were complete and during 1989-93, seed of 42 provenances were distributed to 20 institutions in 19 countries.

Family-level collections of *P. caribaea* var. *bahamensis* were undertaken during a specific DFID-funded project in 1988 (R4437). This was prompted in part by an OFI study into its genetic and seed production characteristics (funded by FAO) and in part by the growing interest in this variety given its growth potential in certain locations and its immunity to pine shoot moth attack, (a significant problem in south-east Asia). Distribution of this seed began in 1989.

Many of the countries that received seed under the programme had never before tested the species while for those that had, the seed provided by DFID/OFI can be considered materially better given the genetic diversity provided and the sampling, collection and recording procedures employed. Prior to the research, there was only limited familiarity with these species and obtaining quality seed from known provenances was virtually impossible. By the end of the DFID/OFI programme, a total of 102 countries had received seed of one or more of the species and over two hundred provenances of these species are now available for distribution from Alice Holt research station in the UK (see Table 4.2 below).

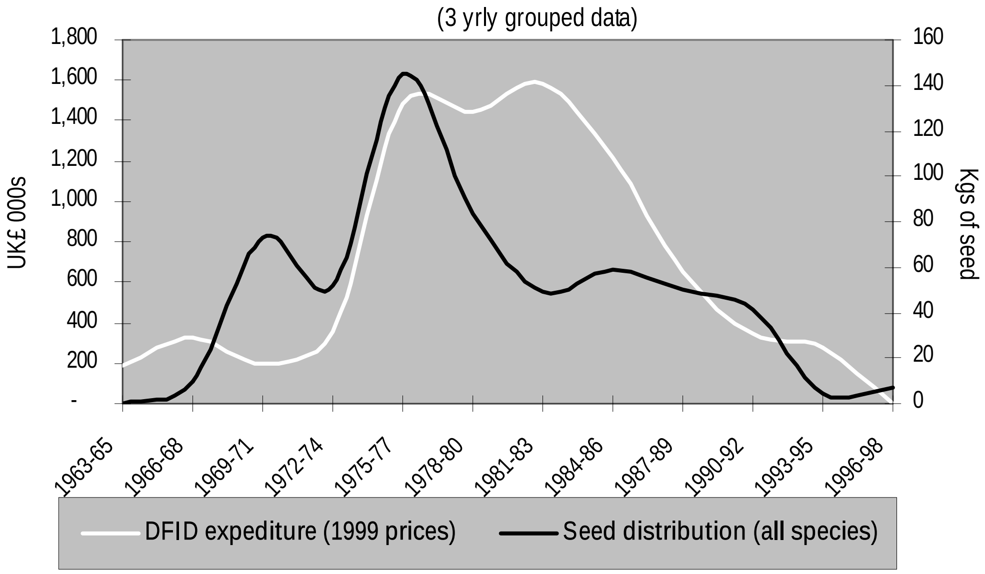
Figure 4.2 below compares real DFID expenditure (see section 4.3.1) with seed distribution over time. In contrast to dissemination, the figure suggests that seed distribution peaked just as the main expenditure on research began, (nearly two-thirds of all distributions had occurred by 1980). This is unsurprising given the role of the international trials programme in driving subsequent research and the lags associated with provenance and provenance/progeny trials (up to eight years in the first instance).

[1] During this period *P. tecunumanii* was distributed as *P. oocarpa.*

**Table 4.2:** Summary of tropical pine seed distribution (1963-98)

| | No. of countries | Kilograms of seed distributed | | | | | | | Provenances stored (1998) |
|---|---|---|---|---|---|---|---|---|---|
| | | *Africa* | *Asia* | *Lat Am & Car* | *Aus & Pacific* | *Eur & N Am* | ***Total*** | *%* | |
| *P. caribaea* var. *hondurensis* | 87 | 45.6 | 45.5 | 41.6 | 43.0 | 42.0 | 217.6 | *38%* | 51 |
| *P. oocarpa* | 74 | 49.6 | 20.6 | 34.0 | 6.4 | 11.4 | 122.0 | *21%* | 84 |
| *P. caribaea* var. *bahamensis* | 79 | 23.8 | 28.6 | 19.2 | 14.7 | 6.8 | 93.0 | *16%* | 26 |
| *P. tecunumanii*[1] | 80 | 28.5 | 15.9 | 15.6 | 6.2 | 15.6 | 81.9 | *14%* | 27 |
| *P. maximinoi*[2] | 37 | 7.7 | 8.7 | 6.7 | 0.5 | 4.2 | 27.8 | *5%* | 16 |
| *P. kesiya* | 26 | 3.1 | 1.0 | 2.0 | 0.4 | 15.9 | 22.4 | *4%* | 4 |
| *P. caribaea* var. *caribaea* | 51 | 1.0 | 1.8 | 2.0 | 0.7 | 1.1 | 6.6 | *1%* | 8 |
| *P. merkusii* | 19 | 2.1 | 0.6 | 0.2 | 1.1 | 0.4 | 4.5 | *1%* | 9 |
| ***Total*** | 102 | 161.4 | 122.8 | 121.2 | 72.9 | 97.4 | 575.7 | | 225 |
| *%* | | *28%* | *21%* | *21%* | *13%* | *17%* | | | |

**Figure 4.2:** Expenditure and seed distribution




## *Species/provenance assessment*

From the outset of the programme, the main responsibility for trial assessment lay with seed recipients. It was intended that these organisations would evaluate species/provenance performance under local conditions while OFI adopted a co-ordinating role in terms of seed distribution and aggregation of the results obtained from individual trials. Although OFI visited a number of trials during the course of the programme, in practice, the majority of seed recipients did not actively collaborate in the exchange of information.

As a result of this and given its role, OFI undertook a number of co-ordinated assessments of the provenance and provenance/progeny trials established under the programme. In practice, the number of trials included in these assessments was limited by the lack of information about the majority of (potential) trials and the resources available for assessment. In addition, of those for which information existed, many were found to be unsuitable because of damage (e.g. fire, typhoon, insect attack) or because they had been planted using an inappropriate design.

During the late 1970s and early 1980s OFI undertook co-ordinated assessments of 16 *P. caribaea*[1] and 13 *P. oocarpa*/*P. tecunumanii*[2] provenance trials in a total of 13 countries[3] (projects R3251 and R3644). These same trials were re-examined during 1987-90 (R4347) using more complex statistical analysis and including information that had been obtained subsequently. Local collaborators' failure to formally publish trial results in part prompted this later exercise. A consolidated report detailing and comparing results across the trials was produced. During the same period, four of these provenance trials were assessed for volume, seed production and pulp yield and quality by OFI under a separate project (R4346).

In 1984, OFI also reviewed the performance of *P. merkusii* and *P. kesiya* provenance trials. In the case of the former, low germination and poor survival rates resulting largely from inadequate seed storage and the lack of the correct mycorrhizal inoculation meant that there were too few trials for a detailed co-ordinated assessment (Pottinger, 1993). At the same time, collaborators expressed only limited interest in the species and second phase family-level collections of *P. merkusii* were not proposed. For *P. kesiya,* the OFI review concluded that there was insufficient coverage to warrant a programme of international assessment and recommended available resources be devoted to the collection of family-level seed of the most promising provenances for provenance/progeny testing. DFSC is currently undertaking a co-ordinated assessment of some 17 trials that resulted. OFI's direct involvement in this activity has been limited due to changing research priorities and resource constraints, though final results will be published jointly by DFSC, OFI and the collaborating countries (pers. com. Christian Hansen, DFSC).

Under project R4346, co-ordinated assessments of second phase, provenance/progeny trials of *P. caribaea* var. *hondurensis* (12 trials in 9 countries) and *P. oocarpa*/*P. tecunumanii* (10 trials in 8 countries) were undertaken (1987-90). In addition, a preliminary assessment of the first five "pure" *P. tecunumanii* provenance/progeny trials in Zimbabwe (established between 1983-86) was also made. Finally, the same project assessed seven phase one *P. maximinoi* provenance trials (in two countries). Family-level collections of *P. maximinoi* were not undertaken.

In spite of problems regarding collaboration by the majority of seed recipients and trial design/ maintenance, the DFID/OFI co-ordinated assessments produced a wide range of results,

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[1] Number of provenances represented was as follows: *P. caribaea* var. *hondurensis* (17); *P. caribaea* var. *caribaea* (7); and *P. caribaea* var. *bahamensis* (1).
[2] Number of provenances represented was as follows: *P. oocarpa* (20); *P. tecunumanii* (4).
[3] The planned evaluation of provenance trials established under the collaborative INIF/OFI programme for *P. oocarpa* did not occur.

providing guidelines on the suitability of particular provenances for different environments and highlighting substantial variation in performance between species/provenances. In particular, it demonstrated that the Mountain Pine Ridge provenance of *P. caribaea* var. *hondurensis*, (the only source in many countries for plantation development of this species), was not potentially the most productive provenance.

While the co-ordinated assessments focused largely on physical traits (e.g. volume, stem form, branching, bark thinness), the DFID/OFI programme also included substantial research into the wood properties of the tropical pines. This work was closely linked with the trials programme given the importance of factors such as wood density, fibre-length, and so on (as well as physical traits) in determining the suitability of a particular species/provenance for industrial use.

The collection and analysis of wood samples was included as a component of the provenance research from the early 1960s, though it was not until the mid-1970s that wood properties research became "projectised". Initially, this focused on the wood density and pulping properties of species, particularly *P. caribaea* and *P. oocarpa*. However, the programme of international provenance trials provided the opportunity to examine in greater detail variation in wood properties between provenances and sites and to explore the possibility of improvement through selection and breeding. From 1976-87, DFID funded three consecutive projects specifically to examine wood properties (R3157, R3642 and R3882) and a further one during 1990-93 (R4619). The research generated results on a wide range of characteristics (e.g. wood density, fibre-length, shrinkage and strength) on a species, provenance and site basis.

### *Other outputs of the trial programme*

In addition to the seed distributed and the results of trial/wood properties assessments disseminated, the DFID/OFI programme developed/improved a number of method and techniques in the course of the research. Seed collection methods were rationalised and new standards in provenance sampling established. Trial design and analysis techniques were improved and databases developed for the maintenance of trial and genetic data. A method to predict whole-tree density from juvenile breast cores was established that was considered a significant development in densitometry research, reducing the need to (and costs of) felling whole trees in trials. OFI also tested a tool for rapid determination of wood density in the field (PILODYN) and recommended improvements to the manufacturer. Finally, in collaboration with the Tropical Development and Research Institute[1], OFI developed a non-destructive micro-pulping technique that could facilitate assessment of pulping characteristics of individual trees without analysing whole trees in the laboratory.

### *Characterising the benefits of research into the utilisation of tropical pines*

Notwithstanding the potential benefits from "other" outputs of the trials programme, it is reasonable to argue that the ultimate objective this component (indeed, all components) was to contribute to the utilisation of the tropical pine species. Realisation of this objective was intended to generate economic benefit in the form of efficiency gains provided by the new technology. This section examines the type of benefits that might be expected to result and considers the challenges posed for economic analysis.

[1] Subsequently part of the Natural Resources Institute.

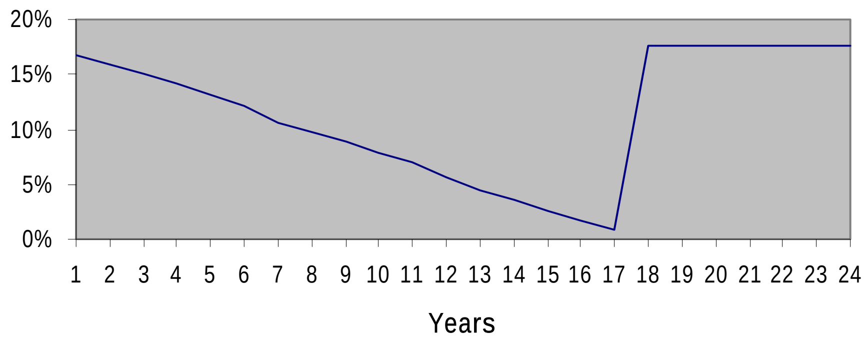
Let us assume that as a result of research the decision is taken to plant a particular provenance commercially. Broadly, there are two (non-exclusive) ways in which this may be implemented: (a) commercial quantities of seed of the particular provenance are obtained directly from native stands, (b) the trials established locally are converted into orchards to produce the necessary seed. The latter implies a longer lag between research results and implementation, though it may be cheaper and allows a degree of selection to increase local suitability of the germplasm.

Commercial plantings suggest two further possible scenarios (again, non-exclusive): the research-related material either replaces an existing species/provenance, or permits the expansion of commercial activities to previously unplanted areas. In the case of the former, the gains (net of production costs) are incremental (i.e. the additional advantage conferred by the new germplasm compared with the species/provenance it replaces). Any changes in production costs associated with the change of germplasm would have to be factored in. For the latter, the extent of benefits will depend on whether the expansion of planted area would have occurred in the absence of the new germplasm. If the answer is no, net benefits may be considered additional (allowing for the opportunity cost of the new land utilised). If the answer is yes, then the benefits can be considered incremental, as discussed above. However, the analysis may be more complicated in this case given potentially greater difficulties in estimating which species/provenance *would have been* planted and what gains *would have been* achieved in the absence of research.

In either scenario, output can be expected to increase. For *ex post* analysis, industrial production data can, in principle, be assessed econometrically to determine the research-induced supply shift. If *ex ante* analysis is being undertaken, estimates of research-induced yield gains/additional production can be used to predict this shift, though care is required in assuming a one-to-one mapping between these gains and supply effects at the industry level (see section 3.3.2). However, for a number of reasons, assessment of "simple" utilisation gains may be less straightforward in practice.

First, while it may be possible to predict research-induced gains based on measurement of growing stands, such gains are only fully realised at final harvest. Assessment of final harvest data, however, is complicated by the fact that trees embody both capital and product and, therefore, plantation managers can choose *when* to harvest. The simplest example helps illustrate this point. A more productive species/provenance is introduced over time on an existing plantation, managed on a 20-year rotation. The new material is managed to produce the same yield ($m^3$/ha) but in a shorter time (17 years). Assuming equal-sized annual blocks, linear growth curves and a constant volume gain across all blocks (of c. 17.5%), the effect on production is presented in Figure 4.3.

**Figure 4.3:** % change in production - new germplasm managed on a shorter rotation



The above graph implies that an immediate gain is realised, which gradually declines to almost zero in year 17. However, the production effect during years 1-17 is solely the result of felling a larger area of the existing stands each year in preparation for the new shorter-rotation provenance. Under the assumptions already mentioned, this could be achieved in the absence of the new germplasm. The *real* effect of the new material is only observed from year 18 onwards as it is harvested.

In reality, many factors such as uneven block sizes, variation in site quality between blocks, non-linear growth curves and the relationship between rotation length and the quality of final roundwood make predicting this graph difficult. More generally, while a “standard” rotation for a softwood sawlog-pulpwood plantation in the tropics may be 18-25 years, in practice this varies from 12-40 years as a result of uneven age classes, variation in market conditions and strategic management decisions.

In most branches of economics, the relationship between output (or yield) and inputs represents a purely physical relationship, i.e. no behavioural assumptions or choice problems intrude. However, when the harvest decision in endogenous, the producer is actually making a decision about what output/ha should be. The forester is looking for a profit maximum, not a yield maximum. The estimated relationships derived from an econometric analysis that regresses yield on inputs and lagged R&D (i.e. a measure of partial productivity) can no longer be interpreted as pure productivity effects. This will probably be true of TFP models as well.

Furthermore, in the example discussed above (i.e. same output/ha, shorter rotation), partial productivity (yield) models will not pick up research-induced effects at all, because yield is the same as before. Dual models may be more appropriate under these circumstances, since they incorporate behavioural realities fully. However, the appropriate model will necessarily be complex in order to capture the complicated dynamics at work.

Second, a particular species/provenance identified by research may be selected, not for its (direct) yield enhancing effects, but for (indirect) loss-avoiding characteristics. The DFID/OFI research programme demonstrated loss avoiding characteristics of the tropical pines for a number of factors, including pest resistance (e.g. immunity of *P. caribaea* var. *bahamensis* to the pine shoot moth), wind firmness (e.g. *P. caribaea* var. *caribaea* and coastal provenances of *P. caribaea* var. *hondurensis*), and drought tolerance (e.g. *P. kesiya* in southern Africa). While, “loss-avoiding” germplasm is unlikely to be planted if it performs significantly worse in an “average” year than existing material, the full benefits will be observed only during periods of stress.

For example, as a result of the DFID/OFI programme and subsequent direct collaboration with OFI, a proportion of the area planted to *P. elliottii* in Sappi’s Usutu plantation (Swaziland) will be replaced with *P. kesiya*. Discussions with researchers at Sappi suggest that drought-related problems can be expected to arise, on average, twice during a rotation (approximately 18 years), however, estimates of the magnitude of the effect on output were not available. Because of site- and species-specificity, simple comparisons between the performance of *P. kesiya* in Usutu and other species planted on the estate are not possible. Quantification of the loss-avoiding gains of *P. kesiya* inevitably depends on the availability of a “control” (e.g. during the transition period when stands of *P. elliottii* targeted for replacement still existed) and/or historical data of sufficient quality to permit realistic comparisons between one period of stress with another at the same site. Further, in this case reliable estimates of the future frequency and severity of drought would also be required.

For econometric evaluation, the main problem is data related. Assuming a properly specified theoretical model exists on which to base the econometric analysis, one would need sufficient occurrences of the losses, in order for the econometric model to pick up loss avoiding gains. Assuming a drought occurs twice in 18 years, for example, the model might require three rotations with droughts (54 years) and also a few rotations when the new species has been introduced, and drought has occurred, but the new species has withstood them.

Third, any analysis is complicated by the fact that industrial roundwood is, in reality, an intermediate good, used subsequently in processing. DFID/OFI research results suggest that the utilisation of the tropical pines may generate gains that are more qualitative than simple volume increases at a forest level. Such gains may only be realised during and post processing and, as such, relatively simple analyses at the forest-level may fail to capture these effects. Stem straightness, branching characteristics and properties such as wood density, fibre tearing strength, resin content and so on, provide examples of factors that can result in gains in terms of (i) an increase in the "effective" roundwood yield; (ii) improved processing efficiency; and (iii) improved quality of the final good. These are considered separately below.

(i) "Effective" yield gains: Higher wood density may not affect the roundwood *volume* but can increase the effective yield of a plantation in terms of the final woodpulp yield. This type of benefit may be observable at the forest-level if plantation inventories or mill conversion rates are adjusted to reflect differences between species/provenances. Alternatively, where a competitive market for plantation roundwood exists, such characteristics may be reflected in a price premium. However, in many countries domestic roundwood markets may be small or non-existent because of the degree of vertical integration within the wood products industry. Similarly, where publicly-owned plantations account for a sizeable proportion of production, prices may be artificially low as a result of government pricing policies. This latter criticism has been levelled at South Africa, among others, in the past[1].

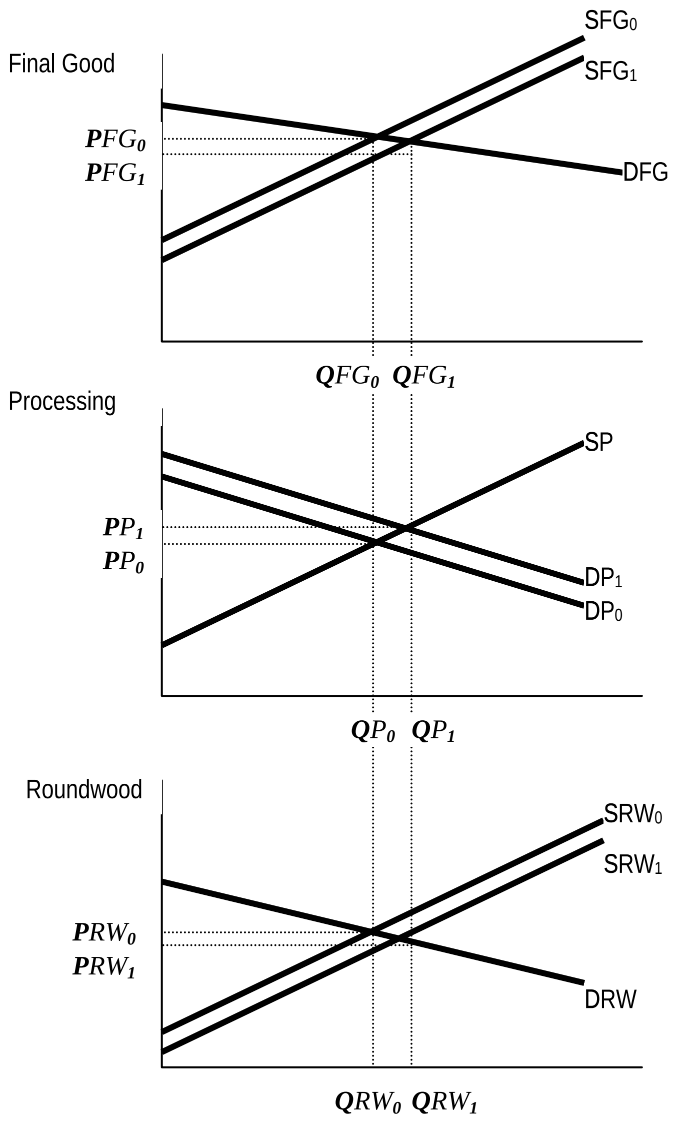
It may, therefore, be necessary to include the processing and final good stages in the analysis. Such a multi-stage approach is presented in Figure 4.4 (below) within a supply and demand framework. The example, adapted directly from Alston *et al* (1995), presents the simplest case, where two inputs – roundwood and a processing "input" – are used in fixed proportions to produce a single homogenous final good, the quality of which is unaffected.

The supply curve for the final good ($SFG_0$) is determined by vertically summing the underlying factor supply functions (SP and $SRW_0$). The demand for roundwood (DRW) is derived from the vertical distance between the demand for the final good (DFG) and the supply of processing inputs (SP). Similarly, the demand for processing inputs ($DP_0$) is derived from the vertical distance between the final good demand (DFG) and the supply of roundwood ($SRW_0$).

Under the assumption of fixed factor proportions/parallel shift, a research-induced shift in the supply of roundwood to $SRW_1$ causes a shift in the supply of the final good to $SFG_1$ (by the same absolute amount per unit) and a shift in the demand for processing inputs to $DP_1$ (again by the same absolute amount per unit). All quantities increase, in proportion, to $\boldsymbol{QFG_1}$, $\boldsymbol{QP_1}$ and $\boldsymbol{QRW_1}$. The final good and roundwood prices fall (to $\boldsymbol{PFG_1}$ and $\boldsymbol{PRW_1}$ respectively) while

[1] Indeed, from July 1993 to April 1998, the South African Forestry Company Ltd (who took over management of public industrial plantations in 1993) more than doubled nominal average log prices for its long term customers (approximately a 50% increase in real terms).

Figure 4.4: Basic multi-stage production model




the price of processing inputs rises (to ***PP**$_1$*). Under these conditions the welfare effects of research can be measured at any of the stages within the model, though the definition of "producers" and "consumers" will differ according to the stage examined.

Adopting a multi-stage approach from the outset has two potential advantages. First, it emphasises the importance of demand in determining research-induced quantity/price effects (and consequent economic gains) and the fact that this demand is in reality *derived* from the final good demand and the cost (supply) of "processing" inputs. Second, it explicitly recognises the importance of the processing stage in turning "potential" gains achieved at the forest-level into actual gains at the final good level[1]. It could be argued that processing losses would exist in the absence of better genetic material, but the type and extent of these inefficiencies are

[1] Indeed, the same caveat can be made with respect to the quality of forest management inputs applied during the course of a rotation.

likely to vary between countries and in practice the margin of gain provided by new genetic material is unlikely to be constant. The drawback of adopting a multi-stage model, of course, is the increase in data required. For example, even when the roundwood supply shift is estimated non-econometrically, use of the above model requires additional information regarding prices, quantities and elasticity estimates at the processing and final good levels in comparison with the basic economic surplus model (see Figure 3.1).

(ii) Improved processing efficiency: New germplasm that provides, for example, improved stem form may also lead to efficiency gains in processing (e.g. easier log handling), without affecting the quality of the final good. This again implies the need to consider the processing/final good stages in the analysis. However, assessing the impact of an improvement that effectively reduces the amount of processing inputs required per unit of roundwood and final good is more complex. This is particularly so if the “fixed proportions” assumption applied earlier is relaxed to permit substitution between inputs in the production of the final good. For non-econometric estimation, the Muth model (see Alston *et al*, 1995) provides a framework to conduct this analysis. However, the approach is significantly more demanding in terms of the skills and data required and, unsurprisingly, it does not appear to have been applied in the evaluation of forestry research.

(iii) Improved quality of the final good: Alternatively, the introduction of new genetic material may lead to improvements in the quality of the final good, e.g. sawntimber with greater strength properties. In the forest products sector, improvements in certain characteristics might result in the product attaining a higher “grade” (and hence, market price). However, if research-induced improvements in final good quality are considered significant but existing markets are not differentiated along the characteristic(s) of interest, then none of the approaches discussed thus far may be appropriate.

Quality improvements have proved difficult to assess in conventional economic evaluation regardless of the field of research. For example, econometric analyses based on production function, partial or TFP models cannot capture quality effects. The standard approach has been to model the change from the demand side, as a shift in demand for the improved final good[1] (a price premium) but this is only justifiable under very restrictive assumptions. The focus on the demand side is for convenience; in reality, it is supply that is affected, but assessing the substitution effects between improved and unimproved final goods in consumption and production is extremely difficult. Consequently, it may be necessary to model different qualities as different “products” and employ a multi-product, general equilibrium approach (in contrast to the single product partial equilibrium models discussed above)[2]. Such an approach, however, is not common in research evaluation generally; complexity and data availability issues suggest the impracticality of such an approach in the context of FRP.

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[1] An econometric analysis might involve demand function estimation combined with use of the economic surplus approach.

[2] Although not discussed here, the same argument holds where research-induced change in the market for one product (e.g. sawntimber) affects the market (and in particular the price) of another good (e.g. woodpulp) as a result of linkages between the products in production (i.e. joint and substitute products).

### 4.2.3 Tree improvement

The research programme's interest in tree improvement progressed naturally from the international trials programme, given the role of breeding in converting the potential demonstrated by trials into consistent gains at an operational level. The presence on the OFI team of a leading pine breeder further contributed to this development. The activities pursued under this component can be broadly divided into three elements: distribution of family-level seed of tropical pines; specific activities designed to promote tree improvement activities; and development of a tree improvement strategy. These are considered separately below, though it is important to bear in mind that these elements were pursued simultaneously with considerable cross-linkages.

*Distribution of family-level seed*

As already discussed, the second phase, provenance/progeny trials were designed to aid in the identification of genetic parameters for the purposes of further improvement by local collaborators. The distribution of family-level seed was intended to enable local collaborators to select individual trees from these trials for the construction of breeding populations. In addition, the availability of family-level seed enabled OFI to distribute seed specifically for the establishment of seed orchards for use by local improvement programmes, though in practice the numbers of requests for seed for this purpose were limited.

Doubts over the success of the provenance/progeny trials in meeting tree improvement objectives, however, were raised by the co-ordinated assessments undertaken by OFI (see section 4.2.2.) in the late 1980s. Project R4346 concluded that while the results of these trials allowed estimation of mean provenance performance across a range of criteria, in the majority of cases there were too few families represented per provenance to provide reliable heritability estimates on an individual provenance basis. Similarly, the numbers of families were considered insufficient for a breeding programme. Consequently, while retention of family identities in the trial design was expected to reduce the risk of in-breeding for any subsequent improvement activities, the gains achievable through selection from the trials were not expected to be higher than if made at the provenance level only. As a corollary, the project concluded that inclusion of the required number of families would significantly increase the scale, complexity and cost of the trials, and recommended more rigorous initial screening to reduce the numbers of provenances subsequently tested using the provenance/ progeny trial design[1].

*Specific tree improvement activities*

During 1981-87, DFID funded two projects (R3644 and R3881) to examine *inter alia* the relative influence of genetics and environment in the control of variation within the tropical pines and the appropriate genetic composition for breeding populations given the likely environments where tropical pines would be planted. Based on this information, the DFID/OFI programme was to develop appropriate breeding strategies at national and international levels. During the course of these projects, DFID/OFI research provided significant input into the tree

[1] A further project (R4725) was undertaken from 1991 to 1995 to examine *inter alia* the reliability/limitations of the combined provenance/progeny test. It was concluded that without careful planning and control there was, in practice, a risk that none of the multiple objectives would be adequately met. The project concluded that if genetic characteristics represented recipients' main interes, then this particular trial design should not be used.

improvement programmes in Zimbabwe, Swaziland, RSA and Fiji. Collaborative/advisory contacts were also established with improvement programmes in Honduras, Brazil, Nicaragua and Mexico.

The rationale for greater international co-operation came from the fact that, while trials had identified the most promising provenances, no one collaborator had sufficient material of a given provenance to conduct local breeding efforts. Significant numbers of superior trees had been distributed throughout the tropics and it was intended that this material should be made available, via regional centres, to national improvement programmes for the development of breeding populations. Attention was given to the selection, conservation and utilisation of the most promising material identified in the early provenance trials.

DFID/OFI activities in this area were further supported by other two other organisations. Under the guidance of project R3881, Shell Petroleum Co. funded OFI to implement a pine scion distribution programme[1]. From 1986, the most promising material from over 200 plus trees included in the provenance trials began to be collected for assembly in regional breeding populations. This led eventually to the establishment of three clone banks, in Australia, Zimbabwe and Brazil. The exact status of the clone banks is unknown to this study, though Zimbabwe appears to have effectively abandoned its bank due to practical/financial problems.

In the mid-1980s, OFI also received support from the European Union to undertake seed collections throughout Central America and Mexico. The objective was to create *ex situ* breeding populations within the host countries and in Zimbabwe, with a view to arranging distribution throughout tropical world at a later date.

In practice, an international, co-ordinated plant breeding programme for the tropical pines did not develop to a significant extent, and efforts focused largely on the national level with a limited number of collaborators. This result, in part, reflected both the relatively small number of seed recipients that operated active breeding programmes and also historical/personal ties between DFID/OFI and the countries concerned.

### *Development of a tree improvement strategy*

The development of breeding strategies, primarily for *P. caribaea* and *P. oocarpa*, was included as a subsidiary objective under R3251 (1977-81). During this period, as a result of collaboration between the DFID/OFI programme and North Carolina State University (NCSU) the concept of the Multiple Population Breeding Strategy (MPBS) was first described (1979).

As a method, the MPBS can be applied to species beyond just tropical pines. Nevertheless, the DFID/OFI programme of research provided the vehicle for much of the development of the MPBS. During the 1980s, its practical application was refined in close collaboration with Zimbabwe Forestry Commission’s breeding programme. Similarly, its ability to incorporate a wide range of new germplasm has close links with DFID/OFI’s provenance collection and testing programme. In addition, it was considered inherently suitable for the international breeding efforts envisaged for the tropical pines.

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[1] The rationale for Shell’s involvement was the opportunity to access available genetic resources, though during the course of project, Shell discontinued its pine research programme and effectively lost interest in the outcome of the work.

In contrast to "classical" breeding programmes, the MPBS, and its central mechanism the breeding seed orchard (BSO), is a more flexible strategy that can yield tree improvement gains more quickly. It is capable of incorporating greater amounts of germplasm to both broaden the genetic base of existing commercial species and evaluate new species while at the same time providing safeguards against in-breeding and loss of variability. The strategy simplifies the process of pedigree control and enables breeding activities to be conducted at different levels of intensity in the face of changing market circumstances. The fact that BSOs can be planted on a number of sites to produce seed for specific regions also provides the opportunity to capture genotype-environment interaction within species if considered important.

*Characterising the benefits of research into the improvement of tropical pines*

The challenges posed for evaluation by the nature of benefits arising from utilisation (see Section 4.2.2) apply equally to subsequent improvement activities. However, in addition to these, further issues are raised. First, assessing the gains from tree improvement programmes is in principle possible but in practice difficult. Indeed, OFI visited Queensland in 1991 to observe what was, at that time, one of the most advanced pine breeding programmes in the world and concluded that quantitative estimates of gains achieved were not available. The lags associated with breeding activities and commercial rotations, even for relatively fast-growing species, compound the difficulties and raise both data and statistical problems for econometric analyses. On the other hand, *ex ante* analyses, applying simple estimates of potential gains, are more flexible but may not be reliable given that the *realisation* of benefits from any breeding programme depends heavily on the quality of nursery, establishment and other silvicultural practices.

Second, while the problem of attributing benefits between DFID/OFI and local collaborators exists in the case of utilisation gains, it is magnified where local tree improvement activities add further value to germplasm identified through DFID/OFI research. It can be argued that DFID/OFI-supplied germplasm provides a "foundation" for these subsequent gains but at the same time the realisation of such gains involves significantly greater input (costs and skills) on the part of local collaborators compared with initial utilisation gains. Econometric techniques have been used to assess the contributions of basic and applied research to utilisation gains in agriculture (see Appendix 3.1), but the timeframe of tree improvement activities and the nature of the relationship between the DFID/OFI-supplied material and subsequent improvement efforts undertaken locally suggest that such techniques would not be easily applied in this case.

For non-econometric estimation, the key question is what would have happened in the absence of research. Where the scope of research is limited (i.e. a few species with only one or two collaborators), it might be feasible to "model" the without-research situation by estimating future gains that would have been possible using the material that was in fact replaced by the new species/provenance. However, given the multi-country scope of the DFID/OFI programme, such an approach is unlikely to be practicable.

Furthermore for a given country, it may be less that the species/provenance would have been unavailable in the absence of the DFID/OFI programme but rather that the availability would have been significantly delayed. If actual net gains arising from local improvement efforts can be estimated, the discounted benefits may be compared with the same gains (again discounted) lagged by the estimated period of delay in order to arrive at a simple estimate of the value of the research. However, such an approach is at best approximate. A further drawback is that as the analysis moves from a single country to the DFID/OFI programme in aggregate, without-research assumptions regarding (delayed) availability become more difficult to sustain. Alternatively, gains may be apportioned on the basis of costs, though again such an approach provides only an approximation. In short, where contributions of different research efforts cannot be isolated econometrically, subjective judgement is required.

Third, further complexity may be encountered if DFID/OFI germplasm is not used in its own right but enters local tree improvement programmes with the aim of broadening the genetic base of an existing species. In addition to the problem of attributing benefit between research organisations, evaluation must attribute benefit between DFID/OFI-supplied and locally available genes. This is not an unlikely scenario. While many countries would not have had access to tropical pine seed during the 1970s (even less, access to seed from reliable collections), a number of countries where pine utilisation was more advanced did indeed have populations of certain tropical pines prior to DFID/OFI seed distributions[1].

A simple approach would be to allocate improvement gains according to the origin of parental material. CIMMYT used this convention in an extensive evaluation of its wheat breeding programme (Byerlee & Moya, 1993). However, in the case of tree breeding, male parentage may be uncertain unless full pedigree is maintained and controlled-crossing techniques used. These are expensive, intensive and are not characteristic of the majority of pine improvement efforts in developing countries. Furthermore, even if use of DFID/OFI-supplied germplasm can be established, for example as one parent in a pine hybridisation programme, a 50:50 division of gains between the two parents again provides only an approximation. In reality, attribution of gains will depend on the characteristics that each parent contributes to the hybrid.

Beyond the general challenges posed by tree improvement research, the benefits associated with the MPBS in particular raise further issues. First, precisely because the MPBS is a flexible strategy, with wide potential application in a number of forms, it poses difficulties when attempting to define uptake/adoption and the gains obtained in each case.

Second, the MPBS cannot easily be equated with a new uniform production technology that achieves the same objective as alternative methods more efficiently. Of course, all breeding programmes in the long term seek to achieve productive gains. However, in reality, the MPBS is a *management strategy* and its applicability (over alternative strategies) will depend on the objectives of management. The additional gains conferred by the MPBS, therefore, will depend on the appropriateness of management objectives as well as on local conditions, (e.g. the importance of genotype-environment interactions, favourable conditions for seed production, and so on).

In order to clarify these points, the discussion here pre-empts section 4.3 and considers the issues in the light of actual experiences. The interplay between management objectives and local conditions suggest that the advantages of the MPBS are likely to be case specific and, unsurprisingly, interviews with key informants during the cases study resulted in little consensus regarding the advantages. The importance of the relationship between management objectives on the one hand and use of the MPBS on the other is illustrated by experiences in Zimbabwe. (Box 4.1).

[1] For example: the first recorded exports of *P. caribaea* seed to South Africa were in 1927 while the first recorded stand established in Queensland was in 1930 (Dieter and Nikles, 1997). *P. caribaea* var. *hondurensis* was first planted in Fiji in 1955 (Barnes, 1991). Breeding of tropical and sub-tropical pines in Zimbabwe began in 1958 (Issac Nyoka, pers. com.). Species trials for a number of the tropical pines began in Brazil in the 1960s (J.Wright, pers. com.).

**Box 4.1: Summary experiences with the MPBS in Zimbabwe**

Prior to 1981 the Forest Research Centre of Zimbabwe operated a "classical" breeding strategy for the limited number of species and provenances included in the programme. In 1981, it was decided to broaden the range of material tested for existing industrial species and increase the number of species in the programme. These "new" species included some that, even then, were thought to have only limited commercial prospects as pure stands (e.g. *P. caribaea* and *P. merkusii*).

While the original strategy had been sound and cost-effective given the previous objectives, it was considered incapable of dealing with the expansion of the programme given likely practical constraints (e.g. how to incorporate different provenances, families and generations of particular species) and biological constraints (e.g. in-breeding). At that time, financial constraints were not significant. Thus, it was the decision to expand the programme that necessitated the change in strategy. The MPBS was adopted in 1981 and applied to all the species in the breeding programme, with each species having populations that varied from one to as many as 14.

Was this a sensible decision? The view in Zimbabwe is "Yes and No". The added value was in the strategy's ability to accommodate a greater range of germplasm. Thus, the genetic base from which existing (industrial) species could be improved was broadened and the potential of new species was evaluated. That is not to say that a classical approach would have precluded the testing of new species, such as *P. tecunumanii* or *P. maximinoi*. However, within-species assessment would have been less efficient and the introduction of new species might have been at the expense of others of interest. Undoubtedly, the MPBS resulted in the selection of trees for advancement that would not have been tested in its absence. In practice, however, the actual number of additional trees may have been relatively small (e.g. three or four) and isolating the contribution of these in the long-term is difficult.

On the other hand, the expansion of the range of species brought its own problems in terms of higher costs and greater management requirements. Had Zimbabwe restricted the range of species tested, it is felt that the MPBS would not have necessarily provided much in the way of additional advantage.

Thus, any evaluation of the MPBS in Zimbabwe would have to: (a) identify the gains of tree improvement activities; (b) identify the additional benefit provided by the MPBS, given the stated management objectives; and, more fundamentally, (c) consider the appropriateness of these objectives. For example, the question may be posed whether the range of species and, consequently, the scale of the breeding programme were necessary for a relatively small plantation estate.

It is generally held that the MPBS provides first generation gains faster than classical approaches because the strategy combines the activities of testing, cleaning and establishment of a seed orchard. Whether this advantage continues in the longer term or is considered to outweigh the gains offered at a later stage by alternative approaches is debatable in each case. For example, in 1997, CSIR (South Africa) compared the MPBS/BSO approach with a conventional breeding strategy for the South African Forestry Company Ltd. (SAFCOL), who was at that time reviewing its breeding strategy for *P. patula*. While the analysis recognised that there were a number of intermediate options between the examples modelled, it predicted a 10% gain from the BSOs within 10 years and a 25% gain after 13 years using the conventional strategy. The key point here is that a simple estimate of the incremental gains achieved by the MPBS cannot be reliably applied across different tree improvement programmes. Instead, analysis should proceed on a case-by-case basis though time and resources precluded detailed assessment by the case study of MPBS uptake world-wide. The information provided by a limited number of examples set out below, however, serves to highlight both the level of interest in the MPBS and the variety of actual experiences:

*Zimbabwe*: The MPBS was introduced in 1981 and received significant input from the OFI research during the 1980s. By the early 1990s it was recognised that the breeding programme had become too large to be efficiently implemented in a climate of steadily declining funds. As a result, in 1994, the breeding strategy was revised and the number of species included in the programme reduced. Although these changes were significant, a modified form of the MPBS continues to be applied.

*RSA:* Sappi has adopted the MPBS and the Institute of Commercial Forestry Research (ICFR), of which Sappi is a member, also applies the strategy on a smaller scale. Sappi's breeding programme is relatively new and received advisory support initially from OFI (largely on a consultancy basis). SAFCOL and Mondi Forests have longer standing breeding programmes and have not adopted the MPBS. The main reasons for the mixed uptake of the MPBS appear to be differences between the level of development reached by the respective programmes and the end-product focus of each organisation, (pulpwood for SAPPI, sawlogs for SAFCOL and Mondi). Some of the factors that influenced SAFCOL's decision not to adopt the MPBS approach are presented in Box 4.2.

**Box 4.2: Factors affecting SAFCOL's decision not to adopt MPBS/BSO approach**

- In the longer term, BSOs were thought to offer lower genetic gains under equivalent scenarios, partly because this approach requires larger trials to obtain the same selection intensity

- Early selective thinning regimes in BSOs might give rise to problems:
  - ~ the effect of uneven competition is still unknown and is assumed to reduce the efficiency of selection;
  - ~ estimation of heritabilities and analysis of data collected after early thinning may be difficult or unreliable;
  - ~ uneven espacement following thinning would make assessment of tree form difficult, an important consideration when selecting for sawtimber but less so for pulpwood

- Flowering might be a problem in that good sites for seed set are not necessarily appropriate for the establishment of trials

- Although BSOs allow for selection for specific environments, a conventional breeding strategy is more appropriate if the aim is to produce "stable" genotypes which do relatively well on a broad range of sites

- The cost of maintaining multiple populations may be prohibitive

*Brazil*: It appears that eucalyptus improvement programmes in Brazil are making use of the MPBS, though OFI's direct involvement in promotion of this appears to have been fairly limited. For the tropical pine species, versions of the MPBS are currently being applied by Duraflora (*P. caribaea* var. *hondurensis* and *P. oocarpa*) and the Instituto de Pesquisas e Estudos Florestais (IPEF), Ripasa and Igaras (for *P. caribaea* var. *hondurensis* only). During the country visit undertaken for the case study, it was suggested that uptake of the MPBS would have been greater if contact with the DFID/OFI programme had been closer.

*Fiji*: The MPBS was introduced in 1981 as a result of an OFI advisory mission (under DFID technical co-operation support). However, severe cyclone damage in the mid-1980s restricted practical implementation of the strategy as efforts focused on emergency seed production rather than breeding. A return advisory visit by OFI in 1991 proposed re-introduction of the approach in preference to a more intensive breeding programme. It is understood, however, that Fiji's breeding efforts are in now in significant decline as a result of funding problems and loss of staff.

*CAMCORE*: The Central America and Mexico Coniferous Resources Co-operative has recently developed a co-operative, regionally-based MPBS for pine improvement efforts undertaken by its 21 active members (in 10 countries). The strategy will operate at different levels of intensity depending on members' interests/capacity. Use of an MPBS approach by CAMCORE would appear to vindicate OFI's belief in the suitability of the strategy for international programmes.

### 4.2.4 Taxonomic research

Prior to the DFID/OFI research, little was known about the characteristics, properties and natural ranges of the tropical pines. Misidentification of the species was common while a number of species had not been formally classified. Although undertaken simultaneously with provenance collections, taxonomic research played a fundamental role in supporting these activities. Taxonomic results guided provenance sampling activities and assisted in identifying the potential application of species. The natural distributions of the tropical pines were mapped in detail and consequently a number of outlying populations were discovered from which collections were made. While a number of participating countries already had access to some of the tropical pine species prior to the research, in many of these cases the material available had been sourced from a very narrow genetic range. In comparison, the extent of genetic diversity provided by the DFID/OFI research for particular species was a key characteristic of the work, and significant given the degree of variation exhibited between provenances.

In the course of the taxonomic research, two species were identified and described: *P. praetermissa,* a minor species in commercial terms, and *P. tecunumanii,* for which industrial interest now exists. Until the late 1970s/early 1980s, the latter was confused with *P. oocarpa* and distributed as such by OFI. The results of the early provenance trials, however, clearly demonstrated that a few *P. oocarpa* provenances performed significantly better on all sites. Morphological and biochemical studies carried out by OFI were instrumental in reclassifying these provenances as a sub-species of a near relative, *P. patula*. *P. tecunumanii* was subsequently re-classified as a distinct species.

In addition, the DFID/OFI programme played an important role in resolving the taxonomy of a number of species alliances, in particular the *P. pseudostrobis* complex that includes *P.*

*maximinoi*. This species has since generated industrial interest in some parts of the world but up to the early 1980s it was commonly confused with *P. pseudostrobis*, a relatively slow growing species with limited commercial prospects. DFID/OFI research in the late 1970s and early 1980s revealed that there are in fact three well-defined species within the *P. pseudostrobis* complex, of which one is *P. maximinoi*.

Along with a large number of journal publications, three major dissemination products were produced. Tropical Forestry Paper No. 6 (1973) drew together the early taxonomic work on *P. caribaea* but remains an authoritative document. At the end of the programme in 1997, OFI produced a field guide to the pines of Mexico and Central America for foresters and breeders and a comprehensive taxonomic monograph with distribution maps and botanical drawings for all the tropical pine species.

*Characterising the benefits of taxonomic research*

In so far as the taxonomic research was intended to contribute to the uptake and utilisation of tropical pines, its "value" can be implicitly incorporated in evaluation by including the associated cost with the costs of other components for comparison with the benefits generated by utilisation. Such an approach provides an estimate of the (average) returns to the overall research programme, which are in effect "shared" across all elements of research.

Isolating the specific contribution of taxonomic research to these returns, however, is significantly more difficult. While taxonomic results provided context for subsequent research and utilisation activities, they cannot be seen as an "essential prerequisite" for the more applied elements of the programme. In reality, where linkages existed these were mutually supportive in the sense that taxonomic research and, for example, provenance collection/testing were carried out simultaneously and the flow of results was two-way.

Determining the influence of the taxonomic research in its own right (i.e. outside of its contribution to the applied research components) is even more difficult. While the practical contribution of taxonomic research to commercial forestry may be debated, it is possible that, for example, the clarification of a species' taxonomic status might have influenced subsequent strategic or operational decisions taken by local collaborators. However, straightforward assessments of where this occurred and the extent of influence are likely to be impossible, particularly given the lack of close contact during the programme between DFID/OFI taxonomic research activities and those responsible for operational decisions in collaborating countries.

### 4.2.5 Conservation-related activities

From the mid-1970s, concerns about the loss of native tropical pine forests meant that increasing prominence was given to conservation in the objectives of particular DFID/OFI projects. In spite of this, however, DFID/OFI's active involvement in conservation activities was relatively limited in comparison with other aspects of the research. Indirectly, the seed distributed under the international programme of trials could provide interested collaborators with the means to establish a form of *ex situ* conservation stand. In addition, seed collected by the programme was also available for the establishment of formal conservation stands. However, with the possible exception of *P. caribaea* var. *hondurensis* and *P. oocarpa,* there appears to have been relatively limited demand for seed for this purpose.

More actively, in the mid 1970s UNEP funded OFI and FAO to initiate a programme to conserve the genetic resources of the most promising seed sources of *P. caribaea* and *P. oocarpa* for establishment of *ex situ* conservation stands. Seed for this purpose was made available in 1978 and subsequently distributed to over 20 countries. In the mid-1980s DFSC undertook further distributions for *ex situ* conservation stands.

In the case of *in situ* conservation, DFID funded OFI advisory inputs to a number of projects/organisations in Central America through a mixture of research and technical co-operation funds. In particular, OFI provided support in the design and implementation of a DFID tree conservation and improvement project in Honduras (CONSEFORH) and advised on conservation and improvement activities to INIF in Mexico and the national seed bank in Nicaragua (IRENA).

DFID/OFI seed distributions and specific conservation-related activities, in conjunction with the efforts of a number of other organisations[1], have contributed to the assembly of a large sample of tropical pine genes around the world. The resources established are of great potential significance for the long-term genetic conservation of these species, given problems posed by *in situ* conservation efforts. However, these resources are controlled by a range of private and public organisations with differing levels of interest in and commitment to the continued conservation of these species. In the majority of cases, the current status of these resources is largely unknown.

### *Characterising the benefits of conservation-related research*

Assessment of the benefit of conservation-related activities pursued under the DFID/OFI programme is difficult. The number of other organisations that have contributed to international efforts to conserve tropical pine genes (e.g. DFSC, FAO, UNEP, CAMCORE) adds complexity to the task of attributing gains to the DFID/OFI programme. This problem is compounded by the lack of information regarding the status of the *ex situ* conservation stands and the provenance trials established at the level of individual countries.

In addition, the nature of the benefit of conservation activities raises challenges for evaluation. In contrast to the “active” use of genetic diversity within a tree improvement programme, conservation of tropical pine genes is primarily concerned with *potential* utilisation in the face of (uncertain) future risks (e.g. pest/disease attack, changes in climatic or market conditions, biological problems encountered with genetic material already in use, and so on). The economic benefit of conservation is a function largely of (i) the frequency and severity of such problems; (ii) the extent to which the conserved material resolves these problems; and (iii) the extent to which this material is no longer available in native ranges. Points (i) and (ii) are, by their very nature, difficult to assess.

Loss of species/provenances as a result of human or natural factors, in comparison, is more predictable. Undoubtedly, particular tropical pine species/provenances are under threat of extinction in their natural habitats: for example, *P. maximinoi*, some populations of *P. tecunumanii* and several provenances of *P. caribaea* are under severe pressure (Dvorak and

[1] CAMCORE deserves mention in this regard. Since 1980, the Co-operative has operated an international testing, improvement and conservation programme which currently spans 10 countries and includes a number of the tropical pines addressed by the DFID/OFI programme. The collaborative model employed suggests that CAMCORE will be aware of the the status of *ex situ* conservation stands established under its programme.

Donahue, 1992). Similarly, the devastation caused by Hurricane Mitch is estimated to have resulted in around 95% loss of forest on Guanaja, the source of a unique provenance of *P. caribaea* var. *hondurensis*. However, for evaluation purposes, such evidence must be considered in the context of the practical implications. For example, in the case of the forest loss on Guanaja, the public seed bank in Honduras reports that seed collections in 1998 provided sufficient stocks to reforest the entire island three times over (*pers. com.* Oscar Leveron). At the same time, the very fact that these collections were made reflects in no small part the previous contribution of DFID research and technical co-operation funds.

For narrowly focused research (e.g. a limited number of countries and species), it might be possible to model, *ex ante,* various scenarios regarding points (i), (ii) and (iii) and combine estimates of possible benefits with forms of risk assessment. Alternatively, contingent valuation techniques might be used to construct a “market” to assess the option value of exploiting the conserved genes in the future. In this approach, relevant representatives of forestry organisations would be surveyed to assess their willingness to pay for additional genetic diversity or willingness to accept compensation for removal of conserved diversity. However, contingent valuation techniques are demanding in terms of skills and resources and are not without controversy. Interviewees’ responses would also be heavily influenced by their perceptions of future risks, which in turn may or may not prove to be realistic. In the case of the DFID/OFI programme, the number of collaborators combined with the lack of adequate records regarding the success of conservation-related activities would raise significant practical difficulties in applying either approach.

## 4.3 Practical experiences

All attempts to assess the economic impact of research require data/estimates of the magnitude and timing of the costs and benefits of research. Thus far, the discussion has considered some of the challenges posed for evaluation by the nature of the potential benefits arising from the DFID/OFI programme. This section now considers practical issues on the basis of the country visits undertaken. It should be reiterated that the objective of this section is *not* to evaluate the DFID/OFI programme. Instead, it considers the feasibility of such an exercise on the basis of the information available.

The availability of data for evaluation is in part a function of the time and resources committed to data collection. In the context of the case study, these resources were relatively constrained given that the case study of the DFID/OFI programme represented only one of the outputs to be addressed. That said, experiences in the countries visited suggest that any significant increase in resources would be unlikely to yield more conclusive results and, as such, would be of questionable value.

The discussion of practical experiences considers first the task of identifying the costs of research.

### 4.3.1 Identifying the costs of research

In the case of the tropical pines research programme, a number of factors complicate this task. These relate to: the age of the research and associated difficulties in locating and isolating data; problems in drawing a boundary around the research investment; and problems in obtaining expenditure estimates for the other organisations involved.

*Availability of DFID/OFI expenditure records*

DFID expenditure on the tropical pines research programme was in two main forms: projects and core funding. It is unsurprising that expenditure data are difficult to locate for the early research projects, though using project and review reports/records combined with estimates of staff inputs and overhead element, it has been possible to obtain reasonably complete estimates of expenditure under the "projectised" element of research. However, up to the early 1990s, DFID also provided core funding support to OFI and obtaining estimates of the proportion of these funds spent on the tropical pines research has been more problematic. Formal estimates (i.e. OFI expenditure statements to DFID) of the core funds expenditure on this research could only be located from 1983 onwards, and even these are approximate. For earlier years, the study has assumed that expenditure under the core funds amounted to 25% of projectised funds, based on the average of those years for which information is available. This, however, is likely to be a conservative estimate given that tropical pine research accounted for a proportionately greater part of the UTS' work programme in the earlier years.

On this basis, it is estimated that DFID-funding of OFI research into the tropical pines amounted to around £3.3 million (Table 4.3, below). The UK GDP deflator is used to convert these costs into real terms, indicating that in constant 1999 prices, DFID expenditure amounted to some £8.1 million or an average cost per project of around £380,000. It should be noted that these estimates take no account of the opportunity cost of DFID's funds.

**Table 4.3:** Estimated DFID expenditure for OFI research into tropical pines

| Year | *Current prices* | *Constant 1999 prices* |
|---|---|---|
| 1963/64 | 2,766 | 37,679 |
| 1964/65 | 5,515 | 70,658 |
| 1965/66 | 6,288 | 76,038 |
| 1966/67 | 9,198 | 105,324 |
| 1967/68 | 9,938 | 108,060 |
| 1968/69 | 10,725 | 111,025 |
| 1969/70 | 7,598 | 75,047 |
| 1970/71 | 7,036 | 65,978 |
| 1971/72 | 6,974 | 60,973 |
| 1972/73 | 12,500 | 99,846 |
| 1973/74 | 16,250 | 120,157 |
| 1974/75 | 20,000 | 138,396 |
| 1975/76 | 25,000 | 150,465 |
| 1976/77 | 150,667 | 711,543 |
| 1977/78 | 150,667 | 618,929 |
| 1978/79 | 149,104 | 537,440 |
| 1979/80 | 149,104 | 482,352 |
| 1980/81 | 149,104 | 421,268 |
| 1981/82 | 239,271 | 566,026 |
| 1982/83 | 227,917 | 483,482 |
| 1983/84 | 268,154 | 528,951 |
| 1984/85 | 296,642 | 555,505 |
| 1985/86 | 217,714 | 390,196 |
| 1986/87 | 162,557 | 275,686 |
| 1987/88 | 125,815 | 206,604 |
| 1988/89 | 163,769 | 255,938 |
| 1989/90 | 128,860 | 189,915 |
| 1990/91 | 58,661 | 80,752 |
| 1991/92 | 102,068 | 132,076 |
| 1992/93 | 112,122 | 136,358 |
| 1993/94 | 95,201 | 110,584 |
| 1994/95 | 95,201 | 107,122 |
| 1995/96 | 53,419 | 58,729 |
| **Total:** | 3,235,801 | 8,069,101 |

Estimated using UK GDP deflator

The above treatment of the expenditure data will be familiar, though it ignores a number of issues for econometric estimation. In these cases, expenditure is used as a proxy for the knowledge produced by research with the aim of formally establishing the relationship between expenditure and subsequent changes in production. In doing this, it is preferable to include only expenditure data that relate directly to the productive effects of research[1]. In the case of the DFID/OFI programme, components such as conservation and taxonomic research that may not have directly influenced commercial decisions should be excluded. However, the fact that projects and core funds were used to address multiple research topics precludes any realistic attempt to do this. Secondly, when converting expenditure into real terms, it is more appropriate to use a deflator that relates directly to the variable of interest, in this case scientific effort. However, in the absence of a "UK Scientists deflator", there is little alternative but to use a more general (and crude) measure such as the UK GDP deflator.

### *Defining the boundary of UK support*

In addition to the 21 projects identified in appendix 4.1, DFID provided other research and technical co-operation funds relating to the tropical pines. Research projects were implemented by the Commonwealth Mycological Institute, Kew (1978-84), Department of Applied Biology, Cambridge (1986-89), and the Natural Resources Institute (intermittently during 1980s and 1990s). Technical assistance was also provided, often via OFI staff, to support related activities in East Africa, in Honduras (ESNACIFOR and CONSEFORH projects), in Mexico (pine growth modelling) and in Fiji and Zimbabwe (advisory consultancies for tree improvement programmes).

In addition, OFI implemented a number of research projects that drew on the tropical pine research but have been excluded on the grounds that their focus was broader than the tropical pines. These include simulation of tropical plantation management (1976-79), the development of OFI's forest genetic resources database (1987-89), general trial management of OFI's tree improvement projects (1990-93) and guidance on the management, analysis and interpretation of data from forestry field trials (1995-96). At the same time, a number of the projects that have been included also addressed other species: R3158 included

[1] This refers only to process of establishing the relationship between R&D expenditure and the effect on production. Of course, all expenditure is included when estimating the overall rate of return to research.

*inter alia* the genera *Cordia, Cedrela, Leucaena, Acacia;* R3882 and R4347 included *P. patula* and R4725 also examined *P. elliottii.*

In the time available, it has not been possible to obtain the necessary data for all other related research/development activities, neither has it been possible to separate out the non-tropical pine elements of the projects included. It should be noted, however, that the information provided in Table 4.3 underestimates total DFID expenditure on the tropical pines. It appears likely that in practice DFID expenditure would have exceeded £10 million (in 1999 prices).

*Collaborators' input into research*

A number of organisations contributed directly at the international level to the research programme, including DANIDA, FAO, the European Union, United Nations Environment Programme, Shell Petroleum Company, INIF (Mexico), the Australian Forestry Research Institute and the UK's Forestry Commission who stored seed in the Alice Holt Research Station, up to the late 1980s at no charge to OFI. It has not been possible in the time available to assess the extent of these various contributions.

More critical, however, is the lack of any systematic record of expenditure incurred at the national level by recipients that participated in the research programme. The "loose" collaborative model employed by the programme in the main explains this, given that collaborators were not required to submit cost data. Even among those countries visited during the course of this case study, it proved impossible to obtain accurate estimates of historical expenditures relating to the DFID/OFI programme. Given local collaborators' central role in the realisation of research impact, this presents major difficulties for econometric techniques that seek to establish the statistical relationship between research expenditures and production effects but also raises problems for the accuracy of any assessment, regardless of the evaluation technique used.

As such, it was only possible to obtain an indicative estimate of expenditures incurred locally. Detailed information regarding the establishment of DFID/OFI trials was available in only Zimbabwe (Forest Research Centre) and South Africa (SAFCOL, Mondi Forests and Sappi[1]). This information indicates the year of establishment, the area of the trial, the timing of measurements and the year of termination (if appropriate). In the case of Brazil, only an approximate estimate of the total number of trials could be obtained (>70), though it is thought that the majority of these are still in existence (Dr J. Wright, personal communication). OFI records indicate that 75% of tropical pine seed distributed to Brazil was sent during 1975-84. In the case of Brazil, therefore, the study assumes that a total of 80 trials were established in 1980 (average size 3 ha), of which one-third were implemented for 8 years and two-thirds for 20 years, with measurements at years 3, 5, 8, and 15 (if appropriate).

Estimates of the *current* costs of a provenance trial were also obtained from each country. However, these estimates vary widely between countries reflecting differences in cost structures, economic conditions and in the precise way the estimates have been calculated. The following "average" cost, therefore, includes considerable scope for inaccuracy:

[1] Includes Sappi's trials in Usutu, Swaziland.

Table 4.4: Average cost of a provenance trial

| Activity | Cost (UK£ 1999) |
|---|---|
| Trial establishment: | £350 /ha |
| Trial maintenance: | £  25 /ha/year |
| Trial assessment: | £ 100 /ha/measurement |

Combining the above information, it is estimated that expenditure in these three countries during 1969-1996 on the DFID/OFI trials was in the order of £445,000 (in 1999 prices). This is recognised as an extremely crude estimate, assuming as it does that there has been no change in the real cost of trials during this period. While significant, this amounts to only around 5% of the (undiscounted) estimate of DFID expenditure (in 1999 prices) presented in Table 4.3. In interpreting this figure, a number of points should be borne in mind. Firstly, the costs of seed collection and distribution probably accounts for <30% of DFID expenditure. Second, the indicative estimates of local expenditure do not include any costs incurred as a result of any subsequent actions. In order to move a species/provenance from a trial to large-scale commercial use, further work is required to obtain seed (either directly from the native range or through the establishment of seed sources domestically) and to adapt the material to local conditions (through selection/improvement efforts).

Finally, the DFID/OFI programme distributed seed to 102 countries. In the majority of cases this was for the establishment of trials. In short, the ratio of local expenditure to DFID/OFI expenditure for provenance distribution and testing is likely to be significantly greater than 5% but it is impossible to determine the precise figure.

### 4.3.2 Identifying the benefits of research

In basic terms, the magnitude of research-generated benefits is a function of: (a) the level of adoption of the technology developed through research; (b) the timing of research-induced production effects; (c) the magnitude of research-induced production effects over the adopting area; (d) the (net) value of research-induced production effects; and (e) the rate at which research-induced production effects depreciate over time.

#### *Adoption*

The DFID/OFI research programme was multi-country in nature. This characteristic *per se* does not raise intractable methodological problems; for example, economic surplus models have been adapted to incorporate research-related price and technology spillovers in a multi-region setting (e.g. Davis *et al*, 1994). Where non-econometric assessment techniques are used, data regarding actual adoption and/or projections of future levels are explicitly required. In the case of *ex post* econometric analysis (at the level say of an individual country), detailed assessment of adoption may be not be necessary if there is sufficient evidence to demonstrate that adoption *has* occurred, and production data can be analysed econometrically to separate out the effect of research (among adopters) from more general factors affecting production.

However, the “open-access” and “loose” collaborative model employed by the programme makes assessment difficult in practice. Beyond the provision of advice on trial design/interpretation and occasional support in response to *ad hoc* requests, collaboration with the vast majority of seed recipients was limited or non-existent. The target area of adoption was not clearly defined and collaborators varied in terms of their interest in and ability to utilise the research. No systematic records were maintained regarding the extent to which countries retained or utilised seed supplied by the programme and, as a result, these issues remain largely unknown.

Identifying research adoption might be more straightforward if good quality data existed for the forest sector in general. However, easily accessible data regarding the extent and composition of plantation resources in individual developing countries are effectively non-existent. Data for those countries with significant plantation resources (≥ 100,000 ha) included in the latest (draft) plantation study sponsored by FAO example are summarised in Table 4.5. Countries for which specific information was obtained during the case study are dealt with separately below.

Table 4.5: Summary of plantation resources in selected developing countries

| Country | Industrial plantations (000 ha) | Pine plantations (000 ha) | Tropical pines (000 ha) | Comments |
|---|---|---|---|---|
| Costa Rica | 100-170 | 0.6 | ? | Pine estimate for Northern region only |
| Chile | 1,800 | 1,398 | ? | Mostly *P. radiata* |
| Colombia | 165 | 57-85 | *P. caribaea* 14; *P. oocarpa* 6; *P. kesiya* 3; *P. tecunumanii* 3; *P. maximinoi* 0.3 | |
| Ecuador | 70-100 | 14-20 | ? | Mostly *P. radiata, P. patula and P. roxbirghii* |
| Peru | 412 | ? | ? | Mainly eucalypts and native species |
| Venezuela | 650 | 600 | *P. caribaea* 600 | |
| Cote d'Ivoire | 80-100 | 0.5 | ? | |
| Kenya | 180 | 58 | ? | 56 – *P. patula* |
| Madagascar | 160 | 80-150 | *P. kesiya* 50; *P. caribaea* 8; *P. oocarpa* 8 | |
| Malawi | 73 | 68 | *P. oocarpa* 15; *P. kesiya* 8; *P. caribaea* 1 | |
| Swaziland | 118 | 95 | ? | Mostly *P. patula, P. elliottii* and *P. taeda* |
| Bangladesh | 178 | ? | ? | Limited use of pines |
| China | 24,000 | 185 | ? | Pine area is underestimate though mostly *P. elliottii, P. taeda* and *P. massoniana* |
| India | 2,000 – 5,000 | ? | ? | |
| Myanmar | 340 – 440 | 7 | ? | |
| Pakistan | 274 | ? | ? | Pines not significant (?) |
| Sri Lanka | 142 | 17 | ? | |
| Vietnam | 674 | 225 | ? | |

*Source: Forest plantation survey report – DRAFT 1997/98 (prepared by OFI for FAO)*

With respect to the above table, it should be noted that in many cases the estimate of industrial plantations currently planted is only approximate while the level of uncertainty regarding the area planted to softwoods and, in particular, the tropical pines is evident.

Even if international data were available at the necessary level of detail, simple interpretation of apparent adoption may be misleading. Unlike agricultural crop research, where particular varieties can, in principle, be traced to the originating research organisation, the species promoted by the DFID/OFI programme could have been obtained independently of the programme. While in the main this is thought unlikely, Venezuela, for example, has planted the single largest area to a tropical pine species (Table 4.5) and obtained reasonable quantities of *P. caribaea* seed from the DFID/OFI programme[1], though was not identified as an example of "high research impact" by OFI. In reality, the process of accessing and sharing tropical pine germplasm in Latin America was already underway by the start of the DFID/OFI programme and areas currently planted do not provide a reliable guide to the uptake of research results. The simple conclusion is, therefore, that country-specific investigation is unavoidable.

Table 4.6 overleaf provides a summary of the information obtained from the countries included in the case study. The reader is urged to consult Appendix 4.3 for a more detailed account of the progress of DFID/OFI research uptake and utilisation in these countries. On a species/variety basis, it is noteworthy that the majority of key informants in these countries indicated that DFID/OFI-supplied germplasm was of significant importance to local research activities. In many instances, the diversity of available germplasm of particular species/variety was limited prior to the DFID/OFI programme. At the same time, in a similar majority of cases, key informants indicated only limited commercial interest in the species/varieties for use in pure stands.

Information presented in Table 4.6 regarding the area currently planted to tropical pines suggests considerably contrasting fortunes of the DFID/OFI research in the case of RSA and Zimbabwe, on the one hand, and Brazil and Australia, on the other. In the RSA and Zimbabwe, tropical pines occupy less than 1% and around 5% of the pine plantation estate respectively, covering a total area of less than 11,000 ha. The apparent conclusion is that there has been very limited uptake of these species in these countries and certainly nothing to suggest significant economic benefit arising from utilisation. Nevertheless, in these countries there are obvious discrepancies between the area currently planted and commercial prospects for: *P. maximinoi* (in Zimbabwe), *P. kesiya* (in RSA), and *P. tecunumanii* (in both countries). For all these species, the DFID/OFI programme played a fundamental role in alerting collaborators to their potential and in assisting their development where interest was expressed. DFID/OFI-supplied material is currently being used within local tree improvement programmes for all these species in both countries though in the case of SAFCOL's *P. tecunumanii* programme in RSA and *P. maximinoi* in Zimbabwe, CAMCORE-supplied material is an important resource.

In the cases of Brazil and Australia, tropical pines currently occupy around 30% of the pine plantation estate in both countries or c.515,000 ha and 56,000 ha [2] respectively.

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[1] Rankings in terms of seed (kg) received from OFI are as follows: var. *hondurensis* – Brazil 6th, Venezuela 13th (out of 87 countries); var. *bahamensis* – Brazil 8th, Venezuela 12th (out of 79 countries); var. *caribaea* – Brazil 6th, Venezuela 3rd (out of 51 countries).

[2] Of the tropical pines included in the case study, only *P. caribaea* var. *hondurensis* is planted on a commercial scale.

Table 4.6 : Summary of experiences in RSA, Zimbabwe, Brazil and Australia

| | | *P. caribaea* var. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *hondurensis* | *caribaea* | *bahamensis* | *P. oocarpa* | *P. tecunumanii* | *P. maximinoi* | *P. kesiya* | *P. merkusii* |
| **RSA:** 883,245 ha [1, 2] | | | | | | | | |
| *Availability pre-DFID/OFI research* | Yes | Yes | Yes | Limited | No/Limited | No | Yes | *n.a.* |
| *Area planted (1998)* | | 1,379 ha | | 364 ha | 2,006 ha | 34 ha | 2,947 ha | 0 ha |
| *% of pine plantations* | | 0.2% | | 0.04% | 0.2% | - | 0.4% | - |
| *Commercial interest as pure stands* | | Low | | Low | Med | Low | Med | *n.a.* |
| *Significance of DFI/OFI material for research* | Med-High | Low | Low | Low-Med | Med-High | High | Med | *n.a.* |
| **Zimbabwe:** 80,000 ha [1] | | | | | | | | |
| *Availability pre-DFID/OFI research* | | Yes | | Yes | No | Yes | Yes | |
| *Area planted (1998)* | | 37 ha | | 650 ha | - | - | 3,340 | - |
| *% of pine plantations* | | 0.05% | | 0.8% | - | - | 4.2% | - |
| *Commercial interest as pure stands* | | Low | | Low | High | Med-High | Low-Med | Low |
| *Significance of DFI/OFI material for research* | | Low | | Low | High | Med-High | Low | Low |
| **Brazil:** 1.7 million ha [1] | | | | | | | | |
| *Availability pre-DFID/OFI research* | Yes | Limited | Limited | Ltd (but good) | No / Limited | Limited | ? | *n.a.* |
| *Area planted (1998)* | 218,000 ha | 75,000 ha | <20,000 ha | 150,000 ha | 50,000 ha | <100 ha | 10,000 ha | 0 ha |
| *% of pine plantations* | 12.8% | 4.4% | 1.1% | 8.8% | 2.9% | - | 0.6% | - |
| *Commercial interest as pure stands* | High | Med | Low | Med | Med-High | Low-Med | Low | Low |
| *Significance of DFI/OFI material for research* | High | Med | Med | Med | High | Med | Med-High | *n.a.* |
| **Australia:** 175,000 ha [1, 3] | | | | | | | | |
| *Availability pre-DFID/OFI research* | Yes | | | | | | | |
| *Area planted (1998)* | 56,000 | | | | | | | |
| *% of pine plantations* | 32% | | | | | | | |
| *Commercial interest as pure stands* | Med | | | | | | | |
| *Significance of DFI/OFI material for research* | High | | | | | | | |

Notes: 1 - estimate of current pine plantation estate; 2 - includes 56,000 ha at Sappi's Usutu plantation in Swaziland; 3 - Publicly-owned plantations in Queensland and Northern Territory, (private plantations mostly hardwoods).

Notwithstanding the facts that only a limited assessment exercise was possible for Brazil, and that no visit was made to Australia, the evidence presented in Table 4.6 provides a more promising *prima facie* case for research impact in these countries. However, the experiences in both highlight, for different reasons, the potential pitfalls of simple assumptions that relate apparent uptake to the effects of research.

In Brazil, the majority of the pine estate is located in the south where it is too cold for the tropical species. However, the availability in the 1970s of subsidies to promote the development of plantations encouraged a general expansion of the pine estate which extended to northern regions, where the tropical pine species are better suited. As a consequence, Brazilian companies sourced significant volumes of seed directly from the native ranges for commercial scale plantings[1]. The DFID/OFI programme of seed distribution and trials coincided with this period of expansion and the results obtained are understood to have influenced the choice of species/provenances in many, but not all, cases. Discussions with operators during the case study indicate that the influence of the trial programme results ranged from (directly) guiding managers in their choice of specific species/provenances, to (indirectly) confirming choices already made.

Crude estimates obtained during the course of the case study mission to Brazil suggest that around 300,000 ha (or c. 60%) of the area currently planted to tropical pines reflect the influence of the DFID/OFI programme. Of this area, however, only 10% or less is thought to be based directly on DFID/OFI-supplied germplasm. As such, a formal evaluation of research success in Brazil would have to identify those cases where research influenced decisions (taken up to 25 years ago) and the degree of research influence. It is unlikely that sufficient data could be obtained to allow econometric estimation of the productive effect attributable to research under these circumstances. A comprehensive survey of users represents a more feasible option that might improve confidence in (non-econometric) estimates of research adoption, though results would inevitably rely on users' subjective opinions and, as such, definitive conclusions might not be possible.

In the case of Australia, the pine improvement programme in Queensland has been for many years among the most advanced in the world. During the course of the DFID/OFI programme, Queensland both tested DFID/OFI-supplied provenances and provided locally improved germplasm to the international trial programme. Discussions (via e-mail) with the Queensland Forestry Research Institute (QFRI) indicate that in research terms, DFID/OFI-supplied germplasm is considered to have been of equal value to QFRI's own material. Access to this germplasm broadened the genetic base available to QFRI and demonstrated *inter alia* important genetic variation in wind firmness between provenances, and the unique potential of the Guanaja provenance of *P. caribaea* var. *hondurensis*. However, in commercial terms, DFID/OFI germplasm and research results have been of negligible importance, as a result of both the advanced stage of QRFI's own breeding efforts and, more recently, changes in market conditions.

At this point it is worth briefly considering the revenue generated from seed sales around the world for those countries where the tropical pines originate. This revenue is commonly considered a benefit of the DFID/OFI programme, a "spin-off" from uptake/adoption of tropical pines. Undoubtedly DFID/OFI's research and promotion efforts, (along with those of other organisations), have played a significant role in stimulating commercial interest in the tropical pines. However, revenues for seed exporters cannot be considered "additional" to the utilisation gains achieved in other countries as these revenues represent costs for countries were tropical pines have been introduced. As such, the "spin-off" benefit of seed sales more accurately relates to the *distribution* of benefits, within a multi-stage production system (see section 4.2.2. *Characterising the benefits…*).

[1] No reliable historical data detailing the expansion of the plantation estate could be located during the course of the case study.

That is not to say that distributional issues are unimportant; indeed, they are quite likely to be of interest to FRP. For illustrative purposes, contact was made with the two seed banks in Honduras, Banco de Semillas (BASE) and Tropical Seeds (SETRO), both of which acknowledge the significant contribution of DFID/OFI research and DFID technical assistance[1] to the development of the seed export business. Recent data from the banks indicate that the *gross* value of seed exports for *P. caribaea* var. *hondurensis, P. tecunumanii, P. oocarpa* and *P. maximinoi* was approximately US$680,000 (c. £415,000) in 1997 and US$760,000 (£460,000) in 1998. *P. caribaea* var. *hondurensis* accounts for the majority of this, though demand for *P. tecunumanii* seed is increasing. However, simple extrapolation of these data, either forwards or backwards, is not possible. On the one hand, seed sales will have increased only gradually over time[2] and, on the other, they will decline as purchasing countries' own domestic seed sources come on stream. In the case of *P. caribaea* var. *hondurensis*, for example, both banks anticipate this decline to begin in the near future.

In practical terms, identifying the contribution of the DFID/OFI programme to seed sales from Honduras is difficult. BASE and SETRO reported that while a proportion of tropical pine seed orders do request specific provenances – an indicator of the possible influence of the research – isolating OFI's specific influence from that of the other organisations involved (both past and present) would involve a survey of all seed purchasers. Such an exercise was beyond the scope of this case study.

### *Research, adoption and benefit lags*

In both RSA and Zimbabwe, the year of establishment for trials of *P. tecunumanii*, *P. kesiya* and *P. maximinoi* ranges from twelve to 25 years ago. Provenance trials involve research lags of between 6-8 years before initial results are available. This may extend to 15 years if industrial wood properties are to be assessed though small-scale commercial uptake may begin during this period. In spite of the age of trials and interest in these species, only very limited plantings have occurred to date. This, in part, reflects the decision by both countries to develop domestic seed sources rather than obtain commercial volumes of seed directly from native stands. This decision, in turn, is best viewed as a form of adaptive research. For example, *P. tecunumanii* demonstrated considerable potential in trials established by both countries but significant problems were encountered with stem breakage. Selection is expected to overcome this trait and the conversion of trials into seed orchards represents the first step in this process. However, the development of local seed sources effectively extends the research lag. Under these circumstances 15-18 years represent a more likely timeframe from the start of provenance trials to the availability of commercial quantities of seed. Given rotation lengths of 18-25 years, some 33-43 years can be expected to elapse from the start of provenance trials to clearfelling of the first stands established as a result of research.

Furthermore, this timeframe assumes that no significant practical constraints are encountered during the period of research. In the case of *P. tecunumanii* in both countries and *P. maximinoi* in Zimbabwe, difficulties have been experienced with flowering and seed production and, as such, the timing of availability of commercial quantities of seed from orchards established with DFID/OFI material remains uncertain.

More generally, both countries have well-established pine processing industries and tree improvement programmes. While these facts explain to a large extent their interest in the DFID/OFI programme, they are also factors explaining slower uptake. Under these circumstances, any new germplasm must compete

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[1] For the establishment of Honduras' first seed bank in 1975.

[2] *StockTaking* (DFID, 1998) reports that during 1975-1985 the gross value of seed exports for *all* species from Honduras averaged US$196,470 year$^{-1}$, with a peak of US$358,405 in 1982.

with established species, familiar to the industry, and local organisations' strategic plans that may have been put in place a number of years earlier. Pay arrangements in plantation companies that are based around volume targets and cost-control further contribute to managers' conservatism. For example, by the time improved *P. tecunumanii* seed is available in Zimbabwe, third generation improved *P. patula* seed will be available, its main "rival" and which currently occupies 61% of the pine plantation estate. Similarly, while Sappi in RSA has demonstrated considerable interest in *P. tecunumanii*, its potential uptake is constrained by the strategic decision to allocate much of the land suitable for *P. tecunumanii* to its hardwood plantations.

In the case of Brazil, in spite of the more promising area currently planted to a number of the tropical pines, "standard" rotation lengths of around 20 years suggest that, at best, only very limited volumes from research-influenced stand have been harvested to date.

In short, given the research, adoption and benefit lags, little in the way of actual production data reflecting the full effect of research is available some 36 years after the start of the DFID/OFI programme.

### *Magnitude of research-induced gains*

In spite of the problems posed by the lags associated with the DFID/OFI programme, production gains can in principle be measured during the course of a rotation. The lack of significant uptake in RSA or Zimbabwe to date and the time available for the mission to Brazil precluded any attempt by the case study to assess this. Nevertheless, a number of problems can be anticipated.

The sheer number of seed recipients and other organisations involved in tropical pine research and the considerable overlap between DFID research and technical assistance funds raise practical and methodological challenges when attempting to measure benefits and attribute (a proportion of) these to DFID's research investment. Even if adequate data existed, it is unlikely, given the non-country-specific nature of much of the research, that productive effects in individual countries could be related directly to DFID expenditure using conventional econometric approaches[1].

While growth data for individual stands can be expected to exist, the availability of adequate historical "control" data is more uncertain. Similarly, reliable juvenile-mature correlation estimates may not exist for new species/provenances. In the case of Brazil, this problem is magnified by the fact that uptake of tropical pine species occurred on newly planted sites. It is considered unreasonable to conclude that expansion of the plantation estate would *not* have been possible in the absence of the DFID/OFI programme. As such, DFID/OFI research results are more appropriately viewed as facilitating the selection of more "efficient" provenances, for those stands that reflect the influence of the research. As such, any non-econometric estimation of research gains must be *net* of the output that would have been achieved using other species/provenances in the without-research (i.e. counterfactual) situation.

In principle, econometric estimation can address the counterfactual problem by holding all other influencing variables constant in order to isolate the effects of research. Data requirements, however, are demanding. While data such as aggregate increases in the mean annual increment (MAI) of pine plantations over time may be readily available, these will reflect the influence of a range of factors. For example, discussions with Zimbabwe Forestry Commission suggest that yield improvements over time reflect as much (if not more) improvements in machinery/equipment and felling/management techniques. Similarly, in Brazil,

[1] A modified approach, for example, that first established the relationship between seed distribution and adoption in individual countries and then estimated country-level production effects might be feasible if adequate data existed.

while pine MAIs are estimated to have trebled in 10 years (from 9 to 27 $m^3$/ha/year), this dramatic increase reflects *inter alia*: improved silviculture (e.g. weed control, fertilisation, thinning, control of leaf cutting ants), improved site-species matching, and the replacement of stands established in the 1950s-1960s with more productive material. Part of these gains will reflect the influence of the DFID/OFI programme and local research into tropical pines, though it is impossible to determine the precise proportion in the absence of adequate data regarding the other influencing variables.

A possible compromise, and one employed in a number of the literature examples identified in section 2, is to project (*ex ante*) estimates of gains based on (*ex post*) research results. In the case of the DFID/OFI programme, however, problems are again encountered. The co-ordinated assessments conducted by OFI in the main reported variation between provenances included in the trials, with volume differences between the best and worst provenances of 40%+. However, this comparison is only meaningful for evaluation if the worst provenance represents a realistic control, in as much as it would have been planted in the absence of research. In the case of RSA and Zimbabwe, the alternatives comprise entirely different species (e.g. *P. patula*). In Brazil also, it is debatable whether such a comparison holds, given that some familiarity with the most important tropical pine species existed prior to the DFID/OFI programme.

Analysis of trial data from individual countries may provide better indication of potential gains as many (though not all) included local germplasm as a control. There are obviously practical problems associated with amassing these data but in addition a number of other issues arise. First, proportional gains will depend on location of the site and care is required in estimating "average" potential gains: for example, in provenance/progeny trials established in 1987 in Zimbabwe, the volume performance of *P. tecunumanii* compared with *P. patula* ranged from –7% to +15% depending on site. Second, while volume represents an important criterion, other factors such as stem-form and branching may be equally critical depending on the intended end-use of the roundwood. For example, while DFID/OFI-supplied material demonstrated promising volume performance in a number of trials established by the South African Forestry Research Institute, less favourable performance against other traits meant that in practice relatively few selections were made. Third, provenance trial results provide only an indication of absolute gains achievable in practice. Discussions during the course of this case study suggest that at the operational level gains may be only two-thirds (and as little as one-half) of the performance recorded in provenance trials.

The only (*ex ante*) analysis of research-induced yield gains arising from the DFID/OFI programme was conducted by OFI in 1982. The approach bears (implicit) similarities with a simple CBA: e.g. constant roundwood prices, projected yield gains translated directly into a horizontal shift of a (vertical) supply curve (see Figure 2.2). However, because the analysis considered only *gross* benefits, no comparison between costs and benefits was attempted[1]. Estimates of potential production gains were based on the results of co-ordinated assessments undertaken by OFI in the late 1970s/early 1980s and are reproduced in Table 4.7 with additional comments provided by this case study.

Even given the conservative adjustment made to these estimates in the original OFI analysis, the comments provided in the table raise doubts regarding the applicability of the assumptions in all cases. For example, it is questionable whether type (1) gains would apply in the case of "research-influenced" plantations in Brazil, given that in the main seed was obtained directly from suppliers in native countries. Similarly, in RSA and Zimbabwe, type (2) gains are not directly applicable given that the choice facing managers was not simply between the best provenances and those sourced without reference to origin but rather between the best provenances and commercial species currently in use.

[1] This approach also enables thornier issues such as local research costs and benefit attribution to be avoided.

In addition, inclusion of types (4) and (5) gains raises concerns relating to both the temporal dimension of these gains and their *incremental* status. With respect to the former, in order for these gains to be realised across an entire plantation, individual trees must have already been selected for the traits in question, and

Table 4.7: Summary of research-induced gains for tropical pines estimated by OFI analysis (1982)

| # | Source of improvement | Production / value gain (%) *Min* | *Likely* | *Max* | *Case study comments* |
|---|---|---|---|---|---|
| 1 | Seed collected from best trees in natural stands | 2% | 5% | 10% | • *Uncertain gain if seed sourced directly from suppliers in native countries* |
| 2 | Correct provenance *vs.* selection without regard to origin (based on trial results) | 18% | 25% | 50% | • *Not relevant if "alternative" choice is different species*<br>• *Selection "without regard" may include best provenance* |
| 3 | Pest and/or wind resistance | 5% | 10% | 25% | • *Not clear if additional to # 2*<br>• *Uncertain accuracy of "average" gain* |
| 4 | Selection of best trees within correct provenance | 15% | 20% | 40% | • *Implies lag (≥10 years) before gain exhibited across all plantings* |
| | *Sub-total:* | 40% | 60% | 125% | |
| | Volume gains adjusted for "non-additional" elements (@50%) | 20% | 30% | 62.5% | |
| 5 | "Price premium" following selection for stem and branch quality | 10% | 17% | 25% | • *Implies lag (≥10 years) before gain exhibited across all plantings*<br>• *Might apply in without-research case also?* |
| | "Price premium" adjusted (@50%): | 5% | 8.5% | 12.5% | |
| | Total effective gain in value: | 21% | 32.6% | 70.3% | |

commercial volumes of this "select" seed produced. Given the lags involved in these activities and practical experiences in Brazil, the inclusion of these gains with the "first-round" effects of types (1)-(3) may be unrealistic. Regarding the latter, while the estimates of gains achieved through selection activities may be reasonable (even conservative), the analysis does not discuss whether types (4) and/or (5) gains could be achieved using the material available in the absence of research. If in fact selection can be expected to generate equivalent gains for "without-research" germplasm, then the estimates of total gains used in the analysis overstate the potential effect of the research.

At this point, it is worth at least briefly mentioning the potential for research to generate "disbenefits". As Hardcastle *et al* (1995) indicate, "the promotion of plantation monocultures may have negative environmental effects, in terms of biodiversity loss for example, if these plantations replace a more diverse form of land use. Similarly, the expansion of industrial plantations may involve costs for local people if they are denied access to land that previously could utilise. From the point of view of development agencies in particular, the benefits arising from industrial plantations may accrue in the main to large scale companies/ multi-nationals with little effect on poorer sections of society." These issues have not been considered in this study, in part because they reflect shifts in development policy and understanding that took place when the tropical pines research was already well advanced. Nevertheless, they highlight the potential dangers for evaluation in an adopting an overly narrow focus. Such a focus may result from the unthinking application of standard single commodity/partial equilibrium, economic surplus models.

*Valuing the research-induced production effects*

Difficulties in obtaining reliable prices for roundwood have already been discussed (see sections 1.4.4 and 4.2.2 "*effective yield gains*"). These problems are expected to be relevant for many of the countries that received seed under the DFID/OFI programme. Certainly during the course of this case study, it was not possible to obtain reliable historical price estimates for RSA and Zimbabwe beyond the last few years. A limited number of publications do regularly report actual prices for forest products (e.g. FAO Forest Product Prices, ECE/FAO Timber Bulletin). However, the number of developing countries represented in these publications is limited.

Use of average export/import values may offer an alternative to actual prices and are certainly more readily available (from FAO production/trade statistics). Indeed, OFI's simple CBA valued estimates of potential gains on the basis of average costs of worldwide pulpwood imports. However, use of such composite prices is at best approximate given the importance of quality/grade issues in forest product markets. Indeed, for many of the countries where DFID/OFI research results may have been utilised, the majority of roundwood production would be for domestic consumption only and import/export parity prices would require adjustment.

*Future research-induced benefits*

Notwithstanding the problems faced when attempting to assess the impact of research to date, the lags involved in tree-related forestry research suggest that any evaluation will necessarily involve a significant element of *ex ante* projection. Furthermore, the uncertainty surrounding projection of key evaluation variables increases with the length of these lags. It is not uncommon, therefore, for *ex ante* to err on the side of optimism. OFI's *ex ante* evaluation (Plumptre and Barnes, 1982) predicted that 615,000 ha of higher-yielding *P. caribaea* and *P. oocarpa* alone would be planted during 1985-2000 as a result of the DFID/OFI programme and its international network of collaboration. It is doubtful whether this has been achieved but definitive conclusions are not possible, given that uptake along similar lines as in Brazil may have occurred in other countries.

What is clear, however, is that even for those involved in pine research among the case study countries, predicting the future area of tropical pine plantations is difficult. Table 4.8 summarises information obtained during the country visits regarding potential uptake in the future. Again, the reader is urged to consult Appendix 4.3 for a more detailed account. The estimates provided in Table 4.8 reflect "most likely" scenarios, given existing constraints (including interest in other species). Even under these conditions, the range of possible outcomes for a number of the species is wide. For example, in Zimbabwe, it is believed that *P. maximinoi* may potentially occupy an area of around 40,000 ha (in terms of site suitability). If the outstanding volume performance suggested in the DFID/OFI trials is realised in practice, uptake may approach this figure. However, 15,000 ha is considered a more realistic estimate in the medium-term and in reality the area planted may be as little as 5,000 ha if flowering/seed production constraints are not resolved.

In addition to the challenge of projecting uptake of forestry research, evaluation must also consider the duration of any future benefit streams arising from the DFID/OFI programme. As already discussed (see section 4.2.3, *Characterising the benefits…*), subsequent gains will reflect increasing contributions by local research. In the case of Brazil, this can be expected to occur as research-influenced stands are gradually replaced at the end of their rotation. In RSA and Zimbabwe, the stands that have yet to be established will (immediately) reflect significant input by local tree improvement programmes.

Table 4.8: Summary of tropical pines potential in RSA, Zimbabwe, Brazil and Australia

| | *P. caribaea* var. *hondurensis* | *P. caribaea* var. *caribaea* | *P. caribaea* var. *bahamensis* | *P. oocarpa* | *P. tecunumanii* | *P. maximinoi* | *P. kesiya* | *P. merkusii* |
|---|---|---|---|---|---|---|---|---|
| **Republic of South Africa** | | | | | | | | |
| *Potential (up to c.2014) as pure stands* | 2 - 5,000 ha | | | Limited | 10 - 12,000 ha | Limited | 9,000 ha [1] | *n.a.* |
| *% change to existing area planted* | + 45-360% | | | - | + 500-600% | - | + 300% | - |
| *Constraints as pure stands* | Low wood density; stem form; cold susceptibility | | | Cold sensitive; growth rate | Broken crowns; seed; cold | Cold sensitive; knot clusters | Cold; branching; aphid; weed comp. | *n.a.* |
| *Further research for pure stands* | Yes | No (?) | No (?) | ? | Yes | No (?) | Yes | *n.a.* |
| **Zimbabwe** | | | | | | | | |
| *Potential (up to c.2014) as pure stands* | Limited | | | <1 - 5,000 ha | 5 - 20,000 ha | 5 - 15,000 ha | ? | - |
| *% change to existing area planted* | - | | | + 0-750% | + .. % [2] | + .. % [2] | ? | - |
| *Constraints as pure stands* | Flowering, coning and seeding | | | Volume; form; site capture | Seed production; stem breakage | Seed production | None significant | Volume |
| *Further research for pure stands* | Limited | | | Limited | Yes | Yes | Limited | No |
| **Brazil** | | | | | | | | |
| *Potential (up to c.2014) as pure stands* | Ltd expansion | 80 - 85,000 ? | <20,000 ha | 100-120,000 ha [3] | 80-100,000 ha | ? | - | - |
| *% change in current area planted* | + 5% (?) | + 7-13% | - | – 20-33% | + 60-100% | - | - | - |
| *Constraints as pure stands* | Wood quality; cold; seed | Seed | Seed; wood quality | Volume | Seed production | Lack of research | Branching | - |
| *Further research for pure stands* | Yes | Yes | Yes | Yes | Yes | Limited | No | No |

Notes: 1 - uptake confined to Sappi's Usutu plantation in Swaziland; 2 – None currently planted; 3 - expected to be replaced by *P. tecunumanii*

It is generally held that gains arising from improved germplasm are "permanent" and from a technical perspective this may be true[1]. However, technical obsolescence is fairly narrowly defined and implies *ceteris paribus*-type assumptions that may not hold in the context of economic obsolescence. To illustrate, recent changes in market conditions have placed Queensland's improvement programme for *P. caribaea* var. *hondurensis* on hold, with the associated result that DFID/OFI research has not been utilised commercially.

In some senses, the practical significance of research depreciation for any analysis is reduced by the combined effect of the timeframe for pine rotations and positive discount rates. However, pine hybrids provide an example of a competing technology that is being developed simultaneously with efforts to improve (pure) tropical pine species. In Brazil pine hybrids will replace an unknown proportion of the areas already planted to tropical pine species (as rotations end). In RSA and Zimbabwe the successful development of pine hybridisation programmes is expected to reduce medium and long term prospects for (any) uptake of the tropical pines as pure stands. Similarly, the success of the *P. elliottii* x *P. caribaea* var. *hondurensis* hybrid in Queensland has been a major factor in explaining the negligible commercial uptake of DFID/OFI research results in Australia.

However, while DFID/OFI research did not address tropical pine hybridisation directly, it may be reasonable to assume that the DFID/OFI programme, by promoting the tropical pines, has contributed to these developments. More directly, evidence from the countries visited during the case study indicates that, in some cases, DFID/OFI-supplied germplasm is being used in local pine hybridisation programmes (Table 4.9), suggesting the potential for further (significant) gains for the DFID/OFI programme, even accepting the major local research effort involved.

Table 4.9: Development of DFID/OFI-supplied germplasm as parent material for pine hybrids

| | | *P. caribaea* var *hondurensis.* | *P. tecunumanii* | *P. oocarpa* | *P. maximinoi* |
|---|---|---|---|---|---|
| South Africa | DFID/OFI-supplied germplasm? | *CSIR*: 1/3 of male parents<br>*Sappi*: No | *CSIR*: No<br>*Sappi*: No | - | *CSIR*: 100% male parents |
| | Start of commercial availability | 2010+ (DFID/OFI material) | 2012 (?) | - | 2013+ |
| Zimbabwe | DFID/OFI-supplied germplasm? | No | <100% of male parents [1] | | - |
| | Start of commercial availability | 2008 (?) | 2008+ (DFID/OFI material) | 2010 (?) | - |
| Brazil | DFID/OFI-supplied germplasm? | Small proportion | 50%-100% ? | Small proportion | - |
| | Start of commercial availability | 2005-2010 | 2005-2010 | 2005-2010 | - |

Note: 1 – *P. caribaea* var. *hondurensis* x *P. tecunumanii* hybrid seed also obtained from Australia. Progress with this material in Zimbabwe is some seven years ahead of DFID/OFI germplasm.

While the contribution of the DFID/OFI programme should not be ignored, once again simple assumptions regarding the relationship between the use of germplasm and the influence of the

[1] Where pest-resistance represents a key desirable trait of new germplasm, evidence from agriculture raises uncertainty regarding the validity of this assumption.

DFID/OFI research should be avoided. For example, in the case of the more recent research in Zimbabwe into a *P. caribaea* var. *hondurensis* x *P. tecunumanii* hybrid, all *P. tecunumanii* (male) parent material is sourced from DFID/OFI germplasm provided under the trials programme. The decision in 1994 to proceed with this hybrid, however, was largely driven by research developments achieved in Australia. The availability of a wide range of P. tecunumanii germplasm in Zimbabwe as a result of the DFID/OFI programme is recognised as a "bonus" but it is not the case that this hybrid would not have been developed in its absence.

## 4.4 Conclusions

There are obvious dangers in drawing definitive conclusions concerning evaluation from the DFID/OFI programme of research into the tropical pines. The number of countries (at least, nominally) involved, the variety of research outputs, problems of benefit attribution and the sheer lack of data available to evaluation suggest, in practical terms, that meaningful economic assessment may be impossible, regardless of approach. Nevertheless, a number of basic observations can be made.

Even in the case of the most "straightforward" of potential benefits, the fact that industrial roundwood is an intermediate good implies a degree of complexity for economic evaluation that may not be encountered when assessing the impact of much annual crop research. This reflects in part issues of market structure in developing countries but also the nature of research-induced benefits and where they are realised within the production chain. Where adequate data on forest-level activities, the processing sector and final good markets are not available, simplifying assumptions will be necessary but these are likely to result in imprecise estimates of economic impact.

The length of the research and benefit lags associated with industrial use of the tropical pines compound this complexity. For *ex post* analysis, the duration of the lags imposes a significantly greater data burden. For evaluation of more recent or on-going FRP research, lengthy lags imply the need for *ex ante* projection of many (if not all) of the key evaluation variables[1]. At the same time, the longer the lags, the greater the uncertainty associated with such projections. The fact that timeframe and uncertainty issues received little or no attention during the course of the DFID/OFI programme highlights the lack of "impact focus" during implementation.

The effect of discounting in the evaluation of research with long lags may be a cause for pessimism, but it does emphasise the importance of realistic appraisal of the minimum likely timeframe for completion/diffusion of planned research and on-going review of uncertainties associated with such projections. Where long lags are anticipated but research is nevertheless considered worthwhile, an effective promotion strategy (aimed at minimising the adoption lag), careful cost control and on-going review of the assumptions underlying the research rationale may offer means to manage the risk of underachievement. In the case of the DFID/OFI programme, no evidence could be found to suggest that periodic reviews of progress against

[1] i.e.: costs of further research, adoption rate and ceiling, magnitude of research-induced gains, value of research-induced gains and the duration/depreciation of research induced-gains.

overall objectives were undertaken, while the incremental value of additional research during the course of implementation was never assessed.

While lags associated with more current FRP projects may in general be shorter (e.g. faster growing species, shorter rotation forest products), the timeframe from the start of tree-related research to realisation of the first benefits may still be ten years or more. That is, considerably longer than the three-year project cycle typical of RNRKS research. As such, time and uncertainty issues appear of critical importance for the evaluation of publicly funded forestry research. Stronger collaborative links between FRP (as distinct from its projects) and overseas institutions responsible for implementation of research might facilitate longer-term monitoring of these issues.

The fact that the DFID/OFI programme was in essence a network, with over 100 "members" and responsible for "enabling" rather than applied research further complicates the task of evaluation. This is likely to be true of all networks given their "arms length" relationship with local research and is not restricted to the forestry sector. For example, an evaluation of CIMMYT's maize improvement research (1966-90) reported a consistent lack of reliable data regarding: the pedigree of lines released in different countries; the area planted to improved varieties and hybrids; and the magnitude of yield gains (López-Pereira & Morris, 1994). As such, in spite of extensive study during the course of a year, economic impact could not be estimated[1]. In the light of these problems, it is not unreasonable to conclude that the DFID/OFI research programme would pose even greater challenges for evaluation given longer production cycles and a more informal relationship with network members.

Public funding of such research is commonly justified on the grounds that it would be uneconomic/impractical for individual countries/organisations to undertake the necessary work separately. In the case of the DFID/OFI programme, however, this argument assumes that the majority of countries included in the programme could/would benefit. In practice, differences between the forest sectors in participating countries determined both interest in and ability to utilise the research. While closer collaboration was established with a few of the more promising countries, the "loose" collaborative model employed by the DFID/OFI programme meant that factors influencing the effectiveness of research among members were never explicitly considered and a clear network strategy was not developed.

The characteristics of the DFID/OFI research suggest any attempt to establish econometrically the direct relationship between DFID expenditure and benefits realised by members would be impossible in practical terms. More simple evaluation models, however, are also constrained by the lack of data regarding research uptake and effects. At the very least, such networks should be subject to informal assessment but to facilitate this, a number of minimum requirements would appear to exist.

First, collaborators and the potential area of adoption should be clearly defined. Where the network includes many members some form of prioritisation should be undertaken. Second, monitoring arrangements should be negotiated with collaborators in advance. Ideally, for the purposes of economic evaluation this would include information on costs associated with the local advancement of research, data relating to the key inputs and output(s) targeted by research, and local assessments of uptake and research-induced gains. At the very least, however, this should involve a systematic approach to obtaining periodic feedback from

[1] In contrast to the evaluation of CIMMYT's wheat improvement research (Byerlee & Moya, 1993)

collaborators regarding progress, outcomes and their perspective on actual and future success. Third, the possibility of imposing conditions on continued collaboration should be considered. Precisely because the seed and information disseminated by the DFID/OFI programme was freely available without conditions, there is no simple indicator of the (minimum) value placed by collaborators on DFID/OFI research[1]. While the imposition of fees may be impractical and/or undesirable, the fulfilment of monitoring and reporting requirements could be made a condition of continued collaboration.

To a certain extent, the challenges associated with evaluating network-type research could be overcome by undertaking country-specific assessments and comparing aggregate local-level net benefits with the cost of the network element of research. Issues of attribution would of course still be encountered but the sensitivity of results to different assumptions in this regard could be tested in an *ad hoc* manner. However, the lack of any systematic data collection effort on the part of the DFID/OFI programme regarding the uptake of research (beyond records of seed distribution) represents a significant constraint on such an approach.

Furthermore, the different experiences in the case study countries regarding the rate and manner of adoption caution against the use of simplistic assumptions in this regard. The existence of a dynamic industrial forest sector was a prerequisite for research uptake. Certainly, the provision by the programme of new tropical pine germplasm alone was insufficient basis to initiate a plantation industry. At the same time, the existence of an established industry and the need for adaptive research were major factors in explaining the relatively slow uptake of the DFID/OFI research in RSA and Zimbabwe. In these cases, the tropical pines faced competition from established (alternative) species. As such, the degree of variation in performance between research-identified provenances was of limited practical relevance to uptake. The importance of comparing research results with existing practices/land uses etc. can be expected to be equally relevant for more socially orientated forestry research, e.g. “trees on farms”.

The lack of significant commercial uptake in RSA and Zimbabwe and the lack of data in the case of Brazil where uptake has occurred effectively preclude the use of econometric techniques in this case. Furthermore, the lags associated with the tropical pines research suggest that conventional, TFP econometric models are likely to struggle to pick up research-induced effects occurring over such extended periods. As an alternative, the University of Reading has outlined the basic requirements of a simplified econometric approach, based on partial productivity (i.e. yield) measures (see appendix 3.1) that may be more practical for tree-improvement research. The approach combines early *ex post* results (FRP and collaborators expenditure, including production costs, and initial indications of yield gains) with *ex ante* estimates (final yield, remaining research lags, rate and ceiling level of adoption, rotation length). While the *ex ante* element of the approach goes some way towards addressing the issues of timeliness, it is recognised that results will not provide a precise estimate of the returns to research. At the same time, data requirements remain demanding:

(a) Maintaining R&D expenditure data from the inception of research

(b) Recording subsequent uptake and further R&D expenditures incurred by beneficiaries

[1] For example, CAMCORE use the continued willingness of its members to meet membership obligations (fees, adherence to trial protocols, etc.) as a key indicator of the on-going value of its programme.

(c) Monitoring growth data from initial plantings to provide the earliest possible indication of potential yield at maturity

(d) Collecting data regarding other managerial and biological inputs as far as possible

(e) Simultaneous to (c), collecting data regarding inputs to and the yields of older tree varieties already in place

(f) Pooling data in (c), (d) and (e), and regressing yields on inputs and R&D expenditure in order to obtain an estimate of the marginal product of R&D on yield

(g) Combining this information with guesstimates of time lags to adoption, extent of adoption and lags to tree maturity, and converting yield figures into value terms in order to provide a measure of the impact of R&D.

Under different implementation arrangements, it is conceivable that the DFID/OFI programme could have collected the necessary data from a subset of the more promising collaborators. In contrast to Brazil, however, adoption experiences in RSA and Zimbabwe, where DFID/OFI material was used by on-going research rather than directly for commercial purposes, raises doubts about the practicability of the above approach in every case.

On the face of it, non-econometric estimation techniques may offer a more feasible alternative given greater flexibility in accommodating data shortages. Certainly simple CBA techniques can be employed at least to inform managers' understanding of potential impact.

In the case of the tropical pines research:

- approximate estimates of DFID research-related expenditure are available
- production cost and price data for "representative" sawlog-pulpwood pine plantations (25 year rotation) in Zimbabwe and RSA were collected during the case study[1]
- the lack of reliable data regarding local research costs incurred by collaborators is a major constraint preventing inclusion of this element in any analysis; it is, therefore, (implicitly) assumed that local research activities would have occurred in the absence of the DFID/OFI programme, though to no productive effect
- this dubious assumption can be to some extent offset by restricting research effects to type (2) gains only (see table 4.7) and assuming a research-induced increase in utilisable yield of just 15%
- combining the above with conservative assumptions regarding production costs, output and prices in a "representative" pine plantation, permits the net benefit (in present value terms) of research to be estimated as: £120 per "adopting" hectare (in 1999 prices)
- it can be further assumed that uptake around the world began in 1985, though in Brazil it was probably earlier while in RSA and Zimbabwe it has yet to happen
- the adoption profile is assumed to be linear, with equal annual areas planted over a 25-year period until a final adoption ceiling is reached in 2009 for the type (2) initial utilisation gains considered here
- subsequent gains resulting from further improvement activities or gains arising from other outputs of research (e.g. conservation-related research) are ignored
- finally, a test discount rate of 10% is used.

[1] Available resources prevented collection of similar data for Brazil.

With this mix of data and assumptions, it is possible to estimate the adoption ceiling needed for DFID expenditure to break even. The results suggest that a final ceiling of just 323,000 ha (by 2009) would ensure this. Results from the country visits suggest that in Brazil alone the DFID/OFI research influenced some 300,000 ha or more of tropical pines already planted. As such, under the above assumptions it may be reasonable to conclude that the benefits of the DFID/OFI programme have outweighed the research investment.

Of central interest to *ex post* evaluation, however, is "by how much" yet this is considerably less certain. Without reliable data (and the prerequisite investment in data collection and management), economic evaluation of research may be reduced to little more than "number crunching" guestimates. In reality, such an analysis as above is significantly more useful if it is undertaken during the course of research, in order to provide management with a yardstick to assess research progress. Undertaking the exercise after completion of research smacks heavily of bolted doors on empty stables.

In practice, any serious non-econometric assessment would require data similar to that outlined for the partial productivity approach, and perhaps some additional requirements (e.g. estimates of supply and demand elasticities for economic surplus models). Undoubtedly, non-econometric approaches are more flexible in accommodating weaknesses in data scope and quality, particularly in the case of *ex ante* analysis. However, this "advantage" may be somewhat illusory. In the absence of data, such approaches may still be feasible but this does not necessarily mean that the results will be reliable.

Section 5 now examines evidence obtained from a range of organisations involved in forestry and/or long-term research to determine how the challenges posed by timeframe, uncertainty and data requirements are resolved in practice within active research programmes.

# 5. Institutional review

## 5.1 Background

While the duration and complexity of the DFID/OFI research programme discussed in section 4 might be considered extreme, problems of timeframe, data availability, attribution and so on can be expected to arise in the evaluation of much current-day FRP research. These problems can be expected to limit the precision with which impact can be estimated. In the case of occasional, one-off evaluation exercises designed, for example, to update DFID on recent FRP achievements, such imprecision may be considered acceptable. However, in the context of an evaluation strategy for FRP, it is legitimate to ask whether such exercises meaningfully contribute to internal programme management requirements (as distinct from external reporting obligations).

With this question in mind, this section reviews a range of forestry and non-forestry institutions that face many of the evaluation problems typical of FRP. The objective is to determine whether guidance, or even "best-practice" models, can be distilled from practical experience/approaches in the public and/or private sectors that would facilitate resolution of such problems strategically within the context of FRP's on-going research portfolio.

Section 5.2 examines experiences from public sector research organisations (forestry and non-forestry). Section 5.3 then considers limited examples drawn from private sector research. Conclusions drawn from these discussions are then considered (section 5.4). Finally, section 5.5 considers the features and possible applicability to FRP of a performance assessment system increasingly used in the North American and European business sectors.

## 5.2 Public sector research

As a starting point, the study attempted to determine the extent to which the major public forestry research bodies have institutionalised evaluation strategies. By no means comprehensive, the range of organisations included is thought to provide a reasonable indication of the current status of evaluation systems in the public sector.

As noted in the literature review (section 2), the **USDA Forest Service** was instrumental in promoting early evaluation initiatives for forestry research. Unfortunately, attempts to contact the USDA Forest Service to ascertain the current status of evaluation initiatives were not successful during the course of the study. It appears, however, that interest in this subject area, at least from a planning perspective, has waned somewhat (pers. com. Prof. H. Gregersen).

The **Centre for International Forestry Research** (CIFOR) is a relatively young International Agricultural Research Centre (established 1993) and the issue of evaluation is high on its emerging agenda. CIFOR is currently implementing two projects that relate directly to the evaluation of forestry operations/interventions: *Research impact, information and capacity building* (CIFOR project 9), and *Assessing the sustainability of forest management: testing criteria and indicators* (CIFOR project 4). The results of the former are expected to be of most direct value to FRP, though "Criteria and Indicators" may provide useful measurement tools that can be applied when evaluating particular FRP projects. At the time of writing, work under Project 9 had focused on the initial activities necessary to assist CIFOR operationalise and efficiently implement its research agenda. These have included capacity assessments of partner organisations that can guide research collaboration based on institutional comparative advantage, refinement of planning and management tools (e.g. the logical framework) for major projects and so on. Work specifically relating to the monitoring and evaluation of research is on-going/planned and, as such, definitive conclusions or guidelines are not available to this study.

CIFOR's work under project 4 reflects a more general interest among a number of R&D organisations in the role of indicators as a tool for performance assessment and evaluation. Proposed frameworks have been/are being developed for a range of applications, of which most pertinent might be: work undertaken by USAID and the World Bank addressing international RNR research (e.g. Alex, 1996), DFID's own approach for development assistance to the forestry sector (Flint, 1996), and wider initiatives to monitor progress against environmental/sustainability objectives (e.g. Hammond *et al*, 1995 and IUCN, 1995).

In general, these efforts seek to identify indicators that are linked at different levels of aggregation (from project/community, through to national or global levels) with the aim of monitoring overall performance against a particular set of objectives. At a strategic level (priority-setting, research identification and planning), indicator frameworks are expected to be useful. Similarly, the contextual information generated through monitoring of regional/national level indicators may be valuable when interpreting performance at the research project level.

However, as a means to improve on-going evaluation within FRP, there are a number of apparent drawbacks. First, many of the indicators can only be expected to capture long-term change and thus do not address the "timeliness" constraint posed for evaluation within FRP. Second, data constraints already highlighted in the forestry sector mean that measurement of indicators may be more difficult in practice. Third, even when selected indicators have a "performance" dimension (e.g. degraded land as a percentage of cultivated area), these approaches are more suited to evaluating aggregate progress over time and less to isolating the contribution of specific initiatives (e.g. a particular FRP research project). In most cases, regional or national indicators are likely to be relatively insensitive to changes in project level indicators, in spite of efforts to design frameworks that link indicators at different levels.

During the course of the study, the author also attended a workshop at the International Centre for Research in Agroforestry (ICRAF) entitled *Assessing the impact of research in natural resources management*. A wide range of national and international research organisations (see Izac, 1998) were represented at the workshop. The subject area is particularly relevant given that much FRP-funded research (agroforestry, trees-on-farms, natural forest management) can be broadly categorised as natural resources management (NRM) research. The workshop was conducted over three days yet no firm conclusions concerning generic institutional approaches to impact assessment were reached. Similarly, from among the organisations represented, no single evaluation model emerged that could be easily adapted to FRP.

This conclusion is supported indirectly by the findings of the Impact Assessment and Evaluation Group (IAEG) of the Consultative Group on International Research (CGIAR). IAEG commissioned a report (CGIAR, 1997a and 1997b) to review *ex post* impact assessment studies conducted by the international agricultural research centres over a period of 16 years. Of the 265 documents received only 87 (33%) were included in the final report, (only one from ICRAF[1]). Reasons for exclusion included: documents did not present the results of a specific evaluation study; documents discussed research activities but did not present evidence of

[1] Given its age, CIFOR was not included in the list of CGIAR centres.

research effects; potential or actual effects were discussed with little or no supporting data; documents only reported results of on-farm trials. Of those documents included in the final report, (accepting the general reservations expressed regarding methodologies and data quality), 70% assessed adoption and nearly 60% assessed yield effects; only 15% assessed the effect of research adoption on income.

IAEG commissioned a further study (CGIAR, 1997c) to examine in-depth eleven of the 87 documents identified in the earlier report. The objectives of this exercise were to (a) identify promising evaluation practices, and (b) compile plausible statements of research centre outcomes. With respect to the former, the factors identified were: clear methodology, use and synthesis of evidence across multiple sources, disclosure of data gaps and limitations, and explicit presentation of logical linkages between activities and outcomes. The report, however, falls short of identifying a "best-bet" generic model. Regarding the second objective, claims relating to the uptake and use of research by institutional clients and beneficiaries were found to be more plausible than those concerning the impact of research (i.e. effects beyond adoption). As the final report concludes:

> "…the documents are relatively uninformative about what kinds of people are using these products and about the short- and long-term effects of the use of the products on beneficiaries. In other words….we still know very little about the degree to which the CGIAR is achieving its mission…"

Interestingly, the final report makes little reference to the time dimension of research, and its possible importance in explaining the above findings.

The Forestry and Forest Products Division of the Commonwealth Scientific and Industrial Research Organisation (CSIRO)[1], Australia, is currently assessing the role of and its approach to evaluation. Up to now, the Division has operated without an explicit evaluation strategy. A mixture of *ex ante* and *ex post* assessments are planned with the longer term aims of: developing more systematic, transparent prioritisation and selection procedures, demonstrating awareness of market and science issues and their relevance to the Division, and marketing the Division to key stakeholders. Issues that have arisen in the course of developments to date include:

- Need for a consistent evaluation approach across projects
- Importance of evaluation objectives, data quality and research timeframe in determining methods
- Greater practicability of simpler, CBA techniques
- Need to combine methods (e.g. performance indicators may provide information about changes but not causal relationships)
- Importance of assessing/quantifying costs and benefits as far as possible

In addition, the Division is considering adapting and applying CSIRO's existing "Attractiveness-Feasibility" framework for strategic priority-setting and research appraisal. In short, attractiveness is assessed in terms of the potential benefits (largely market orientated) and the ability of CSIRO research (and its commercial partners) to capture these benefits. Feasibility is assessed in terms of the prospects of research success, opportunities for CSIRO in the context

[1] In 1997/98, 65% of CSIRO's total income was provided by central government, 35% was provided by external sources, including competitive granting schemes, research funded by industry and other users, and earned revenue.

of wider research efforts in the particular field, and CSIRO's R&D capacity and standing *vis a vis* competitors. The information obtained from these assessments is combined within a graphical framework where proposed projects are plotted against "Attractiveness" and "Feasibility" axes for the purposes of comparison.

The Australian Centre for International Agricultural Research (ACIAR) operates seven research programmes which span the natural resources field. Forestry research has historically centred on the testing of suitable (Australian) tree species in developing countries with commodity-focused objectives (e.g. fuelwood production). While this still represents a major part of the programme, research relating to forest management and sustainability issues (e.g. soil and water issues, pests and diseases) and final utilisation is receiving increasing support. Of the institutions included in this study, ACIAR is the most advanced in terms of developing a systematic approach to economic evaluation. This comprises[1] (see Davis and Lubulwa, 1995):

(i) aggregate research prioritisation analysis using an economic surplus model to examine potential local and international welfare effects of commodity-based research[2];
(ii) project development assessments to evaluate potential economic returns to individual research projects, based on project specific economic assessment (using a surplus model) and interaction between natural scientists and the economists in the Economic Evaluation Unit (EEU);
(iii) *ex post* review of completed projects, which examine economic impact (informally) along with other relevant lessons derived from implementation;
(iv) Senior management review of reports produced under (iii);
(v) Formal *ex post* evaluation of selected research projects (case studies) for strategic/institutional purposes.

The objective of the approach is to support decision-making at various levels within ACIAR. At the same time, the information systems are seen as having an important role in meeting the requirement for greater accountability and transparency in the use of public funds. In spite of the stage of development reached, however, discussions with the Forestry Programme Manager and an EEU economist indicate that forestry research is not always easily accommodated within the approach. For example, joint products from forestry investments (e.g. fuelwood and pulpwood) complicate the aggregate research analysis, while indirect effects and externalities are difficult to incorporate at any stage. Indeed, it is recognised that if the Forestry Programme were to shift significantly towards natural forest management research or environmentally-orientated forestry research, more complex evaluation models would be necessary.

Non-priced outputs of forests remain problematic for the ACIAR system, as does the length of the research, adoption and benefit lags, which in turn constrain the depth of analysis possible at the *ex post* review and evaluation stages. It is also worth noting that the approach does not systematically incorporate the results/assumptions of *ex ante* project development assessments into project implementation/monitoring systems (e.g. as a means to facilitate on-going evaluation). This aspect may develop as the system matures and it becomes possible to

[1] All of ACIAR's programmes are included in this process, though not all projects are subjected to each stage of the process.
[2] This information is used to screen potential research and supplements planning decisions taken annually by the Policy Advisory Committee.

compare predictions made in project development assessments (a relatively recent addition to the approach) with actual results recorded in *ex post* reviews or evaluations.

In spite of the variety of experiences discussed thus far, a number of general conclusions can be made. In the majority of cases, the evaluation strategies in so far as they exist are largely project-based. While reasonable, this implies the need for careful attention to the issue of "representativeness" given that that FRP can formally evaluation only a sample of projects in any year.

In addition, it is apparent that a number of bodies recognise the importance of building evaluation into research management activities at the design and selection stage, rather than relying solely on periodic (*ex post*) assessments.

At the same time, the level of development of the evaluation strategies discussed appears either too limited at this stage to draw significant conclusions or, in the case of ACIAR, too advanced for FRP. Even in the case of ACIAR's strategy, which implies the need for a separate evaluation unit (perhaps pooled across the RNRKS programmes), the difficulties posed for evaluation by forestry research remain. For ACIAR, the degree of approximation involved in forestry research evaluation appears to be traded-off against the more general applicability of the strategy to the commodity-based research undertaken in the other RNR sub-sectors.

In contrast to the more project-orientated strategies, two examples are provided below of organisations that have attempted to develop programme- or institution-based strategies. Of course, this distinction between "project" and "programme/institution" is somewhat artificial in that these organisations, like FRP, are essentially the sum of their project initiatives. At the same time, the distinction is useful in as far as it highlights attempts to overcome the weaknesses inherent in a purely project-focused strategy. These weaknesses relate to the difficulty of aggregating results meaningfully across a wide range of projects, the constraint imposed on reporting by the research timeframe and the problem of measuring impact after completion of a particular project.

In Canada, the **National Research Council** (NRC) has developed its own assessment framework with indicators to assist annual evaluation of institutional performance (NRC, 1997). This framework has also been adopted by the **Canadian Technology Network** (CTN), essentially an information and best-practice support and dissemination service. The framework, along with example indicators is set out below:

| Resources<br>Activities/Outputs | Reach | Results<br>Immediate impacts | <br>Long term impacts |
|---|---|---|---|
| • Identification of key technologies, critical areas<br>• Investment in key technologies, critical areas<br>• Analysis of key firms by economic sector | • Clients and partners<br>• Collaborative arrangements<br>• Networks/ alliances | • Tech. transfer, spin-offs, start-ups<br>• Income/ contributions in-kind<br>• Diffusion of products and services<br>• Client satisfaction | • Economic performance of clients/partners<br>• Acceptability of Canadian products & services<br>• Client feedback<br>• Employee feedback |

Examination of the NRC's annual report 1996-97, which introduced this framework suggests that indicators at the Results level have yet to be fully operationalised or institutionalised and certainly indicators of Longer Term Impacts are likely to pose measurability and attribution problems. Nevertheless, the use of intermediate measures of "success" (i.e. Reach and Immediate Impacts) as performance indicators that can be gauged within a reasonable timeframe is noteworthy.

In Australia, CSIRO itself uses performance indicators for institution-wide assessment (CSIRO, 1997). In the mid-1990s, attempts began to broaden performance assessment beyond simply "external earnings", in order to provide a better indication of CSIRO's responsiveness to needs and contribution to national welfare. The indicators are summarised as follows:

(1) Shift of resources according to prioritisation decisions: CSIRO in conjunction with its main stakeholders undertakes a major review of research priorities on a triennial basis. This indicator assesses congruence between expenditure and the priority areas of research identified.

(2) External earnings: this is considered a measure of the demand for CSIRO's services and the indicator reports external earnings as a proportion of total income, for comparison with an institutional target.

(3) Customer satisfaction: based on follow-up surveys, this is used as a measure of CSIRO's responsiveness to customers' needs; up to now, it has focused on those cases where a contractual arrangement exists (as opposed to, for example, more general advisory support provided to government).

(4) Adoption: the measure seeks to identify examples of research outputs in use by industry, government and the community or changes in practice resulting from advice provided by CSIRO.

(5) Publications, reports and patents: this measures CSIRO's scientific contribution; quantity is measured annually while quality is measured, via citation analysis, triennially.

(6) Training: the number of students jointly supervised and/or fully or partially sponsored by CSIRO is quantified as a measure of the institution's contribution to skills development in Australia.

The two most problematic indicators from the point of measurement, quantification and interpretation have proved to be, unsurprisingly, (3) and (4). Client satisfaction surveys are considered time consuming (in both completion and analysis) and raise a number of methodological issues. These include: the desirability of CSIRO's close involvement in completion of the survey (higher response rates vs. biased results), inclusion of a "value-for-money" question, use of outside expertise for analysis to increase objectivity, and the fact that many divisions use informal means to obtain on-going feedback from clients. While CSIRO attempts to place dollar values on the examples of adoption identified, lags and data availability (particular if commercially sensitive) constrain efforts and the results are more commonly presented in the form of "research highlights". It is noted that many of the examples identified under indicator (4) lack sufficient or appropriate detail to demonstrate the magnitude of benefits.

While both CTN and CSIRO recognise the importance of impact assessment, their evaluation strategies have been broadened to include a mix of indicators that facilitate assessment of performance in the shorter term. This is achieved by balancing evaluation efforts with indicators that focus on areas up to and including the "customer" interface (i.e. areas where the organisation still retains a significant involvement in the process). At the same time, relatively easy to measure examples of impact can be reported through the use of "research highlights" as and when available. Although indicators such as client satisfaction and reach/adoption are themselves not problem free, they provide more practicable measures based on the (reasonable) assumption of a causal relationship between positive signals from these indicators and ultimate impact. Of course, the validity of this assumption is open to question in specific cases, but perhaps the issue of more general importance to FRP is whether such "second-best" measures are acceptable.

## 5.3 Private sector research

To a limited extent, the study also examined evaluation approaches evaluation used in the private sector to see whether any general guidance might be obtained. Direct comparison between FRP and private industrial research organisations is recognised as hazardous given obvious differences in objectives and the institutional environment. For example, whereas an industrial company with in-house research capacity can redirect scientific effort to the more promising areas indicated by M&E systems, FRP does not conduct research itself nor does it directly manage the researchers whom it contracts. Instead, FRP employs a range of institutions for fixed terms to implement research on its behalf. As such, the value of results from on-going evaluation for internal decision-making purposes is necessarily "dampened" by the duration of and structural rigidities in the contracts FRP issues.

Olmstead (in USDA, 1986) reviewed evaluation theory and practice in industrial research and development. He concludes that there is widespread recognition within industry that research by itself is of little value but depends on successful transfer to the market place. This, however, relies on a range of actors within the organisations concerned and will also be affected by market conditions. To demonstrate the importance of such "external" factors, Olmstead cites previous evidence suggesting that the probability of technical success in industrial research is around 50% while the probability of generating a commercially successful product or process is only 12%.

A range of selection/prioritisation methods are discussed, including checklists, ranking exercises, scoring methods, risk analysis and optimisation models. In short, it appears that use of particular methods by industry declines as complexity increases. An earlier study (included in Olmstead's review) of evaluation approaches in UK industries, however, concludes that some measure of financial worth and probability of commercial success are employed by almost all companies when assessing potential research projects. The same study noted that changes in indicators of *potential* success (both technical and commercial), and estimates of further costs (for development and completion) were also commonly used as criteria for reviewing progress of on-going research.

Formal *ex post* evaluation appears to be relatively rare in industrial research, probably because clear, market-orientated indicators of success (e.g. sale volumes) exist and are readily observable. In the cases where it is carried out, the perceived advantages relate to motivating researchers, identifying high risk business objectives, demonstrating research productivity, identifying productive research areas and increasing the level of confidence in predictive evaluations. Examples of the methods used in these exercises include: Return to Research Ratios, which compare the costs of research with the value generated for the company; and Benefit Ratios, which compare the accumulated present values of technologies maturing during the period of analysis with research expenditures during the same period.

In an effort to assess whether alternative evaluation methods for forestry research are applied within the private sector, the Forestry Research Unit (FRU) of Shell International Renewables (SIR) was contacted. FRU focuses exclusively on plantation resources and in the main research is directed towards genetic improvement (including biotechnology) though wood properties research is of growing interest. While detailed, five-yearly research plans are driven by business objectives, both FRU and the parent company recognise the difficulties inherent in identifying trends in future opportunities given the lags associated with the research programme (up to 16 years). As such, the potential of research to generate more general spin-off benefits for SIR (e.g. new technology development, establishment of business links with other organisations) is also an important factor when planning research.

FRU research is organised under a set of on-going programmes that in turn are broken down into components. Timebound milestones are identified at this level and progress monitored. Effectiveness is largely assessed in terms of delivery of outputs to customers and customer satisfaction. The difficulty in providing an in-depth analysis of the "value" of forestry research appears to be recognised by SIR, and as such FRU is not required to use formal evaluation techniques when justifying budgets, etc. Instead, FRU relies on face-to-face discussions with the parent company, supported by in-house knowledge of previous successes that in turn increase confidence in the prospect for future benefits.

For a non-forestry perspective on private sector research planning and evaluation, discussions were also held with BP Exploration and Zeneca Agrochemicals[1]. It is difficult to draw general conclusions from the information provided, as the systems used by each company are specific to their respective objectives and organisation. Nevertheless, a number of common features can be discerned:

- The commercial side of operations plays a critical role in setting the research agenda, in line with established corporate business goals/challenges.
- Potential value *and* technical difficulty are considered when identifying possible areas of research.
- Research portfolios are deliberately managed to include a mix of short-term, lower impact, technically easier research and longer term, higher potential but more challenging research.
- The R&D *process* is monitored to ensure delivery of the necessary stream of technological solutions, and projects are periodically reviewed to assess progress against the key commercial and technical questions.
- Effectiveness is assessed in terms of the delivery and application of results, with no significant reliance on methods such as cost-benefit analysis.
- High quality interaction between the parties involved is considered important, while the development and use of criteria/indicators is considered secondary to this process.

In general, experiences in private sector research suggests greater emphasis is placed on evaluating on-going progress rather than achievements in an *ex post* sense. This is in part explained by the interests of these organisations but also by the fact that the commercialisation of research output is frequently the most expensive phase of R&D. As a result, significant management input and high rates of research "failure" occur in the earlier stages to ensure that any product/process that does advance to the final development stage will have a very high likelihood of (commercial) success.

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[1] Zeneca Agrochemicals were contacted as part of an earlier study, (see Farrington, Thirtle and Henderson, 1997).

The importance of research lags is also recognised and specific efforts are made to manage the research "process" in order to maintain a steady feed along the R&D pipeline. Similarly, outputs or targets are established annually or more frequently, rather than at the end of the intended period of research, and progress is assessed in terms of improving prospects over time. Progress itself is defined both in technical and commercial terms though it is recognised that research has significantly less influence over the latter.

## 5.4 Conclusions

One obvious conclusion from the above institutional review is that there is no single off-the-shelf evaluation model that can fit FRP's resources and requirements. At the same time, there are a number of characteristics derived from the various examples that merit consideration and possible adaptation.

The first is the use of intermediate measures to assist on-going evaluation and reporting. These measures "fill" the gap between the technical outputs of research (as identified in a project's logical framework) and subsequent impact. This gap can be the result of the temporal dimension of the lags associated with forestry research and/or practical measurement problems. Intermediate indicators provide both a measure of achievement that is observable in "real-time", but also point to prospects of achieving impact in the future. They do not, however, quantify the magnitude of these future benefits, nor do they answer the question whether the returns justify the research investment. Whether under these terms such intermediate measures, (of, for example, end-user satisfaction, adoption and so on), are "acceptable" remains an issue for FRP management and DFID more generally.

Second, monitoring of on-going research within the private sector appears to place greater emphasis on objective-led measures of progress, rather than the activity-based indicators common in RNRKS project monitoring reports. These indicators report less on what has been done and more on progress towards the overall objective (e.g. the development of a new product for a particular market). Relative improvements in the "scores" assigned to these indicators are used to gauge research prospects.

Finally, whereas private sector research bodies may not be preoccupied with formal *ex post* evaluation, impact assessment remains a major concern for public research organisations, given donors' own external requirements such as accountability, demonstrating effectiveness and advocacy. Neither can FRP ignore this issue. However, the danger of building an evaluation strategy solely around conventional *ex post* studies is that it may simply fail to address any research that cannot be easily incorporated within this assessment framework. Any FRP evaluation strategy must utilise a mix of indicators that allows both meaningful measurement of progress today, while remaining sensitive to the need, where possible, to demonstrate actual impact.

## 5.5 Balanced Scorecard approach

With these issues in mind, this section takes a closer look at a particular performance assessment framework that has been adopted by a wide range of industrial and service-orientated organisations in both the USA and Europe: the Balanced Scorecard (BSC). The BSC approach was developed by Robert Kaplan and David Norton over a period of six years in the early to mid 1990s. It is essentially a performance measurement system that seeks to marry strategic business objectives with operational management activities. Some of its more salient features are summarised below, though full details can be found in: Kaplan and Norton (1992, 1993 and 1996).

The BSC approach is founded on the belief that conventional business performance measures, which rely solely on summary financial indicators, hinder organisations' capacity to create future economic value and are increasingly inadequate in the modern age. As a result, the framework seeks to provide a "balanced" view of performance across four key components. While specific indicators are context specific, these components are considered generic:

Customer perspective: "*How do we look to customers*?"
The BSC approach recognises that customers judge a company's service against a range of characteristics. While price may be important, issues such as delivery times, quality, and so on, may be as significant in particular circumstances. For the BSC approach, customer satisfaction is a multi-criteria concept that can only be properly defined by customers themselves.

Internal business perspective: "*What must we excel at?*"
An objective of the BSC approach is to link customer perspective indicators with those describing internal actions. Indicators for the internal business perspective should relate to actions of staff involved in a particular process but are objective-led in as much as the are governed largely by customer expectations.

Learning and growth perspective: "*Can we continue to improve and create value?*"
This component focuses on forward-looking targets for continual improvement within the company. Indicators relate not only to new product development or the improvement of existing products/processes but also to the "infrastructure" required to enable strategic objectives to be realised. This infrastructure commonly comprises employee, systems and organisational capabilities. Interest in measuring improvement in these capabilities was prompted by the fact that in the past efforts to investment in these areas proved an easy target for short-term attempts to increase earnings.

Financial perspective: "*How does the company look to the shareholders?*"
While the need to broaden the range of performance measures is recognised, financial measures remain the "bottom line" for businesses. The backward looking nature of financial indicators is in part offset by the more forward orientation of the previous three components. However, financial indicators are recognised as playing a crucial, overall role in determining whether the strategy, as operationalised by the other components, is itself profitable.

The indicators developed under all four components generate a more balanced data set for assessment purposes and explicitly recognise that no one measure provides an adequate summary of overall performance. Indeed, the different indicators included in the BSC approach are often compared with the different instruments in an aeroplane's cockpit for illustrative purposes. However, the effectiveness of the approach is also considered dependent on fulfilling three basic requirements:

(a) *Outcome and performance drivers:* A BSC should have a mix of outcome measures (lagged indicators) and performance drivers (leading indicators). While outcome measures clearly describe objectives, performance drivers describe how outcomes will be achieved and provide an early indication of whether the strategy is being successfully implemented. The importance of leading indicators is highlighted by the example of an insurance company where long lags occur between decisions taken at one point in time and the related outcomes in the future (Kaplan and Norton 1996).

(b) *Cause and effect relationships:* As can be anticipated, a good BSC must explicitly identify cause and effect relationships. These relationships exist not only between the four components of the framework but also between outcome measures and their associated performance drivers. This requirement recognises that any strategy is in fact a set of hypotheses about cause and effect.

(c) *Linkages to financials:* In spite of the more recent interest in concepts such as customer satisfaction, quality, employee empowerment and so on, all causal paths on a BSC should ultimately be linked to financial objectives (e.g. return-on-capital-employed, economic value-added). This requirement reflects not only the longer-term importance of financial indicators but also the shorter-term need for any changes in *process* to demonstrate tangible pay-offs.

There are a number of obvious difficulties in attempting to apply the BSC approach directly to FRP. First, the approach focuses on the internal performance of a strategy *vis a vis* the external environment. Even measures of "impact" (i.e. the financial indicators) can be measured internally. FRP evaluations, in contrast, are essentially required to assess events external to the Programme. Second, the structure and *modus operandi* of the RNRKS precludes the adoption of a truly "balanced" evaluation strategy in the sense intended by the BSC designers. Although FRP receives monitoring data relating to financial and physical progress, it cannot set organisational targets for the institutions it contracts (i.e. internal business perspective), nor can it fund significant capacity development (i.e. learning and growth perspective) among contracted or target institutions. Third, the BSC approach implies continuous assessment. This raises resource and capacity issues for FRP. Finally, because of the continuous, balanced nature of the approach, there is no requirement that the results of each component be combined to produce a single, overall "rating". Arriving at an "overall" score is likely to be difficult in practice, and indeed contrary to the objectives of the BSC approach. In contrast, FRP may feel that such an overall score for projects is necessary/desirable. Under these circumstances, it is not that a judgement regarding overall performance cannot be reached but just that such an assessment is likely to be subjective rather than objective.

At the same time, the principles of the BSC *do* appear to address a number of the inescapable conclusions reached earlier regarding evaluation within FRP. First, while the internal focus of the BSC may present problems for FRP at a programme-level, the practice of linking internal performance indicators to external events represents good practice for project-level M&E. Second, the lags associated with much forestry research suggest there is a strong need for FRP projects to include *leading* indicators of intended impact, if on-going evaluation is to be meaningful during the life of a project. Third, the same lags suggest that actual impact may not be measurable until many years down the line. Periodic assessment of relative changes in lagged and leading indicators appears essential to discern evidence of improving prospects and hence permit reporting of "progress towards impact". Fourth, in spite of the difficulty in combining multiple indicators, the "balance" provided by the mix of components and indicators remains an appealing characteristic of the BSC approach, and one which goes some way towards meeting the requirement identified by earlier literature on the topic. Finally, the importance attached to financial indicators by the BSC approach bears comparison with donors' continued concern that research ultimately demonstrate its contribution to welfare/economic gains. At the same time, breaking the evaluation framework into separate components implies that research may be evaluated even if estimation of economic impact is more problematic.

Section 6 presents the second case study where an attempt has been made to adapt the BSC approach to an example of FRP-funded NFM research. Such research is difficult to assess using conventional economic evaluation methods and examples where these have been applied almost invariably yield "partial" results. For the particular example of NFM research used in the case study, the likely timeframe of the research and adoption lags suggests that the results of even a simple CBA at this stage would be of questionable value.

Before introducing the case study, however, a number of points are worth stressing and should be borne in mind when reading the sections that follow:

- The case study does not attempt to apply the BSC approach in full; rather the principles of the BSC approach have informed the development of the methodology used in a more general sense.
- The methodology has been developed on the basis of one example and does not represent the "final product"; it is recognised that a number of areas require refinement (e.g. the elicitation process, client satisfaction questionnaire).
- While many aspects of the methodology reflect the identified need for a simpler evaluation approach, it is recognised that the case study example is probably still too complex, with too many indicators, given FRP resources and the need for periodic reassessment implied in the methodology. Whether further simplification is possible requires careful consideration.

# 6. Case Study: Community management of *miombo* woodlands in Malawi

## 6.1 Introduction

### 6.1.1 Objectives of the case study

The objective of this section of the report is to consider the challenges and options for evaluating more current FRP research. The example used to explore this objective is provided by research into community management of *miombo* woodlands in Malawi. The FRP project *Sustainable Management of Miombo Woodland by Local Communities in Malawi* (R6709), began in October 1996 and is due to finish in September 1999. It is relatively unusual within the RNRKS in that it is being implemented directly by the Forestry Research Institute of Malawi (FRIM) with no counterpart UK research institution. R6709 is an extension of a previous FRP project (R4599) implemented collaboratively by the University of Aberdeen and FRIM (1992-1995).

The fact that the example is of research focused on a particular country suggests that evaluation may be more practicable than in the case of the tropical pines research discussed earlier (see section 4). However, this example differs from the tropical pines research in a number of important ways, all of which can be expected to compound the challenges posed for evaluation. First, rather than focused on industrial forestry, the FRP *miombo* project includes significant social, institutional and environmental dimensions within the overall objectives of research. Second, in contrast to plantation forestry, the FRP *miombo* project is directed towards the management of natural woodlands, which in turn raise additional data and measurement issues (see section 1). Finally, and perhaps most significant, at the time of the case study evaluation the *miombo* project was still on-going and important aspects of the research had yet to be implemented even on a pilot scale. As such, there was no expectation that the major (potential) outcomes of research would have been realised.

Thus, the FRP *miombo* project was selected not only because it can be considered more typical of research within FRP's current portfolio but also because it is provides an example of a major practical issue that any evaluation strategy adopted by FRP must resolve. That is, how to evaluate the "impact" of research that is still on-going and which may not achieve significant impact for a number of years.

In response, the case study has attempted to develop a modified evaluation approach, adapted from the principles of the Balanced Scorecard performance assessment system discussed earlier. This modified approach allows for conventional economic impact assessment to be undertaken where possible but broadens the evaluation framework to include more explicitly additional, "intermediate" components, on which future impact will be based. These are intended to facilitate the monitoring of progress towards impact (i.e. on-going evaluation) through more systematic assessment of current achievements and future prospects.

### 6.1.2 Approach

The case study was implemented as a collaborative effort with FRIM and an on-going RNRKS project, "Quantitative and Qualitative Analysis" (QQA), funded under the Natural Resources Systems Programme (Socio-economic Methodologies Component). The QQA project, in turn, is being jointly implemented by staff from the Statistical Services Centre (SSC), University of Reading, the Natural Resources Institute (NRI). The overall development of the modified evaluation approach benefited from the inputs of all of the above, without which the case study could not have been implemented. In addition, the QQA project provided specific guidance on the design of the survey work undertaken during the course of the exercise while FRIM assumed responsibility for its implementation.

Section 6.2 provides a summary of the research objectives and status. More detailed description of the design of the project and the progress recorded to date can be obtained from project documents and reports. The discussion focuses on those aspects pertinent to evaluation design. Section 6.3 discusses the research from the perspective of practical evaluation, considering both the potential effects of the research and the likely data and measurement constraints faced.

In the light of these discussions, section 6.4 presents the modified evaluation approach. It is recognised that in the time available for the case study (within the context of the overall study), the approach could not be finalised and all issues resolved. Furthermore, the approach has been developed in the context of one example, and caution may be therefore required in assuming its applicability across FRP's portfolio. Section 6.5 presents the results obtained during the "test" application of the approach. The exercise is reviewed in section 6.6 and outstanding issues and conclusions are presented for FRP to consider.

## 6.2 Summary of the FRP *miombo* research project (R6709)

### 6.2.1 Background

Malawi is one of the poorest countries in the world (nominal per capita income of US$140 in 1994). A "Poverty Profile" conducted by the World Bank in 1995 concluded that 30% of the population have incomes that do not assure basic calorie needs. Around 87% of the population are rural based. These households are largely dependent on subsistence agriculture and over 70% have holdings of less than 1 hectare (National Sample Survey of Agriculture 1992/93). Based on results from the 1987 census and current estimates of population growth (3.2% p.a. overall, 5.6% p.a. in urban areas), Malawi's population can be placed at approximately 11 million. Average population density ranges from around 46/km$^2$ in the northern region to 171/km$^2$ in the southern region.

The average annual decline in forest biomass in Malawi is currently estimated to be around 3.5% per year as a result of both clearance for agriculture and resource degradation through overexploitation. Official estimates (Forestry Department) indicate that wood consumption is increasing at a rate of 9.25% p.a. The bulk of this demand is for fuelwood. Wood is the main source of fuel for cooking and heating water in 98% of rural households and meets virtually all other energy use requirements. Together, charcoal and firewood provide 94% of the total energy consumed in urban households (USAID 1997). The vast majority of rural households are dependent on natural forests for construction materials and for a variety of foodstuffs which supplement household diet. In addition, households that face land shortages are estimated to obtain some 30% of household income from activities based around forest resources on public land (USAID 1997). Background summary statistics for the forestry sector are presented in Appendix 6.1.

In the last five years, the policy agenda in Malawi has changed considerably with respect to the management of natural resources and the environment in general. In 1994, the Government of Malawi (GOM) adopted a National Environmental Action Plan which identified nine key environmental issues: soil erosion, deforestation, water resources degradation, high population growth, depletion of fish stocks, threats to biodiversity, human habitat degradation, climate change and air pollution. In February 1996, the Cabinet adopted the National Environment Policy (NEP) which commits GOM *inter alia* to: promote efficient utilisation and management of natural resources, and promote co-operation between government, private sector organisations and local communities in the management of the environment.

Uncontrolled cutting of live/green wood within publicly owned, protected areas (including forest reserves) is officially prohibited. Roundwood (e.g. poles) felled under the supervision of the Forestry Department (FD) can be purchased while (dead) firewood can be collected on payment of a licence fee. In principle, non-timber forest products (NTFPs) can now be freely collected though some confusion persists, in part because certain products (e.g. grass thatch) have been the subject of fees in the past and also because NTFPs collected for *commercial* use may be subject to charges. Notably, the NEP recognises communities' rights to benefit from sustainable utilisation of natural resources on all public and customary land, though the implications for issues of access and charges have not yet been fully resolved.

### 6.2.2 Current status of R6709

In summary, R6709 is applied, action-orientated, NFM research. Its Purpose is to produce "techniques for sustainable management of forest resources by local people". This is to be achieved through the development and promotion of "co-management" by local communities and government of indigenous *miombo* woodlands situated on forest reserves, estate and customary land.

Detailed descriptions of the research undertaken are available from FRP in the proposals and progress for the current project and its predecessor (R4599). In broad terms, the project's strategy is based on two main lines of investigation. First, research into social/economic aspects of woodland utilisation and management by local people has been undertaken to improve understanding about the range of products *demanded* by local people and the arrangements necessary for successful community management. Second, silvicultural/ biophysical research is attempting to determine the sustainable *supply* of these products from the woodland resource. The results of this twin track approach will be used to design management prescriptions that focus on the production of woodland products demanded by local people but that adhere to sustainability requirements.

To date, the project has worked primarily in two forest reserves where co-management operations are being piloted with surrounding communities: Chimaliro forest reserve (Kasungu/Mzimba districts) located on the border between the central and northern regions; and Liwonde forest reserve (Machinga district) in the southern region. In addition, experiences from a community's own efforts to manage an area of woodland (38ha) on customary land (Mangwere Hill) are also being studied. Areas within both Chimaliro and Liwonde forest reserves have been selected on the basis of site conditions and the wider environmental functions of the woodlands. These have been demarcated into blocks for management purposes and assigned to groups of villages (Table 6.1).

These blocks represent the focus of co-management activities, where silvicultural interventions will take place (according to agreed management plans) in order to generate poles, firewood and other wood products for use by the participating communities. In return, the communities must provide labour for forest management (e.g. boundary marking, firebreak maintenance, controlled early burning, supervised harvesting and patrolling).

Table 6.1: Co-management blocks established by R6709

| | Block size (ha) | No. of villages per block | No. of PSPs per block |
|---|---|---|---|
| **Chimaliro** (152 $km^2$) | | | |
| Block I | 18 | 3 | 14 |
| Block II | 118 | 3 | 13 |
| Block III | 74 | 3 | 12 |
| **Liwonde** (274 $km^2$) | | | |
| Block I | 416 | 3 | 10 |
| Block II | 288 | 4 | 10 |
| Block III | 468 | 2 | 10 |

Co-management is also expected to legitimise communities' rights of access to the reserves more generally, for the collection of non-timber forest products (NTFPs) and dead wood products. The regulatory framework is provided by Co-management Constitutions, drawn up with each community involved, while detailed operations will be guided by block management plans.

Research has been undertaken around Chimaliro to determine the range of *wood products* used by local communities, their preferences for particular species and approximate household requirements. Silvicultural trials in Chimaliro and two other forest reserves (established 1992) are examining the effect of different harvesting intensities on the growth of specific species/wood products. Data are also being obtained from an older coppicing trial established in 1960. These trials are expected to continue until 2006/7. Permanent sample plots (PSPs) have been established in the co-management blocks and inventoried. Data from these indicate the species and products currently available and will be used for long-term monitoring of growth and yield, and population dynamics. Additional harvest/growth monitoring is being implemented on customary land, with two PSPs established in Mangwere Hill village forest area (VFA) and a number of temporary sample plots established at Mangwere Hill and on sites around Chimaliro forest reserve.

Research is also being undertaken into the range of NTFPs produced by miombo woodlands and their potential role as income-generating activities for local people. Important NTFPs have been identified in a number of harvesting and marketing studies and informal monitoring of marketed volumes from project sites at Chimaliro and Liwonde is underway. Periodic measurements of PSPs in the co-management blocks will include quantification of the less seasonally-specific NTFPs with a view to examining the competition/complementarity between silvicultural intervention and NTFP availability. In addition, FRIM is planning further research into specific NTFPs in separate initiatives with GTZ, ICRAF and the International Mycological Institute. Work on NTFPs to date is less advanced than on wood products but FRIM intends to strengthen links with public and private sector organisations involved in small enterprise development and to produce recommendations for the collection/production and marketing of important NTFPs by 2002. The longer-term objective is to raise the total value of the resource to communities and ease the pressure for conversion of woodland to agricultural land.

Finally, the project is developing *generic methodological guidelines* to facilitate application of co-management elsewhere in Malawi. With respect to the technical elements of the research, FRIM plans to identify simple criteria and indicators that will aid characterisation of *miombo* woodlands at other sites to aid selection of silvicultural regimes. Research is also planning to develop a methodology for participatory, multi-resource inventories, focusing on products (wood and non-wood) and end-uses. Preliminary recommendations are anticipated by the end of the project but these will undergo subsequent refinement in the light of on-going results from the silvicultural trials and PSPs. A longer-term objective is to identify relatively simple indicators of sustainability that can be used to predict performance of co-management initiatives in the future.

The research is also intended to produce guidelines detailing the approach and steps required to initiate and implement co-management. A summary of the process identified to date is as follows: community selection and sensitisation; sensitisation and reorientation of Forestry Department field personnel; formation of Village Natural Resources/Forest Committee; needs assessment and examination of supply-demand dynamics; resource inventory and quantification of wood and non-wood products; development of co-management constitutions and by-laws; ratification of constitutions and by-laws by Forestry Department; signing of co-management agreements; monitoring and evaluation.

To date, management structures have been established within participating communities, Constitutions have been drafted and local people have provided labour for basic forest management activities. In return, participating communities have been allowed to collect deadwood and NTFPs from the co-management blocks without charge. Progress of research is significantly more advanced in Chimaliro than Liwonde, reflecting differences in the duration of the project's involvement at each site (around seven and two years respectively). However, there has been no implementation in either site of the silvicultural prescriptions developed by research and, as a result, no research-induced harvesting of live wood products.

This apparent slow rate of progress is the result of two factors. First, common to much NFM research, the timeframe for the generation of results (research lag) is long. R6079 anticipates that by the end of the project (September 1999) only preliminary recommendations will be available from the silvicultural trials, (i.e. seven years after their establishment) and a further eight years will be required before these can be finalised. Second, over the last year or so institutional issues have become more limiting. Although not unique to NFM research, such constraints are common as a result of the complex institutional, tenurial, legal and political factors affecting natural forests on both public and private lands. While the policy framework in many developing countries may be shifting towards a position more supportive of DFID/FRP objectives, a divergence between stated policy and actual practice is frequently observed. In Malawi, as elsewhere, this reflects a combination of entrenched practices and perspectives regarding public control over forest resources, and uncertainty regarding how new policy directives (i.e. the NEP) should be implemented. As a result, R6079 has now been waiting over a year for FD to ratify the co-management constitutions that will permit silvicultural interventions to begin.

In addition, there are other institutional issues that remain unresolved, largely because of the delay in ratification of the constitutions. These include whether communities will be allowed free access to live wood products harvested for commercial purposes. General references to "sharing" are made by FD staff, but it is unclear whether the communities' labour inputs will be considered sufficient[1]. In addition, the duration of co-management agreements has not yet been agreed, nor have procedures for compliance, sanction and arbitration been formalised.

[1] Although figures were not available to the study, current FD revenue generated by the sale of wood products from reserves is thought to be minor in most cases.

## 6.3 Evaluating the FRP *miombo* research project

### 6.3.1 Possible effects of research

By the end of R6079, FRP will have provided some six years of support to this research, at a total cost of £397,537 (or £436,895 in 1999/00 prices). Given this input, and the developmental objectives of FRP research generally, it is reasonable to ask whether the research has brought about any positive change in social welfare.

R6709's objectives include the promotion of community-based woodland management on forest reserves, agricultural estates and customary land (village forest areas). Given the time available for the case study, it was decided to focus only on potential effects within forest reserves for the purposes of methodological development. Justification for this decision is provided by the following reasons:

(i) Up to now, R6709 has undertaken only limited work (inventory and exploratory surveys) in one village forest area (VFA) and none on estate land and is not expecting to produce specific recommendations tailored to these land classes, (in contrast to forest reserves).

(ii) In principle, forestry extension staff already provide basic woodland management guidelines for village and estate forest owners.

(iii) There is much less incentive for communities and estate owners to enter into formal co-management arrangements with FD, given that they already own the resource to be managed.

(v) Information on which to base an assessment of prospects for uptake of co-management on estate and customary land is extremely weak, though the potential area in the short- to medium-term appears relatively small. FD estimates (1994) the number of VFAs to be nearly 1,200 and while data are incomplete the area covered is likely to be less than $40km^2$. Similarly, co-management proper is only likely to succeed on customary land in the short-term where communities are already actively involved in some form of VFA management. Discussions with a major environmental NGO in Malawi suggest that there are only a few such cases in the country (i.e. less than ten).

That is not to say that no potential exists for co-management research to "spill-over" from reserves on to customary and estate land. Indeed, results from the case study exercise suggest that in a limited number of cases this may already be happening. At the same time, the steps apparently being applied to customary woodland as a result of research are fairly basic forest management activities and the value-added of research in this regard must be considered in the light of point (ii) above.

Nevertheless, even when the focus of evaluation is restricted to forest reserves, the potential effects of the project are by no means simple from an evaluation perspective. The project's Goal is "sustainable utilisation and conservation of natural woodlands enhanced" while the Purpose refers to the development of "techniques for sustainable management of forest resources by local people". While these statements clearly signal the situation of the project within FRP's portfolio, they provide only limited insight into intended research impact. Similarly, the Objectively Verifiable Indicators (OVIs) included in the logical framework (log-frame) identify only physical measures of research output or uptake. It is, therefore, left to evaluation to clarify the intended effects of research.

There are around 70 forest reserves in Malawi, all of which have protected area status and are operated, in principle, on a restricted access basis. As such many are reasonably intact, though harvesting of wood and non-wood products still occurs. In other cases, however, exploitation levels exceed the maximum sustainable yield and as a result these reserves have been heavily degraded. The objectives of R6709 include an economic efficiency dimension in terms of raising the productivity of these reserves through more effective management. The involvement of local communities in this process in part reflects distributional objectives of the research but may also contribute to economic objectives in so far as co-management represents a more efficient management approach. In practice, the condition of each forest reserve is likely to be a major determinant of the potential economic effects of research in the short- to medium-term.

Implementation of co-management within **intact** reserves – the condition that reasonably describes Chimaliro and Liwonde forest reserves – can be expected to lead to more productive use of the woodland while at the same time maintaining existing environmental services. Silvicultural intervention is expected to generate new growth and raise overall productivity levels within the demarcated blocks. In this respect, such NFM research may have an advantage over plantation forestry research, in that research induced benefits may be available (almost) immediately following implementation of research-identified silvicultural practices[1]. Under these circumstances, a temporary rise in the availability of certain wood products might be anticipated during a period of conversion as old growth is cut but this will depend on the condition of the resource at that time. Following conversion, levels of production will be determined by growth rates, which are expected to be relatively low, though higher than at present if management objectives include the production of shorter rotation products (e.g. smaller poles). However, reliable estimates of the magnitude of these effects are not yet available.

In addition, formalised rights of access provided under the co-management framework may result in greater utilisation of certain NTFPs and dead wood products from intact reserves though the magnitude of this effect will depend on biological factors governing growth and availability. It should be remembered that even well-stocked reserves are currently utilised (to varying degrees both officially and "unofficially"); it is, therefore, an empirical question whether the with-research level of utilisation in any given reserve is higher than without-research.

Co-management within **heavily exploited** reserves is, by definition, unlikely to generate any significant gains related to increased access, while production gains can be expected to be small (or even negative) in the short-term. The main effect of research might be to prevent (inappropriate) conversion of woodland to agriculture and/or excessive resource degradation resulting from uncontrolled exploitation[2]. Benefits would be in the form of the environmental services maintained/enhanced and future costs avoided. Of course, the environmental effects can have an economic impact in the medium to long term, though estimating this requires an understanding of the social costs of current practices. Assuming that (negative) environmental

[1] Of course, whether initial and subsequent gains are sufficient to make the management of natural forests (typically a low input–low output system) more attractive than say a plantation-based approach is an empirical question, and will depend on a range of factors including: the duration and magnitude of initial gains, relative costs and rates of productivity, and the time preference rates of producers/users.

[2] This would depend on raising perceptions of the longer term value of the resource to local users, by perhaps reducing the transaction costs of harvesting from reserve land, demonstrating effective management techniques and encouraging a greater sense of local ownership and stewardship.

externalities exist, the marginal social cost of production from these reserves will exceed private production/utilisation costs and society's "supply curve" will be located somewhere above and to the left of privately determined supply. The effect of (successful) research might be to establish a new market clearing position where demand is equated with the social costs of production. However, net economic impact will be dependent on the size of the divergence between social and private costs, the relationship between the divergence and different levels of utilisation, and research-induced changes in welfare for producers, consumers and those who bear the costs of the externalities.

R6709 may also affect institutional arrangements within Malawi. It can be argued that the pilot research being undertaken is directly contributing to the implementation of the new national policy regarding environmental/resource management. In its absence, the NEP might progress at a much slower rate in the forestry sector (or even stall). Evaluating the effect of research in this regard is extremely difficult. Conventional economic evaluation could be used to gain insight into the cost of using the project as a vehicle for policy implementation, compared with alternative approaches but definitive conclusions would be unlikely, depending as they would on complicated assumptions/projections regarding with- and without-research conditions.

In addition, the introduction of co-management arrangements implicitly involves more socially orientated objectives. In so far as the research is collaborating with rural communities, the members of which are among Malawi's poorest citizens, R6709 can be considered as having a "poverty-focus". However, at the level of the participating villages, R6709 is (nominally at least) gender/equity neutral in that it does not explicitly target the poorest or female members of these communities. At the same time, the research can be expected to affect other aspects of social life for these communities. For example, improved relationships with local FD staff, the provision of management training among communities, greater rights, responsibilities and sense of ownership of the resource, may all enhance participating communities' "social capital". Estimating the extent of these effects, however, is extremely difficult, while simple methodologies that translate these into economic measures are not readily available. Of course, the more intangible benefits of "empowerment" and "ownership" in part reflect the anticipation of tangible benefit in the future. It is less clear, however, whether the full effects of these social impacts are captured in the future benefits streams conventionally estimated in cost-benefit analysis.

The fact that R6079 includes multiple potential effects is by no means a criticism of the research. The above discussion, however, does indicate the difficulties encountered in clarifying research effects and in attempting to adopt a production-efficiency framework for evaluation. In addition, it suggests that a single, simple evaluation measure is unlikely to capture all elements of research "success".

### 6.3.2 Data and measurement issues

Any attempt to assess the extent of these effects requires data and, in spite of the fact that R6079 and its predecessor have generated a significant amount from research trials and surveys, the available data set is inadequate for evaluation purposes. For wood products, inventory data from PSPs provide estimates of standing volumes within the co-management blocks and, in a useful development, the project intends to convert these data into estimates of the available stock of wood *products*. However, economic analysis is primarily concerned with use and there are no formal estimates of wood product flows. For NTFPs and environmental goods and services, data shortages are even more acute. Nevertheless, certain NTFPs obtained from the reserves are indeed important to local communities, either in general, in particular locations or during particular seasons, while *miombo* woodlands on forest reserves play a major role in the provision of environmental services[1]. For the institutional and social dimensions of the research, R6709's data collection activities to date have not attempted to address these effects.

There are specific instances where the utility of information collected during research might have been improved with more appropriate survey design. For example, *ad hoc* utilisation and marketing studies for wood and NTFPs might have been more systematically designed (e.g. household panel surveys) to yield information on consumption and sales of these products over time. Nevertheless, assembling even a basic data set covering the variety of factors of interest to evaluation can be considered beyond the scope of R6709, while thornier measurement and valuation issues are no more soluble for research than evaluation.

In addition to the issue of data availability, evaluation must seek to estimate the relationship between changes in the flow of relevant goods and services and research intervention (i.e. research-induced changes). This is, in practicable terms, impossible for all but the most limited of analyses. Over the long-term, gross indicators (such as the area of woodland) may be useful in determining the overall success of research (or at least confirming failure in some aggregate sense). However, such indicators are imprecise and are of limited value in the short to medium term.

Even assuming data could be collected within the project areas to permit the estimation and valuation of research-induced change, the problem of site specificity is encountered. In practice, the magnitude of impact following adoption will depend on the conditions obtaining in and around each of the reserves. Supply of products will vary from reserve to reserve, depending on forest type and condition, location, and so on, as will the supply of other goods and services. Demand too will vary for different goods and services at different sites. Even for direct use forest products, demand is likely to be a function of *inter alia*: size of the dependent population; availability of the same products from alternative sources; cost of collection from the reserves compared with alternative sources (which in turn might relate to proximity of sources to households, relative abundance of products at different sources and the transaction costs associated with collection from the reserve); and household preferences regarding conservation of different sources (which might be a function of tenurial arrangements e.g. trees on farm retained as a source of "last resort", etc.). In addition, the without-research situation (i.e. counterfactual conditions) would need to be considered for each reserve where maintenance of environmental functions represented the primary objective. Most of these factors are site-specific and require detailed analysis if crude assumptions are to be avoided. However, relevant data are either scant or non-existent

Finally, it should be remembered that research recommendations have not yet been fully implemented (even at the pilot level) and as a result much of the discussion above is speculative. Furthermore, the additional time required to finalise research results/conclusions is in the order of eight to eighteen years. While wider uptake of R6709's recommendations can occur simultaneously with on-going research, the timeframe over which adoption will occur and the final number of reserves affected are not easy to assess. They depend initially on FD

[1] The primary rationale for Malawi's protected areas is catchment protection (82% of the total area protected); other indirectly productive uses include biodiversity conservation (45%) and sleeping sickness control (12%). Direct productive use is limited to softwood and hardwood production - mostly plantations - (20%), fuelwood (15%) and materials for local construction and grazing (6% each). [*Determined by Inter-Agency Working Group on Protected Areas (submitted to the Land Policy Reform Commission in July 1997)*].

approval of the Co-management Constitutions and subsequently on the applicability of research to other forest reserves, which, in turn, relates not only to the technical aspects of research but also to the social/economic characteristics of those who use the reserves.

Adoption of research recommendations also depends on the capacity of District Forestry Offices to implement new management practices. Time will be needed to train District FD staff, while various preliminary activities will be have to be carried out at each site to mobilise selected communities. In addition, the fact that the research is long-term complicates the adoption process, requiring as it does periodic “re-adoption” by FD in the light of any necessary refinements indicated by on-going research at the project sites. As can be anticipated, available data on which to base any assessment of the likely rate and ceiling level of adoption are limited.

## 6.4 Description of the modified evaluation approach

### 6.4.1 Assumptions behind the evaluation approach

A number of assumptions have guided the development of the proposed approach. First, to be of maximum value, the approach must provide information that is both useful for internal research management purposes and meaningful to external audiences. In order to meet these twin objectives, the approach must report on *actual* events but must situate these within an impact-orientated framework rather than the activity-focused framework conventionally addressed by monitoring. Given that R6709 is long-term in nature yet both internal and external audiences require timely results, *on-going evaluation* (i.e. monitoring progress towards impact) offers the most feasible solution.

Second, for the approach to form the basis of an evaluation *strategy*, it must be applicable to different projects. However, different projects, undertaking different types of research under different conditions will inevitably require different assessment methods. The approach, therefore, must select evaluation criteria that are consistent, widely applicable but also permit methodological flexibility within the overall framework provided by the criteria.

Third, given the long-term nature of much NFM research, the approach to on-going evaluation will necessarily rely on leading, intermediate indicators of progress towards impact. These indicators, however, do not measure “impact” in an absolute sense but rather are relative measures that identify change over time. On-going evaluation, therefore, must be undertaken periodically. This need for repeat assessment implies that the approach must be relatively inexpensive, but also that the depth of analysis possible may be constrained by available resources.

Fourth, given the continued importance attached to economic evaluation, it is recognised that the approach must allow for such assessments to be undertaken. At the same time, it is recognised that in particular circumstances, economic evaluation may be unfeasible and the approach, therefore, must be sufficiently robust so as to avoid being de-railed under these circumstances.

Finally, the general uncertainty surrounding the outcome of research is compounded for NFM research by data shortages, social and institutional issues and long research lags. For the results of an on-going evaluation exercise to be credible, therefore, the key factors that affect the likelihood of achieving impact must be identified and their "riskiness" explicitly incorporated into the assessment process.

### 6.4.2 Summary of the proposed approach

In the light of discussions thus far and the requirements set out above, the study has attempted to develop a modified approach to evaluation, based on the principles of the Balanced Scorecard (see Section 5.5). It should be stressed from the outset that, with the possible exception of the final component, the approach is not "new", but rather draws on a mix of existing evaluation approaches. The novelty lies more in the attempt to develop a framework that can be applied consistently for the purposes of on-going assessment and address research that may be difficult to evaluate using conventional economic analyses. The approach was, however, developed in a relatively short period of time and has been tested only in the context of R6709. For these reasons, the proposed approach should not be considered the final or indeed only solution to the problems posed by NFM research evaluation. Rather, the general principles are presented in the context of R6709 for consideration by the Programme Manager. If all or any of its components are felt to have merit, further development and testing are advised.

Similar to the Balanced Scorecard, the proposed approach comprises four components:

(1) *Internal perspective*
(2) *Client perspective*[1]
(3) *Test of research effects*
(4) *Uptake network*

The inclusion of components (1), (2) and (4) explicitly recognises that all FRP projects share three key characteristics: they have internally established targets (i.e. Outputs), they have clients who are expected to make use of results, and they rely on the actions of external actors for the results of research to be applied more widely. Furthermore, adequate performance against these three characteristics is considered to represent the "lowest common denominator" of successful research[2]. While they are necessary rather than sufficient conditions for impact to be realised, the advantage of these criteria is that they are shared by all projects, even the most problematic for evaluation.

To a large extent, the focus on these criteria emerges from the more practical evaluation approaches developed by certain public and industrial research organisations (see Section 5). That is, it recognises the importance of measuring research performance against internally established targets, it accepts client satisfaction as a meaningful measure of external performance and it includes uptake (or "application", "reach" or "adoption") as a minimum but more measurable indicator of research benefits.

The inclusion of component (3) recognises that some form of assessment of actual (economic)

[1] The term "clients" is used to describe the target audience for the results of research, in the context of its developmental objectives, and does not refer to the Programme or donor. In the case of applied, participatory research (such as R6709), the primary clients are considered also to be the intended beneficiaries.
[2] Research "success" unless otherwise specified refers to achievement of the developmental aims of the project/Programme and not to narrower "scientific" definitions which, for example, may be limited to the testing of hypotheses.

benefits remains an important issue for funding agencies. Most commonly this is provided in the form of an estimate of the rate of return to research (i.e. do the benefits justify the investment). The fact that this is but one of four components in the approach reflects the expectation that definitive answers to this question will in many cases be impossible, given the problems posed by timeframe, site-specificity and measurement/ valuation. Nevertheless, even in the case of on-going research, it is considered reasonable to apply, at the very least, a "minimum test" in this regard; namely to assess whether there is any evidence, albeit at a local level, that research is yielding benefits. In this context, it is also considered important to explore the distributional effects of research, though it is recognised that this is potentially a complex issue. For on-going research evaluation, it is anticipated that in-depth assessment will not be possible and, as such, the approach proposes use of a minimum test to address this issue: i.e. "is there any evidence to suggest that the categories of beneficiaries of most interest (e.g. the poor, women) are doing substantially worse than others?" It is important to note, however, that by proposing minimum tests, the approach does not advocate the abandonment of conventional economic analysis. Indeed, in cases where timeframe and available data permit, more conventional economic cost-benefit analysis should be carried out. For much NFM research, however, cost and data reliability issues may limit what can be done in practice (as was found to be the case in the evaluation of R6709).

There are a number of perceived advantages of the approach in the context of NFM research evaluation. First, by maintaining a distinction between the different components, the approach attempts to address possible weaknesses associated with reliance on a single measure such as NPV or IRR. While it may be difficult to assess the economic impact of certain FRP research projects, issues such as progress against internal objectives, the extent to which the clients for the research results are satisfied with progress and the future prospects of success remain relevant for evaluation.

Second, because the components represent different variables on which research success depends, results from each are intended to facilitate understanding of the "bigger picture". Thus, an optimistic assessment of wider prospects obtained from component (4) would be tempered by say slower than anticipated research progress identified under component (1) or lukewarm interest among clients identified under component (2). Similarly, the combination of good progress against projects Outputs (1), a high degree of satisfaction among clients (2) and some evidence of positive effects in the field (3) would increase confidence that research is on-track. In reality, conventional *ex ante* evaluation considers all of these components when arriving at an estimate of the potential returns to research. However, the need to conflate a broad range of factors into a single measure often requires major simplifying assumptions and results in a relatively static analysis that is of limited value to on-going performance assessment. In contrast, consideration of each component separately is expected to provide a more realistic assessment of on-going research and more clearly identify potential problem areas.

Third, similar to the Balanced Scorecard, the approach uses a mix of lagged and leading indicators that facilitate, respectively, assessment of progress to date and projection of future prospects. Because, however, the approach focuses on assessment of intermediate measures of impact, performance is assessed in a relative rather than absolute sense. Thus, changes in particular indicators over time become the measure of progress towards impact.

Fourth, the use of a consistent framework based on the four components may facilitate aggregate programme reporting across a range of projects. Thus, while individual projects may differ in terms of objectives and characteristics, progress in terms of performance against outputs, level of client satisfaction, improved future prospects, are more generic and can be aggregated more easily (e.g. "four out of five projects assessed recorded high levels of client satisfaction"). The remainder of this section describes each component in more detail.

### *Component (1): Internal Perspective*

The objective of the internal perspective is to assess current and likely future performance of research against stated Outputs, based on the OVIs identified the log-frame. The internal perspective, as its title suggests, is concerned solely with whether research is on-track to deliver against its own targets. Log-frame Outputs describe what research will actually produce and evidence of progress towards these Outputs can reasonably be considered a prerequisite if the research is to achieve any degree of "impact".

Determining progress against Outputs is inevitably a subjective exercise that relies heavily on information provided by the researchers and the judgement of the evaluator. That said, the objective of the internal perspective is limited to general assessment of performance and prospects, with a view to identifying any major problems affecting research implementation. The relatively narrow scope of this component, however, is balanced by the results obtained from the other components.

The basic indicators applied in this component are as follows:

| Lagged indicator | Leading indicator |
|---|---|
| • Individual and average scores of progress to date against Outputs | • Individual and average scores of likely achievement of Outputs |

The "scores" referred to in the indicators have been adapted from DFID's Output-to-Purpose rating system and are as follows:

| Lagged indicator | Leading indicator |
|---|---|
| 5 – Fully achieved | 5 – Fully achieved by target date |
| 4 – Mostly achieved | 4 – Mostly achieved by target date |
| 3 – Partially achieved/in progress | 2 – Unlikely to be achieved by target date |
| 1 – No progress | 1 – Unlikely to be achieved |

It is recognised that the scoring system adopted here does not explicitly take account of the relative importance of one Output compared with another. Individual and "average" results should be interpreted with this in mind.

### *Component (2): Client Perspective*

The objectives of this component are to (a) assess whether significant levels of dissatisfaction exist with the research process to date; and (b) assess the degree of commitment to the future implementation of research.

The concept of client satisfaction has obvious limitations as a one-time indicator of achievement. Satisfaction only reflects perspectives on progress achieved to date and, in the case of research that is still in its early stages, may not be related to any tangible benefits. Similarly, while satisfaction may be easy to assess in a superficial sense, it is more difficult to define at the level of detail (and perhaps "scientific" rigour) more normally associated with evaluation of development initiatives. Finally, a degree of bias can be anticipated in the results of such surveys given respondents' general tendency to provide what is perceived to be the "correct" answer. In the case of this study, this effect may be expected to be greater given that the survey was implemented by FRIM staff who are also collaborating with the respondents in co-management research activities.

None of the above reasons, however, provide convincing arguments for omitting "client satisfaction" from the evaluation approach, but rather indicate the need for careful use and appropriate interpretation of results. First, satisfaction should be measured periodically as part of an on-going process of evaluation and results obtained at a given point in time should be interpreted in the context of the known status of research. A good example of this is provided by R6709 where research has reach significantly different stages of progress at Chimaliro and Liwonde forest reserves. Second, for reasons of cost and practicality, a degree of "superficiality" is considered acceptable as long as there is confidence that any significant dissatisfaction will be detected. Results, therefore, should be interpreted not as confirmation of research excellence but rather as minimum tests to indicate whether serious problems are being encountered. Finally, although definition of a "target" level of satisfaction will to some extent be context specific, the standards against which results are measured should nevertheless be sufficiently high to compensate for the degree of bias inherent in such surveys.

The key indicators of client satisfaction should be defined by and from the perspective of the clients themselves (in the case of R6709, these are also the beneficiaries). This requires that researchers and evaluators alike have a clear understanding how clients judge success. It can be anticipated that such criteria will extend beyond the basic "technical" issues of research. In the time available for this study, however, it was not possible to undertake the necessary exploratory analysis to refine the parameters of "satisfaction" and reliance was placed on information provided by FRIM. The fact that the research to date has been implemented in an applied, participatory manner increases the study's confidence in FRIM's understanding of participating communities' perspective. Nevertheless, this cannot be taken for granted in every case.

Definition of the client base will vary between research projects. For the purposes of this study and given the participatory nature of R6709's research, it is reasonable to treat the local communities involved in the project as the clients. In more upstream research, intermediate institutions may represent the main clients for research. Of course, even for R6709 such institutions can also be identified but within the constraints of this study, focus has been directed to the communities as primary clients.

The primary indicators relating to the client perspective are as follows:

| Lagged indicators | Leading indicators |
|---|---|
| • Awareness of and participation in co-management research<br>• Satisfaction with arrangements established to implement co-management | • Perspectives on the advantages and disadvantages of co-management<br>• Willingness to continue participating in research |

*Component (3): Test of research effects*

This component of the evaluation seeks to:

(a) determine whether there is evidence of positive change among beneficiaries resulting from research;
(b) qualitatively assess the significance of any changes;
(c) assess local perspectives regarding the costs and benefits of participation in the research;
(d) determine whether there is evidence to suggest that particular groups are performing significantly better than others (according to gender, wealth and education).

Without the resources or time to collect primary data on stocks and flows of woodland products, formal assessment of costs and benefits associated with the research has not been attempted. Even if the resources were available, it is doubtful whether primary collection of objective data could be justified given the fact that interventions planned under R6709 have not yet been fully implemented. Nevertheless, it remains of real interest whether the partially implemented research has had any tangible effect on benefits for the primary clients/ beneficiaries at even a local level.

Given that estimates of the with- and without-research productivity of the woodland (by product) are not yet available, the study has relied on participants' views about changes in forest goods and services. Notwithstanding reliability problems associated with subjective perspectives, this approach is considered a more realistic means of assessing actual research effects to date. However, there are shortcomings.

First, a level of bias similar to that under the Client Perspective has to be accepted. Second, attributing changes to the research intervention is inevitably less rigorous given the lack of objective, quantitative data. Finally, while questions can be designed so as to mirror the approach taken in economic assessment, the magnitude of effects and hence the overall relationship between costs and benefits cannot be formally determined.

In defence of the approach taken, however, it should be borne in mind that the aim of this component, at a minimum level, is not to undertake a formal economic analysis. Almost all research at a pilot stage is unlikely to have yielded sufficient benefits to generate a positive result in cost-benefit analysis; a detailed analysis is not needed to reach this conclusion. Furthermore, whether the research ever generates positive results will depend largely on whether results are applied more widely; this issue is specifically addressed in component (4) of the approach. This component, therefore, is limited to the question whether evidence exists to support or refute the belief that research has caused some positive change in the welfare of its clients. By precisely how much is open to debate and the strength of any conclusions drawn must be tempered accordingly. However, the assumption here is that some evidence of improvement at a local level is a prerequisite of more wide-scale impact. In this sense, local-level research effects can be seen as a measure of progress and is thus a legitimate area of interest to research managers.

For obvious reasons, this component focuses on the effect of R6709 on forest goods and services. Within the Sustainable Livelihoods (SL) framework, these fall under the heading of natural capital assets. However, research may also affect the other aspects of participants' livelihoods included in the SL framework, e.g. social/human and financial capital and also influence the structures/processes that define livelihood options for participants. As a means of better defining and understanding how interventions affect the well-being of the rural poor, the broad, inclusive nature of the SL framework may offer some prospect for addressing non-efficiency objectives common to NFM research. However, the SL concept is still being developed and as yet there is little in the way of practical examples of its formal application.

Whether results recorded against the different capital assets are truly additive or simply different reflections of the same effect is uncertain, as is the answer to the question whether this matters at all. In addition, a genuinely SL approach *may* have resource implications that are at odds with the objective of developing a relatively low-cost, repeatable evaluation approach for FRP research.

For these reasons, the case study did not attempt to apply the SL framework. But, in recognition of the more holistic approach implied by the SL perspective (and indeed, good evaluation practice), limited attempts were made to address additional "SL-type" indicators in the case study evaluation. The indicators for this component are as follows:

| Lagged indicators | Leading indicators |
|---|---|
| • Changes in availability of direct use forest products<br>• Influence of research<br>• Perception of costs and benefits of participation in research<br>• Distribution of benefits | • Evidence that indirect/non use forest goods and services are valued<br>• Acceptance of "sustainability" restrictions<br>• Expectations that resource will be available in the future<br>• Local perception of opportunity cost of land |

| *Supplementary indicators* | |
|---|---|
| *Financial:*<br>• Cash importance of forest products<br>• Importance of increased availability of products in terms of expenditure saved | *Social/Human:*<br>• Perspectives on changes in the relationship with Forestry Department<br>• Perspectives on changes in relationships within communities<br>• Perspectives on the value of training<br>• Perceptions of change in ownership of, responsibility for and rights over the forest resource |

### *Component (4): Uptake network*

In spite of the use of leading indicators, the components already discussed essentially focus on performance *to date* in the *project area*. FRP's interest in wider impact, coupled with the growing awareness that such impact is dependent on factors *external* and *subsequent* to research, suggests the need for more systematic assessment of future prospects. This need is considered all the greater for NFM research. In the majority of cases, predicted efficiency gains indicate *a priori* the need for *widespread* adoption in order for research to "pay-off". In addition, the long-term nature of NFM research means that FRP must consider prospects beyond the typical project funding window (three years) in order to allocate research funds effectively.

Component (4) seeks to assess the prospects of wider adoption/impact. While it utilises certain results from components (1)-(3), it is considered a separate element of the approach for the following reasons. First, the network includes other factors that lie outside the remit of components (1)-(3), the outcomes of which be incorporated in the network separately from specific evaluation exercises. Second, while it incorporates objective data (either directly or indirectly) as far a possible, the network is based primarily on subjective assessments. Separate treatment of the network enables these subjective assessments to be periodically "ground-truthed" by the results of the other three components.

The main characteristics of the uptake network are summarised in Box 6.1. It is based on (Bayesian) belief networks using the Netica™ software developed by Norsys Software Corporation. Readers unfamiliar with Bayesian networks are strongly urged to turn to Appendix 6.2 at this point, which sets out a simple, illustrative example. Bayesian techniques are more normally associated with decision-making problems under uncertainty or identification of causes of an event that has already occurred (e.g. in medical diagnosis). They have also been used in the "decision theoretic" approach to value information-related research (e.g. price forecasting) where the difference between the decision-maker's maximum utility with and without the information is estimated and compared with the cost of the research (Bengston, in Ellefson 1989). Use of belief networks for the purposes of *on-going* research evaluation is believed to be relatively novel. However, in the time available, the study could not fully assess current applications of these techniques, most noticeably at ICRAF[1], and it is recommended that these be further explored if the proposed approach is considered of value.

*Box 6.1: Main features of the uptake network*

- Indicators of progress are identified that represent key events or critical success factors (CSFs) that must obtain in order for success to be realised. These can be internal to the research (e.g. research milestones) or external (e.g. actions required of intermediate institutions).
- The CSFs are modelled to indicate the relationships of influence and dependency between them.
- Possible (relevant) outcomes are identified for each CSF and the probability that each outcome will occur is estimated using a belief network framework, on the basis of available information and the likely outcome of influencing CSFs.
- These probabilities are in the main *subjective* and reflect the degrees of belief about future outcomes held by *key informants*, though they obey the laws of probability in all regards. Objective data can be used indirectly, to inform key informants' beliefs or to establish parameters for possible CSF outcomes. In addition, objective data can be used directly to update the network by determining the outcome of an identified CSF (e.g. survey results from an evaluation exercise).
- The uptake network, for reasons of practicability, provides leading indicators that comprise a simplified model of the necessary and sufficient conditions anticipated for research success. In order to ensure its overall relevance, the network should be designed so as to allow periodic "updating" as actual progress is recorded. Over time, the proportion of the network reflecting "certainty" will increase.
- The uptake network provides an assessment of the likelihood of success at some user-defined end-point(s) of research. At the design stage of the network, this will reflect initial prospects but will also be heavily conditioned by the views of the key informants, which may be overly optimistic or pessimistic. The value of this indicator can only be fully realised if it is assessed over time (i.e. on-going evaluation), to capture the direction of change indicating whether prospects are improving or worsening.
- Different NFM research projects will have different objectives, designed to effect impact at different scales, over different timeframes. They will therefore have different uptake networks and care should be taken when comparing relative improvements in the prospects of one project with another. Basic

[1] ICRAF is using belief networks in a range of land use assessments. Examples include estimating deforestation risk, adoption potential of agroforestry technologies, desegregating population and other census data to match with remote sensing data and (work in progress) using hyperspectral data for soil analysis. The author is unclear whether the approaches being developed are for the purposes of on-going or one-time assessment.

economic principles should be used to assist interpretation in this regard.

A problem posed by long-term NFM research is that there may be no one simple "end-point" of a network that represents "success" (e.g. a single utility node that can be maximised). The objective of sustainable management by definition implies the need to measure on-going achievement over an extended period. Furthermore, given growth cycles within natural forests, NFM research may continue to be implemented at a pilot level in parallel with the wider application of preliminary or interim research recommendations. The only feasible way around this problem is to define the end point(s) in a form that is meaningful from an evaluation perspective. For this reason, the example developed for R6709 assumes that the research will have achieved its objectives if: (a) at the pilot level, research progresses and sustains the interest of local clients over the period required to finalise the management guidelines; and (b) at the wider level, Forestry Department adopts the initial, interim and finalised guidelines and applies these to other forest reserves in Malawi. This approach, of course, assumes a relationship between adoption and wider benefits[1].

The uptake network is considered complementary to the log-frame but adds value in the following ways. It attempts to "fill" the uncertainty gap that exists between what research delivers (Outputs) and the intended developmental impact (defined at the Purpose or Goal level). In addition, the network is designed to clarify the relationship between the intended achievements of research and the important assumptions (identified in the right-hand side of the log-frame) and make explicit the perceived "riskiness" of these assumptions.

While networks can be expected to differ significantly between projects, the "generic" element of the approach is provided by: (a) the key questions that each network should address; and (b) the final results of each network, which are in the form of quantitative estimates of the probability that user-defined end point(s) will be achieved. As an absolute indicator, the end-point probability may not be reliable. However, over time the network can be updated as outcomes of critical success factors (CSFs) become known; *relative* changes in end-point probabilities, therefore, can be used to determine changes in research prospects.

For R6709, the network attempts to address four key questions that reflect more generally the main elements of uncertainty in applied, NFM research:

*How long will it take to complete the research?* The longer the research lag, the greater the risk of significant delays in implementation, which in turn affect potential impact. The research lag requires explicit treatment in any evaluation but is particularly important in forestry research where production cycles can impose significant constraints on the pace at which research activities can be implemented. This importance requires that clearer predictions be made of the research lag, on the basis of known parameters affecting the timeframe (e.g. anticipated duration of silvicultural trials, the minimum time required to obtain useful results from PSPs and so on.)

*Will the findings of research be "successful"?*[2] Research "success" has a strong technical

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[1] Further testing of this assumption would be necessary where (a) national (or even international) policies are believed to distort incentives in the wider economy or (b) research results had significant distributional implications.
[2] In many cases, the time allowed for research and the chances of achieving technical success are positively correlated. In NFM research, this relationship probably also holds but over a different scale. Where the research lag is already long (e.g. 15 years), short extensions to research are unlikely to have a significant effect on technical achievements. This question is therefore treated independently.

element (i.e. will research trials yield anticipated results). However, in keeping with an impact-oriented approach, technical success should be defined from the perspective of research clients. In the case of R6709, this refers to changes in the availability of wood and non-wood forest products for participating communities. However, this can only be measured over time, not least because the management guidelines may be revised periodically in the light of data from PSPs and silvicultural trials. In the case of applied research that is primarily directed towards environmental/maintenance objectives, use of clients' perspective can be expected to assist in the identification of practicable, working definitions of "success".

*Will research continue to meet clients' expectations?* Although closely related to the above, this question is treated separately for (at least) two reasons. First, other factors outside the control of research may influence clients' definition of "success" over time. Second, even where an attempt has been made to define research results from the clients' perspective, clients play a fundamental role in the implementation of applied, participatory research and periodic assessment of their satisfaction provides an important intermediate indicator for on-going evaluation.

*Will the research be applicable beyond the project sites?* This question relates to adoption prospects and is influenced by many factors, most of which lie outside the control of the research project. This part of the network attempts to assess the likely ceiling level of adoption of R6709's results and the likely rate of uptake. The latter is conditioned by the results of the former but also by other factors. With respect to these, the study distinguishes between the applicability of results (based on the technical and social characteristics of project sites compared with other forest reserves in Malawi) and the replicability of results (based on FD capacity to implement co-management in each district where forest reserves exist).

### 6.4.3 Data collection methods used

The following section provides an overview of the data collection methods used for each component and highlights some relevant analysis issues, summarised in table 6.2. Available time and space constrains the level of detail that can be included here. Further information on specific aspects of the fieldwork can be obtained on request.

The views of key informants were used directly in the assessments made under components (1) and (4). In the case of the former, interviews with R6709's lead researcher in FRIM provided most of the necessary information. For the uptake network, informants comprised FD HQ staff members familiar with the research and who have detailed knowledge of the forest reserves in Malawi, the lead researcher on R6709 and R6709's UK liaison consultant who has wide experience of forestry in Malawi. For the internal perspective, secondary data (essentially project reports) were used to inform the discussions and subsequent assessment. For the uptake network, secondary data were combined more explicitly with the subjective assessments of key informants to project potential adoption of research.

Assessment of the client perspective was based on a formal questionnaire survey while the test of research effects relied on a mix of formal and informal survey techniques. These are described below.

Table 6.2: Overview of data sources by component

| Evaluation component | Indicators | Formal Q'nnaire Survey | Informal RRA Exercises | Key Informant Interviews | Baseline/ $2^{ndary}$ Data |
|---|---|---|---|---|---|
| Internal perspective | Progress to date against Outputs | | | ✓✓ | ✓✓ |
| | Prospect for achievement of Outputs | | | ✓✓✓✓ | |
| Client perspective | Awareness/participation among communities | ✓✓✓✓ | | | |
| | Information/explanation | ✓✓✓✓ | | | |
| | Implementation arrangements | ✓✓✓✓ | | | |
| | Advantages/ disadvantages | ✓✓✓✓ | | | |
| | Willingness to continue | ✓✓✓✓ | | | |
| Test of research effects | Change in availability of forest products | ✓✓ | ✓✓ | | ✓ |
| | Influence of research | ✓✓ | ✓✓ | | ✓ |
| | Perception of Cs & Bs of participation in research | ✓✓✓✓ | | | |
| | Distribution of benefits | ✓✓✓✓ | | | |
| | Indirect & non use goods and services | | ✓✓✓✓ | | |
| | Acceptability of restrictions on use | | ✓✓✓✓ | | |
| | Expectation of future benefits | ✓✓ | ✓✓ | | |
| | Opportunity cost of forest land | ✓✓✓✓ | | | |
| | *Financial capital* | | ✓✓✓✓ | | |
| | *Social/human capital* | | ✓✓✓✓ | | |
| | *Transforming processes* | | ✓✓✓✓ | | |
| Uptake network | Research timeframe | | | ✓✓✓✓ | |
| | Technical success | | | ✓✓✓✓ | |
| | Meet client expectations | | | ✓✓✓✓ | |
| | Wider applicability | | | ✓✓ | ✓✓ |

A formal household questionnaire survey was conducted within project villages at both Chimaliro and Liwonde sites (150 households included in each site). In addition, four control villages (i.e. not participating in the project) were selected at both Chimaliro and Liwonde from areas *adjacent* to the project areas to facilitate with-research and without-research comparison. 25 households were interviewed in each of the control villages (i.e. total of 100 households at both sites). The major difference between project and control questionnaires was that the latter omitted questions that referred directly to "co-management" or the research. In addition, a selection of questions included in a formal survey conducted under R4599 at Chimaliro in 1994 were included in the questionnaire survey to facilitate before and after comparison.

The sample comprised households selected from villages participating in the research as well as some selected from non-participating villages to serve as controls. A stratified sample design was used with two stratification criteria, defined as follows. At each of the two sites, the villages participating in the research are grouped according to three blocks in the forest reserve. Coverage of all blocks was considered important so they were used as the first stratification factor. Proximity to the forest reserve was also thought likely to influence responses, so the second stratification factor was distance (near or far) of the household from the reserve. The sampling plan required one village to be randomly chosen from each block so that there were three near and three far at each site. One block at the Liwonde site had no "far" villages, so the sample there consisted of four "near" and two "far" villages. The control villages were randomly selected from adjacent groups of villages at each site. Here, proximity to the reserve blocks was not relevant so there was no stratification for the controls. Six control villages were selected from the Chimaliro site, but only four suitably located villages existed at Liwonde. The final sample was therefore drawn from 22 villages: 6 project villages at each site, 6 controls at one and 4 controls at the other site.

The original sample design required households to be randomly selected from the villages with probability proportional to size. In the absence of any lists to serve as sampling frames, however, this turned out to be impracticable with the resources available, so a modified design with a fixed number, 25, households from each village was used. This introduces bias into the design (because there is now a non-constant probability that a given household would be included in the sample). This bias was taken into account at the analysis stage by a system of weighting.

The procedure for selecting the sample of households in each village made use of a participatory approach. A sampling frame was generated through a process of village mapping, with villagers marking the number and location of each dwelling unit in the village, together with the name and sex of the head of household. A systematic sample of households, starting at a random location, was drawn from this list. A copy of the questionnaire used in project villages available at appendix 6.3.

RRA exercises were also undertaken within six project villages (three groups per village) at Chimaliro. The objective of this exercise was to explore more deeply apparent changes in both natural capital and other aspects of livelihood since the start of co-management. The decision to include Chimaliro only based on the objectives of the RRA exercise and the fact that co-management is significantly less advanced in Liwonde. A copy of the RRA format/checklist is presented in appendix 6.4.

The combination of formal and informal survey methods was intended to be mutually reinforcing. Results from the questionnaire survey are "generalisable" but necessarily limited in detail. In contrast, RRA exercises provide the opportunity to test the strength of questionnaire responses and explore a wider range of possible research effects. The use of control villages, the limited baseline data (obtained from the 1994 survey in Chimaliro) and explicit before-after comparisons in the RRA exercise was designed to deepen understanding regarding changes attributable to research, i.e. with/without research and before/after.

Simple cross-tabulations of survey data were sufficient to meet almost all of the survey's aims. For the most part, the data were analysed separately for the Chimaliro and Liwonde sites, although global estimates of some quantities have been provided where appropriate. In most cases, when tests of significance of differences in response were required, they were either comparisons of proportions or tests of association in contingency tables. In either case, chi-square tests were used. The data analysis was accomplished using SPSS for Windows (Version 8). The entire analysis was performed after weighting each case by a factor to equalise the probabilities of inclusion of the households in the sample. Note that tables have been presented with *unweighted* raw counts but percentages calculated after weighting.

RRA data was entered into excel spreedsheets and analysed using SPSS and simple excel tools. Box and whisker plots were used to identify more clearly a number of relationships including: changes in product use; changes in sources of forest products; changes in importance of products gathered from reserve as perceived by respondents; balance between domestic consumption and cash uses of woodland products, and; differences in consumption of products across wealth groups.

In addition to simple percentages/numbers of respondents, component (3) includes an assessment of distributional effects of research. While it is easy to identify respondents' gender or level of education, determining wealth groups is more difficult. A number of questions on the questionnaire aimed to provide information on the relative wealth of the respondent's household. The topics covered by these questions were mainly agricultural capital (amounts of livestock and crops) and domestic possessions. A weighted mean of these responses, with an appropriate choice of weights, was thought to be suitable as a wealth score. The procedure adopted for arriving at the weights was as follows. First a principal components (PC) analysis was performed on the responses and then the PC scores calculated for each case [W.J. Krzanowski (1988)[1] ]. Because the wealth ranking questions were not the same at the two sites (reflecting different local characteristics), this analysis was done separately for each site. Sufficient PCs were retained to account for about two-thirds of the variation. A weighted mean of these scores was then calculated using the relative amounts of variance accounted for by the PCs as weights.

The reasoning underlying this rather *ad hoc* procedure was first that a wealth score should be able to discriminate well between groups; and this is achieved by the PC analysis. It was noticed from the PC loadings that the first component largely represented agricultural holdings and the second was strongly influenced by domestic possessions. Combining the PC scores with weights proportional to the amount of variation explained represents an attempt to retain discriminating power while taking as many aspects of wealth into account as could be justified.

Having arrived at wealth score in this way for each case, cut-off values corresponding to 33% and 67% quantiles were used to group cases into "poor", "medium" and "well off".

In the case of the RRA exercise, three groups included within each of the six villages were selected on the basis of wealth (i.e. well-off, medium and poor). Originally, the intention had been to directly link the RRA results with the questionnaire results by ensuring that the RRA respondents were a sub group of the questionnaire respondents. This would have enabled RRA group composition and responses to be cross-referenced with the data collected during the questionnaire survey and strengthen triangulation of results from these two survey techniques. The field teams were trained to assess responses to socio-economic type questions included in the questionnaire and allocate RRA participants into wealth groups on the basis of predetermined criteria. However, due to non-availability of large number of questionnaire respondents during the RRA exercise, FRIM field staff effectively abandoned this approach. In the end, they had to rely on a combination of opportunity sampling (simply asking villagers at random whether they would be prepared to be involved in the exercise, and then classifying according to the predetermined criteria) and by selection through the chief (i.e. asking the chief to select groups of poor, medium and wealthy on the bais of the predetermined

[1] Krzanowski W.J. (1988) *Principles of Multivariate Analysis*, Oxford

criteria). While this is viewed as a disappointment from the point of view of the evaluation methodology, it is not felt to negate the results, but rather temper the strength of conclusions that may be drawn.

In addition to the specific indicators assessed under each of the evaluation components, contextual information was obtained from key informant interviews, surveys and secondary data to assist interpretation of results. This information included:

- the extent to which forest disappearance is considered a problem by respondents (to aid understanding of the "problem context" or relevance of research)
- differences in conditions between project sites both in terms of availability of woodland and status of research
- the most important forest products as identified by respondents during the fieldwork
- the anticipated effect of research on each of these products
- the evaluation "hypothesis" regarding the potential economic impact at the project sites

These along with the results obtained under each of evaluation components are discussed further in section 6.5.

## 6.5 Results

The objective of the case study was methodological and was not primarily concerned with the evaluation of FRP *miombo* research *per se*. That said, it is recognised that the value of any evaluation approach is ultimately determined by the utility of results generated. As such, the following sections present the findings generated from the modified approach used in the case study.

### 6.5.1 Context

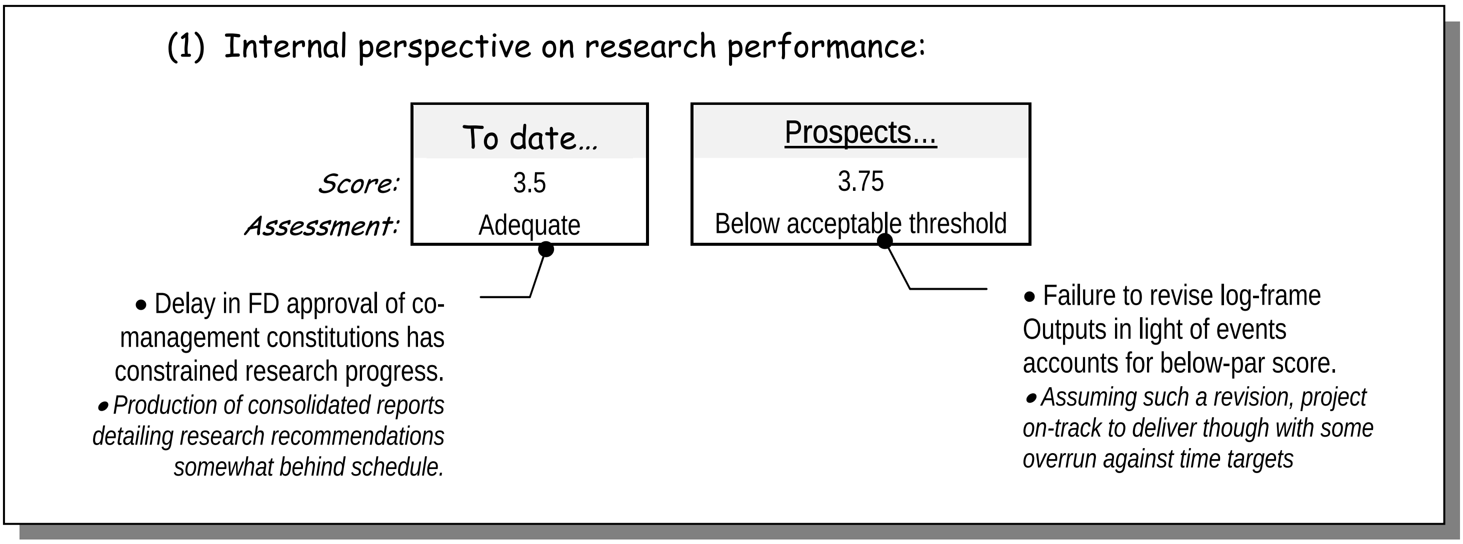
As mentioned in 6.4.4, contextual information for a range of factors was collected to assist interpretation of evaluation results. Appendix 6.5 provides a more detailed discussion for each of these issues. A summary of the conclusions is presented as follows.

The majority of the population included in the evaluation perceives forest loss to be a significant problem. Differences in conditions between the project sites suggest that in Liwonde it may be more acute in absolute terms but this is not detected when comparing perceptions at each site.

In terms of the most important forest products, the surveys identified firewood, grass/thatch, poles/timber, mushrooms, fruits, rope fibres and medicines. It should be stressed, however, that importance here is based primarily on the number of respondents who identified the products and not on any qualitative assessment of significance in particular cases.

In terms of the possible effect of research, two avenues are identified. First, communities may realise material benefit through greater access to the reserve, a previously restricted resource. This is expected to have a positive effect on dry (dead) wood products (essentially firewood and to a limited extent poles/timber) and certain non-wood forest products (see appendix 6.5). Second, silvicultural interventions are expected to increase productivity of desirable wood products - in the main poles and timbers though firewood also as a residue from harvesting. However, no silvicultural operations have been undertaken at either site to date. In addition, the effect of increased access is expected to be markedly less at Liwonde than Chimaliro given the difference in the length of time that research has been operating at each site (two and seven years respectively) and consequently the degree of progress achieved.

### 6.5.2 Overview of results



## (2) Client perspective on research performance:

| | To date... | | Prospects... | |
|---|---|---|---|---|
| | Awareness & participation | Satisfaction with arrangements | Advantage > disadvantages? | Willingness to continue |
| *Findings:* | Med-High | High | High | High |
| *Assessment:* | Adequate | Good | Good | Good |

- Results differ between project sites due to duration and progress of research at each.
- *No evidence to suggest significant levels*

- *High degree of Interest in continuation of co-management process.*

## (3) Test of research effects:

| | To date... | | | Prospects... | | |
|---|---|---|---|---|---|---|
| | Research- induced benefits? | Benefits>Costs at local level? | Distributional effects | Public goods valued? | Acceptance of restrictions | Co-mngt protect future? |
| *Finding:* | High at 1 site | High | Not signif. | High | High | High |
| *Ass'ment* | Adequate | Good | Adequate | Promising | Good | Good |

- *At Chimaliro, research is generating benefits: increased availability of 3 out of 4 main forest products, with spill-over cash effects.*
- *At Liwonde, research effects not yet clear; research is less advanced and conditions differ at this site.*

- *Majority of information obtained from Chimaliro only (RRA);*
- *Respondents demonstrate awareness of importance of reserves and belief co-mngt will ensure benefits can continue to be obtained*

## (4) Future prospects for uptake:

| **Pre-evaluation assessment...** | | Post evaluation assessment... | |
|---|---|---|---|
| Pilot research successfully completed by... | By 2015, applied on... | Pilot research successfully completed by... | By 2015, applied on... |
| 2017: 12% | 50+ reserves: 3% | 2017: 13% | |
| 2020: 33% | 40+ reserves: 17% | 2020: 36% | No |
| 2023: 50% | 30+ reserves: 35% | 2023: 54% | change |
| 2024+: 60% | >30 reserves: 48% | 2024+: 64% | |
| Fail: 40% | Fail: 52% | Fail: 36% | |

- *Results from surveys under components (2) and (3) applied to network to update prospects; Positive direction of change indicated for pilot prospects;*
- *Outcomes of critical success factors affecting wider uptake not yet known.*

The results from each evaluation component are discussed in detail separately below.

However, at the overall level, a number of comments are worth making. First, the level of satisfaction among clients is high, even accepting the different stages of research at each of the main sites. This is considered a key parameter indicative of both the effectiveness of research implementation to date and the prospects for continued participation by clients, at least in the short to medium term. Furthermore, in the case of Chimaliro, evidence from the test of research effects suggests that access to forest products for participating communities have improved since the start of research. The exact magnitude is more difficult to predict but this improvement does appear to be a direct result of the research.

However, it must be remembered that the test essentially assesses effects to date and not the sustainability of achievements or the likelihood of greater impact in the future. Leading indicators are included in this component of the evaluation but these relate to participants' perceptions. R6709 is not yet in a position to provide the necessary objective data to enable projection of future supply trends. Although the lack of quantitative estimates of sustainable levels of supply for forest product is a significant obstacle, it is expected to be a common constraint in much NFM research.

Of more immediate concern are the prospects for the successful delivery of R6709's outputs (internal perspective) and the general uncertainty surrounding longer term prospects (uptake network). At the time of writing, concerns relating to the former reflected in the main issues of timeframe until completion, rather than completion *per se*. In addition, the result of updating the network, post-evaluation, with relevant information from components (2) and (3) indicated (albeit small) improvements in prospects when compared with initial, pre-evaluation assessment. However, some months after the evaluation exercise the lead researcher at FRIM was tragically killed in a road accident and his death casts doubts over the future prospects for co-management research in Malawi more generally. No attempt as been made to amend the case study results in the light of this dreadful event, though it has effectively rendered meaningless any practical implications of the exercise for R6709.

### 6.5.3 Component (1): Internal Perspective

The basic indicators applied in this component were as follows (scoring is discussed in section 6.4.2):

| Lagged indicator | Leading indicator |
|---|---|
| • Individual and average scores of progress to date against Outputs | • Individual and average scores of likely achievement of Outputs |

Table 6.3 below presents the lagged and leading scores assigned to each Output. It should be pointed out that the log-frame available to the evaluation team (in the project memorandum) is particularly weak, and information obtained from the text of this document has been included in the tables below (in italics) in order to assist the assessment.

*Lagged indicator:*

The lagged scores (individual and average) should be interpreted within the context of the time remaining on the project. Given that less than one year remains under R6709, an average score between four and five would indicate good progress. Lower than 3.5 should

Table 6.3: Assessment of research progress against Outputs

| Log-frame narrative OUTPUTS | OVIs | Comments | Lagged Score | Leading Score | Leading score assumptions |
|---|---|---|---|---|---|
| 1. Silvicultural & forest management prescriptions for *miombo* woodlands | *1.* Prescriptions developed *which:*<br>*a) can be implemented by communities under guidance*<br>*b) generate desired products and services*<br>*c) maintain acceptable levels of biodiversity* | • Guidelines developed for Chimaliro<br>• Progress less advanced for Liwonde<br>• Prescriptions not yet finalised<br>• Implementation not yet underway, (awaiting FD HQ approval for over 1 year)<br>• Likely that communities will be able to implement (participatory approach to design);<br>• Sustainability/biodiversity constraints only assessed in long-term – proposed utilisation levels are thought to be conservative | 4 | 5 | • Guidelines only preliminary;<br>• Silvicultural trials continue and guidelines refined subsequently. |
| 2. Methodology and sample studies of demand for forest products services by individuals and communities | *2.* Research reports, *to aid planning and management, which:*<br>*a) synthesise existing information on product use*<br>*b) detail market information on traded forest products*<br>*c) identify factors determining villagers' commitment to woodland management and different patterns of utilisation*<br>*d) outline methods for local-level valuation for cost-benefit analysis of indigenous woodland management activities* | • Reports detailing communities' use of and preferences for forest products available for Chimaliro area<br>• Marketing studies underway but results/ reports not yet available<br>• Range of factors affecting local commitment and woodland utilisation patterns identified; consolidated report not yet available<br>• Valuation techniques and CBA methods unlikely to be produced | 3 | 4 | • 2.b only report on current practice<br>• 2.d not addressed |

Table 6.3 /cont…

| OUTPUTS | OVIs | Comments | Lagged Score | Leading Score | Leading score assumptions |
|---|---|---|---|---|---|
| 3. Guidelines for planning Village Forest Areas, community managed sections of Forest Reserves and woodland areas on estates. | *3.* Appropriate guidelines drawing on Outputs 1 and 2, *which:*<br>*a) outline fully participatory planning process*<br>*b) explain how to mobilise communities, identify local needs/preferences, and select most appropriate prescriptions*<br>*c) provide guidance with quantified estimates of inputs and outputs, and supply-demand balances*<br>*d) present information in user-friendly way for non-specialists* | • Draft general guidelines for outlining the procedure/process in setting up co-management of woodlands on public land available<br>• In-depth information regarding inputs-outputs etc. requires further monitoring<br>• Specific guidelines for community management of woodlands on customary land and estate land unlikely to be produced<br>• Links with NGOs reasonably developed but further work required with Forestry Extension and Agricultural Research & Extension Trusts (estate lands). | 3 | 2 | • Detailed guidelines only to be developed for forest reserves<br>• 3.c requires further monitoring in future |
| 4. Model community forestry plans for two communities | *4.* Pilot plans developed from Output 3, *which:*<br>*a) make full use of other Outputs' results*<br>*b) integrate management with other tree-based activities (where applicable)*<br>*c) incorporate systems for monitoring and review* | • Draft co-management constitutions for 18 communities (six co-management blocks) over two sites developed and awaiting ratification from FD HQ<br>• Development of detailed management plans for co-management blocks in Chimaliro and Liwonde awaiting FD approval of constitutions<br>• Integration with "other tree-based activities" will comprise comparison of supply from blocks and other sources with demand to indicate additional planting requirements<br>• Monitoring systems will require at least two seasons following implementation for initial development | 4 | 4 | • 4.b not fully addressed<br>• 4.c addressed as on-going process |

Table 6.3 /cont…

| OUTPUTS | OVIs | Comments | Lagged Score | Leading Score | Leading score assumptions |
|---|---|---|---|---|---|
| 5. Dissemination of project findings | 5. Field days, conferences and workshops, and reports and publications. | • Field days specified in Qtrly reports<br>• Conferences/workshops specified in Qtrly reports<br>• Project reports/publications specified in Qtrly reports<br>• In addition, FRIM attendance at FD management meetings to report on co-management progress<br>• In addition, training provided in indigenous forest management in selected districts (see Qtrly reports) | ? | ? | In absence of formal dissemination strategy, impossible to score performance in time available |
| Average Scores | | | 3.5 | 3.75 | |

indicate cause for concern though lower than four may mean that closer examination is required.

In the case of R6709, the average score (excluding the output relating to dissemination) is 3.5 primarily because of the on-going delay in obtaining FD approval for the co-management constitutions drafted with the participating communities. In addition, the planned production of consolidated reports for the range of topics covered by the Outputs is somewhat behind schedule.

In the absence of a formal, detailed strategy for dissemination, it is impossible to assess the performance to date against Output 5, and it has therefore been omitted from the analysis. The general impression is that dissemination has been reasonably effective though further work is required to inform intermediate institutions (particularly FD Extension Services) of research findings. In addition to the planned end-of-project workshop, the World Bank's Environmental Management Project (EMP), which includes specific funding for co-management activities, is expected to facilitate this. Indeed, the EMP has recently commissioned FRIM to initiate further co-management activities in selected reserves and village forest areas (customary land) over a ten month period. The work is expected to get underway shortly, though in the original project document it was scheduled for completion by March 1999.

*Leading indicator:*

Given that the leading indicator requires an assessment of likely performance, the period of time remaining for research inevitably affects the certainty with which scores are assigned. For R6709, which has less than a year to run, this problem is not significant but nevertheless, Output OVIs included in the log-frame do not have timebound targets. As such, the evaluation team has assumed a target completion date of "by end of project" for all Outputs. The comments made above regarding dissemination apply equally here.

The average score under this indicator for R6709 is 3.75. Below four is expected to alert managers to potential problems. The reason for R6709 falling below this threshold, in part reflects concern surrounding FD's approval of co-management constitutions, but in the main is explained by anticipated performance against Output 3. This refers to the production of management guidelines for estate and customary land as well as forest reserves. It is considered unlikely that R6709 will produce specific guidelines for the former two land classes by the end of project. No research has been carried out on estate land, while R6709 has carried out data collection exercises only with one community that operates a village forest area (VFA). This finding highlights the real need for more active use by researchers of the log-frame as a management tool. Had Output 3 been revised to refer only to public lands within forest reserves, the average score would have exceeded the threshold.

The implications of underachievement against this Output are more difficult to assess. Output 3, as currently formulated, appears over-ambitious and while in theory potential impact might be significantly greater if it were met in full, it is doubtful whether it is realistic. Formal co-management of VFAs and estate woodlands necessarily implies quite different arrangements given the differences in *de jure* land ownership and in incentives, when compared with forest reserves. Even if tailored guidelines were produced, prospects for implementation would be significantly less certain.

### 6.5.4 Component (2): Client Perspective

The primary indicators relating to the client perspective were as follows:

| Lagged indicators | Leading indicators |
|---|---|
| • Awareness of and participation in co-management research<br>• Satisfaction with arrangements established to implement co-management | • Perspectives on the advantages and disadvantages of co-management<br>• Willingness to continue participating in research |

*Lagged indicators*

The level of awareness and involvement in co-management research across both sites is generally high and considered acceptable (see table 6.4 below). However, major differences exist between Chimaliro and Liwonde that can be explained by the fact that research is less advanced at Liwonde. To some extent, implementation at Liwonde has been deliberately more cautious as FRIM is still awaiting FD's final approval of the co-management constitutions. Nevertheless, results suggest that two years may represent the minimum time required to sensitise and mobilise communities.

Satisfaction with co-management arrangements among those who have heard of co-management is near universal. The strength of this conclusion is somewhat tempered in Liwonde by the fact that a quarter of respondents sampled had not heard of co-management. For certain responses there appear to be significant differences in results when analysed by gender of respondent and level of education of household head. However, no overall pattern emerges of one particular group performing significantly worse/better than others. Overall, the lagged indicators do not provide any indication of major dissatisfaction with research implementation to date.

*Leading indicators*

Respondents were asked to identify the benefits of co-management and the disadvantages (unprompted) in order to improve understanding of overall prospects. In total, 96.6% of respondents who had heard of co-management identified one or more benefit whereas 82.4% could not identify any disadvantage. In Liwonde, where co-management is less advanced, the most common advantage identified related to the anticipation of obtaining forest products in the (short-term) future. In addition, general references to the environmental benefits of co-management/sustainable management were also commonly provided. In Chimaliro, respondents most frequently identified their current ability to obtain forest products as the main benefit. Where answers referred to future access to products these were in the context of a longer-time scale (i.e. subsequent generations).

Although only a small number of respondents identified any disadvantages, the most common category was "unenforceable rules/lack of ratified rules". This relates closely to the delay experienced in obtaining FD's approval for the co-management constitutions and also points to the important role these documents will play in legitimising community management responsibilities. In Liwonde, "misunderstandings between and/or within villages" was most frequently mentioned. This mainly reflects the early stage of implementation at this site but such misunderstandings are not unrelated to the issue of the constitutions.

The key leading indicator - willingness to continue participation in the research - elicited a high proportion of positive responses. In Chimaliro, 99% of those who have heard about co-management research answered yes, while the same figure for Liwonde was 96%. There was no significant difference in responses according to wealth, gender or level of education. What is less certain, however, is the rate at which this willingness may "depreciate" if further delays in implementation are experienced. Nevertheless, the results suggest that the active co-operation of project communities is likely to continue in the short- to medium term at least.

**Table 6.4:** Summary of survey results for Client Perspective component

| LAGGED INDICATORS | Chimaliro | | Liwonde | | *Overall* | | Comments |
|---|---|---|---|---|---|---|---|
| *Awareness & participation* | | | | | | | |
| Q7. Have you heard about co-management…?[1] | 94.5% | | 75.4% | | 81.6% | | |
| | *Q7 = Yes* | *All sample* | *Q7 = Yes* | *All sample* | *Q7 = Yes* | *All sample* | |
| Q8. Respondents identifying two or more of main co-management tasks[2,3] | *89%* | *85%* | *25%* | *20%* | *61%* | *54%* | |
| Q9. Respondents awareness of authority to collect forest products from co-management blocks[2] | 95% | 90% | 49% | 37% | 66% | *54%* | Sig. Diff. at Liwonde: better educated more likely to respond "yes" |
| Q10a. Respondents providing labour for co-management activities[2] | 91% | 86% | 38% | 29% | 58% | *47%* | Sig. Diff. at Liwonde: better educated less likely to respond "yes", women less likely to respond "yes" |
| Q10b. Respondents participating in block management committees[4] | 23% | 21% | 31% | 23% | 28% | *23%* | Sig. Diff. at Chimaliro: women less likely to respond "yes" |
| Q12. Respondents who feel that explanation of co-management is "clear" or "very clear" | 98% | 93% | 92% | 69% | 94% | *77%* | Larger proportion in Chimaliro responded "very clear" |
| *Satisfaction with arrangements* | | | | | | | |
| Q13. Respondents happy with arrangements established | 99% | 94% | 99% | 75% | 99% | *81%* | |
| LEADING INDICATORS | | | | | | | |
| *Advantages & disadvantages* | | | | | | | |
| Q14. Respondents identifying benefits of co-management research | 98% | 93% | 96% | 72% | 97% | *79%* | |
| Q15. Respondents identifying disadvantages of co-management research | 13% | 12% | 20% | 15% | 18% | *15%* | |
| *Willingness to continue…* | | | | | | | |
| Q18. Respondents happy to continue participating in research project | 99% | 94% | 96% | 72% | 97% | *79%* | |

Notes 1 – subsequent questions could not be addressed respondents who indicated "No" for Q7; responses to these questions are nevertheless placed within overall samples for reference

2 - Only limited activities carried out in Liwonde to date: demarcated and inventoried blocks; selected and trained committee members; developed draft constitutions; preliminary sensitisation of villagers

3 - Main tasks: firebreak maintenance, controlled early burning, patrolling, boundary maintenance, supervised/controlled harvesting

4 - Appears that all committee members were surveyed

### 6.5.5 Component (3): Test of research effects

A larger number of indicators were included under this component that in combination were intended to highlight any effects of research to date. Formal and informal survey techniques (the latter at Chimaliro only) were applied in an attempt to address the following basic questions:

(a) whether changes in the availability of certain forest products had occurred;
(b) whether these were the result of research intervention
(c) whether these were of significance for participating communities.

The results are summarised below, while more detail is provided in the associated appendices (referenced in the text tables that follow).

*Lagged indicators:*

• AVAILABILITY OF FOREST PRODUCTS

Table 6.5: CHIMALIRO

| Question | Results | | Comments | See… |
|---|---|---|---|---|
| Are any forest products more available than before (Q2a) | Project respondents significantly more likely to answer "yes" than controls | | Small no. of cases | Appendix 6.6 |
| Important forest products (Q3a + RRA) | 1. Firewood<br>2. Grass/thatch<br>3. Poles/timber<br>4. Mushrooms | 5. Fibres<br>6. Medicines<br>7. Fruits | Based on frequency of identification and average ranks | Appendix 6.5 |
| Which products are now more available to project respondents (Q2b + Q17) | Firewood ++;<br>Grass/thatch ++<br>Mushrooms ++ | Fruit ++<br>Medicines +<br>Fibres +/- | High no. of positive responses to Q17 | Appendix 6.6 |
| Which products are more available since co-management (RRA) | Firewood ++<br>Grass/thatch ++<br>Mushrooms ++ | Fruits +/-<br>Medicines +/-<br>Fibres +/- | Less conclusive for fruits, medicines & fibres due to lower nos. identifying product | Appendix 6.6 |

Table 6.6: LIWONDE

| Question | Results | | Comments | See… |
|---|---|---|---|---|
| Are any forest products more available than before (Q2a) | Larger proportion of project respondents answering "yes" but **not** significantly different from controls | | Smaller proportions than in Chimaliro | Appendix 6.6 |
| Important forest products (Q3a) | 1. Firewood<br>2. Grass/thatch<br>2. Mushrooms<br>4. Poles/timber | 5. Fruits<br>6. Bamboo<br>7. Fibres | Based on frequency of identification | Appendix 6.5 |
| Which products are now more available to project respondents (Q2b) | Firewood ++<br>Grass/thatch +<br>Mushrooms + | Fruits + | Smaller nos than in Chimaliro | Appendix 6.6 |
| Which products are now more available (Q17) | Foodstuffs ++<br>Grass/thatch/<br>fibres/poles + | Firewood +<br>Medicine + | - *ditto* – but sig. diff. with controls | Appendix 6.6 |

The evidence suggests that at Chimaliro, project respondents perceive that certain products are now more available. The main products affected appear to be firewood, grass/thatch, mushrooms, fruits, medicines and fibres. In the case of the last three, however, conclusions must be tempered by the overall importance attached to these products (across all respondents) and, in the case of medicines, the apparent strength of consensus regarding change (RRA results).

In Liwonde, the effect of any increases in availability appears to be appreciated by much smaller proportions of respondents. There does appear to be significant difference between project respondents and controls with respect to perceived availability of certain products. These are largely the same as in Chimaliro. However, for the majority of these products, less than half of project respondents indicated that availability has increased.

● INFLUENCE OF RESEARCH

Contextual information obtained in advance of the evaluation exercise (see section 6.5.1 and appendix 6.5) suggested that the "productive" effect of research to date would reflect increased access to forest reserves facilitated by co-management, rather than any additional output from silvicultural intervention (which has not yet occurred). On this basis, it was anticipated that any positive research-related effect on the most important forest products would be restricted to firewood, grass, mushrooms and fruits while the effect on poles fibres and medicines was expected to be neutral.

Table 6.7: CHIMALIRO

| Question | Results | Comments | See… |
|---|---|---|---|
| Why are products easier to obtain/collected from FR (Q2b follow-up + Q5) | Project respondents appear more likely to cite increased access to FR or co-management as a reason | Respondents not prompted for "co-management" | Appendix 6.7 |
| Change in availability of products at different sources (RRA) | Increased availability from FR for firewood ++, grass/thatch ++, mushrooms ++, medicines +/-, fruits +/-, fibres +/- | Contrasts with declining availability on customary land | Appendix 6.7 |
| Use of Forest Reserve (Q3b + Q4) | Project respondents significantly more likely to use FR and appear to collect a greater proportion of requirements from FR for main products whose availability has increased. Project villages furthest from FR also now appear to make more use of FR than five years ago. | Appears to be a pattern of greater access and use among project respondents compared with controls | Appendix 6.7 |

Table 6.8: LIWONDE

| Question | Results | Comments | See… |
|---|---|---|---|
| Why are products easier to obtain/collected from FR (Q2b follow-up + Q5) | Project-related reasons much less apparent, with possible exception of firewood | Shortages on cust. land & abundance in FR more commonly cited | Appendix 6.7 |
| Use of Forest Reserve (Q3b + Q4) | No clear pattern emerges distinguishing project and control respondents in terms of access to and utilisation levels in FR | Difficult to discern any influence of research | Appendix 6.7 |

The evidence suggests that in Chimaliro, the increased availability of the main products (excluding poles) identified in the previous section is associated with the increased access to the forest reserve brought about by co-management research. There is a significant difference between project respondents and control respondents in the extent to which they use the reserve. In addition, for firewood, grass/thatch, mushrooms and fruits, collections from the reserve appear to meet more than 75% of project respondents' requirements for these products (see appendix 6.7). Given the subsistence importance of firewood and cash importance of grass/thatch (see Box 6.2, below), it is likely that increased access is making a significant contribution to project communities' livelihoods. This may be true of the other products identified, though the lower importance attached to these makes it difficult to draw even qualitative conclusions regarding the magnitude of research effects.

In Liwonde, no clear pattern emerges of differences between project and control respondents in their use of the reserve. Given that the reserve represents the focus of research, it is therefore difficult to discern any influence of research. Combining these conclusions with the results above regarding availability of forest products, it appears reasonable to conclude that while some project respondents may actually be materially better off since the start of co-management research, the effect has not been widespread at Liwonde to date. This would appear to be in keeping with the stage reached by research at that site. However, it is also anticipated that there are greater shortages of forest products on customary land at Liwonde than at Chimilro and, as a result, higher levels of pre-research utilisation of the reserve. Together, these factors may constrain the extent to which improved access (via co-management research) can result in substantial gains in product availability in the future.

### • PERCEPTIONS OF LOCAL COSTS AND BENEFITS

In an attempt to assess, in a general sense, the perceived costs and benefits associated with research participation to date, respondents in the questionnaire survey were asked:

Table 6.9: Do you feel that the benefits of co-management justify the effort you are required to put in?

| | Project respondents who have heard of co-management | | | All project respondents |
|---|---|---|---|---|
| | Near to reserve | Far from reserve | Overall | Overall |
| Chimaliro (%) | 98 | 100 | 99 | 95 |
| Liwonde (%) | 93 | 90 | 92 | 72 |

No significant difference by proximity

In Chimaliro, 99% of those who had heard of co-management in project villages indicated that they felt the benefits do justify the effort of participating in the research. In Liwonde, the same figure was 92% though it should be remembered that only 75% of respondents in project villages here had heard of co-management.

The costs of co-management represent currently the labour that participants are required to provide for forest management and the time/effort required to agree and implement co-management arrangements. In drawing conclusions from the results of this indicator, it must be remembered that only a limited number of forest management activities have been implemented in Liwonde while access to tangible benefits (in the form of forest products) has also been limited to date (see sections above).

It is also unlikely that respondents' assessed the question in a formal "economic" sense. However, it is considered reasonable to assume that local clients will to some extent implicitly assess the trade-offs involved with participation. To the extent that responses may reflect an expectation of benefits in the near future, then it is reasonable to assume that some element of respondents time preference will have been incorporated in the answers. Nevertheless, the evaluation is not able to predict with any confidence if these expectations will be met and as such results should only be treated as a very broad indicator of perceptions regarding costs and benefits.

It is anticipated that co-management will be a relatively low input - low output operation but, in the face of shortages of forest products elsewhere, free access to additional products may well be perceived as sufficient as to justify the limited requirements of participants' labour. In addition, other less tangible benefits may also be reflected in the responses obtained (see Boxes 6.3 and 6.4).

| • DISTRIBUTION OF BENEFITS |
|---|

Within the constraints of this study, the approach has been to subject a few key indicators to a "minimum test". This is effectively the null hypothesis that there should be no clear pattern of one particular group of project respondents performing substantially worse/better than another. The indicators selected for both Chimaliro and Liwonde are: whether respondents have access to the reserve, whether they can obtain more of the main products since the start of co-management and whether they feel the benefits of co-management justify the effort. The responses have been re-analysed according to wealth group (poor vs. well-off), sex (women vs. men), and level of education of household head (none vs. secondary education). In addition, the results of the RRA exercise that examined respondents' perceptions regarding the availability of products from the reserve "before" and "after" co-management are presented on the basis of the wealth groups selected (poor vs medium+well-off). Appendix 6.8 presents the results.

In short, no clear pattern emerges from the minimum tests applied. That is not to say that the research is leading to a significant improvement in the relative position of the poorest, least educated or female members of the client base. Rather, the results suggest that there is no evidence that research is disproportionately benefiting other categories of clients. It is reasonable, therefore, to conclude that research is not unduly accentuating existing levels of inequality within communities along the criteria identified. Of course, the extent of existing levels of inequality, if any, has not been determined.

### *Leading indicators:*

Leading indicators of future effects are of particular importance in NFM research not only because of the anticipated length of the lags involved but also because such research often includes some aspect of "sustainability" as a primary objective. Lagged indicators may capture the value placed by clients on more products today or the anticipation of more products in the short term, but at some point in time a certain level of consumption must be foregone if sustainable levels of production are to be maintained. Given the complexity of the issues involved, the evaluation only attempted to assess broad attitudinal indicators that provide some insight into future prospects at the local level. While some associated questions were included in the questionnaire survey, greater reliance was placed on the RRA exercise though the results are largely qualitative in nature, making simple, quantitative summary difficult.

| • EVIDENCE OF VALUE PLACED ON OTHER FOREST GOODS AND SERVICES |
|---|

All 18 focus groups in Chimaliro identified the important role played by the reserve in protecting local soils (erosion control, fertility maintenance) and in acting as a catchment for local rivers. In addition, almost all groups expressed the belief that the presence of the reserve ensures regular rainfall, pointing out that they had never experienced a serious drought. Other perceived services included: windbreak functions, aesthetic value and provision of "clean air". It is, of course, difficult to assess the depth of understanding regarding these services or indeed the level of commitment to them compared with direct use forest products. However, evidence from the RRA exercise in Chimaliro at least suggests a high level of awareness of the importance of the public good functions provided by the reserve.

## • ACCEPTANCE OF RESTRICTIONS ON USE ("SUSTAINABILITY")

The RRA focus groups demonstrated widespread recognition of the importance of restrictions placed on utilisation under co-management arrangements. All groups viewed these as positive, indicating that current restrictions were both necessary and welcome to ensure continued access to forest products from the reserve in the future. A number of the groups specifically mentioned that without control on use, there will be "no trees left".

## • EXPECTATION OF CONTINUED ACCESS TO THE RESOURCE IN FUTURE

All focus groups expressed the view that co-management will enable them to obtain more products from the reserve in future than would otherwise have been the case. In the majority of cases, this belief was explained by the fact that through co-management participants were learning to manage the forest sustainably. Whether sustainable levels of product supply will meet these expectations is less certain. Nevertheless, evidence regarding the acceptance of restrictions on use suggests a degree of optimism in this regard at least in the short to medium term.

In addition, the questionnaire survey asked all project respondents who have heard of co-management whether they thought that co-management would help protect the reserve for future generations.

Table 6.10: Do you think that co-management will help protect the FR for future generations?

| | *Chimaliro* | | *Liwonde* | |
|---|---|---|---|---|
| *Wealth Group* | No. of cases | % yes | No. of Cases | % yes |
| Poor | 33 | 96.4 | 22 | 93.8 |
| Medium | 88 | 99.3 | 70 | 97.1 |
| Well off | 25 | 100.0 | 18 | 100.0 |
| *Overall* | *146* | *98.8* | *110* | *96.9* |

Base: all in project villages who have heard about co-management

Table 6.10 above shows the result overall and also by wealth group. Although it appears that there may be some relationship between wealth and perspective on the value of co-management for future generations, it is not statistically significant.

## • LOCAL PERCEPTION OF OPPORTUNITY COST OF LAND

Attitudes towards land use (agriculture compared with woodland) is considered an important component of any leading indicators for NFM research. However, the underlying concept of interest to the evaluation (the opportunity cost of land) is complex and difficult to assess in simple questionnaire surveys. In addition, the evaluation was constrained in terms of the type of questions that could be put for fear of raising any suspicion/expectation that part of the reserve may be converted to agricultural land. With the aim of generalising results, the issue was addressed in the questionnaire survey using a single question which asked all respondents for their views on the balance between agricultural land and woodland. Respondents were given three options: (a) too much agricultural land, not enough woodland; (b) balance is about right; (c) too much woodland not enough agricultural land. In hindsight, the evaluation team concluded that this was insufficient to elicit views on the trade-offs between land uses. For example, even if respondents feel that the remaining woodlands are more important for the forest goods and services they provide, it is doubtful whether they actually believe that there is "too much agricultural land". As a result, it is possible that this question may have been misinterpreted and significant conclusions cannot be reliably drawn from the results. Nevertheless, responses are interesting in terms of the stark differences thrown up.

Table 6.11: What do you think of the balance between agricultural land and woodland? Do you think that …

| | Chimaliro % | | | Liwonde % | | |
|---|---|---|---|---|---|---|
| | Project | Control | Overall | Project | Control | Overall |
| Too much agric. not enough woodland | 89 | 96 | 93 | 5 | 8 | 7 |
| Balance about right | - | - | - | 1 | - | |
| Too much woodland, not enough agric. land | 11 | 4 | 6 | 95 | 92 | 94 |

Base: all respondents

For each site, no significant difference between project and control respondents

In attempting to assess the results, the real risk of misinterpretation on the part of respondents must be borne in mind. Accepting this, higher population pressure and less fertile soils may account for the greater demand for agricultural land in Liwonde. However, the same population pressure which has reduced customary woodland might have been expected to encourage some respondents to identify a relative shortage of woodlands. It may be that respondents' close proximity to both a forest reserve and national park which are protected may have influenced their views. More likely, however, is the fact that respondents' responded mainly to the prompt of "not enough agricultural land". In contrast, in Chimaliro the presence of a large tobacco estate nearby and levels of in-migration to the area may have influenced responses. Given the problems of interpretation which stem from inadequacies in question design, the evaluation is not confident in drawing any conclusions from the results. However, indirectly they indicate the extent of the challenge facing co-management research in Liwonde and provide some basis for a re-examination of the issue during a subsequent evaluation exercise.

## BOX 6.2: Financial effect

Although recognised as a significant livelihood asset in the SL approach, the effects of research to date on communities' financial capital was not evaluated in depth. The approach taken in part reflects the time available and the challenge of fully assessing changes in financial capital. The evaluation attempted to derive some general conclusions from information obtained during the RRA exercise with project villages in Chimaliro. The omission of Liwonde from this aspect of the evaluation is not considered a major weakness given that any positive effects that have occurred are more likely to have been realised in Chimaliro, given the stage of research at each site.

First the focus groups were asked to indicate for each of the main forest products harvested the approximate proportional division between domestic consumption and sale. Each product was given ten "beans" for division in this manner.

| | | Grass | Firewood | Poles | Mushrooms | Medicines | Fibres | Fruits |
|---|---|---|---|---|---|---|---|---|
| All Groups | Score | 3.8 | 6.5 | 5.5 | 6.2 | 1.3 | 6.5 | 7.1 |
| | (No of cases) | (18) | (17) | (15) | (13) | (9) | (8) | (7) |
| Poor | Score | 3.0 | 6.0 | 5.2 | 4.5 | 0.0 | 6.0 | 4.0 |
| | (No of cases) | (6) | (5) | (5) | (4) | (2) | (3) | (2) |
| Well-off + Medium | Score | 4.2 | 6.7 | 5.6 | 6.9 | 1.7 | 6.8 | 8.4 |
| | (No of cases) | (12) | (12) | (10) | (9) | (7) | (5) | (5) |

Scale: +10 = all domestic consumption; -10 = all marketed

The results across all groups confirm that in the main the major share of each product harvest is used in domestic consumption. Indeed, only in the cases of grass and medicines did any groups indicate that a larger proportion was sold than consumed though the numbers were relatively small: two out of 18 groups identifying grass as a product and three out of nine groups identifying medicines. Although the relative scores between domestic consumption and sale cannot be used with confidence as a measure of magnitude, it is considered reasonable to use these as an indicator of "certainty" to assist interpretation. On this basis, it appears that grass/thatch, poles and medicines are more likely to be sold by those collecting them, but it should be noted that in the case of medicines only half the groups identified this product. Similarly, it appears that the poor groups are in general more likely to sell a greater proportion of forest product harvests than the medium and well-off groups. However, this conclusion should be treated cautiously given the approximate nature of the scoring system. It should also be borne in mind that forest products may be used as inputs in other commercial ventures (notably firewood in beer-brewing or brick-making). It is unlikely that the full cash importance of products as inputs has been captured in the scores.

Next, the focus groups were asked to score each forest product in terms of its importance for income generation. Ten beans were allocated to the most important and other products scored in relation to this. In terms of the relative cash importance between forest products, grass/thatch appears to be the most significant direct source of income. The majority of groups ranked it highest and its overall average score (7.7 out of 10) is considerably higher than the next product, firewood, which averaged a score of 4.8 across all groups. The proviso regarding the importance of firewood as an input in commercial activities, though, also applies here. On the basis of average score across all groups, poles is the third most important product (3.4) followed by mushrooms, medicines and fibres.

Given the findings regarding research's effects on the availability of certain products, it seems reasonable to conclude that in the cases of thatch, firewood, mushrooms and possibly medicines (for a more limited number of participants), research has had some positive impact on direct sources of cash income. However, the magnitude of this impact is more difficult to assess.

*Box 6.2 /cont…*

| | No. of groups that identified product | Average score across all groups | Average score across identifying groups |
|---|---|---|---|
| Grass | 16 | 7.7 | 8.6 |
| Firewood | 14 | 4.8 | 6.1 |
| Poles | 10 | 3.4 | 6.1 |
| Mushrooms | 10 | 2.6 | 4.7 |
| Medicines | 8 | 2.1 | 4.8 |
| Fibres | 8 | 2.0 | 4.5 |
| Fruits | 3 | 0.7 | 4.3 |

In an attempt to "benchmark" the information obtained, RRA groups were asked to identify and rank all sources of income (including forest products). On the basis of average ranks across all groups, only grass and firewood are included in the top ten sources of income (fifth equal and tenth respectively). Comparisons between the wealth groups in the RRA exercise must be interpreted cautiously but results suggest that these products may have greater cash significance for the poor when compared with the well-off. The average ranks for grass and firewood across poor groups were fourth and eighth respectively, compared with ninth and twelfth for well-off groups.

In the context of financial capital, however, it is necessary to consider the cash effect of expenditure saved as well as income generation. In the case of R6709, there are two main aspects to this. First, research may increase availability of products that might otherwise have to be purchased and, second, co-management may now allow certain products to be collected free from the reserve whereas in the past royalties/fees would have been payable.

Regarding the former, it cannot be concluded that shortages of all products would necessitate purchase. Instead, the evaluation considered only those cases where buying was specifically mentioned as a potential source by focus groups. The table below presents the results. Again, cautious interpretation of differences between wealth groups is necessary but it results appear to suggest that the poorer groups are less likely to view buying as an option.

| | No. groups mentioning "Buying" as source | | | |
|---|---|---|---|---|
| **Product** | Well-off | Medium | Poor | Total |
| Mushrooms | 4 | 3 | 3 | 10 |
| Grass | 4 | 4 | 2 | 10 |
| Poles | 4 | 4 | 2 | 10 |
| Firewood | 3 | 4 | 1 | 8 |
| Fibres | 0 | 3 | 2 | 5 |
| Medicines | 2 | 2 | 0 | 4 |
| Fruits | 2 | 1 | 1 | 4 |

Examining the results further, views about changes in the availability of particular products can be compared with views on changes in the incidence of buying. The table below presents the results. For grass, mushrooms and firewood, increases in availability from the reserve are associated in a minority of cases with reductions in the incidence of buying though in the majority of cases, buying is also increasing. For these products, it seems reasonable to assume that greater availability provided by co-management is having some positive, indirect effect on cash incomes. However, the indication above that poorer groups may be less inclined to buy these products suggests that this effect is unlikely to be across the board. For other products, the smaller number of cases where buying was identified as a source makes conclusions difficult.

*Box 6.2 /cont…*

| | Incidence of Buying UP, availability in reserve… | | | Incidence of Buying DOWN, availability in reserve… | | |
|---|---|---|---|---|---|---|
| | UP | SAME | DOWN | UP | SAME | DOWN |
| Mushrooms | 7 | 1 | - | 2 | - | - |
| Grass | 7 | - | 1 | 2 | - | - |
| Poles | 4 | 2 | 3 | - | - | 1 |
| Firewood | 4 | - | 1 | 3 | - | - |
| Fibres | 1 | 3 | 1 | - | - | - |
| Medicines | 2 | 1 | 1 | - | - | - |
| Fruits | 3 | - | - | 1 | - | - |
| TOTAL | 28 | 7 | 7 | 8 | 0 | 1 |

The cash effect of waiving Forestry Department charges for certain products under co-management is also difficult to assess given that (a) the current schedule of royalties and licence fees is somewhat unclear as amendments are being made in the light of the revised Forest Act (1997); (b) enforcement of charges in the past appears to have been variable; and (c) communities harvested from the reserve "illegally" in the past. A comparison between the charges for certain forest products in 1993 and what is believed to be the current schedule is presented below. Given the status of co-management research in Chimaliro, it is likely that any positive cash effect realised through the waiving of official charges is restricted to firewood collection.

| | | | 1993 | 1999 |
|---|---|---|---|---|
| **Indigenous:** | Firewood | (headload) | K0.5 | K5 |
| | | (cubic meter) | n.a. | K250 |
| | Poles (per pole) | 1-6 cm | n.a. | K20 |
| | | 6-8 cm | n.a. | K25 |
| | | 8-10 cm | n.a. | K30 |
| | | 10-12 cm | n.a. | K35 |
| | | 12-14 cm | n.a. | K45 |
| | | 14-16 cm | n.a. | K50 |
| | | *Etc. up to 20cm* | | |
| **Eucalyptus:** | Firewood | (headload) | K0.3 | K2.5 |
| | | (cubic meter) | K30 | K60 |
| | Poles (per pole) | 1-6 cm | K1.2 | K15 |
| | | 6-8 cm | K1.7 | K17 |
| | | 8-10 cm | K2.2 | K21 |
| | | 10-12 cm | K2.8 | K25 |
| | | 12-14 cm | K4.5 | K30 |
| | | 14-16 cm | n.a. | K35 |
| | | *Etc. up to 20cm* | | |
| | | **Grass/thatch**[1] (week's collection) | K5 | Free |
| | | **Mushrooms**[1] | Free | Free |
| | | **Commercial beekeeping** (per hive p.a.) | n.a. | K100 |
| | | **Commercial grazing** (per head p.a.) | n.a. | K5 |

Sources: FRIM report 93008 & FD HQ

Note 1:Other NTFPs are also free to communities for domestic use under the most recent schedule but access "may be determined by agreement"

**BOX 6.3: Social/Human effects**

Although not a major element of this evaluation exercise, issues relating to social and human capital are considered important aspects with the SL framework and may also provide leading indicators of future impact in as much as they relate to the local capacity and support systems that facilitate future implementation. These issues were explored only in the RRA exercise with project villages in Chimaliro, partly because of resources, and partly because it was expected that any significant effects to date would be restricted to this site.

First, groups were asked whether relationships with the Forestry Department and within the communities themselves had changed in any way since the start of co-management. All focus groups reported that relationships with FD staff had improved significantly since co-management. The previous relationship appears to have been characterised by resentment and mutual suspicion, with FD staff viewed at best as police or at worst as exploitative. The groups referred to FD staff now as partners working with the communities to ensure effective management of the resource. Perhaps more surprisingly, implementation of co-management appears to have had spin-off benefits for all groups in terms of facilitating intra-community organisation and co-operation in other communal projects (e.g. community farming, bridge construction, road maintenance). Respondents explained that whereas in the past, people might have been forced to co-operate, the experiences from co-management have now increased members' willingness to collaborate with one another.

The RRA exercise has also been reviewed to assess the extent to which "training" was identified (unprompted) as valuable in the context of some other question. Not all groups referred explicitly to training, though there does appear to be widespread recognition of the value of the training in forest management received.

- In particular, within the context of future use, the widespread anticipation of continued use of the reserve in the long-term appears based on the fact that they are learning how to manage the resource. The converse of this is the impression that in the past, uncontrolled utilisation has lead to resource degradation. In addition, in response to questions regarding "ownership" and "responsibilities", five of the focus groups interviewed referred specifically to the value of training in terms of increasing villages ability to manage the resource (and hence strengthen ownership claims) and fulfil their obligations under co-management.

The focus groups were also asked whether they felt aspects of the co-management practices in the reserve could be applied to woodlands on customary land. The responses here were more variable:

- Only one group felt that management of customary woodland should continue as present. All others saw benefit of applying some of the features of co-management on customary woodland
- Three of the villages appear to have already started applying some activities to customary woodland, in particular, firebreak maintenance, controlled early burning and patrolling. Other aspects of co-management (restrictions on harvests, benefit-sharing arrangements, and so on) were not identified. This may be explained, in part, by the fact that the objective of applying the activities, at least initially is to ensure rehabilitation, but also in part because of the greater complexity surrounding management of common property resources.
- There appears to be strong demand for additional assistance in rehabilitating bare lands by planting and in promoting other income-generating activities.

BOX 6.4: "Transforming processes"

Evaluation was interested in the extent to which co-management gave people a greater stake in the reserve resource. In the case of sustainable natural forest management, the lack of ownership, rights and responsibilities are expected to reduce the perceived future value of the resource. Again the RRA exercise in Chimaliro was used to probe respondents.

- All groups expressed the belief that they now felt greater ownership over the resource. Respondents recognised that they in fact "owned" the reserve before gazettement but that irresponsible management had caused the government to intervene. Under co-management, respondents felt that the government was recognising the communities' ownership rights but that co-operation was required to manage it effectively.

- All groups felt that the communities were now more responsible for the management of the reserve. The concept of responsibility was viewed in two ways: in terms of the tasks that communities must fulfil as part of their management obligations, but also in terms of a more general responsibility for stewardship to ensure that future generations will continue to benefit from the resource.

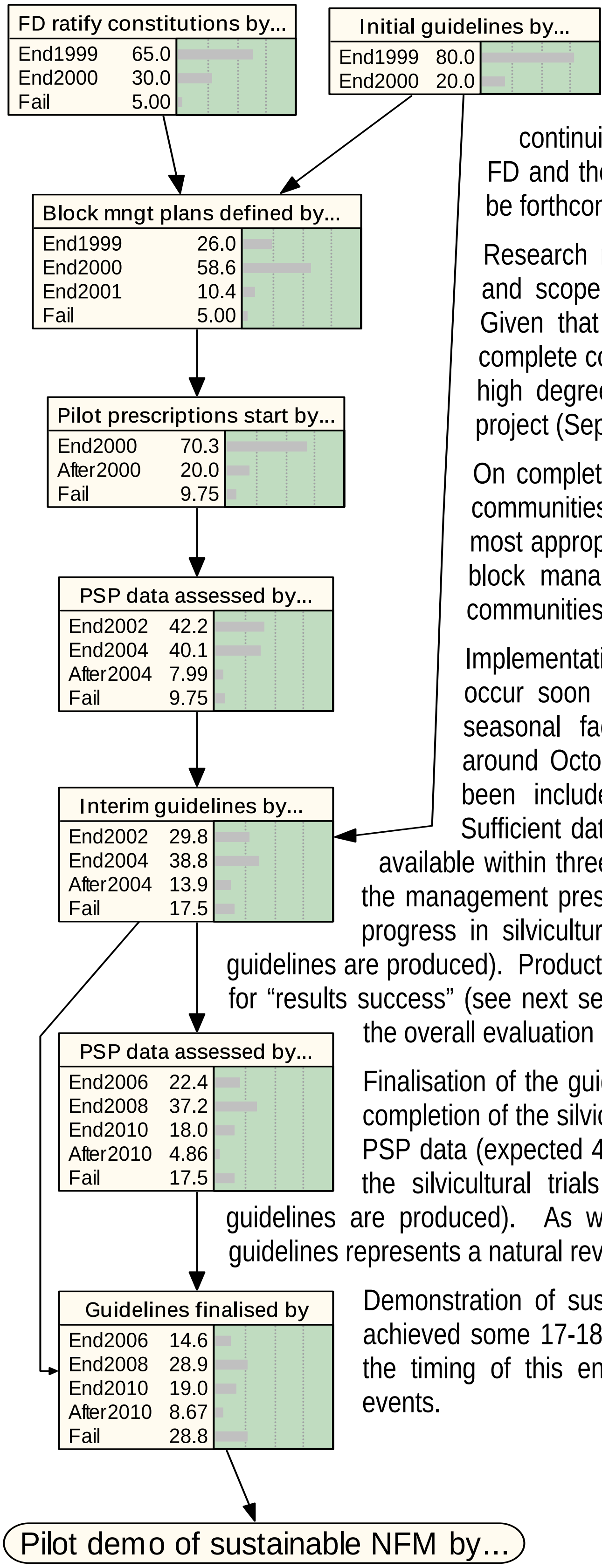
- All communities felt that they now held greater rights over the reserve as a result of co-management. Again this was viewed in two ways: first, in terms of a right of access to collect products compared with the past; second, communities also recognised the rights they now have via the constitutions to impose sanctions on offenders who contravene the co-management agreements. The authority provided by the constitutions, with the government as a co-signature, appears to be widely recognised, though as mentioned earlier, there is some degree of frustration with the delays in obtaining formal approval from the Forestry Department.

### 6.5.6 Component (4): Uptake network

It is not feasible within the confines of this report to provide a detailed explanation of the probabilities calculated for each CSF in the uptake network. Face-to-face question-and-answer sessions are the only effective means of presenting the workings of the model and demonstrating the potential value of the approach. As a result, this section attempts only to describe briefly the network in terms of the CSFs selected and consider the overall results.

Each component of the uptake network is presented "cumulatively" along with probabilities (reflected in the outcome percentages) estimated before the evaluation exercise. At the end of this section, information from the evaluation is entered in order to update the network and observe the effect on the overall prospects of success.

• How long will it take to complete the research?




Ratification by FD of the co-management agreements has been identified as a critical prerequisite for research to advance. FRIM is confident that this will occur sooner rather though continuing delays relate to the availability of legal advice in FD and there remains a small chance that ratification will not be forthcoming.

Research must produce initial guidelines defining the range and scope of silvicultural prescriptions that can be applied. Given that this step is fully within FRIM's control, there is complete confidence that the guidelines will be produced and a high degree of confidence that it will be by the end of the project (September 1999).

On completion of the above two steps, FRIM and the project communities will zone each management block and select the most appropriate prescription for each zone (i.e. define detailed block management plans) according to forest condition and communities' interests.

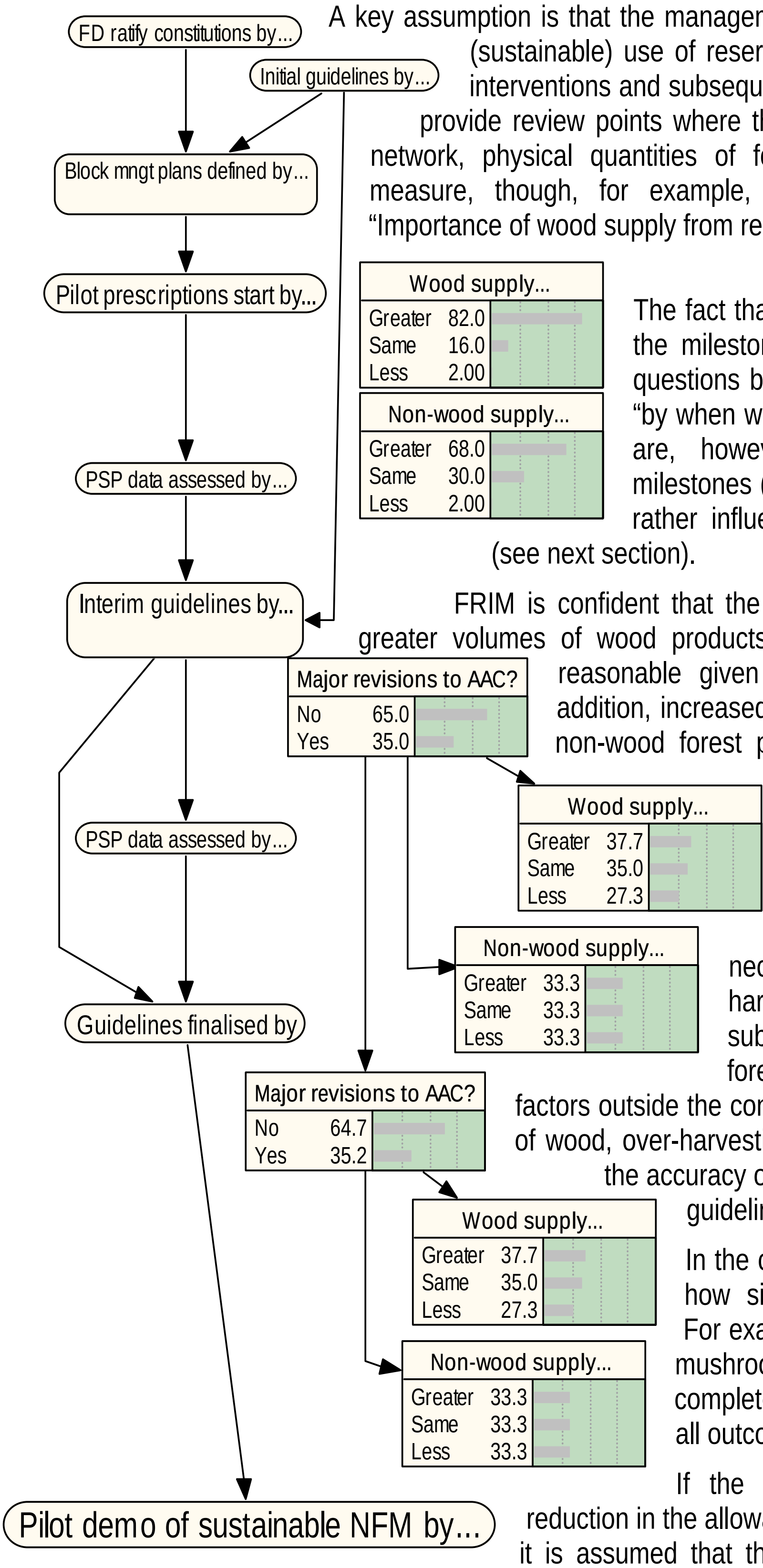
Implementation of the management plans proper is expected to occur soon after design though start date is also related to seasonal factors (the spring flush for regeneration occurs around October). A small residual chance of failure has also been included at this point to allow for unknown factors. Sufficient data from PSPs within the blocks are expected to be available within three years of operations on which to base a review of the management prescriptions but the timing of this will also depend on progress in silvicultural trials (represented by the year in which initial guidelines are produced). Production of the interim guidelines, given their implications for "results success" (see next section), provides an appropriate review point where the overall evaluation approach could be repeated.

Finalisation of the guidelines will require further data from the PSPs and completion of the silvicultural trials and the timing will depend on available PSP data (expected 4 years after the interim guidelines) and progress of the silvicultural trials (represented by the year in which the interim guidelines are produced). As with the interim guidelines, production of the final guidelines represents a natural review point for evaluation.

Demonstration of sustainable NFM on a pilot scale is expected to be achieved some 17-18 years after the start of full implementation though the timing of this end-point will depend on the progress of previous events.

- **Will the findings of research be "successful"?**

A key assumption is that the management prescriptions will enable more productive (sustainable) use of reserves than at present. The start of silvicultural interventions and subsequent refinements of the management guidelines provide review points where this assumption can be tested. In the current network, physical quantities of forest products are taken as the indicators measure, though, for example, "Wood supply…" could be re-defined as "Importance of wood supply from reserve" to convey the sense of relative value.




The fact that the "success" nodes are not linked to any of the milestone nodes reflects the different nature of the questions being asked. For milestones, the only issue is "by when will the event be completed". Research results are, however, not directly related to progress of milestones (either as influencing or dependent events) but rather influence the level of on-going client satisfaction (see next section).

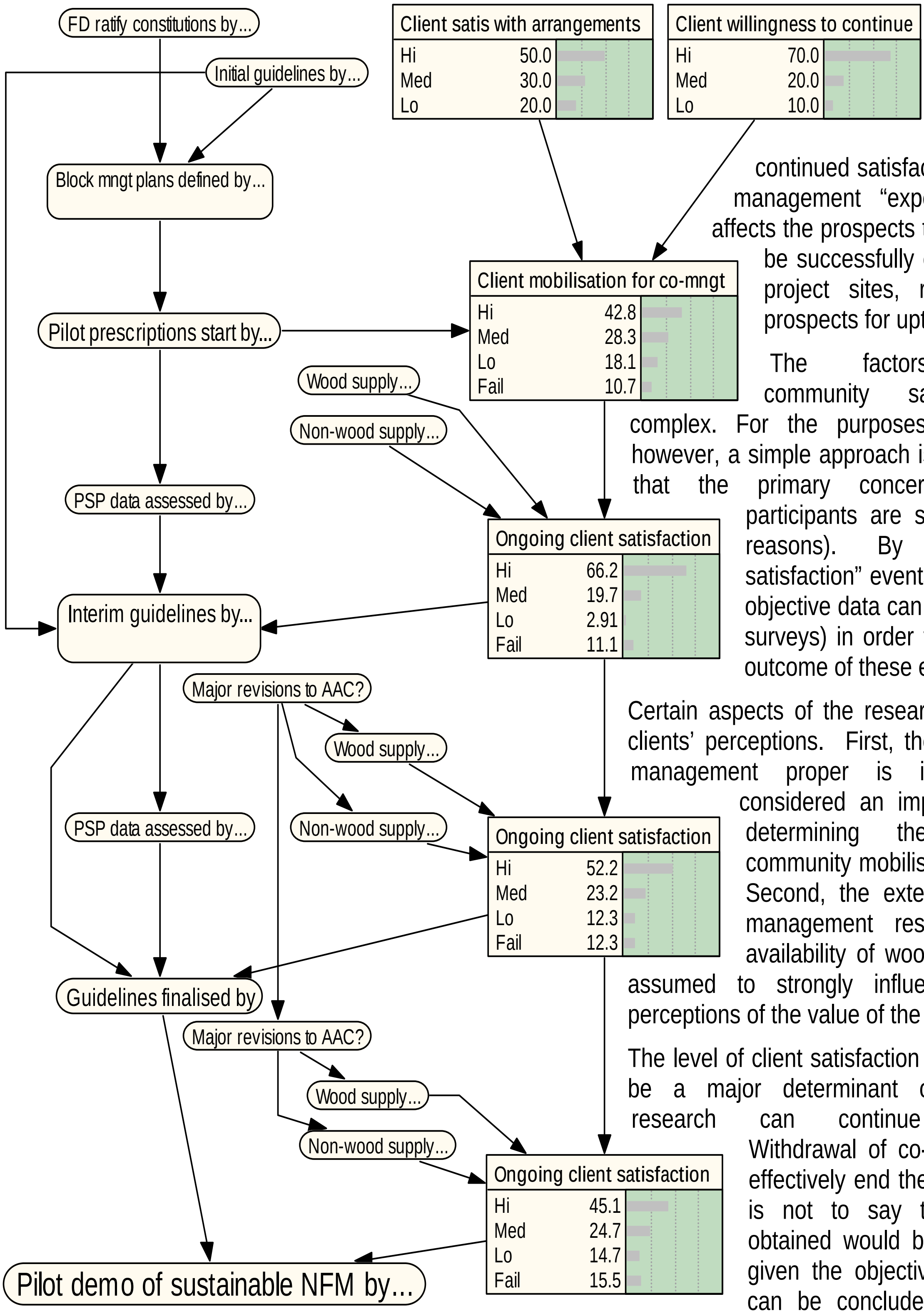
FRIM is confident that the start of silvicultural prescriptions will lead to greater volumes of wood products (or same volume at lower cost). This is reasonable given existing stocks in the blocks/reserve. In addition, increased access is expected to increase availability of non-wood forest products (though existing levels of utilisation make the magnitude of this effect unclear). The assessments presented here reflect the belief of the research leader before the evaluation exercise.

Production of the interim guidelines will necessarily determine whether the allowable harvest has to be revised, which in turn will affect subsequent supplies of wood and non-wood forest products. This decision may be affected by factors outside the control of research (e.g. illegal cutting in the case of wood, over-harvesting in the case of NTFPs) but will also reflect the accuracy of the original predictions embodied in the initial guidelines.

In the case of the most important NTFPs it is unclear how silvicultural intervention will affect availability. For example, availability of thatch may increase while mushrooms may decline. Where information is completely lacking, equal probabilities are assigned to all outcomes (the Laplace rule of ignorance).

If the interim guidelines conclude that no major reduction in the allowable harvest of wood products is required, then it is assumed that there will be a higher likelihood of a similarly favourable outcome at the next major review point (i.e. when the guidelines are finalised).

- Will research continue to meet clients' expectations?



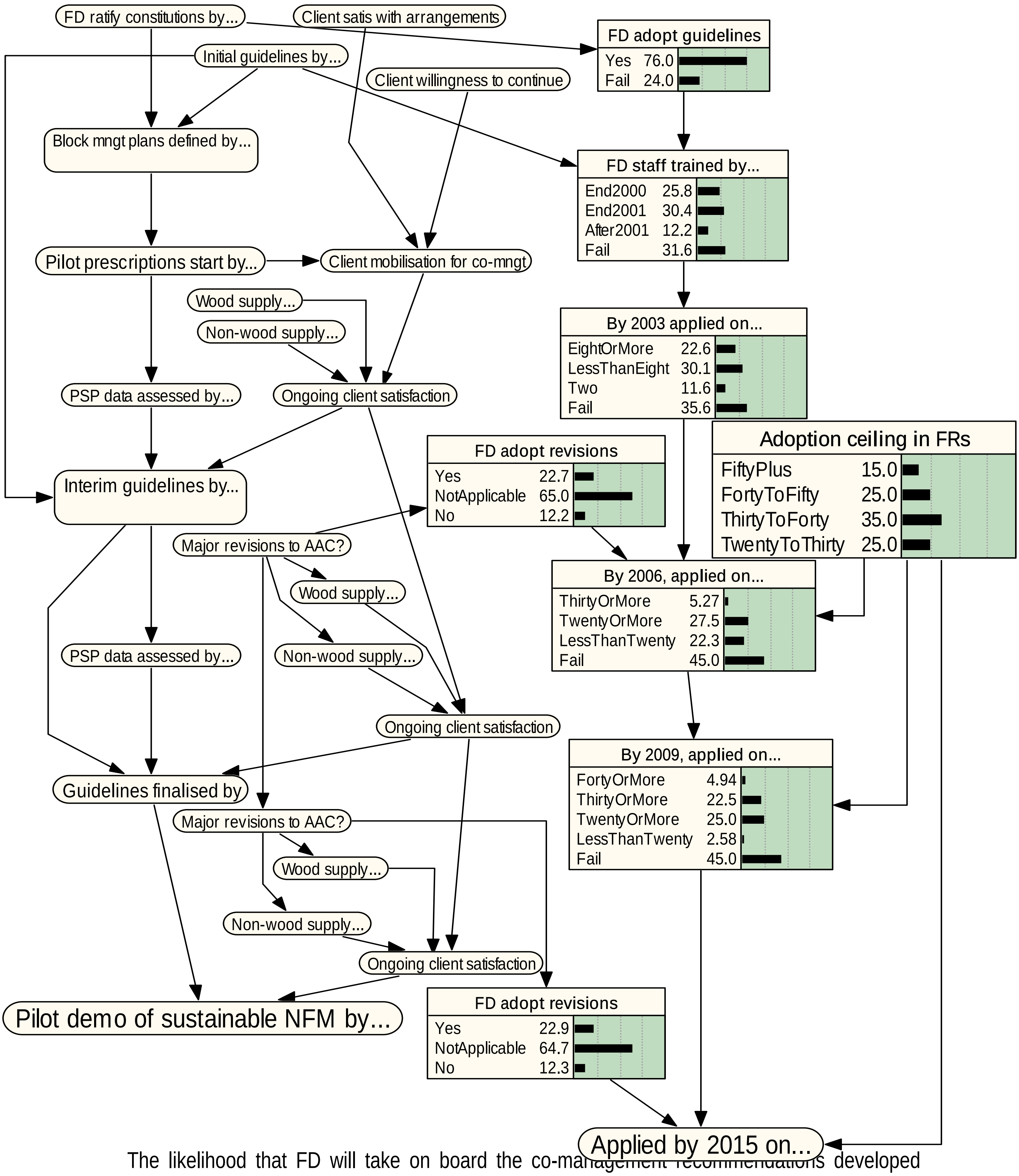

Research success largely depends on participants' continued satisfaction with the co-management "experiment". This affects the prospects that research will be successfully completed in the project sites, rather than the prospects for uptake elsewhere.

The factors influencing community satisfaction are complex. For the purposes of evaluation, however, a simple approach is sufficient given that the primary concern is whether participants are satisfied (not the reasons). By including "client satisfaction" events in the network, objective data can be collected (via surveys) in order to determine the outcome of these events.

Certain aspects of the research will influence clients' perceptions. First, the lag before co-management proper is implemented is considered an important factor in determining the degree of community mobilisation at start up. Second, the extent to which co-management results in greater availability of wood and NTFPs is assumed to strongly influence community perceptions of the value of the research.

The level of client satisfaction is, in turn, felt to be a major determinant of whether the research can continue successfully. Withdrawal of co-operation would effectively end the research. That is not to say that the results obtained would be worthless but, given the objectives of R6709, it can be concluded that such an outcome would represent failure for this project.

• Will the research be applicable beyond the project sites?




The likelihood that FD will take on board the co-management recommendations developed under R6709 is felt to be reasonably high, given the presence of Environmental Management Project (World Bank) which is actively supporting FD in implementing co-management. Approval of the Co-management Constitutions is, however, believed to be prerequisite. The existence of the World Bank project, however, raises the possibility that FD may implement "co-management" but without reference to the recommendations developed under R6709. Assessing the extent of adoption of recommendations by intermediate institutions should be possible with a mix of objective information (e.g. FRIM attendance at FD management planning meetings) and key informant interviews. More refined assessment of the extent of adoption should be the responsibility of subsequent evaluation exercises.

Research recommendations will require dissemination in the form of training for FD field staff if they are to be implemented elsewhere. This is believed to be dependent on (a) whether FD adopt R6709's recommendations (and therefore whether FRIM are involved in the training) and (b) when R6709 produces the initial guidelines, on which training will be based.

A major objective of future research is to refine the management guidelines in the light of information obtained from the on-going silvicultural trials and PSP measurements. For wider application of co-management arrangements to be attributable to R6709's research, it will be necessary for FD to incorporate any major new findings/recommendations developed as research progresses. This process has been represented by two discrete events coinciding with production of the interim and finalised guidelines. The outcomes will depend on (a) whether R6709 identifies the need for major adjustment (i.e. applicable or "not applicable") and (b) whether FD take on board any recommended changes (i.e. "yes" or "no").

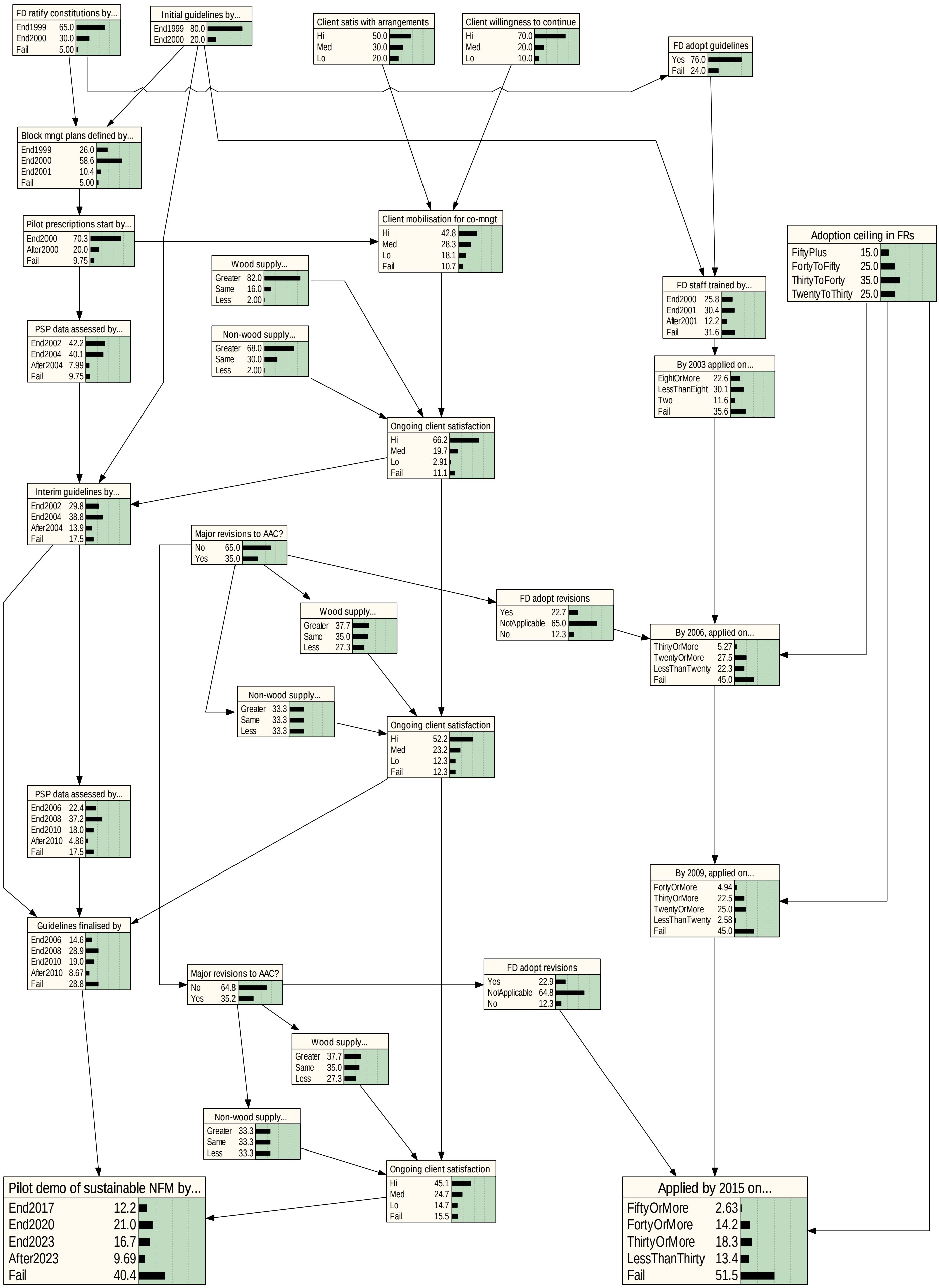
The remaining events under this part of the network relate to the potential ceiling level of adoption (defined as the number of forest reserves applying R6709's co-management recommendations) and the rate of adoption (defined as the number of reserves doing so, at particular points in time). Appendix 6.9 describes in full the steps taken to parameterise these events and outcomes. In short, the evaluation approached this issue by distinguishing between applicability of results in the project sites, on the one hand, and replicability in each district (where reserves are located), on the other.

Applicability was assessed by combining key informants' subjective assessments of the chances of successful co-management for each reserve and objective data relating to the silvicultural zones and forest types and condition of each reserve, estimates of population pressure around each reserve and district-level estimates of forest available on customary land. Results were used to rank each forest reserve in terms of chances of success, which in turn facilitated assessment of the likely adoption ceiling. In addition, adoption lags (i.e. further adaptive research in particular reserves), which affect the rate of adoption were also estimated based on applicability ranks.

Replicability was assessed in terms of FD's district staffing capacity per head of population living within five kilometres of the reserves in each respective district. The ranks obtained from these data were used to further refine estimates of the likely rate of adoption.

The overall uptake network is presented below, based on the results of the assessment exercise prior to implementation of the client perspective survey (component 2) and Local-level impact assessment (component 3). The two end points of the network reflect the long-term nature of the research, both in terms of demonstrating sustainable management on a pilot scale and in terms of achieving wider uptake. The probabilities calculated for the outcomes in each of these end points should be interpreted as follows.

## R6709 Uptake Network (pre-evaluation)



For the completion of research at the project sites, pre-evaluation assessments indicate that there is around a 12% chance that the research will reach this end point by 2017, a 33% chance that it will do so by 2020 (12.2% + 21.0%), around a 50% that it will be achieved by 2023 (33.2% + 16.7%) and a 60% chance that it will be achieved after 2023 (49.9% + 9.7%). The prospect of failure is around 40%.

In the case of wider adoption, it is recognised that this is a continuous process but for the purposes of evaluation the uptake network assumes a cut-off point of 2015. This of course could be extended by the addition of a subsequent event (e.g. Applied by 2020 on…). Again when assessing the chances that R6709's recommendations will be applied on a specific number of reserves, the probabilities should be interpreted cumulatively, as above. Thus, there is only 3% chance that more than 50 (of the 70 odd reserves) will adopt, a 17% chance (2.6% + 14.2%) that it will be applied on 40 or more reserves, and so on.

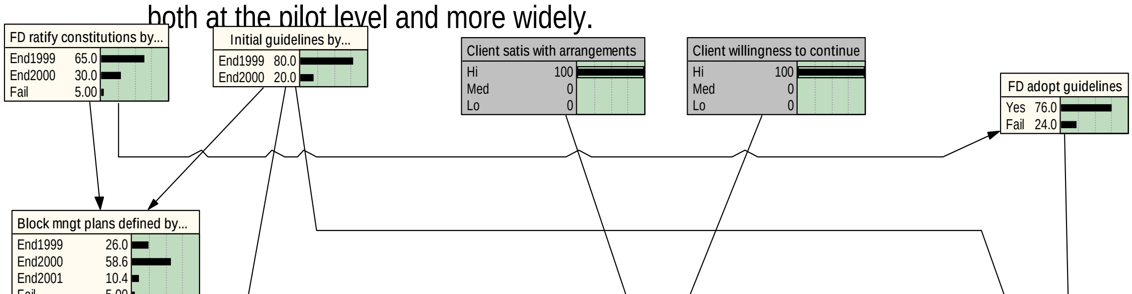
The results indicate that the prospects of (any) success and failure are more finely balanced (almost 50:50). This is not considered to be unrealistic at this stage of the process. However, as soon as the research results are applied on any other reserve(s), the overall chance of failure falls significantly. The remaining risk of failure relates to the possibility that FD does not adopt any major revisions to management guidelines that research at the pilot-level identifies as necessary.

The results of the evaluation enable the network to updated. Indeed the process of updating is considered essential if the network is to be of value for on-going evaluation. Specifically, the results from the client perspectives survey (component 2) yielded objective estimates of the level of satisfaction with the arrangements established under co-management to date, and participants' willingness to continue in the research. In order to enter this information into the network, the analyst must have some standard against which "High", "Medium" and "Low" can be assigned. During the feedback session with project staff, the evaluation team attempted to gauge results by asking what would be considered a "high" etc. result, in advance of presenting actual results. This process was successful only up to a point. Nevertheless, the results obtained from the questionnaire survey of client perspectives are considered sufficiently unequivocal to allow "High" to be entered under both events.

Similarly, the results of the component (3) suggests the need to revise the prior probabilities assigned to the outcomes under the first "Non-wood supply" event. Although these already indicated reasonable confidence that the start of co-management would at least for an initial period increase the availability of NWFPs, results from Chimaliro (questionnaire survey and RRA exercise), where only partial implementation has occurred, suggest that the likelihood of "Greater" should be revised upwards and "Same" revised downwards.

The updated (post-evaluation) network is presented below. The effect of updating the network is to reduce the likelihood of failure from 40.4% to 35.6%. This change of 4.8% is automatically redistributed between the other outcomes on the basis of their relative chances of occurring. These revisions, however, do not affect the prospects of wider uptake because of the relationships of influence identified in the network. It could be argued that initial promising results might positively influence FD's decision whether or not to adopt the research recommendations in a general sense. However, it is felt that this conclusion needs to be tempered by the fact that R6709 still awaits approval from FD for the draft Co-management Constitutions. On balance, individual indicators of positive progress at the project sites are not expected to hav[illegible] FD's implementation of co-management elsewhere. However, if FD do[illegible] the draft co-management constitutions, then the result is failure both at the pilot level and more widely.

R6709 Uptake Network
Post-evaluation



## 6.6 Conclusions

Ultimately, the value of the modified approach proposed above depends on the extent to which it delivers information that is useful to the audience (i.e. the Programme Manager). This raises two potential issues: (a) whether the information provided under the four components meets the Programme Manager's requirements (i.e. for internal management and external reporting); and (b) whether the components themselves represent the key areas of interest for the Programme Manager. In the case of (a), it might be felt, for example, that the "minimum test" approach to assessing the distributional effects of research is insufficient and a more in-depth approach is required. With respect to (b), more fundamentally, it is recognised that a number of dimensions of potential research "impact" have been omitted, e.g. institutional development in FRIM resulting (indirectly) from FRP's support.

Any evaluation involves simplification and the issues examined inevitably reflect the resources available for study. However, the four components included in the approach were selected with generic applicability in mind, based on the assumption that each represents a key area in which "successful" research must demonstrate progress. Treating each component separately enhances this applicability. Thus, while the timeframe of research and its location on the strategic-adaptive continuum may in particular cases constrain the extent to which economic impact can be assessed, progress within the other components can still be evaluated.

At the same time, a number of issues arose during the course of the case study exercise that could not be resolved either because of their more general nature or because the necessary time was not available. Given that development of the modified approach has been based on a single example of research, further consideration of these issues is recommended before wider application of the approach is attempted.

First, there is obviously a need for similar evaluations to be conducted for a number of projects within a given time period. At the same time, the modified approach proposes that repeat assessments be carried out in order to capture changing prospects as individual research projects progress. The timing of these repeat assessments would be dictated by relevant critical success factors and are not expected to be annual exercises. Nevertheless, if the approach is to form the basis of an evaluation strategy within FRP, careful thought will be required to design an appropriate rolling programme of evaluation that is tailored to FRP's available resources.

Second, related to the above, it may be necessary to further simplify the proposed approach for reasons of cost-effectiveness. It is estimated that the entire case study cost approximately £50,000. This high cost in part reflects the developmental nature of the research and £25-30,000 is likely to be a more realistic cost as the approach is standardised. In the case of component (3), however, considerable amounts of data were required to obtain even the approximate estimates of research effects presented above. Furthermore, any expansion of evaluation criteria resulting from, for example, systematic application of a Sustainable Livelihoods framework is likely to compound this difficulty.

A simpler approach could be adopted. For example, in attempting to attribute change to research, reliance could be placed solely on beneficiaries' views expressed in a formal survey with limited or no use made of other "triangulation" instruments (i.e. controls and RRA exercises). Whether such further approximation is acceptable depends largely on FRP's perceived needs.

An alternative and perhaps more appealing means of controlling evaluation costs would be to ensure that the modified approach is built into all new research from initiation. The lack of a formal evaluation "perspective" within R6709 added considerably to the workload of the case study. In spite of the existence of project documentation (including a log-frame), causal relationships between research, satisfaction among participating communities, likely effects and wider factors influencing uptake had to be determined (almost from scratch) by the case study team. Clearer specification of the relationship between the different components from the start of research, including the development of an (initial) uptake pathway, could be expected to facilitate on-going evaluation efforts.

Third, in the time available it was not possible to formalise the procedures for eliciting subjective probabilities under component (4). In general, the methods used were *ad hoc.* For example, the subjective probabilities for uptake in other forest reserves were estimated by the case study team *on the basis* of key informants' views (see appendix 6.9). Given more time, these probabilities could have been obtained directly from the key informants themselves. To facilitate such an exercise, the information collected during the case study regarding the ranks assigned to different reserves and local capacity in each district could have been used as "benchmarking" data. Just how much time would be required for a relatively complex exercise such as this is open to question. In part this will depend on the interest of key informants. It must be recognised that, in many cases, those involved (formally or informally) with implementation activities may perceive forestry research to be of limited practical relevance.

Nevertheless, the case study recognises that more formal consideration of *inter alia* key informant selection criteria, numbers of key informants to be included, and benchmarking methods to assist the identification of prior and conditional probabilities, would be desirable before wider application of component (4).

Fourth, much of the research supported by FRP is long-term in nature and may be expected to continue after the conclusion of FRP support. In cases where the benefits of research are expected to be realised post-FRP support, there may be no problem *if* results obtained during the life of the project under components (1), (2) and (4) are considered acceptable measures of performance. If this is not the case, FRP might alternatively consider two options. The first would involve extending FRP's involvement in (promising) research in order to permit continued access for evaluation purposes. Three-year project cycles could be maintained but firmer commitment to follow-on research projects might be provided from the start[1]. Second, FRP could seek to strengthen its relationship with overseas collaborators at the programme-level (as opposed to project-level). FRP could support local capacity development to enable collaborators to continue evaluating progress periodically even after completion of a given FRP project. This option may be more appealing though it may not necessarily be cheaper.

Fifth, presentation requirements suggest that the results of each component should be relatively easily summarised, both for the immediate audience but also for aggregation purposes. In the case of the internal perspective, client perspective and uptake network, simple scores or percentages facilitate this. In the case of the test of research effects, however, summarising the various indicators is difficult where a standard measure of worth (e.g. NPV) cannot be estimated. Further consideration of the optimal trade-off between the value of summary results, on the one hand, and the loss of detail, on the other, might be

[1] Fulfilment of this commitment would, of course, be dependent on evidence of progress demonstrated during the three-year project cycle.

considered for component (3).

Finally, to be of general value, the results of the approach should permit comparison between projects. Given that only one case study was examined, the potential for this could not be examined. *Aggregation* of evaluation results across projects, at least for components (1), (2) and (4), is expected to be relatively straightforward (e.g. "four out of five projects assessed recorded a high degree of client satisfaction with research"). *Comparison between* projects, however, is expected to be more problematic given that results are context specific. Greater effort to define acceptable levels of performance against selected indicators *in advance of evaluation* might facilitate this.

When considering these issues, and indeed the overall utility of the approach, it should be remembered that the aim was to develop a credible approach that meets the (minimum) requirements of the Programme Manager but that is also replicable within the context of FRP. The basic question is whether the modified approach meets these criteria. Further development is recommended if all or any of the components are considered to have merit.

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