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POTENTIAL GAINS FROM FORESTRY RESEARCH AND A COMPARISON WITH AGRICULTURAL COMMODITIES: A PRELIMINARY ASSESSMENT

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1. INTRODUCTION

The Australian Centre for International Agricultural Research (ACIAR) supports collaborative research projects in a range of important sectors of developing country economies. While the major share of funding concentrates on agricultural inputs and commodities, approximately 20 per cent of funding supports research in the forestry and fisheries sectors.

ACIAR has included as part of its decision making support system the development of a set of procedures for quantifying, in a systematic manner, the potential economic welfare effects of research. The methodology used to generate this information has been summarised in Davis, Oram and Ryan (1987) and progress on its application to 24 major agricultural commodities has been outlined in Davis and Ryan (1988).

The information generated by this analysis serves as one input into decision making which involves making choices between research options for different commodities and different regions. For example, should ACIAR's research program place emphasis on cassava or coconut research in South East Asia? Similar decisions are required regarding choices between research on different forestry products, for example, fuelwood or sawlogs. More importantly, ACIAR must also make decisions regarding the appropriateness of funding forest product research or agricultural product research. For example, fuelwood versus rice research in South East Asia.

The aim of this paper is to expand the analysis already undertaken for agricultural products to include forestry products. This will provide a systematically based set of information to assist with research priority decision making in ACIAR. In particular it will provide support for decisions regarding the potential importance (or otherwise) of forestry products in ACIAR's research portfolio.

In addition to providing an expanded information base to assist decision making in ACAIR it is hoped that the paper will prove useful to other institutions involved in forestry research. There has been limited application of research evaluation methodology to forestry research. This paper will hopefully therefore provide a stimulus for further developments in this area.

Section 2 provides some brief highlights of world forest production trends and a review of previous forest research evaluation studies. The data requirements to facilitate application of the methodology are reasonably demanding. Section 3 of the paper provides a detailed discussion of data needs and how these have been addressed for this preliminary study. A summary of potential research benefits for a set of forest products is provided in section 4. A comparison of forestry and agricultural product research priority relativities is discussed in section 5. It is important to recognize when reading this paper that much of the information used is in a preliminary form. This will be revised and refined during the next year or so as part of the evolutionary nature of ACIAR's decision support system development process.

2. TRENDS IN WORLD FORESTRY AND PREVIOUS FORESTRY RESEARCH EVALUATION

2.1 World Forests

This section provides a brief description of the world's forest base and highlights some historical trends on forest product use. This should assist in forming a perspective for the forestry research evaluation process.

In all their various forms from closed temperate and tropical to open shrubland, forests cover approximately one third of the world's land mass (World Resources Institute (1986)). This is about 5.2 billion hectares and represents about a 30% reduction from original levels due to human disturbance. Historically forests have been important sources of food, shelter and wood but modern societies primarily utilize forests for their wood products. Table 1 identifies total world wood removals for various regions from 1946 to 1986. At this aggregate level, removals in most regions have been increasing since 1946. It is interesting to note the relative insignificance of Oceania as a world player in wood removals.

Forests can also provide stable ecosystems for water catchments, conservation reserves, and opportunities for recreation. Unfortunately many of these less tangible outputs are not priced in economic markets. This makes estimation of economic impacts due to these benefits difficult. This analysis will therefore be targeted more at estimating the benefits of research attempting to enhance wood production.

Examining trends in the production of major wood products can provide insights on the use of world forests. Figures 1 through 6 highlight the production trends for 6 major forest product categories. These figures illustrate that the absolute level of wood production is not decreasing. Many regions have relatively constant production trends. However there are exceptions to this generalization. North American production of pulpwood and coniferous sawlogs has been increasing. Asia has taken on increasing importance in the world forest products sector, particularly in the non-coniferous sawlogs and other industrial roundwood categories. The trends for fuelwood, particularly non-coniferous are smoothly linear and increasing for developing regions which suggests the possibility of data problems. Nevertheless the absolute magnitude of fuelwood production indicates its importance in many parts of the world. Note, however, that the aggregate trends in figures 1 to 6 can mask sub-regional/country declines in wood supplies. (See Repetto and Gillis (1988)).

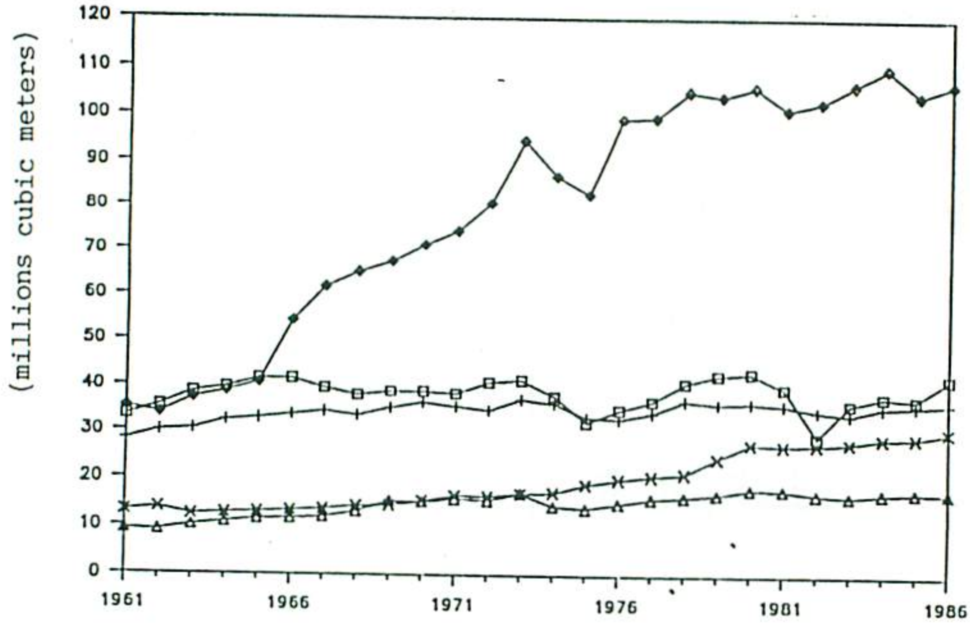
Many countries experiencing severe wood shortages often have significant institutional and economic barriers which may prevent forest development. Forestry research should not be expected to be a panacea for poverty improvement when a country's land tenure system and forest allocation policy provides few incentives for regeneration or leaves the property rights to forest resources poorly defined.

TABLE 1: TOTAL WORLD WOOD REMOVALS 1946-86 (million cubic metres)

	1946	1951	1956	1961	1966	1971	1976	1981	1986
Europe	299	294	302	327	305	328	34	334	351
USSR	186	297	342	351	372	385	384	358	378
North America	353	390	419	383	438	454	480	564	665
Latin America	176	184	213	223	253	278	277	332	373
Africa	99	98	175	196	264	301	384	442	449
Asia	202	224	347	383	582	657	855	898	998
Oceania	14	18	23	25	25	28	31	36	38
World	1329	1504	1823	1888	2240	2431	2727	2963	3252

Source: FAO. Yearbooks of Forest Products (Various Issues)

Figure 1: Sawlogs and Veneer Logs (non-conif.)



Legend

N. America □
Europe +
Asia ◇
Africa △
S. America ×

Figure 2: Fuelwood coniferous

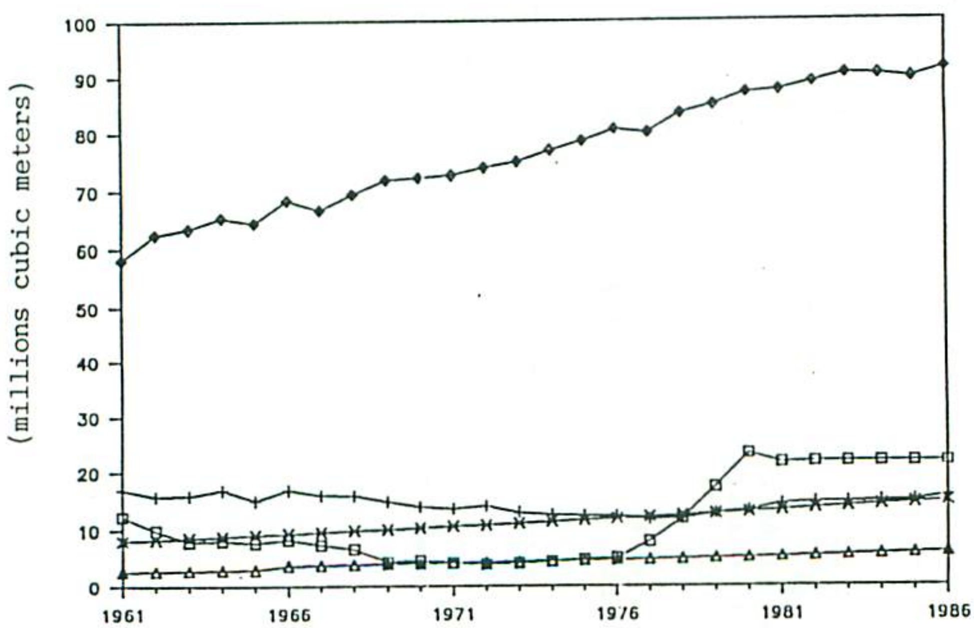
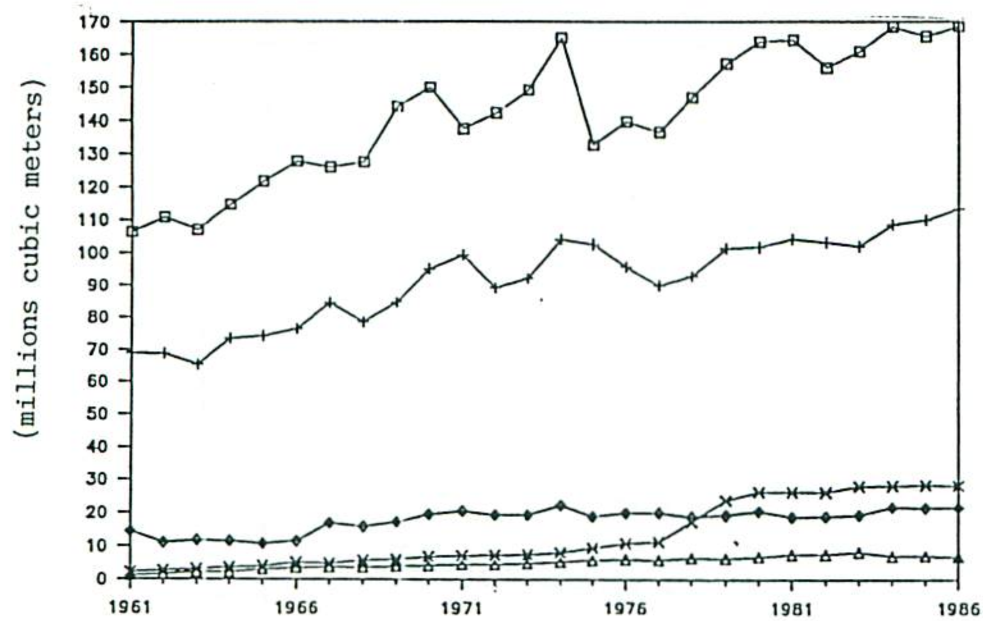


Figure 3: Pulpwood



Legend

N. America □
Europe +
Asia ◇
Africa △
S. America ×

Figure 4: Sawlogs and Veneer Logs (coniferous)

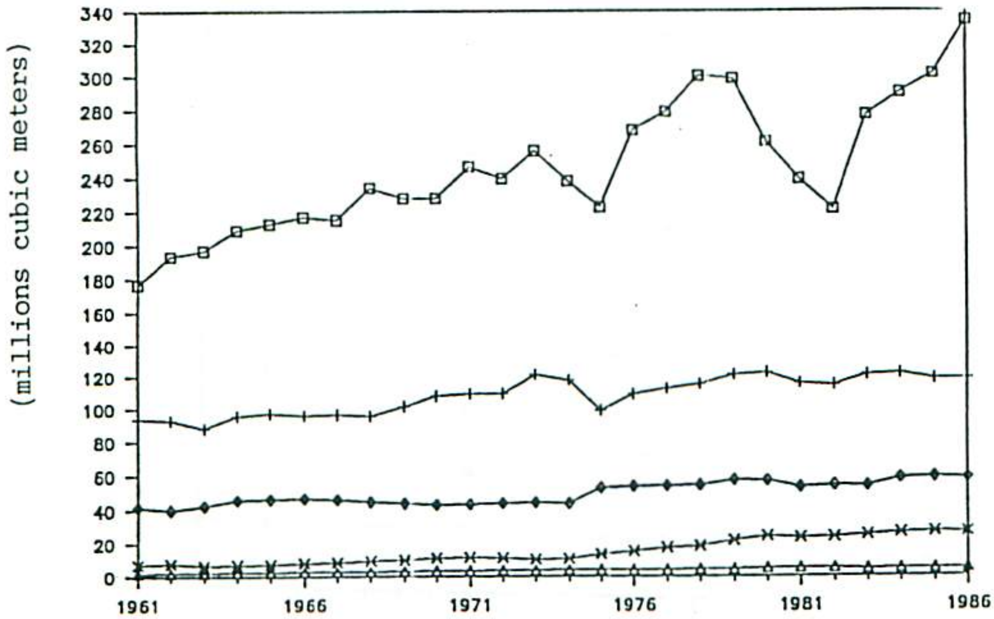
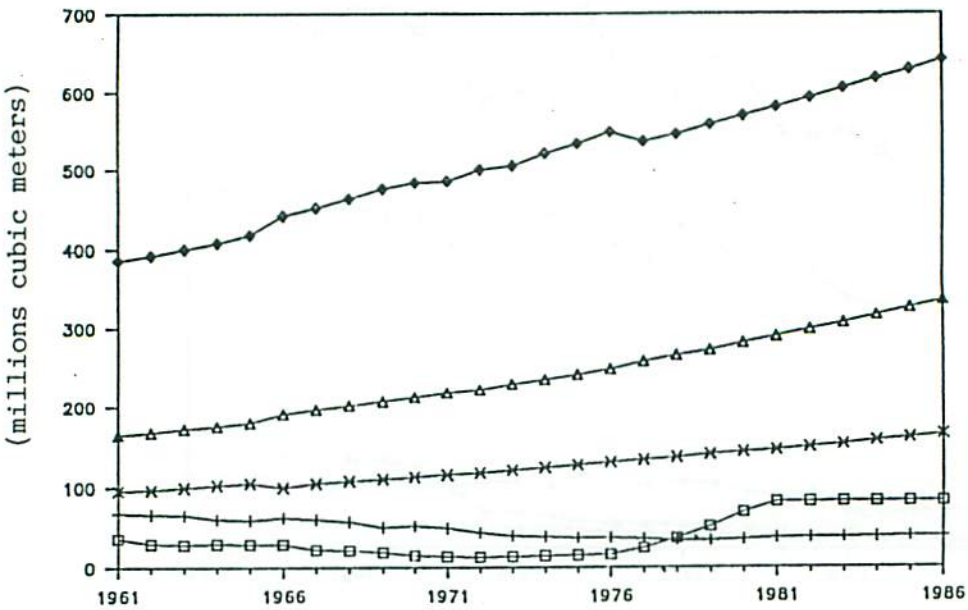


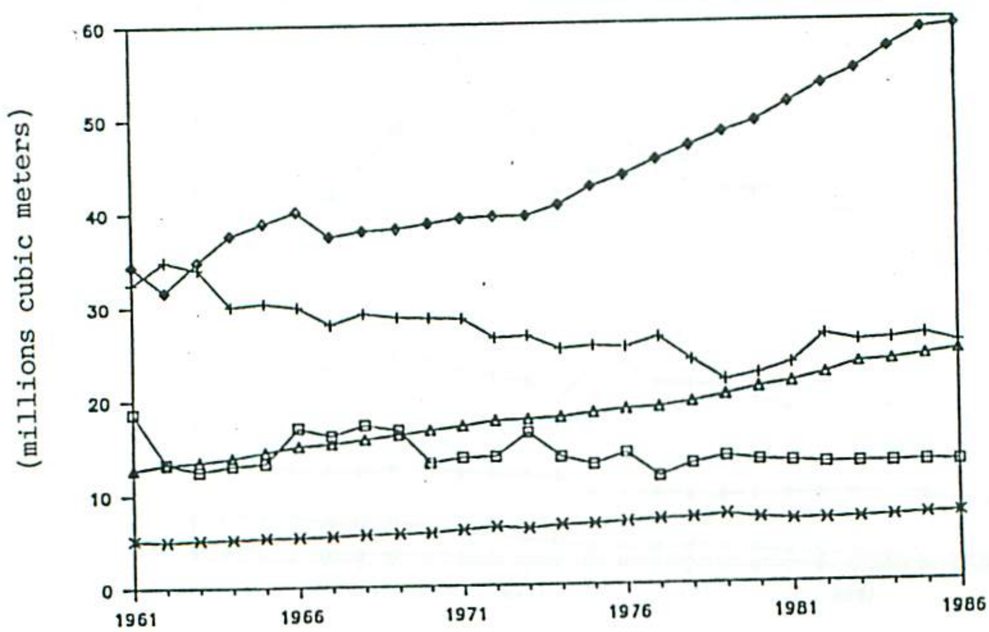
Figure 5: Fuelwood - non-coniferous



Legend

N. America □
Europe +
Asia ◇
Africa △
S. America ×

Figure 6: Other Industrial Roundwood



2.2 Previous Forestry Research Evaluation Studies

Research programs in forestry cover a wide myriad of disciplines such as physiology, genetics, entomology, silviculture, management and processing. Economic evaluations of forestry research are small in number compared to agriculture. Bethune and Clutter (1969) provide one of the earliest applications in this area. Hyde (1983) edited a book on evaluating economic investments in forestry research and provides an overview of various methodologies. Fox (1986) also identifies a number of possible economic models to assist in identifying public forest research priorities. These include linear programming models, dynamic cost-benefit analysis and optimal growth models.

Risbrudt and Jakes (1984) compiled the results of a workshop on forestry research evaluation in the United States. A number of case studies and methodologies were presented. Other recent case studies in this general area are found in Westgate (1986), McKenney et al. (1989), Mergen et al. (1988), and Bergston (1984).

An international task force on tropical forestry research targeted five areas for increased research funding (International Task Force on Forestry Research (1988)):

(i) agroforestry and watershed management

(ii) natural forest ecology and management

(iii) tree breeding and tree improvement

(iv) utilization and marketing

(v) policy and socio-economic issues.

These recommendations were based on the intuition of the assembled experts rather than a quantitative examination of the potential benefits of research in various fields and included both wood and non-wood values. The benefits of research will vary according to factors like institutional research strengths, rates of adoption, spillover effects and lag periods between research and benefits received (Davis et al. (1987). The analysis presented here explicitly includes these factors in examining the benefits of wood oriented research programs.

It is hoped that the framework and analysis presented here will inspire both national and international research administrators to more closely examine their forestry research priority processes and begin to consider factors like success and adoption rates, spillover effects and lag periods.

3. DEFINITION OF FOREST PRODUCTS AND DATA ASSEMBLY

3.1 Introduction

Davis, Oram and Ryan (1987) summarise the categories of information required to apply a partial equilibrium multi-regional traded good model to evaluate the potential benefits from research for a particular commodity. Requirements include: product definition; production and consumption information; prices; supply and demand elasiticities; potential spillover effects of research; assessments of the relative strength of different research systems and ceiling levels of research adoption for each country/region; and assessments of research and adoption lags. This section discusses the sources of this information and procedures used to adapt it for use in the analysis.

3.1 Forest Product Classification

To help evaluate the potential economic benefits of research in forestry, forest products must be categorised. The best source of world-wide production and consumption data are the United Nation's Food and Agriculture Organisation's "Yearbook of Forest Products" (eg. FAO (1983)). However, the structure of the FAO's classification system is not readily apparent. Without an understanding of the linkages between forest products as one moves through processing stages, overestimation or underestimating of benefits may occur.

Figure 7 provides a schema of the perceived market linkages and the total world production (from the FAO year book) for each category. A summary of the FAO definitions of each product category is provided in Appendix 1. The data available for many of the products listed is: (i) production, (ii) import quantity, (iii) import value, (iv) export quantity and (v) export value.

Due to the complexity of market linkages and the fact that ACIAR's forestry research projects are orientated more at the forest level rather than processing, it was decided to use the less processed categories for the analysis. Other considerations included the availability of price data and the fact that the more highly processed products are often only found in developed countries - ACIAR's research programs are intended to assist developing countries. One other important point is that utilising value-added prices for processed goods would bias upwards the benefits of forest-based research.

The following eight products were included in the analysis:

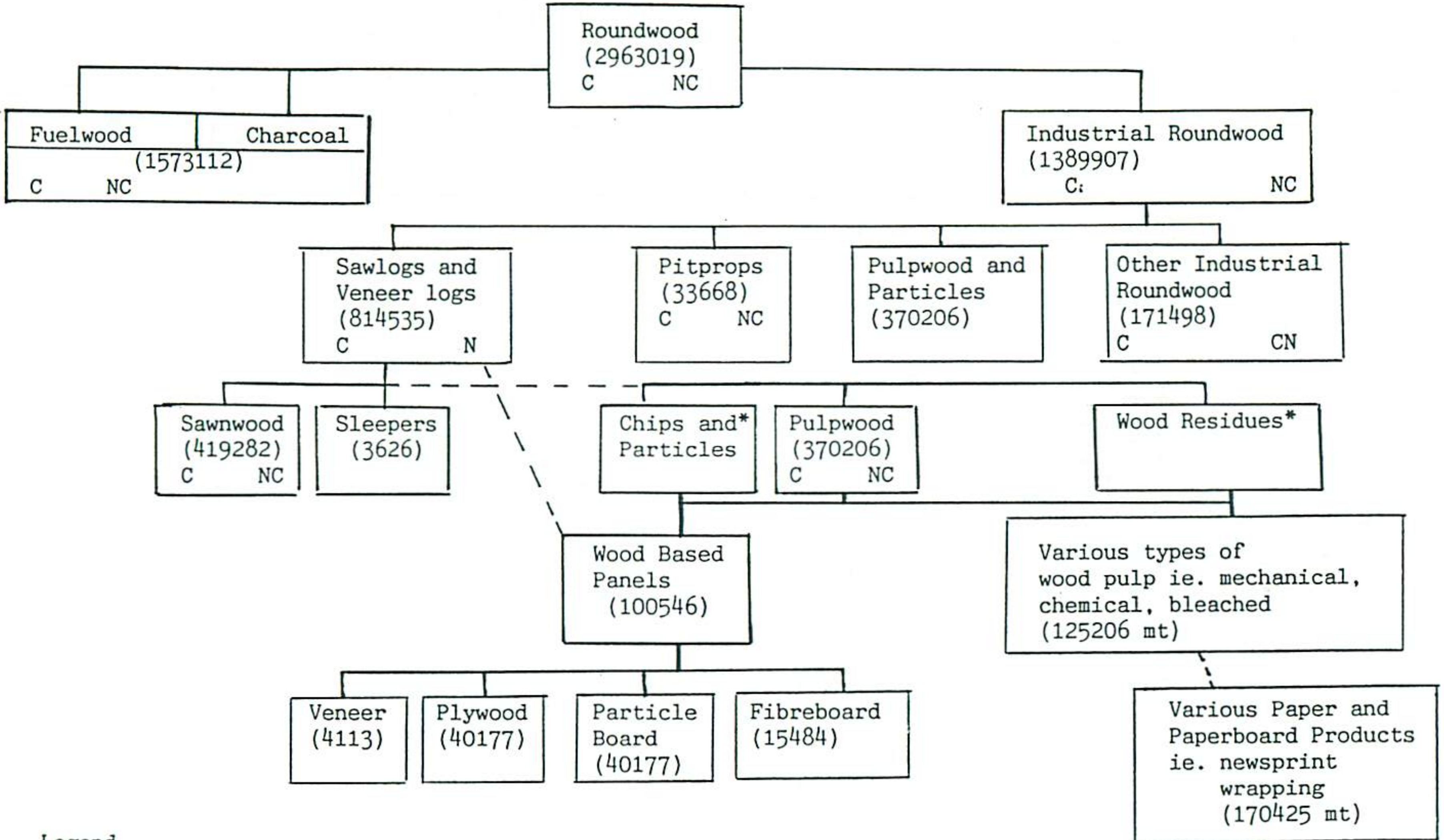
- Fuelwood - non-coniferous
- Fuelwood - coniferous
- Charcoal
- Sawlogs and Veneer logs - non-coniferous
- Sawlogs and Veneer logs - coniferous
- Pitprops
- Pulpwood
- Other industrial roundwood

The production and consumption data were obtained from FAO computer tapes.

3.2 Forest Product Prices

For the analytical framework used in this study prices are only of significant importance when they are used to provide the basis for the

FIGURE 7: SCHEMATIC REPRESENTATION OF FAO FORESTRY PRODUCT DATA



Legend

☐	FAO Product
C	Coniferous
NC	Non-coniferous
(1234)	Total world Production 1981 (000's) in - Cubic meters unless mt - metric tons
*	Only trade figures reported - no production data
———	direct link or sub-category
----	unclear linkage in FAO classification

potential unit cost reduction estimates due to research. Table 2 identifies the price information available from the FAO (FAO (1985)). The information is very sparse; in fact, incomplete price data is the rule in forestry rather than the exception. Attempting to obtain prices for individual countries for each product proved to be a futile task.

The FAO does provide aggregate weighted world export unit values for many of the products listed in Table 2. Due to the lack of better information these values were used as the price and hence the basis for the unit cost reduction estimates. Table 3 summarises the price data used in the analysis. Some explanation is required since the price categories do not match the product categories identified in section 3.1. Pulpwood, fuelwood and charcoal prices do match the FAO product classification scheme, however, prices for the other classes have to be inferred. Some simplifying assumptions have to be made due to data limitations. The following summarises the assumption made in identifying prices for some products.

(i) The coniferous sawlogs and veneer logs category used the coniferous log price series.

(ii) Depending on the country location the non-coniferous sawlogs and veneer logs category used: (a) the non-coniferous logs; (b) tropical logs-Africa; and (c) tropical logs-Asia, price series.

(iii) The same price was used for both coniferous and non-coniferous fuelwood.

(iv) Pitprops and other industrial roundwood were assumed to have the same price as pulpwood.

3.3 Supply and Demand Elasticities

Elasticity estimates for primary forest products are more scarce than price data. Buongiorno (1978) calculated income and price elasticities of demand for paper and paperboard for developed and developing countries. For newsprint, printing and writing paper and, other paper and paperboard products own-price demand elasticities ranged from -.21 to -.83. Low-income countries consistently had the higher elasticities. Haynes (1977) discusses the linkage between the stumpage (trees in the forest on the "stump") and lumber markets in the United States. His general comment is that the demand for stumpage is less elastic than the final product demand. This would be expected following the theory of derived demand (Friedman (1976)).

Kallio et al. (1987) suggest that Canada and Norway are the only countries that have generally available data for econometric factor demand analysis. They provide some wood own-price elasticities estimates for the construction sector (-.38 to -.44), the furniture sector (-.68 to -.92) and the paper or office sector (-.99 to -1.09).

The general lack of demand and supply elasticity estimates for the primary forest products resulted in the need to rely on intuition. There are of course a myriad of factors that influence both demand and supply elasticities. These include factors such as substitute products and their

TABLE 2: COMPARISON OF FORESTRY PRODUCT PRODUCTION AND PRICE DATA

Price Category Yearbook Production Data Category	Closest FAO	Comments
Stumpage fees and Royalties	Roundwood	22 countries, very variable
Fuelwood	Fuelwood	31 countries
Charcoal	Charcoal	25 countries
Pulpwood	Pulpwood	19 countries
Coniferous logs	Industrial roundwood	15 countries
Non-coniferous	Industrial roundwood	5 countries
Tropical logs	Industrial roundwood	16 countries
Coniferous sawnwood	Coniferous sawnwood	23 countries
Non-coniferous sawnwood	Non-coniferous sawnwood	10 countries
Tropical sawnwood	Non-coniferous sawnwood	12 countries
Plywood	Plywood	12 countries
Particleboard	Particleboard	10 countries
Fibreboard	Fibreboard	10 countries
Various categories of wood pulp and paper products.	Same categories	

TABLE 3: FOREST PRODUCTS WORLD PRICES *

PRICE CATEGORY	1979	1980	1981	AVERAGE
Pulpwood	26	36	39	34
Fuelwood	33	47	43	41
Charcoal	166	185	194	182
Coniferous logs	84	90	81	85
Non-coniferous logs (temperate zone)	140	140	112	131
Tropical logs: Africa	106	128	113	116
: Asia	87	93	79	86

* From FAO (1985) in $US/cubic metre except charcoal $US/metric tonne

prices and both private and public forest policy. Table 4 summarise estimates of both demand and supply elasticities used for the study.

3.4 Country Groupings

It was necessary to aggregate countries to keep the analysis manageable and relevant to ACIAR's needs. Obviously, the aggregation does not preclude analysis of countries that may be of specific interest to other researchers. Several criteria were used to determine the aggregation.

(i) Whether or not the country was of particular interest to ACAIR (e.g. research projects already in place or being considered)

(ii) Whether or not the country was a big producer relative to world production (The rule of thumb used was that countries with greater than .25 percent of world production were included separately).

(iii) Countries that have similar forest production environments.

To summarise the aggregation process: a core of countries that are of particular interest were selected (see Table 5); any country that was a large producer remained separate in the analysis; other countries were grouped according to their production environment similarity.

3.5 Estimation of Potential Spillover Effects for Forestry Products

3.5.1 Background

Davis, Oram and Ryan (1987: pp 22-27 and pp 36-37) discuss the procedure used to estimate the potential spillover effects of research between countries and/or regions for agricultural commodities. Spillover estimates were based on the notion that research done on a commodity grown in one set of agroclimatic conditions has strong potential to be applicable to production in similar agroclimatic regions of the world. On the other hand, production of the commodity in dissimilar agroclimatic regions is unlikely to be influenced by this research output.[1] In Davis, Oram and

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1 The notion of research spillovers is a complex issue. The nature of the research undertaken will have an important impact on the potential spillover. For example, the output of what is often referred to as 'basic' research could be equally applicable in quite diverse production environments. On the other hand, some directly applicable knowledge may only be relevant to very specific environments. The spillovers used in this study refer to the notion of a mean of this distribution of effects for each set of production environments and each commodity. If the distribution is felt to be multi-modal then it may be necessary to develop several spillover matricies for each commodity and each type of research.

TABLE 4: SUMMARY OF FOREST PRODUCT ELASTICITIES USED IN STUDY

PRODUCT	TYPE OF COUNTRY	DEMAND ELASTICITY	SUPPLY ELASTICITY
Pulpwood	Developed	0.9	0.3
	Developing	0.8	0.3
Fuelwood	Developed	0.8	0.8
	Developing	0.4	0.6
Other Industrial Round Wood	Developed	0.9	0.3
	Developing	0.8	0.3
Charcoal	Developed	0.9	1.2
	Developing	0.9	1.2
Sawlogs and Veneer Logs	Developed	0.8	0.3
	Developing	0.8	0.3
Pitprops	Developed	0.9	0.3
	Developing	0.8	0.3

TABLE 5: COUNTRIES USED IN BASIC ANALYSIS

SOUTH ASIA	SOUTH EAST ASIA	CHINA
Afghanistan Bangladesh Bhutan India Nepal Pakistan Sri Lanka	Burma Indonesia Kampuchea Laos, PDR Malaysia Philippines Thailand Vietnam Soci	People's Republic of China Mongolia
SOUTH PACIFIC	**AFRICA**	**WEST ASIA / NORTH AFRICA**
Fiji Nauru Papua New Guinea Western Samoa Solomon Islands Tonga Tuvalu Vanuatu Others Grouped According to Production/Climatic Conditions	Ethiopia Kenya Malawi Tanzania Uganda Zambia Zimbabwe Others Grouped According to Production/Climatic Conditions	All Grouped According To Production/ Climatic Conditions
LATIN AMERICA	**DEVELOPED**	
All Grouped According to Production/Climatic Conditions	Australia According to Production/Climatic Conditions	

Ryan (1986) agricultural production environments were classified using the set of agroecological zones (AEZ) developed by FAO (1978a, 1978b, 1980a, 1980b).

Production of commodities within an individual country often straddle AEZ's. Potential spillovers therefore need to take into account the proportion of production in each AEZ within a country as well as between countries. Davis, Oram and Ryan (1987) obtained FAO derived commodity production shares by AEZ's for many countries and most commodities. These were used as a basis for allocating countries to a single AEZ, for example, using the AEZ with the major share of production to categorise the country. If major shares of production came from two or more AEZ's then a composite classification was used and subjectively weighted spillover effects estimated.

Application of this methodology with a global focus requires considerable subjective input. This is essential to stimulate the evolutionary adaptation of the information to suit the decision making process. Nevertheless, it is important to build on these subjective assessments overtime and ensure that documentation is sufficient to enable replication and improvement. In this forestry application an attempt has been made to replace some of the subjectivity of the previous spillover estimation process used for the agricultural commodities with a more systematic procedure. This revised procedure is briefly outlined and then the component estimates discussed.[2]

3.5.2 Spillover Estimating Procedure

The country level focus of the analysis (rather than sub-regions within a country) means there is often diversity in the production environment mix within particular countries. Countries such as China, Australia and India include a diversity of production environments. The assumption that the production environment with most production of a commodity is the production environment to use in spillover estimation may be too simple. For example, it implies that the direct effect of research in the country results in an equal unit cost reduction for production in all regions of that country. If the commodity is produced in a range of these production environments this is unlikely to be a reasonable assumption. It would require the notion of a multiple-facet research project which covered all regions. This in turn, however, would raise the further issue of within project spillovers as well as a research cost homogenity problem between countries. An alternative process has been developed for this study.

A simple matrix representation of the process used is given as:

$$S = R\ C\ F$$

Where:

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[2]A more detailed discussion of the importance of research spillovers and the basis for the estimation procedure used here is given in Davis (forthcoming).

S is an n x n matrix of estimates of the potential research spillover weights on a scale of 0 to 1 among the countries/regions chosen for the analysis; n is the number of countries/regions considered.

R is an n x m matrix of potential research emphasis parameters; m is the number of production environments relevant to production of the commodity.

C is an m x m matrix of production environment spillovers (on a scale 0 to 1) among the production environments for each commodity.

F is an m x n matrix of commodity production shares for each country by production environment.

The elements of **S** are the equivalent of the potential spillovers used in Davis, Oram and Ryan (1987). Each column and row in this matrix represents a country (or sub-region within a country if that is the focus of the study). Thus s_{ij} is the potential spillover effect of research undertaken in country 'i' on production in country 'j'. (i,j = 1....n)

The introduction of **R** is required to account for countries/regions with production in multiple production environments. The potential research emphasis parameters included as r_{it} (t=1.....m) can also be viewed as the likelihood of the research being applicable to production in a particular production environment in a country. An example is the best way to illustrate. If a country produces a commodity in only one production environment then it is reasonable to expect any research undertaken to be applicable to all production in that country. If so r_{i6}=1 for production environment number 6 and zero for t≠6. On the other hand, if the commodity is produced in five production environments then a decision needs to be made regarding whether any research undertaken is likely to emphasise applicability to a subset of these environments. If most production is in, say, production environment number t=10 then it may be reasonable to assume $r_{i,10}$=1 and the remaining, say t=2,6,25 and 92 environments have r_{it}=0 (along with all remaining environments with no production). Alternatively if production is concentrated in environments 10 and 62 it may be appropriate to conclude that research has an equal chance of emphasising applicabilities to either zone. This being the case $r_{i,10}=r_{i,62}$=0.5 may be appropriate parameter values (all other r_{it} values being zero). If research is expected to emphasis a particular environment, an alternative parameter structure could be adopted to reflect this.

Elements of **C** represent estimates of the potential spillovers due to production environment factors, ignoring country production environment composition. For most commodities it is expected that potential spillovers will be close to 1 for the same environment. The larger the differences between production environments the closer c_{tt} is likely to be to zero.

The elements of **F** represent the share of production in each production environment for each country. Ideally these will be forecast shares at the time that research becomes applicable to production of the commodity. For completeness and consistency between commodities and countries a column is included for each possible production environment, that is, **m** is the total possible number relevant to any commodity. As a result each **F** (and **R**) will be a sparse matrix.

3.5.3 Assumptions and Information Used For Forestry Spillover Estimation

Sound technical knowledge of world forestry is essential to provide estimates of the information required for the analysis. Detailed quantitative information is not available to estimate all of the parameters required. Subjective assessments were therefore necessary.

Davis, Oram and Ryan (1987) used the FAO AEZ classification system to define production environments for agricultural commodities. Discussion with forestry and climatic zonation researchers led to the conclusion the agroclimatic classification developed by Papadakis (1975) was an appropriate production environment classification system for forestry. For the preliminary results generated in this paper, this system was felt adequate. In subsequent revisions more detailed effort may be required to adopt a common classification to ensure maximum consistency with forestry and other products.

Briefly the Papadakis system separates agroclimatic conditions into ten broad categories. Zone 1, which includes tropical environments, to Zone 10, which includes polar categories. Within each of those zones there are up to nine single decimal sub-zones which include separations based on, for example, altitude and temperature. Although the system is available to a four decimal classification only the single decimal classification was used in this study. For this analysis therefore **m=72** was used.

The country groupings used for forestry gave a total of between 50 and 60 countries/regions depending on the product, that is **n=50 to 60**.

Table 6 provides a condensed outline of the basic agroclimatic spillover estimates used in the analysis. These correspond to matrix C. The diagonal elements include values 0.9 and 0.5, The former, 0.9, refers to the value used as the research spillovers to the same first decimal sub-zone. Thus the spillover from zone 1.1 in country 1 to zone 1.1 in country 2 is 0.9. On the other hand, the spillover from zone 1.1 in country 1 to zone 1.3 in, say, country 3 was judged to be 0.5. Each of the entries in the rest of the table represent a block sub-matrix of, up to, 9 rows and 9 columns.

The potential research emphasis parameters, **R**, are difficult to assess at an aggregate multi-country level. For this analysis it was assumed that the research emphasis for each zone within each country was the same as the proportion of output produced in that zone for the commodity concerned. In this study, therefore, it was assumed that **R=F'**.

Information on forestry product production shares for each agroclimatic zone was not available. These shares were therefore determined using subjective assessments by forest researchers of production distributions for each country.

The procedure used in this analysis is likely to lead to spillover estimates not necessarily consistent with those estimated by Davis, Oram and Ryan (1987). To begin with they assumed research would be applicable to the agroclimatic zone with the largest production share. This led to a diagonal set of direct research effect parameters of 1. In some cases when

TABLE 6: **BASIC SPILLOVER VALUES BETWEEN AGROCLIMATIC ZONES - CONDENSED.**

AGROCLIMATIC ZONE	AGROCLIMATIC ZONE 1	2	3	4	5	6	7	8	9	10
1	0.9 0.5	0.3	0	0.3	0	0	0	0	0	0
2	0.3	0.9 0.5	0.3	0.3	0.3	0	0	0	0	0
3	0	0.3	0.9 0.5	0.3	0.3	0.3	0	0	0	0
4	0.3	0.3	0.3	0.9 0.5	0.3	0	0	0	0	0
5	0.	0.3	0.3	0.3	0.9 0.5	0.3	0.3	0	0	0
6	0	0	0.3	0	0.3	0.9 0.5	0.3	0	0	0
7	0	0	0	0	0.3	0.3	0.9 0.5	0	0	0
8	0	0	0	0	0	0	0	0.9 0.5	0.3	0
9	0	0	0	0	0	0	0	0.3	0.9 0.5	0
10	0	0	0	0	0	0	0	0	0	0.9 0.5

NOTES: Agroclimatic Zone numbers refer to those of Papadakis (1975) production is distributed over a range of zones within a country the direct effect of research will be sustantially smaller than 1.[3]

3.6 Other Parameter Estimates

3.6.1 Relative Research Strengths and Ceiling Level of Adoption

The relative chance of forestry research being successful in each country/ region was subjectively assessed using knowledge of the strength of national research systems and therefore their likely ability to successfully complete forestry research projects. It was felt that researchers were fungible between forestry products and therefore the same estimates were appropriate for all eight products. Table 7 summarises the information used.

Ceiling levels of research adoption were felt to differ between two groups of forestry products. In many countries fuelwood is grown either as natural forest or in relatively small areas, rather than in large scale public forests. With relatively weak forest extension services and limited availability of other infrastructure, education etc, facilities it was felt that ceiling adoption levels would be lower for these products. For the remaining products, pulpwood, saw and veneer logs, pitprops and other industrial roundwood larger scale production is more likely concentrated in industrial or publicly owned forests and therefore adoption levels were judged to be higher. Table 7 summarises these values for the two different groups of products.

3.6.2 Lags and Discount Rate

The lags for research and adoption used in Davis, Oram and Ryan (1987) were 11 years in the country undertaking the research and 15 years for those receiving spillover benefits. For forestry this type of lag structure was felt to be applicable for products such as fuelwood, pulpwood, charcoal and pitprops. However, there is clearly doubt about the applicability of these lags to sawlogs and veneer logs. Lags of 30-40 years or more are often suggested. For the preliminary results presented in this paper the same lag for all products is used. Some sensitivity analysis indicates the importance of this assumption.

The discount rate used is 12 per cent. Since this is a real rate it is higher than often used in benefit cost analyses. On the other hand, since most agricultural research evaluation studies show internal rates of return

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3 Note in the results presented below the $s_{ij}=1$ for i=j restriction was used to override these estimates. This was in an attempt to make these preliminary results more comparable with the agricultural commodities. Estimation using both alternatives revealed some difference in the mean values used here although these were not great. At the individual country level some substantial differences occur. Work is underway to re-estimate the agricultural spillovers using the same approach. Future comparisons will therefore be more consistent.

TABLE 7: **SUMMARY OF PROBABILITY OF SUCCESS AND CEILING LEVEL OF ADOPTION ESTIMATES FOR FORESTRY RESEARCH**

		CEILING LEVEL OF RESEARCH ADOPTION	
COUNTRY/REGION	PROBABILITY OF RESEARCH SUCCESS	FUELWOOD/ CHARCOAL	OTHER FOREST PRODUCTS
AFGHANISTAN	0.45	0.35	0.42
BANGLADESH	0.60	0.55	0.66
BHUTAN	0.45	0.50	0.60
INDIA	0.75	0.60	0.72
NEPAL	0.65	0.55	0.66
PAKISTAN	0.75	0.55	0.66
SRI LANKA	0.65	0.55	0.66
S A OTHER	0.45	0.55	0.66
BURMA	0.50	0.45	0.54
INDONESIA	0.65	0.55	0.66
KAMPUCHEA	0.50	0.50	0.60
LAOS, PDR	0.50	0.50	0.60
MALAYSIA	0.80	0.60	0.72
PHILLIPINES	0.65	0.55	0.66
THAILAND	0.70	0.55	0.66
VIETNAM SOCI	0.55	0.50	0.60
CHINA PEOPLE	0.70	0.55	0.66
MONGOLIA	0.65	0.55	0.66
FIJI	0.60	0.50	0.60
NAURU	0.45	0.50	0.60
PAPUA NEW GUINEA	0.50	0.50	0.60
WESTERN SAMOA	0.55	0.50	0.60
SOLOMON ISLANDS	0.60	0.50	0.60
TONGA	0.55	0.55	0.60
TUVALU	0.55	0.50	0.60
VANUATU	0.60	0.50	0.60
SPAC OTHER	0.55	0.50	0.60
ETHOPIA	0.50	0.40	0.48
KENYA	0.60	0.60	0.66
MALAWI	0.60	0.50	0.60
TANZANIA	0.55	0.45	0.54
UGANDA	0.55	0.35	0.42
ZAMBIA	0.60	0.50	0.60
ZIMBABWE	0.70	0.50	0.60
ZAIRE	0.50	0.35	0.42
AFR 1.4/1.1	0.50	0.36	0.42
AFR 1.5/1.4	0.50	0.35	0.42
AFR 3.2/1.5	0.50	0.35	0.42
AFR 1.7/1.5	0.50	0.35	0.42
MOZAMBIQUE	0.70	0.55	0.66
AFR OTHER	0.50	0.50	0.60
TURKEY	0.65	0.55	0.66
WA/NA OTHER	0.60	0.55	0.66
BRAZIL	0.60	0.60	0.72
COL/PERU	0.55	0.50	0.60
ECU/MEX	0.60	0.50	0.60
EL SALVADOR/HAITI	0.55	0.40	0.48
ARG/CUI/PAR	0.60	0.60	0.72
L AM OTHER	0.55	0.40	0.48
ASIA DEVED	0.80	0.75	0.90
AUSTRALIA	0.80	0.75	0.90
CANADA	0.80	0.75	0.90
DEVD 7/8/6	0.80	0.75	0.90
SOUTH AFRICA	0.80	0.75	0.90
USA	0.80	0.75	0.90
USSR	0.75	0.60	0.72
DEVD OTHER	0.75	0.60	0.72

Source: Subjective assessment by Dr J. Turnbull, ACIAR Forestry Research Coordinator greater than this, it may be viewed as an appropriate opportunity cost of public research funds. Regardless, as long as research costs are assumed to be similar and lags the same, only absolute values will be affected by this assumption not the relativities which are of primary interest here. Clearly once lags and other parameters are allowed to vary between commodities choice of this parameter takes on increased importance.

4. POTENTIAL BENEFITS FROM FOREST PRODUCT RESEARCH

4.1 Introduction

The analyses generates a considerable body of information on the potential benefits from research on each product in each country/region and the likely distribution between countries and groups within countries. Presenting an appropriate summary of this information provides a challenge. An important step in determining the appropriate summary information is to clearly define the research objectives of the institution. After several discussions (which are still continuing) ACIAR's primary objective has been defined as to maximise the regional benefits from its research funding. Regional benefits have been defined as direct and spillover benefits to all countries in the geographical region where the research is undertaken. For example, if a project is funded in the Philippines the regional benefits are measured as the benefits directly accruing the Philippines plus those which result from the spillover effects to all other countries in South East Asia. A simple average of these benefits for all countries in the region is used as a summary indicator. The five geographical regions in ACIAR's mandate are South East Asia, South Asia, China, South Pacific, and Papua New Guinea, and Africa. Information for all regions and forest products is presented in this section.

The joint Australian researcher/partner country research collaborative nature of ACIAR's activities means that the potential priorities of collaborating Australian research institutions will be important in project development. The analysis can provide some information concerning this issue and this will also be discussed.

Once priority groupings of forest products have been suggested it is possible to compare current and past research funding patterns with these priority groupings to determine the emphasis of ACIAR's research program. A research project database has been established in ACIAR which includes all past and current projects and facilitates this comparison. This information is presented at the end of this section.

4.2 Potential Regional Benefits from Forestry Research

As a starting point, research is assumed to have an impact of reducing the unit cost of tree production by a common five percent of the current equilibrium price for all products. In addition a thirty-year planning horizon is adopted with the twelve percent discount rate and eleven and fifteen-year lags as discussed in section 2.

Table 8 summarises the present value of these benefits for each of the eight forest products and for each of the five geographical regions included in ACIAR's charter. The top half of Table 8 gives the monetary measure of the potential regional welfare gains from forest research. The bottom half presents what has proven to be more useful information. These are the "commodity relativities" for each forest product. This abstracts from the somewhat arbitrary use of a five percent unit cost reduction. These relativities are found by dividing the highest expected benefit by each other benefits. These can be interpreted in the following manner. For research on Other Industrial Roundwood in South East Asia to produce the same benefits as research on non-coniferous fuelwood a unit cost reduction twenty three times that expected from fuelwood is necessary.

Both halves of Table 8 reveal substantial potential regional benefits from Non-Coniferous Fuelwood research but also in some cases Saw and Veneer logs and even, for China, Coniferous Fuelwood research. The results show also very low potential regional benefits to some of the other forestry products. With many of the latter unless research is expected to produce very large cost reductions (or yield increases) it is unlikely that net present values will be positive.

Several points should be born in mind.

(i) The analysis at this stage is preliminary. Verification of the data and parameters used in the analysis is still occurring and could result in changes.

(ii) The production, consumption and price base period is a 1979 to 1981 average. Potential growth in production and consumption can be readily incorporated in the analysis if forecasts of these are available. While the absolute benefit estimates will be increased if growth is expected (or decreased if industry decline is expected) the relativities will not change if growth rates for all products are expected to be approximately the same.

(iii) The results for Saw and Veneer Logs are based on the 11 and 15 year lag structure. If this is extended the present value of benefits will fall. For example, an analysis was undertaken with lags of 40 and 45 years and a planning horizon of 80 years. With a 12 percent discount rate the present value of benefits to South East Asia fell from \$107m to \$4.3m for Non-coniferous Saw and Veneer Logs. With this product closer attention is also required of the issue of production trends, these could well be declining by the time research results are applicable.

(iv) In the analysis it has been assumed that each product is relatively homogenous and therefore that research undertaken on one product is unlikely to reduce production unit costs of other products. This assumption is probably incorrect for several of the products, for example, charcoal and fuelwood can be obtained from the same tree species. When this is the case the benefits for each product should be added to give a joint benefit estimate. Similar cases of joint products arise in the agricultural sector, for example, cotton seed and lint, palm oil and kernels.

TABLE 8: POTENTIAL REGIONAL BENEFITS FROM FOREST PRODUCT RESEARCH (Present Value $USm).

SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC AND PAPUA NEW GUINEA		AFRICA	
COMMODITY	REGIONAL BENEFITS ($USM)	COMMODITY	REGIONAL BENEFITS ($USM)	COMMODITY	REGIONAL BENEFITS	COMMODITY	REGIONAL BENEFITS	COMMODITY	REGIONAL BENEFITS
Fuelwood NC	140	Fuelwood NC	130	Fuelwood NC	196	Fuelwood NC	2	Fuelwood NC	66
Saw & Ven NC	107	Saw & Ven NC	18	Saw & Ven NC	143	Saw & Ven NC	2	Saw & Ven NC	9
Other Ind R Wd	6	Other Ind R Wd	4	Other Ind R Wd	134	Other Ind R Wd	0	Other Ind R Wd	7
Charcoal	3	Charcoal	4	Charcoal	89	Charcoal	0	Charcoal	4
Saw & Ven Con	1	Saw & Ven Con	3	Saw & Ven Con	53	Saw & Ven Con	0	Saw & Ven Con	1
Pulpwood	1	Pulpwood	3	Pulpwood	21	Pulpwood	0	Pulpwood	1
Pitprops	0	Pitprops	1	Pitprops	9	Pitprops	0	Pitprops	0
Fuelwood Con	0	Fuelwood Con	1	Fuelwood Con	0	Fuelwood Con	0	Fuelwood Con	0
	COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY		COMMODITY RELATIVITY
Fuelwood NC	1	Fuelwood NC	1	Fuelwood NC	1	Fuelwood NC	1	Fuelwood NC	140
Saw & Ven NC	1	Saw & Ven NC	7	Saw & Ven NC	1	Saw & Ven NC	7	Saw & Ven NC	107
Other Ind R Wd	23	Other Ind R Wd	34	Other Ind R Wd	11	Other Ind R Wd	9	Other Ind R Wd	6
Charcoal	45	Charcoal	34	Charcoal	22	Charcoal	18	Charcoal	3
Saw & Ven Con	107	Saw & Ven Con	43	Saw & Ven Con	*	Saw & Ven Con	73	Saw & Ven Con	1
Pulpwood	116	Pulpwood	50	Pulpwood	*	Pulpwood	73	Pulpwood	1
Pitprops	*	Pitprops	186	Pitprops	*	Pitprops	164	Pitprops	0
Fuelwood Con	*	Fuelwood Con	217	Fuelwood Con	*	Fuelwood Con	*	Fuelwood Con	0
Regional Relativity	1.4		1.5		1.0		89.0		3.0

Notes: * No significant production.

Despite these points the results of the analysis are employed in the rest of the paper to illustrate how it can be used as part of a decision support system to assist research decision making.

4.3 Forest Product Regional Research Priorities

To assist with research resource allocation decision making it has been found useful to allocate commodities into priority groupings. Experience in ACIAR has shown that six groupings are appropriate. Allocation to these groups has been based on the commodity relativities given in Table 8. Although arbitrary, the following ranges have been used for this grouping:

PRIORITY GROUP	COMMODITY RELATIVITY RANGE
I	0 to < 5
II	5 to < 7
III	7 to <15
IV	15 to <27
V	27 to <40
VI	40 and above

Table 9 illustrates the priority groupings for forest products using this mechanism. Therefore within the forest product sector Fuelwood (non-coniferous) is in the highest priority group (I) for all five regions. Saw and Veneer Logs are in the high grouping (I and II) for several regions and five of the eight forest products are in the highest priority group for China. On the other hand, several of the products are in the lowest priority grouping for all regions. Given limited research resources only projects with exceptional potential to reduce production unit costs are likely to warrant funding from this group. As discussed above the exception may be if, in some cases, these products can be viewed as joint products with the high priority products for a research effort.

Information which has also proven to be of interest is included as the last row in Table 9. This gives the "regional research relativity" for forest products. It is found by dividing the highest regional benefits, (Non Coniferous Fuelwood in China) by the highest benefit products in each other region. Thus Fuelwood (NC) in South East Asia would need to generate 1.4 times the unit cost reduction as Fuelwood (NC) in China to give the same regional welfare gains. As most would expect, these relativities highlight the potential high opportunity cost of funding research on any forest product in the South Pacific and Papua New Guinea and the potential influence of China's population on world-wide research priorities.

4.4 Priority Groupings and ACIAR's Forestry Research Portfolio

The priority groupings can be used in a number of ways to provide information to assist with research resource decision making. One possibility is to compare the pattern of past and current project funding with the commodity priority groupings. A project database has been developed at ACIAR which can be used to provide this information.

TABLE 9: FORESTRY RESEARCH PRIORITY GROUPINGS FOR REGIONAL BENEFITS OBJECTIVE.

SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC AND PAPUA NEW GUINEA		AFRICA	
COMMODITY	RELATIVITY	COMMODITY	RELATIVITY	COMMODITY	RELATIVITY	COMMODITY	RELATIVITY	COMMODITY	RELATIVITY
I Fuelwood NC	1	I Fuelwood NC	1	I Fuelwood NC	1	I Fuelwood NC	1	I Fuelwood NC	1
Saw & Ven NC	1			Saw & Ven Con	1	Saw & Cen NC	1		
		II Saw & Ven NC	7	Fuelwood Con	1			II Charcoal	7
				Saw & Ven NC	2				
IV Other Ind R Wd	23			Other Ind R Wd	4	III Saw & Ven Con	11	III Saw & Ven NC	9
		V Fuelwood	34						
		Charcoal	34			IV Pulpwood	22	IV Other Ind R Wd	18
VI Charcoal	45			III Pitprops	9				
Saw & Ven Con	107								
Pulpwood	116	VI Saw & Ven Con	43	IV Pulpwood	22			VI Fuelwood Con	73
Pitprops	*	Other Ind R Wd	50			VI Pitprops	*	Saw & Ven Con	73
Fuelwood	*	Pulpwood	186			Other Ind R Wd	*	Pulpwood	164
		Pitprops	217	VI Charcoal	*	Charcoal	*	Pitprops	*
						Fuelwood Con	*		
Regional Relativity	1.4		1.5		1.0		89.0		3.0

Table 10 summarises the commodity, regional and priority grouping breakdown of ACIAR's forestry funding patterns. It is seen that for most regions virtually all funding has concentrated on the highest priority forest products. Two exceptions are worth close discussion. In the South Pacific and Papua New Guinea most funds are in the lowest priority grouping. Two points are important: (i) funding in this region is relatively small; and (ii) the project concerned is a multi-region project with fuelwood as the major emphasis of the project in the other region (South East Asia).

China has 64 percent of funding on high priority commodities and the remainder in the medium priority set. Again the pulpwood component arises as a joint product of projects which have primary emphasis on fuelwood.

Most cases where low priority commodities are included have resulted from the Australian collaborating institutions expressing strong desires for this emphasis in addition to the primary fuelwood emphasis. This possible conflict between ACIAR and Australian institutional objectives is discussed in the next section.

4.5 Potential Benefits of Research to Australian Forestry

The analysis generates results for each individual country as well as providing summary regional information. It is therefore possible to focus on national research objectives as well as regional or international.

Potential Australian collaborators often belong to research institutions which have a national rather than regional focus. If national objectives lead to different research priorities then comparisons of these may be useful information to assist ACIAR decision making.

Table 11 summarises some of the information for research undertaken in Australia. Column (1) is an estimate of the potential research benefits to Australia from a 5 percent unit cost reduction. The same assumptions apply as with previous illustrations and therefore the Saw and Veneer Log (NC) benefits may be overestimated due to the short lags used. With this limitation in mind the results suggest that three products Saw and Veneer Logs (NC and CON) and Pulpwood offer the highest potential Australian returns to research. Unless substantial unit cost reductions are expected from the other products they offer less attractive research possibilities. Column (2) highlights this by providing the research relativities. Column (3) indicates priority groupings for an Australian benefit maximisation objective.

Columns (4) and (5) summarise different levels of aggregation of the potential spillover benefits to countries/regions other than Australia due to this research. This information demonstrates that the relative importance of research among forest products can change substantially depending on the geographical focus of a research institution's objectives. It highlights the importance of clearly identifying these objectives.

This information may be of relevance to decision making in ACIAR. If potential collaborating research institutions in Australia have Australian benefit maximising objectives there is potential for conflicts between their priorities and ACIAR's regional priorities. Figure 8 illustrates how

TABLE 10: ACIAR FUNDING PATTERNS FOR FORESTRY RESEARCH.

SOUTH EAST ASIA

	Commodity	Funding $m	%
I	Fuelwood NC	2.10	85
	Saw & Ven NC	0.11	4
	Total	2.21	90
IV	Other Ind R Wd	0.16	7
	Total	0.16	7
VI	Charcoal	*	0
	Saw & Ven Con	0.00	0
	Pulpwood	0.09	4
	Pitprops	0.00	0
	Fuelwood Con	0.00	0
	Total	0.09	4
	Total Regional Funding	2.46	

SOUTH ASIA

	Commodity	Funding $m	%
I	Fuelwood NC	0.25	83
	Total	0.25	83
II	Saw & Ven NC	0.02	7
	Total	0.02	7
V	Fuelwood Con	0.00	0
	Charcoal	*	0
	Total	0.00	0
VI	Saw & Ven Con	0.00	0
	Other Ind R Wd	0.03	10
	Pulpwood	0.00	0
	Pitprops	0.00	0
	Total	0.03	10
	Total Regional Funding	0.30	

CHINA

	Commodity	Funding $m	%
I	Fuelwood NC	0.91	31
	Saw & Ven Con	0.00	0
	Fuelwood Con	0.00	0
	Saw & Ven NC	0.17	6
	Other Ind R Wd	0.78	27
	Total	1.86	64
III	Pitprops	0.16	5
	Total	0.16	5
IV	Pulpwood	0.89	31
	Total	0.89	31
VI	Charcoal	*	0
	Total	0.00	0
	Total Regional Funding	2.91	

S.PACIFIC &PNG

	Commodity	Funding $m	%
I	Fuelwood NC	0.01	8
	Saw & Ven NC	0.00	0
	Total	0.01	8
III	Saw & Ven Con	0.00	0
	Total	0.00	0
IV	Pulpwood	0.00	0
	Total	0.00	0
VI	Pitprops	0.00	0
	Other Ind R Wd	0.11	92
	Charcoal	*	0
	Fuelwood Con	0.00	0
	Total	0.11	92
	Total Regional Funding	0.12	

AFRICA

	Commodity	Funding $m	%
I	Fuelwood NC	1.60	95
	Total	1.60	95
II	Charcoal	*	0
	Total	0.00	0
III	Saw & Ven NC	0.00	0
	Total	0.00	0
IV	Other Ind R Wd	0.08	5
	Total	0.08	5
VI	Fuelwood Con	0.00	0
	Saw & Ven Con	0.00	0
	Pulpwood	0.00	0
	Pitprops	0.00	0
	Total	0.00	0
	Total Regional Funding	1.68	

Note : * Charcoal is included in Fuelwood NC.

TABLE 11: POTENTIAL BENEFITS TO FORESTRY RESEARCH UNDERTAKEN IN AUSTRALIA

COMMODITY	NATIONAL		PRIORITY GROUPING	BENEFITS IN ACIAR'S REGIONS ($USM)	BENEFITS TO ALL DEVELOPING COUNTRIES ($USM)	TOTAL INTERNATIONAL BENEFITS ($USM)
	BENEFITS ($USM) ($USM)	RELATIVITY				
	(1)	(2)	(3)	(4)	(5)	(6)
Saw and Veneer Logs	42.9	1	I	27.4	40.0	120.9
Saw and Veneer Logs (CON)	19.8	2.2	I	8.8	21.6	235.8
Pulpwood	17.9	2.3	I	1.2	6.3	87.4
Fuelwood (NC)	3.5	12	III	108.0	138.4	169.7
Other Industrial Round Wood	2.0	21	IV	6.0	8.4	27.2
Fuelwood (CON)	1.0	43	VI	8.5	12.7	27.5
Pitprops	0.6	72	VI	1.4	1.4	4.9
Charcoal	0.4	107	VI	6.3	10.6	11.7

conflict may exist and therefore trade-offs between objectives may be necessary.

The Southwest/Northeast diagonal boxes in Figure 8 include forest products where ACIAR regional priorities are the same as those likely to be based on Australian national benefit maximising objectives. Saw and Veneer Logs (NC and CON) and Charcoal provide the only clear match. In this instance Saw and Veneer Logs are in the number 1 priority grouping for both ACIAR and Australia, while Charcoal is in the lowest priority group for both. The position of the remaining commodities indicate that research is likely to satisfy one institutions objective well but not the other and vice versa. Similar situations apply to the other regions.

The conclusion that can be drawn from this is that projects may need to emphasise issues that are relevant to several products to avoid conflicts between Australian and partner country objectives. Alternatively, collaborating institutions may require higher funding contributions to warrant research staff working on lower priority (to them) commodities.

5. A COMPARISON BETWEEN FORESTRY AND AGRICULTURAL COMMODITIES

Although the results for both agriculture and forestry are still preliminary and need further verification, it is possible to use them to provide information regarding the comparability between forest product research and research on other agricultural commodities.

Table 12 provides estimates of the potential regional benefits from research for the eight forest products and 23 agricultural products analysed so far. Research relativities can be calculated from this information and used to determine commodity priority groupings for each of the five regions of interest to ACIAR. The results are given in Table 13.

Fuelwood (NC) is seen to maintain its research attractiveness even when compared with agricultural commodities. It is a high priority research commodity in all regions except China. With China, however, the regional relativities need to be kept in mind (that is, the last row in Table 13). Although fuelwood (NC) is medium priority (group III) in China the level of benefits would place it near the top of the high priority list in all other regions. For example 10.2/6 = 1.7 places it just below rice in South East Asia. On the same basis many of the other forest products in China would potentially provide sufficient benefits to be comparable with high priority commodities in other regions.

Despite the attractiveness of fuelwood (NC) and in some regions some of the other forest products, there are clear cases of low priority classification of several forest products. In several cases the research relativities indicated that considerable research impacts would be required to warrant funding of research on these products. Thus unless a project includes between product spillovers it would be difficult to justify funding this research if regional benefits maximisation is the research objective.

FIGURE 8 : COMPARISON OF ACIAR REGIONAL OBJECTIVE WITH AUSTRALIAN NATIONAL OBJECTIVE - FORESTRY

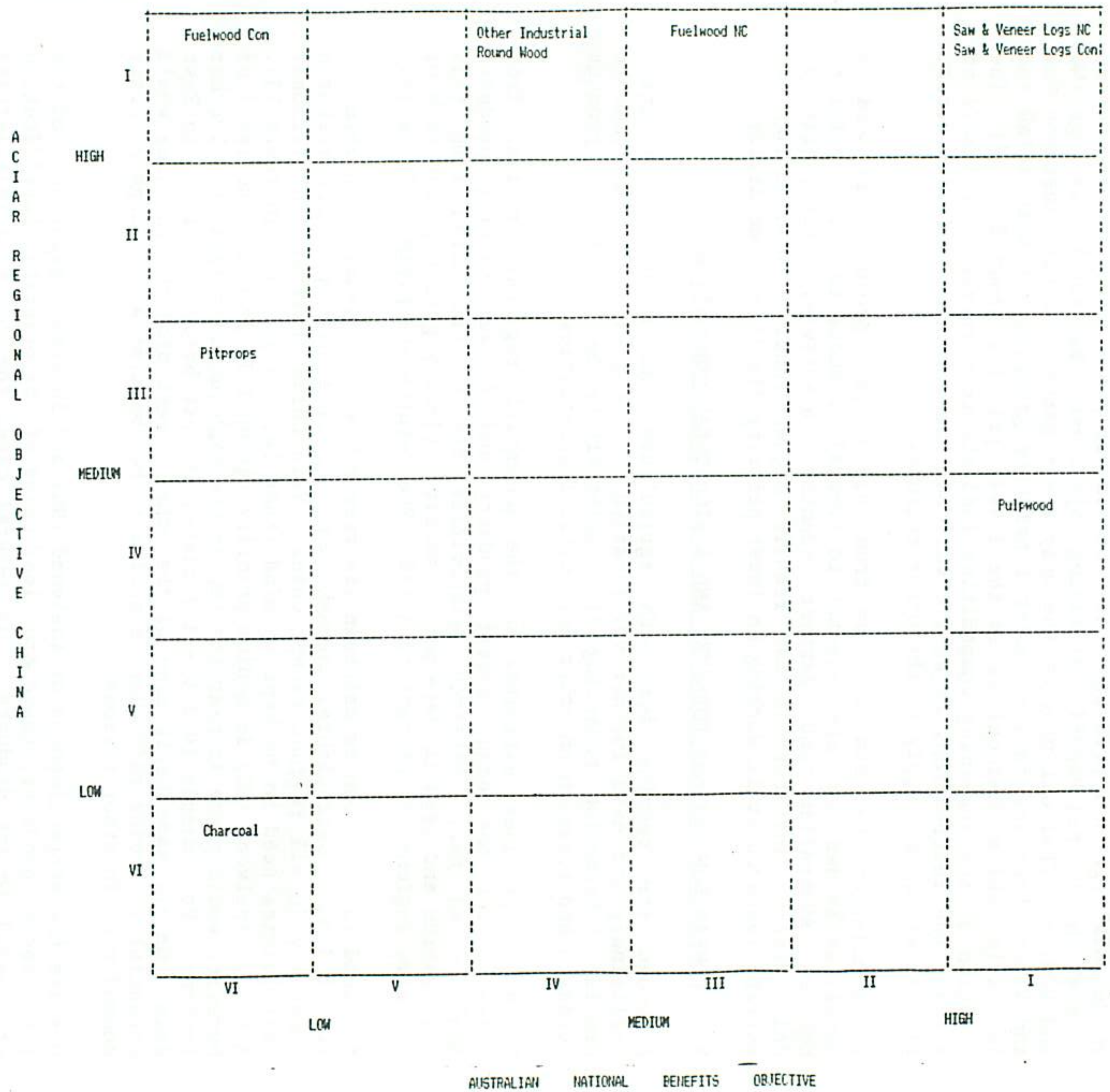

TABLE 12.; POTENTIAL REGIONAL BENEFITS FROM RESEARCH (Present Value $USm.)

SOUTH EAST ASIA		SOUTH ASIA		CHINA		S.PACIFIC &PNG		AFRICA	
Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits
Rice	358	Rice	520	Rice	1992	Sugar	9	Fuelwood NC	66
Fuelwood NC	140	Wheat	140	Potato	718	Banana/plantain	5	Cassava	46
Saw & Ven NC	107	Pulses	131	Sweet potato	432	Fuelwood NC	2	Banana/plantain	33
Palm-total	75	Fuelwood NC	130	Wheat	236	Coconut	2	Milk	19
Coconut	66	Sugar	124	Fuelwood NC	196	Coffee	2	Beef & buffalo	19
Banana/plantain	47	Milk	92	Pulses	193	Saw & Ven NC	2	Rice	18
Sugar	33	Sorghum	66	Saw & Ven Con	143	Sweet potato	1	Cocoa	15
Cassava	32	Potato	55	Fuelwood Con	134	Cocoa	1	Palm-total	12
Maize	23	Sheep/goat meat	41	Soybean	121	Palm-total	1	Sheep/goat meat	12
Sweet potato	19	Groundnut	28	Saw & Ven NC	89	Saw & Ven Con	0	Charcoal	9
Coffee	17	Banana/plantain	23	Maize	80	Cassava	0	Pulses	9
Pulses	12	Maize	22	Sugar	64	Pulpwood	0	Sorghum	9
Rubber	11	Coconut	21	Sorghum	54	Pitprops	0	Maize	8
Beef & buffalo	10	Millet	20	Other Ind R Wd	53	Sorghum	0	Millet	8
Potato	9	Oranges	18	Milk	43	Other Ind R Wd	0	Coffee	8
Other Ind R Wd	6	Saw & Ven NC	18	Sheep/goat meat	40	Soybean	0	Saw & Ven NC	7
Soybean	5	Cassava	13	Groundnut	37	Millet	0	Sugar	7
Groundnut	4	Wool	10	Wool	37	Maize	0	Groundnut	7
Oranges	4	Beef & buffalo	9	Millet	35	Milk	0	Sweet potato	4
Milk	3	Sweet potato	9	Pitprops	21	Groundnut	0	Other Ind R Wd	4
Charcoal	3	Coffee	6	Beef & buffalo	13	Rice	0	Potato	3
Sheep/goat meat	3	Soybean	5	Oranges	11	Wheat	0	Wool	3
Cocoa	2	Fuelwood Con	4	Cassava	9	Sheep/goat meat	0	Wheat	2
Millet	1	Charcoal	4	Pulpwood	9	Wool	0	Coconut	2
Saw & Ven Con	1	Saw & Ven Con	3	Palm-total	8	Potato	0	Soybean	2
Pulpwood	1	Other Ind R Wd	3	Rubber	4	Charcoal	0	Rubber	1
Sorghum	1	Rubber	2	Banana/plantain	4	Rubber	0	Fuelwood Con	1
Wheat	1	Pulpwood	1	Coffee	1	Pulses	0	Saw & Ven Con	1
Pitprops	0	Pitprops	1	Charcoal	0	Oranges	0	Pulpwood	0
Wool	0	Palm-total	0	Cocoa	0	Fuelwood Con	0	Oranges	0
Fuelwood Con	0	Cocoa	0	Coconut	0	Beef & buffalo	0	Pitprops	0

TABLE 13 REGIONAL COMMODITY PRIORITY GROUPINGS - 31 COMMODITY ANALYSIS

SOUTH EAST ASIA

Priority Grouping	Commodity Ranking	Relative Benefits
I	Rice	1.0
	Fuelwood NC	2.6
	Saw & Ven NC	3.3
	Palm-total	4.8
II	Coconut	5.4
	Banana/plantain	7.6
III	Sugar	10.8
	Cassava	11.3
IV	Maize	15.4
	Sweet potato	18.8
	Coffee	20.8
V	Pulses	29.6
	Rubber	34.1
	Beef & buffalo	34.8
	Potato	39.8
VI	Other Ind R Wd	59.7
	Soybean	70.2
	Groundnut	87.4
	Oranges	91.8
	Milk	105.4
	Charcoal	115.5
	Sheep/goat meat	137.8
	Cocoa	183.5
	Millet	255.9
	Saw & Ven Con	275.5
	Pulpwood	298.5
	Sorghum	398.0
	Wheat	398.0
	Pitprops	0.0
	Wool	0.0
	Fuelwood Con	0.0
	Regional Relativity	6

SOUTH ASIA

Priority Grouping	Commodity Ranking	Relative Benefits
I	Rice	1.0
	Wheat	3.7
	Pulses	4.0
	Fuelwood NC	4.0
	Sugar	4.2
II	Milk	5.7
III	Sorghum	7.8
	Potato	9.4
	Sheep/goat meat	12.6
IV	Groundnut	18.6
	Banana/plantain	22.8
	Maize	23.4
	Coconut	24.5
	Millet	25.7
V	Oranges	28.3
	Saw & Ven NC	28.6
VI	Cassava	41.3
	Wool	50.5
	Beef & buffalo	56.5
	Sweet potato	57.2
	Coffee	83.9
	Soybean	100.0
	Fuelwood Con	136.9
	Charcoal	136.9
	Saw & Ven Con	173.4
	Other Ind R Wd	200.0
	Rubber	226.1
	Pulpwood	743.0
	Pitprops	866.8
	Palm-total	0.0
	Cocoa	0.0
	Regional Relativity	4

CHINA

Priority Grouping	Commodity Ranking	Relative Benefits
I	Rice	1.0
	Potato	2.8
	Sweet potato	4.6
III	Wheat	8.5
	Fuelwood NC	10.2
	Pulses	10.3
	Saw & Ven Con	13.9
	Fuelwood Con	14.9
IV	Soybean	16.4
	Saw & Ven NC	22.4
	Maize	25.0
V	Sugar	31.0
	Sorghum	36.6
	Other Ind R Wd	37.5
VI	Milk	46.1
	Sheep/goat meat	50.2
	Groundnut	53.4
	Wool	54.4
	Millet	57.6
	Pitprops	93.9
	Beef & buffalo	153.2
	Oranges	184.4
	Cassava	223.8
	Pulpwood	226.3
	Palm-total	262.1
	Rubber	538.3
	Banana/plantain	538.3
	Coffee	1991.6
	Charcoal	0.0
	Cocoa	0.0
	Coconut	0.0
	Regional Relativity	1

S.PACIFIC &PNG

Priority Grouping	Commodity Ranking	Relative Benefits
I	Sugar	1.0
	Banana/plantain	1.6
	Fuelwood NC	3.9
	Coconut	4.3
II	Coffee	5.3
	Saw & Ven NC	5.3
III	Sweet potato	7.7
	Cocoa	7.7
	Palm-total	10.6
VI	Saw & Ven Con	42.5
	Cassava	42.5
	Pulpwood	85.0
	Pitprops	0.0
	Sorghum	0.0
	Other Ind R Wd	0.0
	Soybean	0.0
	Millet	0.0
	Maize	0.0
	Milk	0.0
	Groundnut	0.0
	Rice	0.0
	Wheat	0.0
	Sheep/goat meat	0.0
	Wool	0.0
	Potato	0.0
	Charcoal	0.0
	Rubber	0.0
	Pulses	0.0
	Oranges	0.0
	Fuelwood Con	0.0
	Beef & buffalo	0.0
	Regional Relativity	234

AFRICA

Priority Grouping	Commodity Ranking	Relative Benefits
I	Fuelwood NC	1.0
	Cassava	1.4
	Banana/plantain	2.0
	Milk	3.4
	Beef & buffalo	3.4
	Rice	3.6
	Cocoa	4.4
II	Palm-total	5.5
	Sheep/goat meat	5.5
III	Charcoal	7.0
	Pulses	7.1
	Sorghum	7.4
	Maize	7.9
	Millet	8.0
	Coffee	8.5
	Saw & Ven NC	9.0
	Sugar	9.4
	Groundnut	10.1
IV	Sweet potato	16.8
	Other Ind R Wd	17.8
	Potato	22.7
	Wool	23.5
V	Wheat	36.5
VI	Coconut	41.1
	Soybean	43.8
	Rubber	73.0
	Fuelwood Con	73.0
	Saw & Ven Con	73.0
	Pulpwood	164.3
	Oranges	164.3
	Pitprops	0.0
	Regional Relativity	30

6. CONCLUSIONS

This paper has outlined the application of a systematic mechanism that can be used to generate information regarding the potential impact of forestry research. How this can be used to assess whether certain funding strategies are likely to achieve a research institution objectives has also been addressed.

The preliminary results suggest the following:

(i) There is considerable inter-product diversity in the potential gains from forest product research. This can lead to some products being classified as high and others as low priority for research funding.

(ii) The importance of clearly identifying research institution objectives was demonstrated. The potential for conflicts between national institution and international institution objectives was highlighted. Information regarding these potential conflicts has been developed as a source of useful information to assist research decision making.

(iii) The method of analysis can facilitate comparisons between forest product and other sector commodity research possibilities. An application to agricultural and forest products has shown that some forest products are likely to be ranked in the high priority research groupings along with important agricultural products for most of the regions of the world considered in the analysis.

(iv) The results are based on a large body of information some of which is purely judgemental. These information sources require continual verification and refinement to improve confidence in the results. It is hoped that the systematic nature of the approach adopted will facilitate this improvement process.

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APPENDIX 1

DEFINITIONS

The following defines the major commodities identified in Figure 7. Definitions were taken from the 1983 FAO yearbook of forest products. "C" and "NC" refer to coniferous (softwoods) and non-coniferous (hardwoods):

Roundwood

Wood in the rough. Wood in its natural state as felled, or otherwise harvested, with or without bark, round, split, roughly squared or other forms (eg. roots, stumps, burls, etc). It may be impregnated (eg. telegraph poles) or roughly shaped or pointed. It comprises all wood obtained from removals, ie. the quantities removed from forests and from trees outside the forest, including wood recovered from natural felling and logging losses during the period - calendar year or forest year. Commodities included are saw logs and veneer logs, pitprops, pulpwood, other industrial roundwood and fuelwood. The statistics include recorded volumes, as well as estimated unrecorded volumes. Statistics for trade include, as well as roundwood from removals, the estimated roundwood equivalent of chips and particles, wood residues and charcoal.

Fuelwood and Charcoal

The commodities included are fuelwood, coniferous and non-coniferous and the trade statistics include the roundwood equivalent of charcoal using a factor of 6.0 to convert from weight (metric tonnes) to solid volume units (cubic meters).

Wood in the rough (from trunks, and branches of trees) to be used as fuel for purposes such as cooking, heating or power production. Wood for charcoal, pit kilns and portable ovens is included. The figures for trade in charcoal are given in weight.

Industrial Roundwood

The commodities included are sawlogs or veneer logs, pitprops, pulpwood, other industrial roundwood and in the case of trade, chips or particles and wood residues.

Sawlogs and Veneer Logs

Logs whether or not roughly squared, to be sawn (or chipped) lengthwise for the manufacture of sawnwood or railway sleepers (ties). Shingle bolts and stave bolts are included. Logs for production of veneer are processed mainly by peeling or slicing. Match billets are included as are special growth (burls, roots, etc) used for veneers.

Pitprops

The aggregate includes coniferous and non-coniferous pitprops. Pitprops are wood in the rough or slabbed wood used in mining operations. Sawn pitwood is excluded here but included under sawnwood.

Pulpwood and Particles

In production the commodities included are pulpwood coniferous and non-coniferous. In trade the aggregate includes, in addition, chips or particles and wood residues.

Pulpwood

Wood in the rough other than logs - for pulp, particle board or fibreboard. Pulpwood may be barked or unbarked and may be in the form of roundwood or splitwood. In production, it may include the equivalent of wood chips made directly from roundwood.

Chips and Particles

Wood which has been deliberately reduced to small pieces from wood in the rough or from industrial residues, suitable for pulping, for particle board and fibreboard production, for fuelwood or for other purposes.

Wood Residues

Wood residues which have not been reduced to small pieces. They consist principally of industrial residues, e.g. sawmill rejects, slabs, edgings and trimmings, veneer log cores, veneer rejects, sawdust, bark (excluding briquettes) residues from carpentry and joinery production, etc.

Other Industrial Roundwood

Roundwood used for specialty products like tanning, distillation, match blocks, gazogenes, poles, piling, etc.

Sawnwood

Sawnwood, unplaned, planed, grooved, tongued, etc, sawn lengthwise or produced by a profile-chipping process (eg planks, beams, joists, boards, rafters, scantlings, laths boxboards, "lumber" etc) and planed wood which may also be finger jointed, tongued or grooved, chafered, rabbeted, v-jointed, beaded, etc. Wood flooring is excluded. With few exceptions, sawnwood exceeds 5mm in thickness.

Sleepers

Pieces of wood of more or less rectangular shape laid transversely on the railway road-bed to support the rails.

Wood-based Panels

The following commodities are included in the total - veneer sheets, plywood, particle board and fibreboard compressed or non-compressed.

Wood Pulp

The following commodities are included in this aggregate: mechanical, semi-chemical and dissolving wood pulp.

Paper and Paperboard

The following commodities are included in this aggregate: Newsprint, printing and writing paper, other paper and paperboard.

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