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AN OVERVIEW OF ACIAR'S ECONOMIC ASSESSMENTS OF THE POSTHARVEST PROGRAM PROJECTS

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CONTENTS

ABBREVIATIONS

ACIAR:	Australian Centre for International Agricultural Research
BOM:	Board of Management, ACIAR
CAB:	Commonwealth Agricultural Bureau
GRDC:	Grains Research and Development Corporation
IRR:	Internal rate of return

ISNAR:	International Service for National Agricultural Research
NPV:	Net present values
PAC:	Policy Advisory Council, ACIAR
PMIS:	Project Management Information System—now renamed PISA

1. INTRODUCTION

During the past six to seven years ACIAR has been developing an institutional **Information System** to support decision-making at various levels within the Centre. A significant aspect of this **Information System** is the importance of the interaction with collaborating project scientists during the establishment and refinement process.

This paper highlights some of the noteworthy aspects of the **Information System** as it relates to the project development and review component of ACIAR's activities. Some of the aspects of specific importance to postharvest research are also highlighted. The objective of the paper is to inform those working with ACIAR of trends in this area, and to initiate a basis for further interaction to assist in the further refinement of the **Information System** The paper also aims to provide a summary of efforts to evaluate research for the postharvest area. It is hoped that this will be of general interest and assistance to those at the meeting beyond just the ACIAR interaction.

The paper begins with a brief outline of the **Information System** which is used to support decision-making at ACIAR. Some highlights of the aggregate-priority-setting analysis and how this might apply to the postharvest area are provided. The project-level assessments are also summarised and those applicable to the postharvest area highlighted. The results of other attempts to evaluate postharvest research are also reviewed. This is followed by a discussion of the project evaluation process and how this is being adapted to suit ACIAR's postharvest program. The paper concludes with an indication of the areas that require further development and the importance of interaction for this to be achieved.

2. ACIAR'S INFORMATION SYSTEM AND THE PROJECT SELECTION PROCESS

2.1 The importance of institutionally-based information systems to support research decision-making

Allocating research resources in the public sector has increased in complexity during the last few decades. As this has occurred, the demand for a more systematic, accountable basis for allocating resources has increased. An important source of this demand has been the decision-makers in the public sector research institutions. However, decision-makers in other areas of the public sector have also begun to insist on this. Accountability for public sector expenditure in general is increasingly being demanded.

In this atmosphere, decisions based largely on the intuitive judgement of senior management are becoming less acceptable. There has been an increased demand for this intuitive judgement to be complemented by more systematically-based information. Sometimes there is an inclination to infer that such information can substitute for the final judgement of senior management. While systematically-based information can often strengthen decision-making, especially by providing continuity for decisions even when senior management changes, it is unrealistic to expect such information to be comprehensive enough to replace the need for the judgement of managers. Better informed judgements, however, are more likely to satisfy the increased accountability being required from public sector institutions. It is also important to recognise the value of generating information to help in decision-making. Thus, it is often the process of gathering the information, rather than the information per se that provides the greatest improvement in decision-making quality. The more complex the decision-making environment becomes the more likely this will be the case.

Figure 1 illustrates a typical decision-making process in a research institution. In most institutions, decisions are made by an executive group (or groups). This group is usually drawn from a variety of backgrounds. Indeed, it is a diversity of experience that is usually necessary to provide effective decisions. As indicated in Figure 1, a range of information sources will influence each of the decision-makers. These may include such things as: past experience; professional training; peer group interactions and pressures; and political considerations. The intuitive judgements of each decision-maker, based on these different sources of information, are generally combined to give institutional decisions for research priorities and resource allocations. With increased public demand for accountability by these institutions it is often important to complement these decision-maker inputs with institutionally-generated information. In this way there will be an established set of information that can be well documented and remains with the institution as, inevitably, the decision-makers change.

As indicated in Figure 1 an important feature of any institutional information system should be that it evolves through interaction between the decision-makers, institution members and those interacting with the institution. In this way the important experience and information contributed by these groups can be systematically incorporated into the institutional information. If the information system is effective it should contribute to a strengthening of the decisions made by the institution.

2.2 A brief overview of ACIAR's information system and project evaluations

During the early days of ACIAR's development it was decided that it was important to develop an institutionally based **Information System** to support decision-making at various levels. There were a range of reasons for this decision. These included: the increased importance being placed on public sector accountability; the diverse nature of ACIAR's mandate research areas and the need to be able to make comparisons between these; and the expectation that the scientific expertise would change overtime and, therefore, an institutionally-based **Information System** which drew on this expertise, and evolved with it, was considered important.

A detailed account of the evolution of ACIAR's **Information System** is provided in Davis and Ryan (forthcoming, chapters 8 to 11). A brief summary is also provided in, for example, Davis and Fearn (1992). Figure 2 provides a simple illustration of the structure of the institutional **Information System** developed by ACIAR and the interface of this **System** with groups within ACIAR and the institutions it collaborates with. The two-way flow of information is highlighted as a crucial component of the **System**. One important component comprises two databases. These are:

(i) A project management database

The project management database is called the **Project Management Information System** (PMIS). It is a complete record of the information set for each Project funded by ACIAR since its inception. The information ranges from the detailed budgets to the publications and the country/commodity focus of the project. The database has been designed to produce a range of reports. Some are used to assist day-to-day project management while others provide summary information for all projects or various groups of projects.

Figure 1: The Complementarity Between Institutionally Based Information Systems and Other Information Sources Which Support Decision-Making

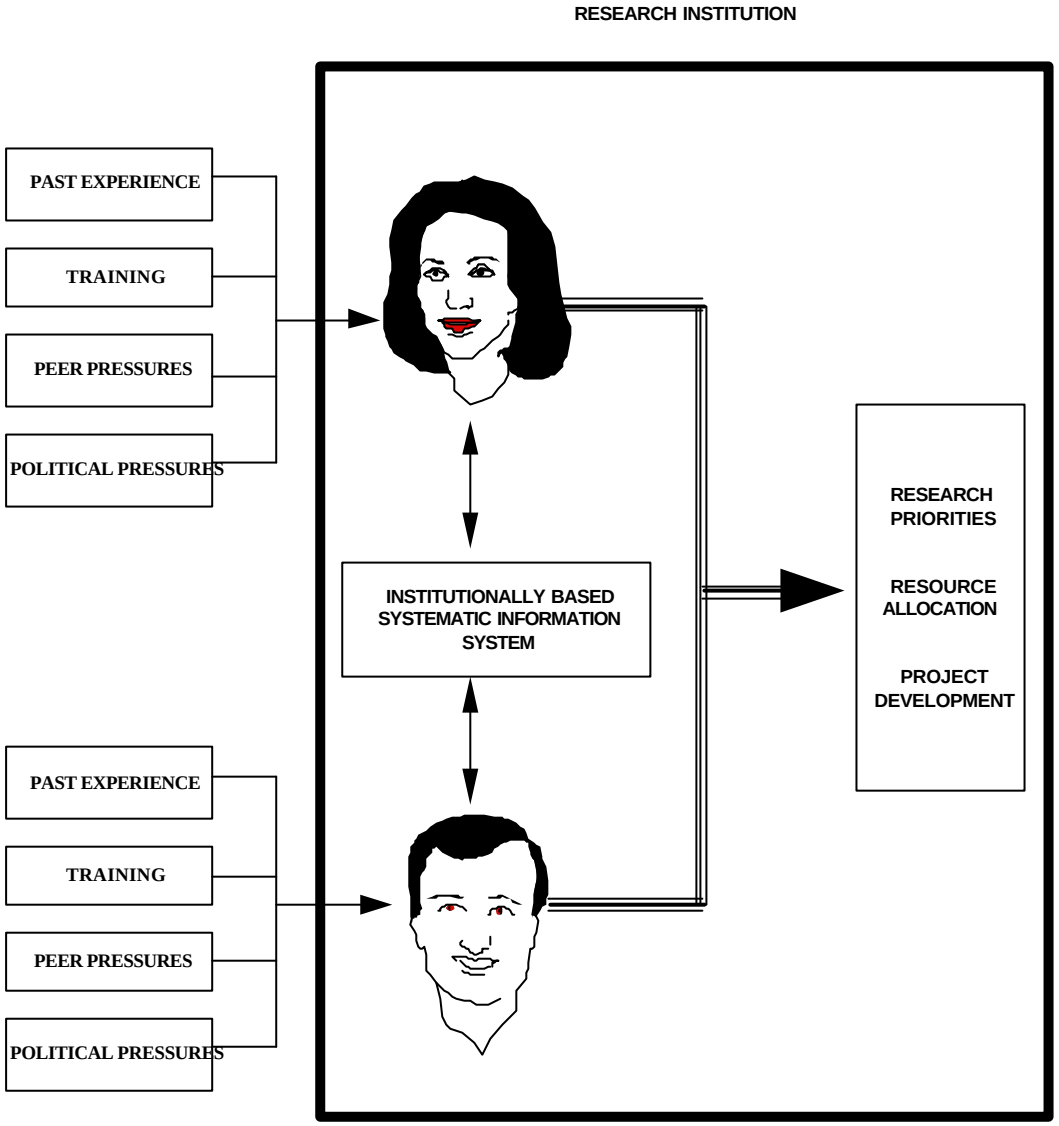
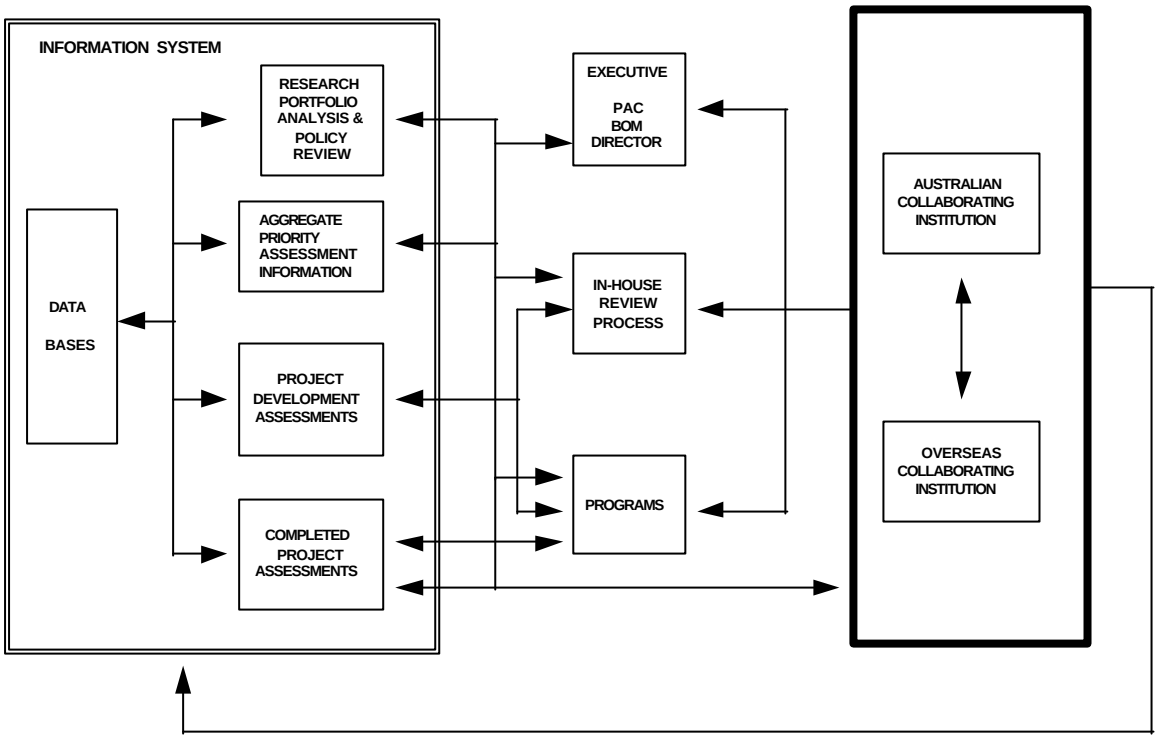


Figure 2: An Illustration of the Information System Interface with Decision-Making Groups for ACIAR



(ii) A research evaluation database

The **Research Evaluation** Database has been developed to make use of an extensive set of research evaluation literature produced during the last two decades. The methodology that has evolved has been adapted to suit decision-making in ACIAR. This has entailed incorporating more detailed technical parameters in the underlying models and involving technical scientists in the collection of the data used in the subsequent analysis. The models currently used are based on a detailed interpretation of the research process which interfaces the technical and socio-economic aspects of a multi-country world (see Davis, Bantilan and Ryan [forthcoming] or Davis and Fearn [1992] for more details of this research process model).

The technical dimensions of the research-process model focus on estimates of the relative strengths of the research systems in different countries, the potential for research output to spillover to other countries, and the potential adoption levels of the final technologies. Estimates of the information used to represent these components have been obtained by consulting research managers and technical experts. While the current estimates still require further verification and validation, they do represent a comprehensive set of data.

The socio-economic components have been modelled using a multi-region traded good model with the concept of producer and consumer surplus used to estimate the potential welfare effects of the research. To accommodate this part of the model a range of data sets have been added to the database. These include production, consumption (both commercial and subsistence), prices and elasticities. As well as the basic data, the database includes a full set of the estimates of the potential welfare changes from research.

To support aggregate-level decision-making, an important assumption used for the base-case set of welfare changes is that the research results in a 5% reduction in the cost of producing a unit (usually a metric tonne) of the commodity.

In its current form the database includes data and estimates of the parameters for all countries, however, these are then aggregated into 75 countries or aggregations of countries. Inclusion of all countries is necessary to facilitate incorporation of any world price effects, which might flow from the technology spillovers to developed countries. In addition to the 75 political/geographic regions the technical research spillovers are estimated using between 5 to 75 different production environment classifications, depending upon the commodity. This spillover information is, therefore, available for each of these production environments for each country—although each country will only contain a small subset of possible production environments.

The information and analysis is currently available for 45 different commodities. These include 27 from the agricultural sector, 8 from forestry and 10 from the fisheries sector.

In addition to the aggregate-level information the database is used to develop project-level evaluations. The important additional information required is details of the costs associated with production of commodities in different production conditions (production environments) and the assessments of the potential impact different types of research are likely to have on these costs and production conditions. This information is combined with project specific revisions to the aggregate parameter set to provide assessments of the potential welfare impact of specific research projects.

Both of the databases described above have been computerised. The **PMIS** follows a more conventional database format while the **Research Evaluation** database uses spreadsheets.

The databases developed as part of the **Information System** are extensive. To be useful for supporting decision-making it is necessary to develop summary reports that condense this information into useful ready-reckoner forms. Considerable effort has been focused on this aspect of the **Information System**. More effort is still required to refine the summary reports to ensure that they achieve maximum effectiveness. Davis and Ryan (forthcoming, chapter 11) provide a detailed outline of these efforts and indicate how this has been an evolutionary process.

Figure 2 summarises, in simple terms, the components of the **Information System** The two databases have been discussed above. These are used as a basis for producing summary information to provide support to several decision-making groups. As indicated this summary information currently takes four main forms.

(i) Project related information.
(ii) Aggregate-priority-assessment information.
(iii) Project-development assessments.
(iv) Completed-project assessments.

In the rest of this paper we will summarise some of the important dimensions of this Information System that are specific to the postharvest research program and, in so doing, illustrate how the information can be used to highlight some possibly important issues.

2.3 Aggregate priority assessment information with a postharvest focus

A crucial aspect of developing summary information to support priority-assessment decisions was clear determination of ACIAR's objectives. This clarification is still ongoing, for example, the ACIAR PAC meeting in December 1994 will discuss this issue. Currently maximisation of the mandate regional benefits is given most prominence. However, Australian benefits are beginning to receive more attention. The large set of welfare-gain information estimated in the **Research Evaluation** database has been employed to support priority assessments. These estimates provide an indication of the likely ordering of the commodities by the regional welfare gains that might result from successful research. Table 1 illustrates the monetary measures of the potential regional welfare gains from research if it is undertaken on problems relevant to the region and generates a 5% unit cost reduction for each commodity. In this case the regions illustrated are four of the five mandated for ACIAR.

Table 1. Gross Present Value of Regional Welfare Benefits for a Regional Research Focus (Welfare measured in $US M.over 30 years with 12% discount rate).

South Asia Regional Benefits		Southeast Asia Regional Benefits		China Regional Benefits		South Pacific Regional Benefits	
Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits	Commodity Ranking	Regional Benefits
Rice	421	Rice	200	Rice	1157	Tunas,bonitos etc	6
Milk	269	Saw & ven. logs (NC)	181	Pigmeat	594	Fuelwood (NC)	6
Fuelwood (NC)	204	Fuelwood (NC)	167	Sweet potato	311	Saw & ven. logs (NC)	4
Wheat	131	Palm Oil/kernel	96	Maize	277	Sugar	2
Pulses All	115	Rubber	64	Potatoes	237	Banana/plantain	1
Potatoes	63	Sugar	23	Wheat	233	Palm oil/kernel	1
Cotton	52	Coconut	22	Cotton	130	Coffee	1
Sugar	50	Banana/plantain	20	Eggs (poultry)	102	Cocoa	1
Saw & ven. logs (NC)	38	Cassava	16	Soybean	60	Demersal/other pelagic	0
Sorghum	37	Pigmeat	14	Pulses all	59	Pigmeat	0
Groundnut	35	Demersal/other pelagic	13	Fuelwood (NC)	59	Coconut	0
Millet	24	Prawns/shrimps	13	Saw & ven. logs (C)	45	Pulpwood	0
Sheep & goat meat	24	Maize	12	Sugar	44	Saw & ven. logs (Con.)	0
Banana/plantain	20	Eggs (poultry)	11	Fuelwood (Con.)	40	Sweet potato	0
Maize	18	Coffee	11	Poultry meat	37	Milk	0
Beef & buffalo	16	Poultry Meat	10	Sheep & goat meat	30	Prawns/shrimps	0
Eggs (poultry)	15	Beef & buffalo	8	Groundnut	29	Rice	0
Prawns/shrimps	14	Tilapias	7	Saw & ven. logs (NC)	28	Tilapias	0
Coconut	13	Cocoa	7	Milk	25	Beef & buffalo	0
Demersal/other pelagic	8	Oth. ind. rdwood	6	Oth. ind. rdwood	19	Cassava	0
Oranges & tangarines	8	Tunas,bonitos etc	4	Prawns/shrimps	17	Charcoal	0
Herrings & others	7	Mackerels & others	3	Millet	14	Cotton	0
Cassava	6	Charcoal	3	Sorghum	13	Eggs (poultry)	0
Fuelwood (Con.)	6	Sheep & goat meat	3	Wool	12	Fuelwood (con.)	0
Saw & ven. logs (Con.)	6	Herrings & others	3	Oranges & tangarines	9	Groundnut	0
Soybean	6	Soybean	2	Beef & buffalo	8	Herrings & others	0
Charcoal	6	Milk	2	Pitprops	7	Lobsters	0
Oth. ind. rdwood	4	Pulpwood	2	Mackerels & others	5	Mackerels & others	0
Wool	3	Sweet potato	2	Demersal/other pelagic	5	Maize	0
Poultry Meat	3	Pulses all	1	Cassava	4	Millet	0
Coffee	3	Saw & ven.logs (C)	1	Rubber	4	Oranges & tangarines	0
Tilapias	3	Groundnut	1	Palm oil/kernel	4	Oth. ind. rdwood	0
Pigmeat	3	Cotton	1	Pulpwood	3	Pitprops	0

Rubber	2	Oranges & tangarines	1	Tunas,bonitos etc	3	Potatoes	0
Pitprops	1	Lobsters	1	Banana/plantain	1	Poultry meat	0
Pulpwood	1	Potatoes	0	Coffee	0	Pulses all	0
Sweet Potato	1	Sorghum	0	Herrings & others	0	Rubber	0
Mackerels & others	1	Wheat	0	Charcoal	0	Sheep & goat meat	0
Tunas,bonitos etc	1	Millet	0	Cocoa	0	Sorghum	0
Lobsters	0	Fuelwood (Con.)	0	Coconut	0	Soybean	0
Cocoa	0	Pitprops	0	Lobsters	0	Wheat	0
Palm oil/kernel	0	Wool	0	Tilapias	0	Wool	0

con.—coniferous; NC—non-coniferous; Oth. ind. rdwood—Other industrial roundwood; ven.—veneer

It has been found that this type of presentational format is not always the most convenient for quick use by decision-makers to assist in priority setting. Instead, an alternative format has been developed. This format uses, what have been called, break-even relativities (Table 2). These relativities are calculated by ordering the commodities from highest regional benefits to lowest and then dividing the highest by each of the other commodity's expected gains. For example, in South Asia a 5% cost reduction from prawns/shrimp research is expected to generate a welfare gain in present value terms of US$14m (a research and adoption lag of 11 years and a 30 year planning period is assumed and a real discount rate of 12% used). On the other hand, the same 5% unit cost reduction from rice research is expected to provide regional welfare gains to South Asia of US$421m. The break-even relativity for prawns/shrimp is 421/14 = 30. In other words, prawns/shrimp research would need to generate approximately 30 times the percentage cost reduction to provide the same regional welfare gains as rice research.

Table 2. Regional commodity research priority groupings for a regional benefits objective.

South Asia Regional Benefits			South East Asia Regional Benefits			China Regional Benefits		
Priority Group	Commodity Ranking	Break-even Relativities	Priority Group	Commodity Ranking	Break-even Relativities	Priority Group	Commodity Ranking	Break-even Relativities
	Rice	1		Rice	1		Rice	1
	Milk	2		Saw & ven. logs (NC)	1		Pigmeat	2
	Fuelwood (NC)	2		Fuelwood (NC)	1		Sweet Potato	4
1	Wheat	3	1	Palm Oil/kernel	2	1	Maize	4
	Pulses all	4		Rubber	3		Potatoes	5
	Potatoes	7		Sugar	9		Wheat	5
	Cotton	8		Coconut	9		Cotton	9
	Sugar	8		Banana/Plantain	10			
							Eggs (poultry)	11
	Saw & ven. logs (NC)	11		Cassava	12	2	Soybean	19
	Sorghum	11		Pigmeat	14		Pulses all	20
2	Groundnut	12		Demersal/other pelagic	15		Fuelwood (NC)	20
	Millet	17	2	Prawns/shrimps	16			
	Sheep & goat meat	18		Maize	16		Saw & ven. logs	
(Con.)	26	3	Pulpwood	30				
				Eggs (poultry)	18		Sugar	26
	Banana/Plantain	21		Coffee	18	3	Fuelwood (Con.)	29
	Maize	23		Poultry meat	19		Poultry meat	31
3	Beef & buffalo	27					Sheep & goat meat	39
	Eggs (poultry)	27		Beef & buffalo	25		Groundnut	40
	Prawns/shrimps	30	3	Tilapias	27			
	Coconut	33		Cocoa	28		Saw & ven. logs (NC)	41
				Oth. ind. rdwood	33	4	Milk	46
	Demersal/other pelagic	53					Oth. ind. rdwood	62
	Oranges & tangerines	55		Tunas, bonitos etc	57		Prawns/shrimps	67
	Herrings & others	64		Mackerels & others	61			
4	Cassava	67	4	Charcoal	63		Millet	81
	Fuelwood (Con.)	67		Sheep & goat meat	65		Sorghum	89

	Saw & ven. logs (Con.)	67		Herrings & others	67	5	Wool	97
	Soybean	75					Oranges & tangerines	129
	Charcoal	77		Soybean	83		Beef & buffalo	139
				Milk	95			
	Oth. ind. rdwood	98	5	Pulpwood	111		Pitprops	163
	Wool	136		Sweet Potato	133		Mackerels & others	214
5	Poultry meat	140		Pulses all	143		Demersal/other	
pelagic	227		Maize	0				
	Coffee	145		Saw & ven. logs (Con.)	143		Cassava	276
	Tilapias	156					Rubber	276
				Groundnut	167		Palm Oil/kernel	289
	Pigmeat	162		Cotton	200		Pulpwood	413
	Rubber	183		Oranges & tangerines	222	6	Tunas, bonitos etc	463
	Pitprops	301		Lobsters	286		Banana/Plantain	1286
	Pulpwood	324		Potatoes	500		Coffee	5786
6	Sweet Potato	351	6	Sorghum	500		Herrings & others	5786
	Mackerels & others	421		Wheat	667		Charcoal	0
	Tunas, bonitos etc	842		Millet	2000		Cocoa	0
	Lobsters	2105		Fuelwood (Con.)	0		Coconut	0
	Cocoa	4210		Pitprops	0		Lobsters	0
	Palm Oil/kernel	0		Wool	0		Tilapias	0
Regional Relativities	2.7			5.8			1	

con.—coniferous; NC—non-coniferous; Oth. ind. rdwood—Other industrial roundwood

Notice that as well as the break-even relativities for all commodities within a region, Table 2 also includes the relativities between the geographical regions. This is calculated by dividing the highest regional welfare gains, that is China, by each of the highest gains in the other regions. Therefore, it is seen that for tuna, bonitos etc. research in the South Pacific to generate the same welfare gains as rice research in China, about 200 times the percentage unit-cost reduction would be required.

In addition to calculating these relativities, it has proven useful to use priority groups instead of an ordered list. Six priority groups have proven useful and the following relativity ranges have been found to be appropriate:

Priority Grouping	**Range of Break-Even Relativity**
1	0–10
2	11–20
3	21–40
4	41–80
5	81–160
6	> 160

Care is obviously required in using this type of summary information to support decision-making. In ACIAR it is not used to dictate that research should only be supported for the highest expected gain commodities. Rather it is used more as a screening device. That is, research focusing on commodities that are in the 4, 5, and 6 priority groups is flagged as requiring closer scrutiny for the likely level of welfare gains. The trend is toward having more detailed economic assessments included with these types of projects to demonstrate more clearly that, as well as scientifically attractive attributes, there are high potential regional welfare gains.

This aggregate type of information has been used to support decision-making by most of the decision-making groups illustrated in Figure 2. However, it has especially been used as an input to the In-House-Review process.

The possible types of uses which can be made of this aggregate information will be briefly illustrated here with a focus on postharvest research. It is important to emphasise that some additional care is required when considering postharvest research. The analysis used to generate the potential benefits from the impact of research is based on the assumption that the research will result in a reduction in on-farm production costs. Since relativities are used to determine priority groupings it is possible that these will be reasonable indicators for postharvest research. However, if the relative postharvest costs are markedly different from farm-level costs for each of the commodities, then these research relativities may not be reliable. In addition it is possible that postharvest research is more often applicable across many commodities. If this is so, it may be necessary to add the individual gains from research on each commodity and re-estimate the relativities.

If we keep these points in mind, it is possible to use a combination of the PMIS and Research Evaluation databases to look at some broad trends in the postharvest research program at ACIAR. As indicated above, the PMIS contains detailed information for each project. One set of information is the commodity emphasis and the project funding. If we combine this information with the aggregate-priority groupings from Table 2 for several time periods, it is possible to determine whether there have been any clear trends in the program's emphasis.

Table 3 summarises this aggregate information by regions for every commodity and for all ACIAR's postharvest research projects. It can be seen that the postharvest program has focused primarily on one of ACIAR's mandate regions, Southeast Asia, although during the past three or four years there has been an expansion to South Asia and China. While in China the commodity focus has been on the three important grains, but in Southeast Asia, and more recently South Asia, there has been a more diverse commodity focus. Originally there was considerable emphasis on rice but other commodities such as herrings etc. and groundnuts have also received some research funding. More recently there has been a shift in focus to tropical fruits. At this stage only a few of these tropical fruits, for example banana, have been included in the aggregate-priority-evaluation analysis. There are plans to extend the analysis and database to include more of these. However, given the relative importance of these crops (even though this is increasing) it is unlikely that the individual fruit commodities will be in the high priority groups. This is not to say that if projects have a potential impact on several of these fruits together, that as a combined 'commodity' they might not be in the higher priority group.

Table 3. Postharvest research funding by region, commodity and priority group.

Commodity	Priority Group	Southeast Asia ($'000)			Commodity	Priority Group	South Asia ($'000)			Commodity
		1982–94	1982–88	1989–94			1982–94	1982–88	1989–94	
Rice	1	4,387	3,189	1,197	Wheat	1	156	0	156	
	Maize	1	261	0	261					
					Rice	1	122	0	122	
	Rice	1	457	0	457					
Mango	2	2,220	982	1,238	Milk	1	52	0	52	
	Wheat	1	283	0	283					
Coffee	2	46	46	0	*Total*		*330*	*0*	*330*	*Total*
Maize	2	1,925	1,383	541						
Total		*4,191*	*2,411*	*1,779*	Groundnut	2	34	0	34	
Herring etc.	4	579	579	0						
Mungbeans	5	101	101	0						
Pulpwood	5	43	43	0						
Soybeans	5	138	138	0						

Total		*282*	*282*	*0*					
Groundnuts	6	498	106	392					
Sorghum	6	8	8	0					
Wheat	6	537	249	288					
Total		*1,043*	*363*	*680*					
Sub Total		**10,482**	**6,824**	**3,656**	**Sub-Total**	**330**	**0**	**330**	**Sub-To**
Fruit /Veg	ni	657	288	369	Fruit /Veg	172		172	
Non-Specific	ni	256	256	0	Non-Specific	51		51	
Lychee	ni	271	0	271					
Avocado	ni	165	0	165					
Cucurbit	ni	106	0	106					
Longans	ni	106	0	106					
Mangosteen	ni	106	0	106					
Papaya	ni	106	0	106					
Sub Total		**1,773**	**544**	**1,229**	**Sub Total**	**223**		**223**	
Total		**12,255**	**7,368**	**4,885**	**Total**	**653**	**0**	**653**	**Total**

Table 4 summarises this information as percentages for each priority grouping. It can be seen that for Southeast Asia, over 35% of the funding has been in the highest priority group with over 70% in the highest two groups. Interestingly there has been a significant change in this pattern between the first and second six-year periods. During the first six-year period over 75% of postharvest funding was for projects in the top two priority groups. For the last six years this has fallen to under 60%. This has been caused by a significant shift from grains to primarily fruit postharvest research. In China and to a lesser extent South Asia the primary focus has still been on the high priority commodities, especially grains. Although in South Asia the shift to some focus on tropical fruit has also occurred.

Table 4. Research funding by research priority groupings and regions (%).

Priority Group	**Southeast Asia**			**Priority Group**	**South Asia**			**Priority G**
	1982-1994	**1982-1988**	**1989-1994**		**1982-1994**	**1982-1988**	**1989-1994**	
1	35.8	43.3	24.5	1	56.1	0	56.1	1
2	34.2	32.7	36.4	2	5.9	0	5.9	2
3	0	0	0	3	0	0	0	3
4	4.7	7.9	0	4	0	0	0	4
5	2.3	3.8	0	5	0	0	0	5
6	8.5	4.9	13.9	6	0	0	0	6
Not Included	14.5	7.4	25.1	Not Included	38.0	0	38.0	Not Inclu

The aggregate-priority-assessment information is based on the assumption of a standard average research project with a 5% cost reduction as the impact. Therefore, unless the fruit projects are expected to have a substantially larger impact than the grains project, this information suggests that the trend in funding could mean

that the expected gains from the research could fall. It seems important to consider in more detail whether this is likely. This type of issue can only be addressed by considering specific projects and the technologies generated by these. As is indicated in Figure 2, the project development and completed project assessments have been included in the Information System to add this detail. These are briefly discussed below.

2.4 The current status of ACIAR's project-level assessments

The initial emphasis of ACIAR's **Information System** was to provide information to support the determination of aggregate-priority-assessment directions. After the initial impact of this information, it became clear that its effectiveness could be enhanced by project-level assessments of potential and actual research impacts. This section briefly summarises these assessments and highlights the postharvest research program component. Assessments have been separated into the following two groups:

(i) Completed project assessments

In preparation for ACIAR's Sunset Review it was decided to have commissioned a set of completed project economic assessments. Initially, a set of 20 projects or 12 research areas were selected. The primary basis for choosing these projects was that the benefits from the projects had started to flow and that they were identifiable. Since this time several further projects have been evaluated. These included a Tuna Bait Fish Biology project which had also been the subject of an earlier project development assessment. However, the major addition to these completed project evaluations have been the evaluation of four postharvest tropical fruit projects. These were undertaken during the past year. The longer-term aim is for ACIAR to evaluate projects in a more integrated way by assessing them from the initial idea stage through to when the project has been completed and affected production. Table 5 summarises the results of the seventeen assessments completed to-date. A detailed description of these studies is given in Menz (1991), Fearn (1991) and Lubulwa and Davis (1994a) and will not be repeated here. Some trends do appear in these studies. Most of the projects were on issues relevant to commodities that are in the first two aggregate-level priority commodity groups for the region where the research was undertaken. Some of the high benefit projects are also in this category. The postharvest tropical fruit projects have been shown to have had good impacts and reasonable rates of return for the funds invested.

Table 5. Summary of economic assessments for selected completed ACIAR research project areas.

Economic Assessment Number	Project Number	Short Project Title	Program Area	NPV Estimate[1] Most Likely ($ million)	Internal Rate of Return (%)	Region	Co
1	8340	Salvinia Control	Crop Sciences	25.0	469	S Asia	Sr
3	8203/8601	Straw Utilisation by Livestock	Animal Sciences	117.0	100	S Asia	In
8	8307	Stored Grain Under Plastic	Post Harvest	9.2	38	S E Asia	Ph M
9	8309/8609/8311	Integrated Pesticide Use in Grain Storage	Post Harvest	24.3	43	S E Asia	Ph
5	8321	Tick-Borne Disease Control	Animal Sciences	30.7	68	S Asia	Sr
7	8334/8717	Newcastle Disease of Poultry	Animal Sciences	144.0	50	S E Asia	M In
12	8457/8848	Australian Trees for China	Forestry	115.0	37	China	Ch
10	8207	Grain Sorghum Book	Land and Water	9.2	38	S Asia	In
2	8343	Fruit Fly Control	Crop Sciences	176.2	260	S E Asia	M

6	8469/8839	Rapeseed Breeding	Crop Sciences	66.3	58	China	Ch
11	8332/8733	Giant Clam Mariculture	Fisheries	1.9	-	S Pacific	
South Pacific	Giant Clams	6					
4	8451/8929	Nematodes To Control Pests	Crop Sciences	97.0	80	China	Ch
		Sub-Total (Assessment 1-12)		*815.8*			
-	8543/9003	Tuna Bait Fish Biology	Fisheries	3.8	21	S Pacific	
South Pacific	Tuna	1					
	8355	Postharvest Technology for Banana	Postharvest	50.6	48	S E Asia	M
	8356	Chemical Control of Fruit Disease	Postharvest	36.6	41	S E Asia	M Th
	8844	Cool Storage, CA and Chemical Controls of Fruit	Postharvest	18.7	27	S E Asia	Th
	8319	Vacuum Infiltration of Fruit with Calcium	Postharvest	2.7	21	S E Asia	In

1. Values represented in 1990 dollars, with NPV (net present values) estimated for 1990.
2. All research costs, including expenditures by the collaborating and commissioned organisations are included.

ni not presently included in priority assessment commodity group

Six of these completed project assessments have been for projects in the postharvest program area. Two have investigated aspects of the storage of grains, especially rice in Southeast Asia, while the rest have been the tropical fruit projects. The gains from these research areas have, in general, been significant. However, these evaluations do suggest that the smaller volume fruits have tended to have lower payoffs than the higher priority commodity projects. In fact the benefits to the 'Vacuum Infiltration of Fruit' (Pn 8319) project are expected to be relatively small, have yet to be realised and may not be realised without further development effort which is not currently under way.

(ii) Project development assessments

Project development assessments have been a more recent addition to ACIAR's **Information System**. They have developed for a number of reasons. Important among these has been the need to develop a way to compare projects from the diverse program areas within ACIAR. They are also used to provide a mechanism for demonstrating under what types of conditions high welfare gains will result from technically attractive projects which focus on, what appear on average to be, potentially lower research-benefit commodities. In addition these activities have been found to provide a useful interdisciplinary interaction which often results in clearer project specification and objectives.

Table 6 includes a list of the 34 project development assessments that have been included in recent ACIAR project proposals. There has been a range in the sources of these assessments. Some have been incorporated in the proposals by the researchers preparing the documents. Others have been developed with extensive interaction between the project researchers and the economists at ACIAR. There have not been sufficient of these assessments undertaken to draw any firm trends from the information included in Table 6. However, the potentially low (group 5 and 6) priority commodities do seem to require substantial impacts on the commodity output to generate rates of return that are in the range of those found in past evaluations of agricultural research. Care is required at this stage because assessment procedures are not necessarily comparable between assessments. The fully interactive assessments (there have now been twelve of these) have generally been fruitful. Both the scientists and

economists have usually agreed that a better understanding of the issues have resulted. In addition the project proposals have usually become much clearer as a result of the interaction.

Table 6. Recent project development assessments of projects considered for funding by ACIAR.

Project Number	Description	Program	Region	Country	Commodities		Priority Grouping	
Internal Rate of Return	Unit Cost	Change in	Level of Area Analysis		Primary	Other		Most I
9323	Dairy Policy in Indonesia	Economics	SEA	Indonesia	Milk		5	
94%	ne	na	na	Internal (FI)				
9318	Improved Ruminant Production through	Animal Science	SEA	Indonesia	Beef/Buffalo	Sheep/Goat	3/4	
71%	ne Efficient Use of Shrubs	na	10%	Internal (PI)				
9109	Coconut Marketing and Policies in Philippines	Economics	SEA	Philippines	Coconut		1	
70%	ne	na	na	Internal (PI)				
9404	Water Management in Vietnam	Land & Water	SEA	Vietnam	Rice	Maize, Vegetables	1/2	
53%	28–64%	na	na	External				
9411	Prawn Health Management and Disease Control	Fisheries	SEA	Thailand	Prawns		2	
52%	38–72%	na	na	External				
9132	Self-Medicated Blocks for Ruminants	Animal Science	SA/SEA/SP	Fiji, India, Malaysia	Milk	Sheep/Goat	1/3	
50%	41–48%	na	na	Internal (PI)				
9105	Edible Coatings for Fruit and Vegetables	Post Harvest	SEA/China	Thailand, China	Durian	Lychee	ni	
50%	45–89%	na	na	Internal (FI)				
9123/9049	Liver Fluke Vaccine and Control in Indonesia	Animal Science	SEA	Indonesia	Beef/Buffalo		3	
41%	35–50%	15%	20%	Internal (FI)				
9045	Water Use in Fruit Production	Land & Water	China	China	Peaches		ni	
40%	50–150%	37%	40%	Internal (PI)				
8923	Economic Pressures on Thailand Agricriculture	Economics	SEA	Thailand	Rice	Maize, Cassava	1	
40%	34–77%	5%	na	External				
8940	Efficiency of Urea as Fertilizer	Plant Nutrition	China	China	Rice		1	
40%	40–73%	1.7%	8%	Internal (MI)				
9040	Soybean Improvement in Thailand	Crop Science	SEA	Thailand	Soybeans		5	
39%	26–54%	11.3%	20%	Internal (PI)				
9048	Improvement of Rainfed Rice	Crop Science	SEA	Thailand	Rice		1	
39%	21–49%	9.5%	15%	Internal (PI)				
9120	Boron Fertiliser in Oilseeds	Land & Water	China	China	Rapeseed		ni	
39%	28–82%	11%	25%	Internal (FI)				
9313	Non-Chemical Control of Fruit Disease	Postharvest	SEA	Thailand	Mango,	Avocardo, Longan, etc	2	
38%	30–45%	na	na	Internal (FI)				
9406	Replacements for Methyl Bromide in Timber	Postharvest	SEA	Malaysia	Saw & Veneer Logs NC		1	
34%	23–36%	na	na	Internal (FI)				
8911	Mineral Limiting Sheep Production	Animal Science	China	China	Wool	Sheepmeat	5	
32%	14–40%	4.9%	10%	Internal (MI)				
9017	Control of Peanut Stripe Virus	Crop Science	SEA	Indonesia	Groundnuts		6	
32%	ne	ne	ne	External				
8938	Clay Soils	Land & Water	SEA	Philippines	Pulses	Rice	5	
31%	13–31%	20%	105%	Internal (FI)				
9003	Baitfish For Tuna in South Pacific	Fisheries	SP	Solomon Is, Kiribati, Fiji	Tuna		1	
30%	14–56%	2.25%	0	Internal (FI)				
9009	Use of Mix of Grain Protectants	Post Harvest	SEA	Philippines, Malaysia	Rice	Maize, Groudnuts	1	
30%	3–48%	ne	ne	External				
9039	Philippines Livestock Sector	Economics	SEA	Philippines	Beef/buffalo		3	
30%	20–40%	na	na	Internal (PI)				
9316	Trees for Salt Affected Land	Forestry	SA/SEA	Pakistan, Thailand	Fuelwood NC		1	
26%	18–37%	na	na	Internal (PI)				
8845	Grain Storage in Plastic Enclosures	Post Harvest	SEA	Philippines	Rice	Maize	1	
25%	-6–30%	ne	ne	External				
9303	Forages for Red Soils in China	Land & Water	China	China	Milk		4	
25%	20–50%	na	na	Internal (FI)				
9317	Plant Tissue Culture in Tea	Crop Science	SEA	Indonesia	Tea		ni	
23%	19–23%	30%	300%	Internal (FI)				
9407	Pineapple Quality Improvement	Postharvest	SEA	Malaysia	Pineapple		ni	
22%	18–25%	na	na	Internal (FI)				
9020	Economics of Native Forests Vanuatu	Economics	SP	Vanuatu	Saw&Veneer Logs NC	Tourism	1/?	
20%	19–28%	1%	na	External				
9107	Papaya Improvement in the Philippines	Crop Science	SEA	Philippines	Papaya	Fruit/veges	ni	
20%	15–40%	5.5%	360%	Internal (FI)				
9131	Pearl Oyster Resource Development	Fisheries	SP	Cook Is, Kiribati	Pearls		ni	
18%	0–26%	34–37%	133%	Internal (FI)				
9008	Multipurpose Grain Drying Systems	Post Harvest	SEA	Philippines	Maize	Rice	2/1	
17%	14–20%	8%	0	External				

9206	Genetic ID & Stock Improvement of Tilapia	Fisheries	SEA/SP	Malaysia, Fiji	Tilapia		3
11%	4–25%	13%/22%	20%	Internal (FI)			
8913	Small Ruminants in South Pacific	Animal Science	SP	Fiji	Sheep/Goat Meat		5
11%	11%	12/25%	110%	Internal (PI)			
9302	Forage Production from Saline and Sodic Soils	Land & Water	SA	Pakistan	Sheep/Goat Meat	Beef/Buffalo	2/3
$12m NPV	$2–20m NPV	na	na	External			

Notes:

ni—not presently included in priority assessment commodity group
ne—not directly estimated
na—not applicable
Internal (MI)—Internal ACIAR assessment, minimal interaction
Internal (PI)—Internal ACIAR assessment, partial interaction
Internal (FI)—Internal ACIAR assessment, full interaction
External—External assessment by project proponents
Shaded Projects are in the Postharvest Program area

So far there have been seven assessments of projects from the postharvest program. Four of these assessments have been undertaken by the project proponents and three with full interaction between the project scientists and the Economic Evaluation Unit at ACIAR (see for example, Lubulwa, Desmarchelier and Davis [1994] and Lubulwa, Underhill and Davis [1994]). The most likely rates of return have varied from 13% to 50%. All except two of these projects were from the high priority commodity groups. The first, the edible coatings for tropical fruit project, was found to have a high rate of return, the highest for this group of projects and one of the highest of all assessments undertaken so far. This is because the project output is likely to be applicable to several fruits and the impact of the research is expected to be very significant. The second, the pineapple quality improvement project, has been estimated to have a potential impact that is at the lower and probably marginal end of the scale. Pineapples in the countries involved are relatively small volume crops.

Two important points highlighted by these project evaluation activities are:

(i) It is important to recognise that the information from this type of system, and especially the economic assessments component, can only be used to support decision-making, not to make decisions for or replace decision-makers. This is a crucial point to highlight and recognise. Often both technical scientists and economists fail to appreciate the importance of this point.

(ii) At the project/program level it is the interaction between the technical and economic scientists which is as important, if not more important than, the assessment numbers which are generated. This interaction has been found to result in clearer project specification and a better understanding of the potential research impact by both sides. In the case of ACIAR, this improved Project clarity has usually resulted in a better understanding by others involved in the project review process, especially, the In-House-Review process.

2.5 A brief overview of previous evaluations of postharvest research

As well as the recent evaluations of a few of ACIAR's postharvest research projects there have been several studies during the past 10 years that have addressed the issue of postharvest research. The majority of these studies have concentrated on methodological development. When applications were included, they were generally hypothetical rather than relating to a specific research project or outcome. Several subsequent studies have applied the methodology to specific research issues and in some cases projects. Table 7 provides a brief summary of eighteen of these studies. These will not be discussed in detail here.

Table 7. Summary of some previous postharvest research evaluation studies.

Description	Commodity	Country	Research Type	Net Present Value ($M)	Internal Rate of Return (%)	Benefit Costs Ratio	Comr
Suppression of Grain Dust	Wheat GRDC (1992)	Australia	Wastage	14.5	143	54:1	
Postharvest Technologies for Banana	Banana Lubulwa & Davis (1994)	Malaysia, Philippines, Australia	Wastage	50.6	48		
Integrated Pesticide Use in Grain Storage	Rice Chudleigh (1991)	Malaysia/Philippines/ Australia	Wastage-Storage	24.3	43		
Control of Fruit Diseases	Mango etc Lubulwa & Davis (1994)	Malaysia, Thailand, etc	Wastage	36.6	41		
Stored Grain Under Plastic	Rice Ryland (1991)	South East Asia/ Australia	Wastage-Storage	9.2	38		
Reduced Amylose in Rice	Rice Only Annual Benefits reported	Indonesia	Quality Unnevehr (1986)	117.0	37		
Cool Storage, etc of Fruit	Longan, Mango Lubulwa & Davis (1994)	Thailand, Australia	Wastage	18.7	27		
Vacuum Infiltration of Fruit	Avocado Lubulwa & Davis (1994)	Indonesia	Wastage	2.7	21		
Reduced Amylose in Rice	Rice Only Annual Benefits reported	Philippines	Quality Unnevehr (1986)	227.0	29		
Pigmeat Fat Reduction	Pigs PV of year 5 benefits no research costs	USA	Quality Lemieux and Wohlgenant (1989)	977.5			
Reduction in Dark-Cutting in Beef	Beef Potential benefits; no research costs	Australia	Quality Voon and Edwards (1990a)	905.0			
Boxed to Tray Ready Beef Processing	Beef Annual impact; no research costs included	USA	Processing Mullen et al (1988)	845.6			
Increased Protein Content in Wheat	Wheat Potential benefits; no research costs	Australia	Quality Voon and Edwards (1990b)	447.0			
Reduced Backfat Depth in Pigs	Pigs Potential benefits; no research costs	Australia	Quality Voon and Edwards (1990c)	66.0			
Wool Carding Improvement (Sirocard)	Wool Benefits only; no research costs included	Australia	Processing Mullen and Alston (1990)	21.9			
Component Pricing and Grading	Soybeans Annual impact; no research	USA	Grading/Quality Updaw (1980)	-12.6			

	costs included			
Wheat Quality for Middle East	Wheat	Australia/Middle East	Quality	?
	Qualitative assessment only		GRDC (1992)	
Safe Storage of Oilseeds	Rapeseed	Australia	Wastage-Storage	$5/t
	Impact per tonne only assessed		GRDC (1992)	

One important feature is the considerable variability in both the evaluation method used and the types of results reported. Only nine out of the eighteen provided a complete assessment which included an assessment of the lags from the commencement of the research and the adoption levels and patterns as well as the annual welfare impacts of the research. (Six of these nine were the ACIAR studies.) These nine are listed at the top of Table 7 and in the order of the highest to lowest internal rate of return (IRR). The rates of return reported range from 21% to 143%, which are similar to the returns reported for farm-level research. The other studies have reported estimates of the annual welfare gains to the countries where the research was expected to have an impact. Some of these are estimates of the potential gains rather than those for a specific completed project. There are some very large estimates reported, especially for the livestock sectors. One of the eighteen reported negative returns to the project and two found it difficult to apply the available methods to the research project considered.

Care is required in drawing general conclusions from these studies, as the methods and format for presentation are not necessarily comparable. Literature reviews, especially such as that provided by Alston (1991), have been very useful in guiding the choice of methods for evaluating research. However, so far the classification has been based on the economic characteristics only. During the process of applying research evaluation methods at a project level at ACIAR (and this experience has been confirmed by other institutions) it has been found that it is important to be able to select an evaluation method that best suits the type of research being undertaken, as well as the economic characteristics facing the production of the commodity(ies) the research will eventually influence. This is especially important as there appears to be a marked lack of information on the best way to estimate the research-impact parameters in the economic models. The nature of these parameters will depend on the type of research. Davis and Lubulwa (1993) have discussed this issue and suggested several possible ways to classify research areas. They related the methodology classifications, suggested by Alston (1991), to these research area classifications. A summary of the section of their discussion relevant to postharvest research is provided in Table 8. This emphasised that the type of model is likely to vary with the type of postharvest research.

Table 8. Summary of possible postharvest research area classifications

Research Classification Area	Type of Evaluation Model (Based on Alston (1991)	Comments
Post-Farm gate		
Wastage Reduction	Multi-regional vertical market model	Wastage reduction version can be useful simplification.
Processing Methods	Multi-regional vertical market, probably factor-biased, model	Private sector relevance could be important since most research gains are appropriable.
Transport	Multi-regional vertical market model	Private sector relevance could be important since most research gains are appropriable.
Farm & Off-Farm		
Product Quality	Multi-commodity, related in consumption, vertical market model	Care is required if a simple increase in price model is used.

New Product	Single or multi-regional, multi-commodity supply shift model subject to more error.	Quantity associated with minimum TAC required. Care is required as estimates are
Policy/Regulation	Value of information with saving in dead weight loss model.	Model not well developed and few applications.
Environmental Issues	Single or multi-regional, multi-commodity supply shift model	Other areas also involve environmental issues.
Human Health	Labour supply shift, demand for health services	Models not well developed or applied.
Institutional Analysis	Value of information with saving in dead weight loss model.	Model not well developed and few applications.

The recent versions of the multi-regional vertical market models as outlined in Alston (1991) are becoming relatively complex, especially from an economic perspective. Yet procedures for estimating the research impact parameters included in them are not very well developed. Davis (1993) and Davis and Lubulwa (1994) discuss this and suggest a simpler model that focuses on waste reduction at the postharvest level as an alternative for this sub-set of research projects.

2.6 Summary

ACIAR has been evolving an extensive Information System that includes aggregate priority setting and project-level assessments for several years. In this section we have used the aggregate priority information to summarise the trends in ACIAR's postharvest research program. We have found that the recent trend away from the major grains to fruit and other commodities also means a trend away from the higher priority commodities for the regions concerned. It was felt important to ask the question: is this trend to lower priority commodities likely to mean lower returns to the research funds being invested? To address this question it is necessary to focus on project-level assessments in the Information System.

The existing set of ACIAR completed-project assessments suggests that the higher return projects have mostly been on the high priority commodities for particular regions. The majority of the postharvest projects that have been evaluated were in this category. The rest of the postharvest projects have focused on some of the relatively minor tropical fruits. These have been found to have reasonable welfare impacts, however, not as high as many of the other projects ACIAR has funded.

At this stage only two postharvest projects that are not on high priority commodities have been assessed during the project development stage. One is on the issue of edible coatings for tropical fruit. The expected initial benefits from this proposed project were found to be very high. This was due to two factors. The impact of the project was expected to be very high; it is expected to considerably reduce the postharvest wastage and is expected to achieve this with very small additional postharvest input costs. It should also benefit a reasonably wide range of tropical fruit. The other project will be on postharvest pineapple quality. Pineapples are a relatively minor crop in the countries involved in the project. The potential impact is therefore relatively smaller than for most other projects. It is a marginal project even though the expected net welfare impacts are positive.

As these few examples illustrate, evaluations of the impacts of individual projects are becoming increasingly important for supporting decision-making at ACIAR (this is also a trend with many other research funding bodies). It is therefore useful to consider in more detail some further aspects of such evaluations.

3. THE PROJECT EVALUATION PROCESS FOR POSTHARVEST RESEARCH

3.1 ACIAR's project evaluation process in perspective

The current range of project evaluation work has been undertaken by, and in association with, ACIAR for several reasons; and in many cases to satisfy reasonably narrow objectives. One of the reasons for the establishment of the Economic Evaluation Unit was to consolidate this effort, develop consistency in approaches and establish a program for the integration of this information into the institutional **Information System**

The experience, so far, has revealed that there are several sources of gains from this process. In particular, the interaction between project scientists and economists has been found to be especially important. This has generated more effective understanding of the research process and potential impacts by both groups. The clarity of project proposals has also been enhanced by this interaction.

Several of the early assessments were undertaken quickly and involved minimal interaction between the research proposers and the economists. While the information generated did prove useful to decision-makers, these benefits were often not clear to the researchers preparing the proposals. Since they were often undertaken at the later stages of the project-development cycle they ran the risk of being viewed negatively by the researchers. More recently, emphasis has been placed on undertaking these assessments earlier in the project-development cycle and incorporating more interaction between the research proponents and the economists. While it is often not wise to generalise, these assessments have resulted in positive interaction and a genuine interchange of ideas. The result, it has usually been agreed, has been an improvement in the specification of the projects and proposals that have been clearer to understand.

There is clearly a considerable way to go and the processes still require refinement. There are no easy blackbox procedures, and the way researchers and economists interact is critical. It is important to continually assess whether the costs of this type of activity are matched by improvements in the decision-making and research process.

Although they may not always be warranted it is useful to develop some guidelines for the consistent application of project-level assessments. This has two primary advantages; first, the results of this type of activity will then be more readily comparable and it should reduce the resources required to generate them. Second, while the economic methodology used is reasonably well documented, the mechanisms for incorporating them within different decision-making environments has not been. Consistency in the development of assessments should assist in resolving these application problems and issues.

Figure 3 illustrates the evaluation mechanisms being adapted at ACIAR to assist with the integration of the project-evaluation activity with the development cycle currently used by ACIAR to assess research proposals. Important features are:

(i) Researchers and economists should begin to interact early in the project's development. In ACIAR's case this would mean at or just after the Phase I stage of a project. This initial interaction could involve supply of basic economic information as background to the clarification of ideas, for example, provision of time series data on production levels of the commodities likely to be involved.

(ii) Linkage with the **Information System** to avoid duplication in data collection and analysis.

(iii) Early clarification of the technical aspects of the research effort and then translation of this into a cost analysis format. This has proven to be an important step in the evaluation process as often simple assessments of only output changes have resulted in considerable overestimation of the potential gains from research.

(iv) Incorporation of a sensitivity analysis. This often provides useful information for improving the focus of the research effort.

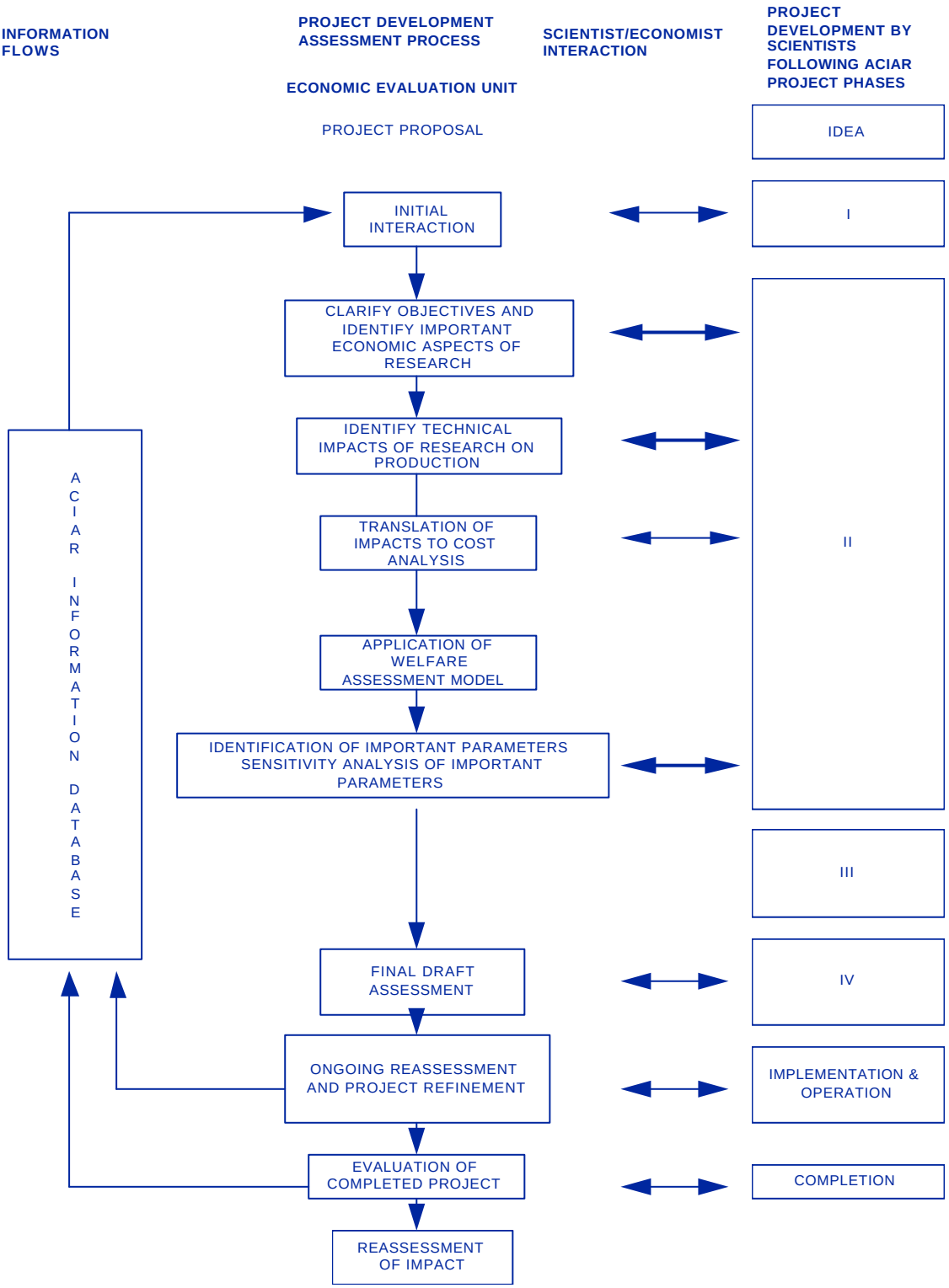
(v) Linkage of the project-development assessment with additional assessments during the course of the project and then a completed-project assessment. This can reduce the effort required at each stage and ensure that appropriate information is collected during the course of the project.

(vi) Completed project assessment and re-assessment after the technology has had sufficient time to have a full impact.

An important aspect of the project development assessment component of this suggested process is continued interaction during Phase II of the project-development cycle. Many of the previous partial and minimal interaction assessments have commenced at the end of the Phase II stage. This has usually eliminated the scope for sufficient and productive interaction.

In the rest of this section we will highlight some of the different aspects of what we are calling project development and completed project assessments and then provide an overview of all current and past postharvest projects in relation to these activities.

Figure 3: Project Development Process at ACIAR and Assessment Interaction



3.2 Desirable features of a detailed project development assessment

3.2.1 Introduction

To improve the understanding of how projects are assessed during the development stage, it is useful to discuss boxes 1, 2, 3, 4, 5 and 6 in the centre of Figure 3 in more detail. The activities included in these boxes provide the basis for developing sections 2.2 and 2.7 of a phase 2 ACIAR document. The discussion can be separated into several areas. These include: the need to provide a detailed indication of the industry background and where the problem to be addressed fits; a clear description of the potential technical impacts of the research if successful; the types of information that need to be collected to facilitate the evaluation; and the types of quantitative models that can be used to determine the welfare impacts of the research. Each of these are briefly discussed in this section.

3.2.2 Industry background and perspective of the problem to be addressed (Section 2.2 of project document)

It is important to provide a clear perspective of the industry(ies) the research has potential to have an impact on. The following issues are often important to consider:

- The commodity(ies) likely to be affected by the research output.
- The level of production of these commodities in the country of focus.
- An indication of the country's position in the world market for the commodity(ies).
- The regional distribution of the commodities and whether the research is likely to have a uniform regional impact.
- In the case of postharvest research, a description of the farm-to-consumer transport, processing and other costs and activities and how the research problem impacts on this.

In many cases the aggregate databases in ACIAR's **Information System** can be drawn upon to provide much of this information. At this stage, however, these databases have very limited information on the farm-to-consumer processes and margins. A concerted effort is required to fill this gap.

3.2.3 Description of the potential technical impact of the research (Section 2.7 of project document)

It is important to clearly identify the potential technical impacts of the research effort. In the case of postharvest research this means identifying the stage in the postharvest chain the research is focused on. This description should include details of both the scientific nature of the research and how this is likely to influence the cost or other dimensions of the postharvest process. In addition, efforts should be made to identify whether the impact on output is uniform both for different types of products that might be produced and in the different regions of the country. Some indication of whether the research will influence the use of all inputs to the postharvest activity or just a sub-set is important.

3.2.4 Information required to undertake a project evaluation (Section 2.7 of project document)

Once the description of the technical aspects of the research has been clarified, a range of information is required to transform this assessment into an indication of the potential welfare effects of the research. In most

cases this set of information is likely to be different depending upon the type of research undertaken. Nevertheless, there is a common set of information that is required. This includes:

- Estimates of the production expected by the time the results of the research are available.
- Estimates of the consumption in the country(ies) and therefore whether imports or exports are important.
- Estimates of the prices at both the farm and retail levels.
- Estimates of the postharvest costs for each stage from the farm-to-consumer and especially the changes in these costs after the research results have had an impact.
- Estimates of the original level of postharvest wastage levels and the change in these due to research.
- Assessments of the research lag or time that is expected before the research will result in useable technologies.
- Assessments of the time and factors likely to influence the final level and rate of uptake of the technology once it becomes available. For postharvest research there can be two important dimensions of this adoption. First, it is important to know what share of production enters the postharvest process. For many commodities in some countries a reasonable share of production is consumed on the farms or in the local communities. This share of production may not be influenced by the research outcome. Second, adoption can be influenced by, for example, development requirements, attitudes, and availability of credit for processors (or perhaps farmers in some cases).
- Applicability of the research to other areas or potential spillover effects of the research—especially whether results are likely to apply to other substitute commodities.
- How responsive to price the production of the commodity is and also the responsiveness of consumers to price. Also whether there are close substitutes for the commodity or products produced from it. These factors can have an important bearing on whether certain groups will gain or lose as a result of the research.
- The length of time the research results are likely to take to generate benefits to society and whether the nature of the technology is such that its effects will be short-lived.
- Whether there are any external effects of the technology which are not likely to be imposed on those actually using it, for example, pollution effects, increased government subsidies or taxes.

Crucial to this evaluation, especially of postharvest research, is the model used to transform this list of information into a measure of the welfare effects of the research, and in some cases the distribution of these welfare impacts between different groups. The latter is often important because, in many cases, there are likely to be groups that will gain but others that will be worse off as a result of the research. There is evidence that indicates this mixed situation is especially possible with some forms of postharvest research. The next section discusses some of these issues in more detail.

3.2.5 Models for estimating the welfare effects of postharvest research

Many early attempts to evaluate the welfare impacts of postharvest research adopted a simple change in the value-of-output model. This model relied on estimates of the expected change in output after the research impact and estimated the gains as a change in the retail price of the commodity. It can be readily shown that this

model is a special case and implicitly makes assumptions that are generally unrealistic. More importantly, this model is likely to overestimate the research gains. Some evaluation studies still seem to adopt this simple model.

During the last 15 years there has been a growing body of literature that has focused more closely on measuring the welfare impacts of research on the postharvest section of the agricultural sector. This work extends the methodology developed to evaluate research affecting farm productivity. Early work is reported in, for example, Davis (1976), Freebairn, Davis and Edwards (1982, 1983), Alston and Scobie (1983), Mullen, Alston and Wohlgenant (1989), Mullen, Wohlgenant and Farris (1988), Unnevehr (1986), Davis (1993) and Davis and Lubulwa (1994a). Alston (1990) has recently reviewed some of these methods and applications. The complexities of the potential interactions that can occur at the postharvest level can often require quite complex estimation methodologies. So far, however, there have not been many attempts to adapt the methods developed in these research efforts to provide relatively simple procedures for quick and easy application at a project-evaluation level. This requires some classification of the types of postharvest research into groups based on whether simplifying assumptions can be adopted without a large risk of error when estimating potential research impacts.

Work has commenced at ACIAR to fill this gap. It still has some way to go before generally useable conclusions are available. However, the following is a preliminary list of some possible categories and a brief discussion of each.

(i) Cost-Change Model—Fixed proportions, minimal processing of commodity

The first variation from the model that relied only on an output value was to a model that assumed the commodity affected by the research did not change its form during the postharvest process. Such commodities would only be graded on the farm and then involve postharvest activities such as transport and storage. Usually it is assumed that there is no wastage during the postharvest stage or at least that this wastage rate is fixed and not influenced by the research activity. In this case postharvest research results in a reduction in the costs of the postharvest activity, for example, transport and/or storage. Models of this type have been discussed by, for example, Freebairn, Davis and Edwards (1982). The important assumption is that the primary farm product is used in fixed proportions with the postharvest inputs and the commodity does not change form in this process; examples are many fruits, vegetables and possibly eggs. While relatively simple, this model can provide a reasonable approximation in many cases.

(ii) Complex Processing Model

Clearly the majority of agricultural (and forestry and fisheries) commodities require some postharvest processing; and many require complex processing before they are in the form consumers desire. When complex processing takes place, it is possible that other products will be substitutes for the primary agricultural commodity. The model for evaluating the welfare impacts of postharvest research can also then become more complex. Much of the recent literature on postharvest research evaluation has focused on this, for example, see the review by Alston (1990). A crucial implication from this work has been the care required in evaluating postharvest research, if the distribution of the research gains between different groups in the production chain is important. It has been shown that, after research results are adopted by the processing sector, farmers may receive only a small share of research gains.

Indeed, depending on the nature of the processing sector and the type of research, the farmers may be worse off.

Application of this type of model has the significant drawback that it requires detailed information on substitution and product transformation parameters, which are some of most difficult to measure. In addition, the concepts associated with these parameters are some of the more difficult, and counter-intuitive, economic principles to grasp.

(iii) Wastage Reduction Model

Some commodities require postharvest processing additional to transport and storage. This processing does not necessarily have complex substitution relationships. In such cases the quantity of the commodity leaving the farm will often change by the time it reaches consumers. This is usually product wastage. For example, with fruit and vegetables there are often significant differences between the quantity leaving farms and that eventually used by consumers, even though the physical form of the commodity has not necessarily changed very much. For this group of commodities the more complex substitution relationships can be assumed to be relatively simple without much risk of error. Research in this area of postharvest activity often focuses on factors that result in a reduction in the postharvest 'wastage". In most cases this new technology has increased costs associated with it which need to be off-set against the wastage reduction gains. The earlier literature did not give direct attention to this group of commodities and type of research outcome, although they can be accommodated by using special case values of the substitution parameters in the complex processing model. Work at ACIAR has recently focused on developing a simple version of this model and a clear empirical application method, see Davis (1993), Davis and Lubulwa (1994a) and Lubulwa et al. (1994).

(iv) Health Impacts of Research Model

In several areas of the agricultural sector there is increasing awareness of the potential health impacts of production, processing and distribution activity. At the farm level one obvious example is the impact of pesticides. At the postharvest level several examples are available, such as the aflatoxin problem in stored grains. There has been a substantial set of analyses which have looked at the issue of estimating the welfare effects of public health. Only a small subset of these have assessed gains from health related research. There is a need to adapt these analyses to suit possible areas of on-farm and postharvest agricultural research. Lubulwa and Davis (1994b) have started to do this with an attempt to evaluate the welfare costs of aflatoxin in stored grain. Lubulwa et al. (1994) have also attempted to estimate the health gains from reduced chemical use in postharvest activities.

(v) New Product Development Model

Although probably not as common as suggested, some research results in the development of a new commodity or product from a commodity. This is more likely to be a product of postharvest research. Some researchers are inclined to estimate gains from this research as the value of the new product. This is certain to overestimate the gains. Account needs to be taken of the alternative uses of the resources which are likely to be diverted into the production of the new product. Use of the difference between the new and old product price to value the gains also needs to be treated with caution. Evaluating the

gains from research on processing is complex and, if the model used for this must take this complexity into account.

(vi) Change in Quality Model

Some research can result in a change in the quality of the commodity or product. Several past studies have tended to estimate the gains from this type of research using the difference in the price between the low and high quality product. While this may be an appropriate method in some cases, these are likely to be special cases. In general a model that incorporates complex demand, and even possible substitution products, will be required. Some progress has been made in this area, however, a straightforward, easily applied model is not yet readily available.

Any research project may well have several impacts on the postharvest process. For example, it may reduce the cost of transport and storage and have an impact on public health. To fully measure the gains (or losses) from a such research, more than one of the welfare measurement models may need to be employed. An important component of the Economic Evaluation Unit's future plans is to fill some of the gaps in these models and especially to develop simplified procedures and guidelines for effective evaluation procedures. An important part of this process will be the interaction between researchers and the Unit's staff to resolve some of the important issues and ensure the models are appropriate.

3.3 Important features of ACIAR's completed-project assessment activities

Completed projects are assessed in a similar way to developing projects. This consistency in approach and methodology for assessing different phases of a project is an important feature of ACIAR's information system. Some of the first twelve completed project assessments did not necessarily use the same methods and approaches. The impact benefits are not therefore perfectly comparable. The longer term aim at ACIAR is to standardise these assessments and, as discussed at the beginning of section 3, ensure there is integration between the project development and completed project assessments. Eventually the assessment of a completed project will be an update of the one made during the project's development. Even when this happens, there will be differences, especially, for example, in the types of information collected to estimate the impacts. Completed-project assessments place important emphasis on identifying the impact of the research and verifying the adoption levels through time.

In addition, after a project is completed, it should be possible to assess other important aspects of the lasting impact of the initial research. These include such things as the contribution of the research to the general scientific stock of knowledge which can be very important to subsequent research impacts. In addition, many ACIAR and other research projects include scientific human capital development activities which have important implications for future research activities and chances of success in both partner countries and Australia.

Recognising the possibilities of this range of ultimate impacts of research activities, ACIAR has developed a survey form as a preliminary part of the assessment process for completed projects As well as being the first stage of assessing a completed project the survey provides a preliminary overview of a larger set of projects. The survey form seeks information on:

- Project title, project leaders, commodity/country focus, funding levels etc.
- Scientific and other publications related to the project.
- Indications of links to other research projects and efforts.
- Brief descriptions of the technologies or other useable outputs from the project

- Summaries of whether and how the technologies or other project outputs have been used in production activities and adoption patterns.
- Training aspects of the project activity—these may provide either a formal degree or less formal training in research methods etc.
- Increasing physical capacity such as supplementing equipment supplementation.
- Any relevant intellectual property rights of project outcomes.

3.4 Summary of current and past ACIAR postharvest research projects

As the preceding discussion has highlighted, there has been considerable evaluation of projects in ACIAR's postharvest program. To place them in perspective Table 9 lists all past and current postharvest projects. It also summarises the research area, type of evaluation activity if any and the summary internal rate of return.

Table 9. Summary of ACIAR's past and current postharvest research projects.

Project Description	Project Number	Type of Research	Type of Evaluation Return (%)	Internal Rate of
Long-Term Storage of Grain Under Plastic	8307/8845	Wastage	CPA	38
Drying in Bulk Storage	8308	Wastage	None	-
Moisture Movement in Grain	8310	Wastage	None	-
Drying of High Moisture Grain in Humid Tropical Climates	8608	Wastage	None	-
Integrated Pesticides in Grain Storage in Humid Tropics	8309/8311/8609	Wastage	CPA	43
Grain Quality	8314	Quality	None	-
Fungi and Mycotoxins in Asian Food and Feed Stuffs	8806/9104	Wastage/Health	Internal (FI)	ne
Vacuum Infiltration of Fruit with Calcium	8319	Wastage	CPA	21
Transport and Storage of Fresh Fruit	8354	Wastage	None	-
Postharvest Technologies for Bananas	8355	Wastage	CPA	48
Chemical Control of Fruit Diseases	8356	Wastage	CPA	41
Development of Postharvest Handling Technologies for Fruit	8844	Wastage	CPA	27
Outdoor Storage of Grain in Plastic	8845	Wastage	None	-
Improved Processing Systems for Dried Fish	8304/8313 /8846	Wastage/Health	External	ne
Multipurpose in Store Grain Drying	9008	Wastage	None	-
Increasing Efficacy of Pest Control and Pesticide Residues	9009	Wastage/Health	External	30
Integrating Grain Protectants into Storage Pest	9035	Wastage	None	-Management
Development of Heat Systems for Disinfectation in Tropical Fruit	9051	Wastage	None	-
Development of Simple Edible Coatings for Fruit and Vegetables	9105	Wastage	Internal (FI)	50
Multipurpose Instore Grain Dryers	9008	Wastage	External	17
Pesticides in Foodstuff	9309	Health	None	-
The Impact of Phosphine Exposure on the Quality of Stored Grains	9415	Wastage	Internal (PI)	ne
Tropical Fruit Storage and Life Extension	9313	Wastage	Internal (FI)	38
Managing Pests in Stored Grain	9321	Wastage	None	-

Replacements for Methyl Bromide in Timber	9406	Health	Internal (FI)	34
Pineapple Quality Improvement	9407	Quality	Internal (FI)	22
Minimal Processing of Leafy Vegetables	??	Quality	Internal (FI)	ne

CPA—Completed Project Assessment; ne—not estimated by assessment; Internal (FI)—full interaction with ACIAR; Internal (PI)—partial assessment & interaction with ACIAR; External—assessment by project group.

It is seen that the vast majority of projects have considered the issue of wastage reduction usually with respect to some aspect of storage. Of the 27 research projects or research areas 16 have included some form of economic evaluation activity. This represents about 60% of all projects.

The EEU is about to update some of the earlier completed project assessments. Two of these are in this postharvest group.

4. OVERVIEW

This paper has highlighted some of the features of the **Information System** that has been developed at ACIAR to support research decision-making. It has presented a sub-set of this information that illustrates some of the aspects likely to be important in developing project-level evaluations for postharvest research projects. It has highlighted a recent trend in the postharvest research program away from the high priority commodities, such as the major grains to other crops, especially tropical fruit. The question as to whether this might result in lower gains from this research effort was raised. Evaluation of projects that focus on other than high priority commodities suggest two points. First, although there are concrete examples of projects on lower priority commodities that should provide high returns, the returns do seem on average to be lower than for the high priority areas. Second, if the research results from projects on lower priority commodities are applicable across many commodities, then the cumulative impact can be similar to projects that focus on the single high priority commodities.

An overview of many of ACIAR's current and past postharvest research projects suggests that wastage reduction in the postharvest sector has received the most attention. However, public health issues and product quality have also been important. There is a need to further refine and adapt evaluation methodology to focus on these areas, some recent evaluation at ACIAR seem to have been the first attempts in this area.

In total ACIAR has evaluated between 50 and 60 (or about 20–25%) of its about 250 projects. A significant share of these have been in the postharvest area where about 60% of the projects have been evaluated in one form or another.

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