A DECISION SUPPORT SYSTEM TO ASSIST AGRICULTURAL RESEARCH PRIORITY SETTING : EXPERIENCE AT ACIAR AND POSSIBLE ADAPTATIONS FOR THE TAC/CGIAR

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Whilst our colleagues provided invaluable assistance, especially with the data compilations and scientific assessments of key parameters which are used in the paper, they are not responsible for the interpretations of these and the conclusions drawn. We must take the blame for any errors of commission or omission.

CONTENTS

1. INTRODUCTION

In 1984 ACIAR commenced development of a decision support system to assist with its research resource allocation decisions. Development of the system focussed on providing information to assist with priority setting. By 1987 a framework developed from available methodology had been adapted to suit decision-making in ACIAR. Davis, Oram and Ryan (1987) provide an outline of this framework plus some preliminary quantification of the type of information generated. Davis and Ryan (1988b) describe how this information has been adapted to support decision-making in ACIAR.

In this paper we summarise the important features of the framework, describe the type of information which it can generate, and how it can be used by international agricultural research institutions such as ACIAR and TAC/CGIAR.

The role of agricultural research in promoting agricultural and general economic development in developing countries in the first section of the paper, provides the background for a discussion of the importance of clear definition of research objectives in establishing research priorities in the second section. This is followed by an overview of the methodology and the data requirements to make it operational. Preliminary results from applications of the framework are then discussed, including the effects of specification of alternative regional and distributive objectives on research priorities, and the value of a comparison of current research portfolios with assessed priorities in making adjustments to research resource allocations. Some possible refinements to the framework as currently used in ACIAR which might facilitate the development of a decision support system for TAC/CGIAR are suggested in the penultimate section, prior to some concluding comments.

2. AGRICULTURAL RESEARCH, TECHNOLOGICAL CHANGE AND ECONOMIC GROWTH

In most developing countries, a strategy which emphasises agriculture is appropriate for achieving both economic growth and poverty alleviation. Agricultural research and technological change are key ingredients in strategies which emphasise agricultural and general economic growth in developing countries. The resulting increases in agricultural productivity have important macroeconomic consequences due to the significance of the agricultural sector in the economy.[1] The initial result of increased productivity is to increase incomes of landowning farmers. These farmers typically spend most additional incomes on food and the balance on locally produced, nonagricultural goods and services like textiles, transportation, health services and housing.[2] Production of these goods is generally more labour-intensive than in urban-based large-scale industries. As a

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1 These are elaborated in more detail in Mellor (1987), on which we have drawn in this section.

2 In the Muda irrigation scheme in Malaysia Alderman (1986) found that low-income families spent 88% of each additional Ringgit of income on food.

result of the increased incomes of landowning farmers, the rural poor are provided with more nonagricultural employment opportunities. This is in addition to the direct employment - creating effects which adoption of the new technologies by farmers generates.

The enhanced direct and indirect employment opportunities for the poor provides them with additional income which they in turn also spend significantly on food and nonagricultual goods. This generates strong multiplier effects which stimulate additional growth in the economy. Inexpensive food from increased production helps keep unit labour costs down, thereby also encouraging urban employment growth.

The importance of agricultural research and technological change to economic growth in developing countries is demonstrated by the high rates of returns on past research investments revealed in many ex post studies. The historically high rates of return to agricultural research suggest that current levels of research investment remain well below what they should be to fully exploit the opportunities for increased agricultural production and enhancement of economic development and human welfare.

Where technological change occurs in predominantly exported crops, cost reductions generate both increased foreign exchange earnings and increased incomes for producers, with little or no direct benefits to domestic consumers, unless the exporting country is a major contributor to world trade in the commodity. In such cases marked downward pressure on world prices can result. Lower prices are to the benefit of domestic and foreign consumers, who then share in the benefits of technological change - at the expense of producers. Where research spillovers to other producers of the same tradeable commodity are significant, the impact of national research on world prices can be more exaggerated, and hence the share of the economic benefits to consumers is increased even further.

Most ex post studies of research impacts have used closed economy approaches and ignored research spillover effects to other countries. It is hence not surprising that consumers are shown to have been the main beneficiaries. The framework described later in the paper allows for simple international market price transmission effects and research spillovers to be incorporated explicitly into the assessment of likely research benefits. In preliminary ex ante empirical applications (Davis, Oram and Ryan 1987, Davis and Ryan, 1987a and b) the shares of benefits to producers usually exceed those of consumers.

The precise distribution of research benefits where no research spillovers to other countries occur depends on whether the increased agricultural output in a country replaces food imports, is exported, or is added to the domestic food supply. If a considerable proportion of the additional output is exported or used to replace food imports - the latter being the case for wheat and rice in India and Pakistan during the initial phases of the green revolution - farmers are likely to obtain a relatively large share of the benefits. If, on the other hand, the additional output is added to prevailing domestic supplies and prices are permitted to fall to a new market equilibrium, consumers will share the benefits with producers, the proportions depending on the elasticities of supply and demand for the commodity and how cost-savings affect supply response.

In general, agricultural research and the technological changes which it generates have their comparative advantage in contributing to the economic growth objectives of governments. This is especially so in countries where the agricultural sector provides the bulk of the gross national product, export income and employment, as is the case in most developing countries. Due to the constraints which nature imposes on scientists' ability to predict research outcomes with assurance, the complex interactions in commodity and input markets, and the difficulties of attainment of several research objectives simultaneously, agricultural research is a much less effective direct instrument of social policy.

Often social objectives can only be satisfied directly by suitably guiding agricultural research, if one is prepared to sacrifice considerable economic growth in the process. A good example of this is the trade-off CIMMYT has made in improving the yield potential of maize because of its strategy to enhance lysine content by incorporation of the "opaque-2" gene into improved cultivars. The latter strategy was founded on the laudable objective of improving the protein quality and content of maize so that nutritional deficiencies of people who relied on maize as a staple food could be alleviated. Unfortunately, after more than 25 years of research, commercially attractive cultivars with high quality protein are still to be widely adopted, although CIMMYT released new cultivars several years ago. The opportunity cost has been (i) the diversion of research resources into the quality protein breeding program at the expense of other objectives, including the enhancement of yield potential, and (ii) the general inverse relationship between protein content and crop yield. Nutritional well-being can be improved more effectively by yield-oriented breeding strategies.

Agricultural research, which has as its ultimate objective the enhancement of the productivity of the most limiting resources used for commodity production and/or in post-harvest activities, should have its priorities established by reference to where the prospects for achieving those productivity gains are best. Cost-reducing technological changes arising from such targeted research have the best potential to increase the economic pie and other, more effective policy instruments can then be utilised to distribute the larger pie in line with national redistribution goals.

Acceptance of the proposition that agricultural research is primarily an engine of economic growth and that the economic benefits of research are largely transmitted through the impact of research on costs of production of agricultural commodities, has a clear implication for priority assessment.[3] That is that research resources should be allocated as far as possible using criteria which reflect the potential of the research to generate maximum economic benefits. In this way objectives of the CGIAR such as food self-reliance can be most effectively achieved. To assess this requires that the commodities which are expected to have their costs

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[3] Production research largely affects costs of production, whereas post-harvest research can affect costs of production and/or derived demand as a result of product transformation.

of production and/or derived demands most affected by the research, should form the basis of any methodology developed for determining agricultural research priorities. Whether we are comparing research on soil science with plant breeding, or entomology with weed science, all will potentially impact on commodity productivity and hence costs of production (or derived demands) in the near- or long-term. It is in this commodity context that their relative worth ultimately should be assessed for the purposes of allocating scarce research resources. A framework which has been developed for this purpose, and how it relates to the formulation, implementation and review of agricultural research policy will be discussed in the following sections.

3. DEFINING CGIAR RESEARCH OBJECTIVES AND ESTABLISHING PRIORITIES

The choice of appropriate priority assessment procedures depends upon the objectives of the research institution one is dealing with. These objectives generally depend on whether the research organisation is operating at a primary or secondary level. The TAC/CGIAR would be regarded as a primary international research organisation, in the terms of Davis and Ryan (1988a). Its research resource allocation concerns relate to issues such as the appropriate regional and commodity balances, the relative emphasis on basic/strategic/applied/adaptive research, and the priority to be accorded to short- versus long-run outcomes.

Accepting that the attainment of food self-reliance in developing countries is the pre-eminent objective of the CGIAR system means that TAC can consider which food or non-food commodities can best contribute to that objective in allocating its scarce research resources. Dropping food self-sufficiency in each and every developing country as the operative objective in favour of food self-reliance allows the CGIAR to entertain research on non-food crops, which might generate sufficiently large new income streams to poor producers and consumers to enable them to satisfy all their food and nutritional needs, where research on the food crops themselves may not.

As agricultural research generates economic benefits to society primarily by way of its impact on the cost of producing and/or marketing commodities, it is appropriate that the choice of commodity research portfolios is one of the most critical decisions for primary research organisations such as the TAC/CGIAR. Such choices of necessity must be made jointly with decisions about the regional focus of research activities, given that agroecological and socioeconomic characteristics of regions largely define the set of feasible commodity research portfolios.

In subsequent sections we focus on decisions related to the ex ante choice of alternative commodity and regional research portfolios at the research policy implementation stage, which generally involves a primary research organisation like the TAC/CGIAR. A framework is described in the next section which has relevance for international, regional and national research agencies. It contrasts with approaches which employ multiattribute scoring models with subjective weights (Anderson and Parton, 1983), congruence techniques (Boyce and Evenson, 1975), domestic resource cost analysis (Longmire and Winkelmann, 1985) and those with eclectic approaches as described in Davis, Oram and Ryan (1987, p.11). Its use requires decision-makers to specify the precise objectives of agricultural

research from which commodity and regional research portfolios which best achieve these objectives can be identified.

4. THE NATURE OF THE APPROACH

After reviewing the literature, it was decided to use the producer-consumer surplus approach to measure the scope for research to contribute to welfare maximisation or redistribution objectives. This has the advantage of allowing comparisons to be made among commodities with different attributes, using the potential gross welfare benefits of research resulting from a shift of the supply curve to the right as an indicator of the priority which ought to be accorded to it (Figure 1). These benefits are generated by the reduction in output prices for the commodity (including those such as rice and rubber which cannot be compared by other measures such as nutritional value, area cultivated, etc.); while at the same time providing a measure of the distribution of those benefits between producers and consumers, both domestic and international. Moreover, it has already been shown to be a useful tool for evaluative purposes in previous work related to research benefits in Australia, Brazil, and the United States.

It is important to note here that in the current empirical application the framework will not indicate the distribution of benefits among individual components of the two broad groups of producers (small farmers, landless, women, etc.) and consumers (rich, poor), although it can be refined to do this if data permit. This will be discussed later in the paper. It is thus a means of allocating research resources to attempt to maximise the total size of new income streams which might result, although by using judgements as to the nature of commodity supply and demand, a general assessment of the probable distributive benefits of research can be also inferred.

For an organisation such as the CGIAR, an important consideration in deciding its priorities is not simply to assess the benefits which might accrue to a country with which the CGIAR Centres are collaborating in a specific research project, but also how widely those benefits might be distributed globally to other countries, particularly developing countries, thus achieving a multiplier effect from use of CGIAR resources. For this the closed economy single country producer-consumer surplus model described in Figure 1 is insufficient. It was therefore decided to utilise a more comprehensive model which would also give some indication of the potential 'spillover' benefits to other countries of research undertaken in a specific environment with international assistance. This has three advantages: First, it can provide a broader measure of payoff, even for an individual research project, to decide if it is worthwhile; second, it allows a more balanced assessment to be made among commodities competing for the CGIAR's and other donors' research resources on a global basis; third, it could indicate whether a research effort focused on an individual country, or through developing a network linking a number of countries with similar needs, would be more productive. This is particularly important for commodities which are outside the mainstream of international research institutions, such as cotton, coconuts, sugar, bananas and plantains, and small livestock; as well as for ecological regions including many small countries such as the South Pacific, the Caribbean, and Central America.

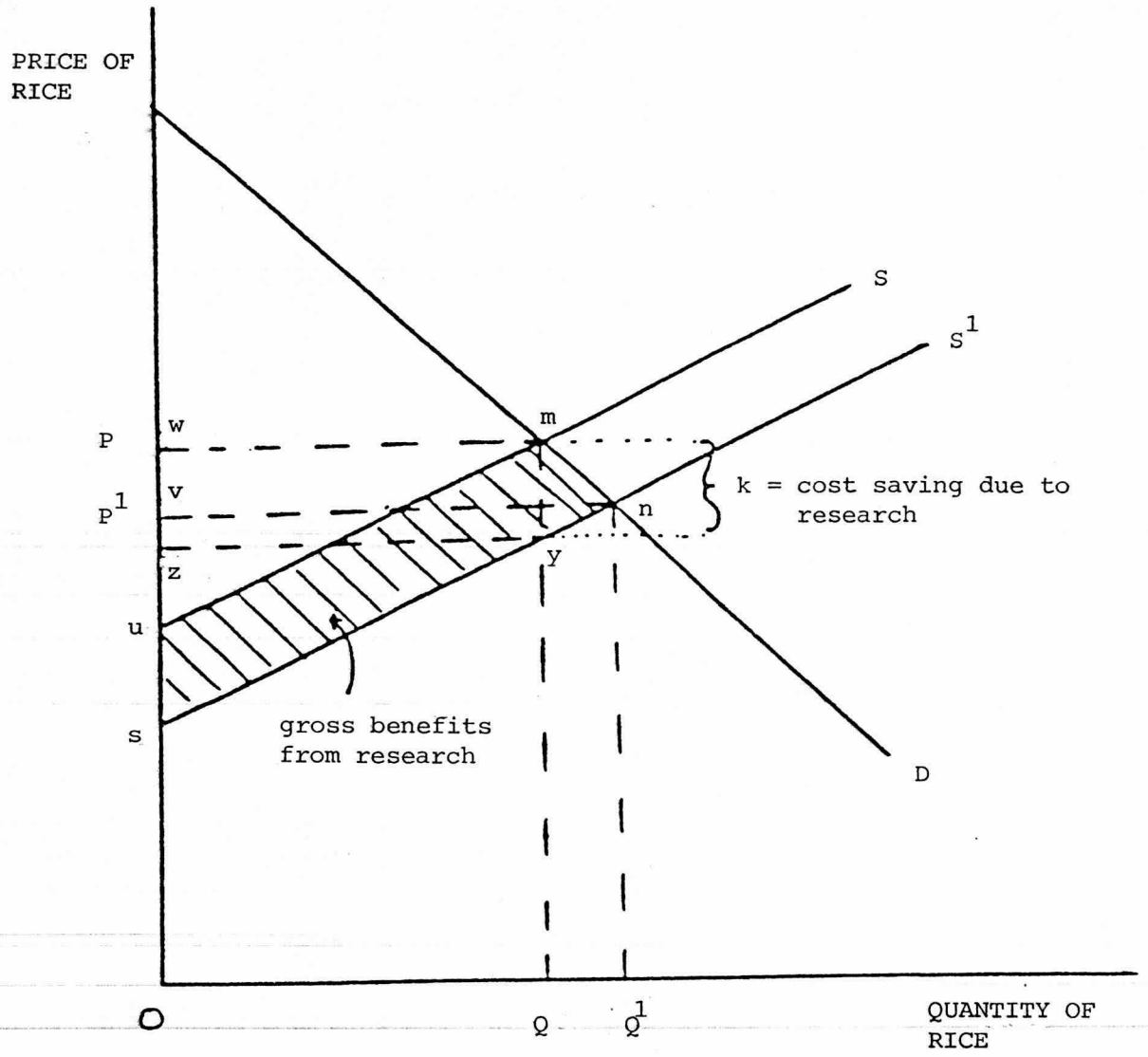

FIGURE 1 Measuring the Economic Surplus Generated by Agricultural Research

Coincidentally, these also tend to have economies heavily dependent on some of the commodities mentioned above.

Spillover effects of research can stem from two sources:

i. The applicability/transferability of research results among similar production environments in different countries;

ii. the effect adoption of research results may have on commodity production and world prices.

In developing countries national governments may ignore these spillover effects and make research investment decisions only on the basis of likely national benefits, which would be perfectly rational on their part. International organisations such as ACIAR and the CGIAR have presumably been established with a view to taking both national and international benefits into account when funding agricultural research. The foregoing framework can be extended to provide estimates of these global benefits, their distribution between countries, and also among groups within these countries.

Davis, Oram and Ryan (1987) describe in detail their adaptation of the Edwards and Freebairn (1984) methodology to enable intercountry or interregional (intracountry) spillover effects to be explicitly incorporated into an ex ante analysis of aggregate commodity and regional priorities in agricultural research, using the concepts of economic surplus couched in an international trade model. The Davis, Oram and Ryan framework allows differential probabilities of research success and ceiling adoption levels amongst commodities and regions to condition the expected economic benefits from alternative strategies and the distribution of these benefits among consumers, producers, importers and exporters.

International research support, whether bilateral, regional or multilateral, can be designed with the aid of the framework described, both to complement national research activities and in addition to generate maximum international or regional benefits, rather than just individual national research benefits. National research priorities also can be established with the framework by using the concept of regional homologues to make research more cost effective. This can be achieved when selecting research portfolios by explicitly considering the likely extent of spillover benefits among countries or among regions within a country having similar production and socioeconomic environments[4].

The model assumes that research on an agricultural commodity generates economic benefits by lowering costs of production of the (export) commodity of interest by k_{aa} (Figure 2(a)). This causes the supply schedule to shift down to the right from S_a to S'_a. If the research also has

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[4] ACIAR has collaborative country studies underway in the Philippines, Thailand and Papua New Guinea which are refining and institutionalising the framework for use at the national level and is cooperating with ISNAR in a similar study in Indonesia.

relevance in an importing country (B), with a suitable lag it can be expected to lead to a lowering of costs of production in that country also, shown as k_{ba} (Figure 2(c)). The combined effects of the direct cost reduction k_{aa} on the economic welfare of producers and consumers of the commodity in both the exporting and importing countries is shown by the shaded areas in Figure 2.

Formulae have been developed to measure the shaded areas and these have been converted into a Fortran computer program adapted for use on an IBM AT microcomputer.[5] These measures assume that supply shifts resulting from research impact neither on prices of other commodities or services, nor macroeconomic variables such as exchange rates and employment. World price effects are accommodated for the commodity experiencing technological change, however linear demand and supply schedules are assumed along with parallel supply shifts resulting from research. The current set of results assume static demand and abstract from the distortions caused by government taxes and subsidies.

The approach to the assessment of agricultural research priorities described offers no panacea to policy makers. However, to international or national agencies concerned with the allocation of scarce research resources, it does offer a means of collapsing the multifarious criteria which have been cited in support of particular decisions into a consistent framework. By being able to array the efficiency and equity trade-offs which might be involved in the choice of particular commodity and regional portfolios, policy makers can be better equipped to rationalise their choices with the declared objectives of agricultural research policy.

While the model as developed can be used to take account of more detailed distributive effects, to achieve this is likely to be demanding in terms of information and computational requirements. What the information generated by an aggregative application of the model can highlight is the potentially high opportunity costs of using research policy to achieve distributive objectives, and also the complexity of this area. Scoring models do not in general offer such insights and also suffer from the same disadvantages when disaggregation of distributive effects is required.

The framework does not replace scientific judgements of experienced researchers and administrators. Indeed their input is required in order to assess likely research spillovers, probabilities of research success, ceiling adoption levels, and research and adoption lags from alternative portfolios. Initial commodity and regional priorities assessed using the suggested framework "from the top down", should be continuously modified in the light of the experience of scientists working with extension staff and farmers "from the bottom up" (Figure 3).

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5 The formulae and associated program will not be repeated here. Instead readers are referred to the Davis, Oram and Ryan monograph (1987).

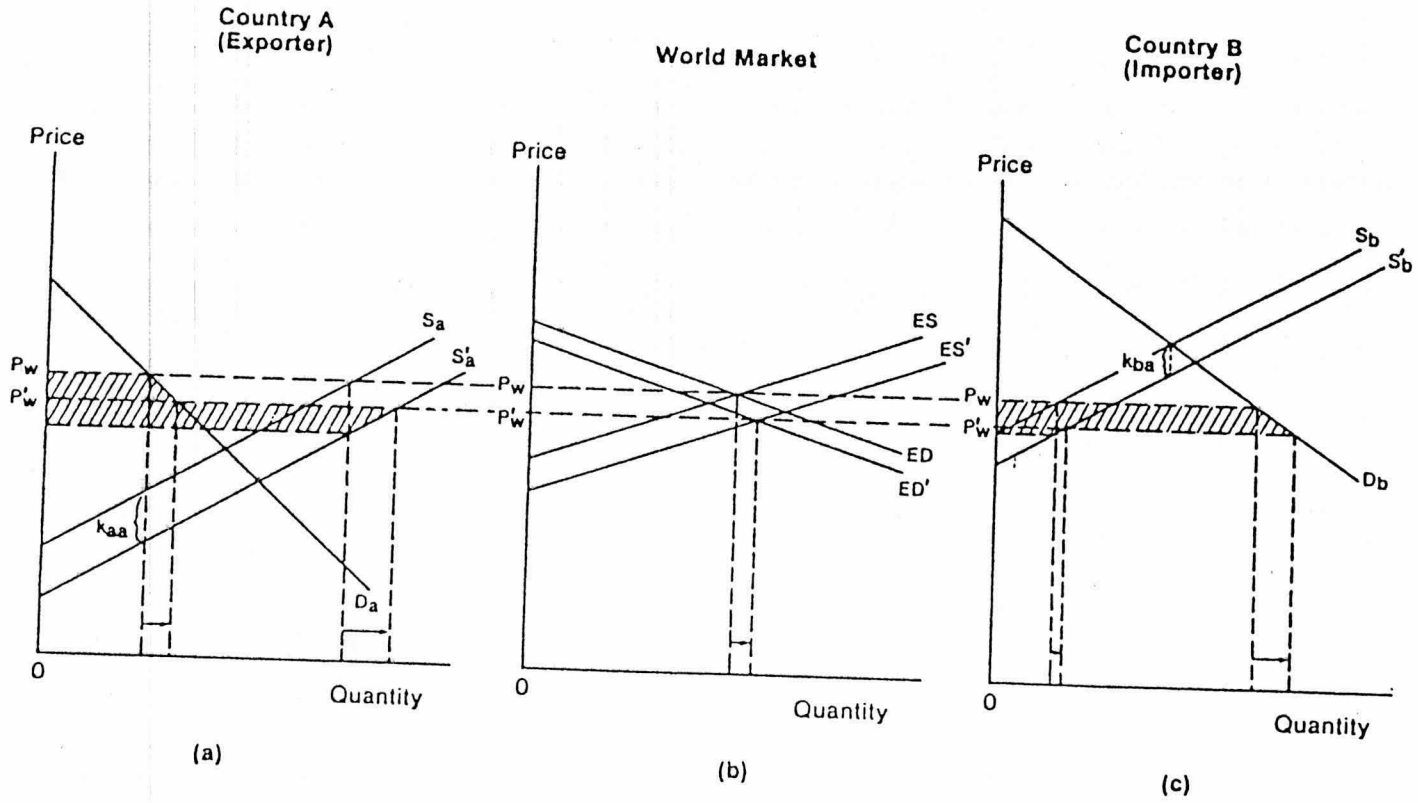

FIGURE 2. Two Country Diagrammatical Representation of the Model.

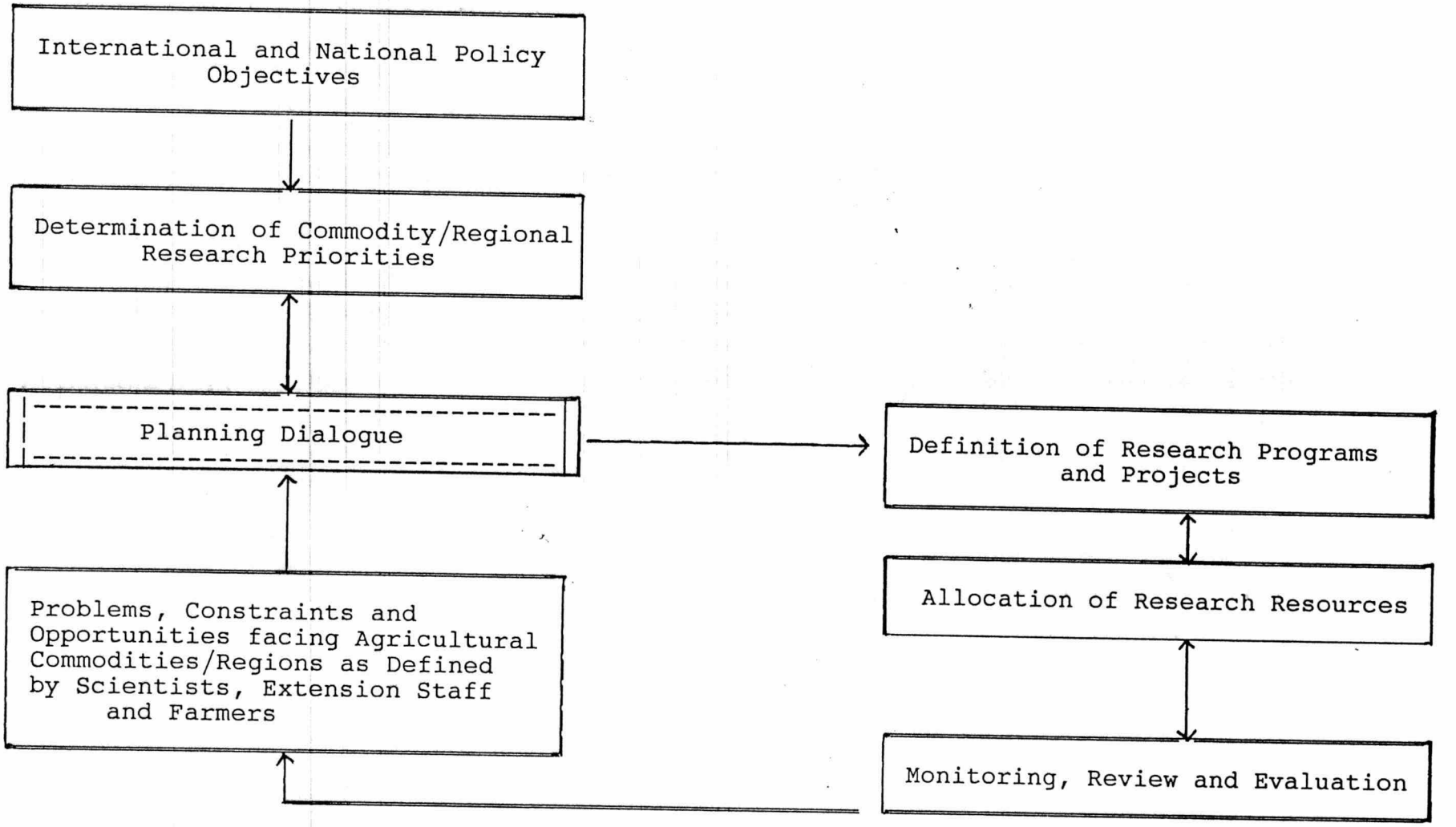

Figure 3 Intersection of International and National Policy Objectives and Research Opportunities

5. DATA REQUIRED TO QUANTIFY OBJECTIVE MEASURES AND ASSIST PRIORITY SETTING

Several types of information are required to implement the framework:

(i) Data on production and consumption of the commodities of interest, apportioned among countries and production environments within them. Ideally these data should relate to those expected to maintain at the time research begins to lead to adoption of resulting technology options by farmers, rather than to current levels.

(ii) Assessments of the likelihood that research on each candidate commodity will generate results that spillover into countries with similar production environments[6].

(iii) Assessments of the relative strengths of national agricultural research systems (NARS), and transforming them into probabilities of research success for each commodity in each country. These are estimated subjectively taking account of the numbers of qualified scientists undertaking research in the respective NARS and the financial resources NARS provide to them. An attempt is made to differentiate between the ability of the various NARS to conduct strategic or originating research, and their ability to conduct adaptive research.

(iv) Estimates of the likely ceiling levels of adoption of technology options emanating from research are subjectively assessed at the country and commodity levels. Variables thought to influence ceiling adoption include the extent of rural infrastructure such as roads, fertiliser consumption etc.

(v) Research lags between the initiation of research and the availability of adoptable technology options for farmers were assumed to be eight years for all commodities, with a three year adoption lag before adoption reaches ceiling levels following research in originating countries. In third countries a further

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6 The notion of research spillovers is a complex issue. The nature of the research undertaken will have an important impact on the potential spillovers. 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 locations. The spillovers used in this study refer to the means of the likely spillovers from an array of research for each set of production environments and each commodity. If the spillover distribution is felt to be multi-modal then it may be necessary to develop several spillover matrices for each type of research envisaged. Appendix A contains a detailed description of the methodology developed to evaluate research spillovers. It has been taken from Davis, McKenney and Turnbull (1989).

period of four years was assumed to be required for adaptive research to be completed to enable spillover effects to be captured (see Appendix B).

After the three year adoption lag in the current analysis it was assumed adoption would instantaneously reach assessed ceiling levels in each case. We are in the process of refining the adoption lags to better reflect the influence of variations in the extent and quality of extension systems among developing countries, and climatic influences. This will allow us to specify simple linear approximations to the standard sigmoid adoption curves asymptotic to the respective ceiling levels. These linear functions will approach the estimated ceiling adoption levels more rapidly for countries with strong extension networks and more slowly for those with weaker systems.

(vi) The social rate of discount chosen for the analysis so far 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 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 among commodities and regions, only absolute sizes of economic surplus estimates will be affected by this assumption and not the relativities, which are of primary interest. Clearly, once lags and other parameters are allowed to vary among commodities, choice of this parameter takes on increased importance.

(vii) The prices of commodities are important inputs into the analysis as they may affect the size of the unit-cost reduction resulting from successful productivity-enhancing research. The estimation of the likely economic benefits from alternative commodity and regional research portfolios is first done by assuming each commodity has a standard 5 per cent reduction in its costs of production per tonne[7].

Ideally one would prefer to use world equilibrium prices to estimate the economic benefits of successful research, whether these accrue to exporters, importers, or those countries which are self-sufficient in the commodities concerned. The appropriate prices would refer to those expected to maintain (in the absence of the international research proposed) when adoption begins after the eight- (for originators) or twelve- (for adapters) year

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7 This can be varied subsequently based upon scientific judgement and intuition where it is felt some commodities and/or zones have better or worse research potentials than others. Recall however that other variables such as probabilities of research success and research spillovers further condition the 5 per cent figure, so that in effect some allowances are already made.

research lags have elapsed[8] . In practice it has been found difficult to obtain such figures for a comprehensive list of commodities, and for non-tradeable commodities such as yams, some pulses and sweet potato it is virtually impossible to establish a world price, even for current production (see Appendix C). The analysis for now relies on a mixture of projected world prices for selected tradeable commodities as published by the World Bank (for 1995 only) and current prices where the Bank has not made projections. For non-tradeables, current prices in major producing countries in each region are used. In future analyses it is planned to use current prices, averaged over three years. To assess the sensitivity of assessed commodity and regional priorities to changes in relative prices, it is also proposed to conduct the analyses using average prices that reigned 10 and 20 years ago.

(viii) Estimates of the price elasticities of supply and demand for each commodity in each country and/or zone are required if one is particularly interested in measuring the distributive consequences of alternative commodity and regional research portfolios. Estimates of the aggregate economic benefits are not very sensitive to variations in the assumptions about price elasticities of supply and demand.

Price elasticity data are much less widely available than those on income elasticities, and even though we have tapped FAO, the World Bank, USDA, and a wide range of miscellaneous publications, there are still important gaps. Again these mainly affect tropical food crops, particularly those which are not internationally traded, although for others such as oilseeds, price elasticities of supply exist only in aggregate and not for individual oilseed commodities.

The above eight sets of data provide the inputs into the framework, which estimates the expected economic surplus from alternative commodity and regional research portfolios, and their distribution amongst producers and consumers. As stated earlier, the formulae required for this are described in Davis, Oram and Ryan (1987) and will not be repeated here[9]. The formulae essentially estimate the shaded areas in Figure 2.

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8 Price estimates are important only if it is contended that unit-cost reductions achievable by research on different commodities are directly related to their prices. If scientists can assess likely unit-cost reductions independently of prices, then the actual prices used in the model will have a minimal effect on the estimates of economic surplus. Production and consumption levels will continue to exert a major influence.

9 Note though that significant refinements to the framework described in Davis, Oram and Ryan (1987) have been and are continuing to be made.

We will now proceed to illustrate the type of output which emerges from the application of the above framework for 23 agricultural commodities and eight forestry products. We emphasise the results presented are preliminary, and that revised estimates will soon be available incorporating some of the refinements alluded to earlier in this section. Peter Oram was responsible for providing most of the empirical data and subjective estimates for the agricultural commodities. John Turnbull and Dan McKenney provided the equivalent information for forestry.

6. SOME PRELIMINARY RESULTS AND THEIR USE TO ASSIST DECISION-MAKERS

In this section we wish to illustrate the type of information which can be generated by applying the framework. We first examine the implications for priority choices of a regional versus a global perspective. A discussion of the likely trade-offs which might be implied by incorporation of specific distributive objectives into research portfolio choices then follows, with examples of how the framework can be used to elicit these. A suggested means of operationalising the framework within an international research organisation such as ACIAR is presented in the final segment. It includes a comparison of commodity priorities and budget shares.

6.1 Research Priorities with a Regional Benefit Maximisation Objective

Table 1 presents some results from an analysis which ranks the 31 commodities, including food and non-food crops, livestock and forestry products, according to the size of their expected impact on the incomes of producers and consumers of those commodities (ie. economic surplus) in five geographic regions[10]. They have been estimated assuming research on each has the potential to cause a 5% reduction in the unit costs of production of each commodity. After adjusting this for subjectively assessed probabilities of success, ceiling adoption levels and spillovers to other countries using the Davis, Oram and Ryan framework, an assessment of the relative expected economic surplus to producers and consumers from research in each particular region is arrived at[11].

The allocation of each commodity to a particular priority group in Table 1 is based on the present value of the expected economic surplus from research on that commodity relative to the commodity with the highest expected economic surplus for that region. For example in South East Asia,

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10 These five regions have been identified as of functional importance to ACIAR in its priority assessment activities. Any suitable aggregation of countries can be accommodated to suit the needs of users. These five are used here for convenience only.

11 Note that the methods used to estimate the spillover matrices for the eight forestry products in Table 1 are somewhat different to those used for the agricultural commodities. Hence the estimates for the two groups are not strictly comparable and are used here only for illustrative purposes. We are in the process of standardising the spillover estimations for agricultural commodities to the same basis as forestry products, as described in Appendix A.

rice is expected to provide the largest surplus. If expected total rice surplus is divided by the surplus for each of the other commodities, an indication of the relative size of break-even unit-cost reductions before the economic surplus generated from other commodities equals that from the numeraire commodity (rice) is derived. This information is given in the third column for each region in Table 1. It was used to allocate each commodity to a research priority grouping using the following classification:[12]

Grouping		Range of Break-even Relative Unit-cost Reductions
I	Highest	1 to 5
II	High	>6 to 7
III	Moderate	>8 to 15
IV	Modest	>16 to 25
V	Low	>26 to 40
VI	Lowest	>40

The relativities in Table 1 can be interpreted in the following way: for South East Asia, groundnut research has a relative benefit entry of 87. This means that for groundnut research to produce the same expected regional economic surplus as rice research, it would have to have 87 times the cost-reducing effect as any possible rice research. This information can be useful in focussing research resource allocation discussions on issues such as the likelihood that research opportunities for groundnut are indeed far better than they are for rice. This type of discussion should be presumably the major preoccupation of bodies such as ACIAR's PAC/BOM and the CGIAR's TAC. Information like that contained in Table 1 can guide these discussions in ways that capitalise on the combined scientific wisdom and judgement of such bodies.

The relativities in Table 1 should not be regarded as anything but indicators of the likely opportunity costs of alternative commodity portfolios within each region for an organisation like the CGIAR. The opportunity costs in this instance represent the likely ability to contribute to food self-reliance in an aggregate, country-wide sense, using the size of expected new income streams resulting from research as a proxy for the ability to gain access to needed food. At this point we do not attempt to specify the extent to which the poor in developing countries share in any enhanced food self-reliance at the regional (or country)

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12 In future we plan to modify the grouping accordingly:

Grouping	Range of Break-even Relative Unit-cost Reductions
I	1 to 10
II	11 to 20
III	21 to 40
IV	41 to 80
V	81 to 160
VI	>160

TABLE 1: Preliminary Regional Commodity Priority Groupings Using as Objective the Maximization of Regional Economic Benefits

SOUTH EAST ASIA			SOUTH ASIA			CHINA			S.PACIFIC &PNG			AFRICA		
Priority Grouping	Commodity Ranking	Break-even Relativity	Priority Grouping	Commodity Ranking	Break-even Relativity	Priority Grouping	Commodity Ranking	Break-even Relativity	Priority Grouping	Commodity Ranking	Break-even Relativity	Priority Grouping	Commodity Ranking	Break-even Relativity
I	Rice	1.0	I	Rice	1.0	I	Rice	1.0	I	Sugar	1.0	I	Fuelwood NC	1.0
	Fuelwood NC	2.6		Wheat	3.7		Potato	2.8		Banana/plantain	1.6		Cassava	1.4
	Saw & Ven NC	3.3		Pulses	4.0		Sweet potato	4.6		Fuelwood NC	3.9		Banana/plantain	2.0
	Palm-total	4.8		Fuelwood NC	4.0					Coconut	4.3		Milk	3.4
				Sugar	4.2								Beef & buffalo	3.4
II	Coconut	5.4				III	Wheat	8.5	II	Coffee	5.3		Rice	3.6
	Banana/plantain	7.6	II	Milk	5.7		Fuelwood NC	10.2		Saw & Ven NC	5.3		Cocoa	4.4
							Pulses	10.3						
III	Sugar	10.8	III	Sorghum	7.8		Saw & Ven Con	13.9	III	Sweet potato	7.7	II	Palm-total	5.5
	Cassava	11.3		Potato	9.4		Fuelwood Con	14.9		Cocoa	7.7		Sheep/goat meat	5.5
				Sheep/goat meat	12.6					Palm-total	10.6			
IV	Maize	15.4				IV	Soybean	16.4				III	Charcoal	7.0
	Sweet potato	18.8	IV	Groundnut	18.6		Saw & Ven NC	22.4					Pulses	7.1
	Coffee	20.8		Banana/plantain	22.8		Maize	25.0					Sorghum	7.4
				Maize	23.4				VI	Saw & Ven Con	42.5		Maize	7.9
V	Pulses	29.6		Coconut	24.5	V	Sugar	31.0		Cassava	42.5		Millet	8.0
	Rubber	34.1		Millet	25.7		Sorghum	36.6		Pulpwood	85.0		Coffee	8.5
	Beef & buffalo	34.8					Other Ind R Wd	37.5		Pitprops	0.0		Saw & Ven NC	9.0
	Potato	39.8	V	Oranges	28.3					Sorghum	0.0		Sugar	9.4
				Saw & Ven NC	28.6	VI	Milk	46.1		Other Ind R Wd	0.0		Groundnut	10.1
VI	Other Ind R Wd	59.7					Sheep/goat meat	50.2		Soybean	0.0			
	Soybean	70.2	VI	Cassava	41.3		Groundnut	53.4		Millet	0.0	IV	Sweet potato	16.8
	Groundnut	87.4		Wool	50.5		Wool	54.4		Maize	0.0		Other Ind R Wd	17.8
	Oranges	91.8		Beef & buffalo	56.5		Millet	57.6		Milk	0.0		Potato	22.7
	Milk	105.4		Sweet potato	57.2		Pitprops	93.9		Groundnut	0.0		Wool	23.5
	Charcoal	115.5		Coffee	83.9		Beef & buffalo	153.2		Rice	0.0			
	Sheep/goat meat	137.8		Soybean	100.0		Oranges	184.4		Wheat	0.0	V	Wheat	36.5
	Cocoa	188.5		Fuelwood Con	136.9		Cassava	223.8		Sheep/goat meat	0.0			
	Millet	255.9		Charcoal	136.9		Pulpwood	226.3		Wool	0.0	VI	Coconut	41.1
	Saw & Ven Con	275.5		Saw & Ven Con	173.4		Palm-total	262.1		Potato	0.0		Soybean	43.8
	Pulpwood	298.5		Other Ind R Wd	200.0		Rubber	538.3		Charcoal	0.0		Rubber	73.0
	Sorghum	398.0		Rubber	226.1		Banana/plantain	538.3		Rubber	0.0		Fuelwood Con	73.0
	Wheat	398.0		Pulpwood	743.0		Coffee	1991.6		Pulses	0.0		Saw & Ven Con	73.0
	Pitprops	0.0		Pitprops	866.8		Charcoal	0.0		Oranges	0.0		Pulpwood	164.3
	Wool	0.0		Palm-total	0.0		Cocoa	0.0		Fuelwood Con	0.0		Oranges	164.3
	Fuelwood Con	0.0		Cocoa	0.0		Coconut	0.0		Beef & buffalo	0.0		Pitprops	0.0
Regional Relativity		6			4			1			234			30

levels. How this can be done will be alluded to in a later section. The framework is equipped to handle this if the data disaggregation required is up to the task.

For South East Asia, Table 1 suggests that rice, non-coniferous fuelwood, non-coniferous saw and veneer logs, and oil palm are the highest priority commodities for research. On the other hand, sorghum, wheat, pitprops, wool and coniferous fuelwood are among the lowest priority commodities. All commodities in Groups I and II can be regarded as high priority, those in Groups III and IV medium priority, and those in Groups V to VII low priority. Clearly research on commodities in the lower groups would have to be expected to generate substantially higher productivity gains than higher priority commodities to justify funding, if the major objective is to maximise the contributions international research makes to economic growth and food self-reliance in developing countries in these geographical regions.

Commodity priority groupings such as these can be used in a number of ways. If an economic growth or self-reliance objective is confirmed as appropriate, then a table such as Table 1 might be adopted as a policy guideline for the development of new research initiatives. Any initiatives which consider research issues associated with low priority commodities would be required to provide documentation of the reasons why considerably larger cost-reduction (productivity) effects can be expected. Thus funding of low priority commodity research would not be precluded but would require ample justification. This is how we attempt to use such information in ACIAR.

Non-coniferous fuelwood is seen to have good prospects of contributing to a food self-reliance objective, even when compared with agricultural commodities. It appears to be a high priority research commodity in all regions except China, with the qualification that the forestry results may not be strictly comparable with those for agricultural commodities, for the reasons given in footnote 11. With China, however, the regional relativities need to be kept in mind (that is, the last row in Table 1)[13]. Although non-coniferous fuelwood is a medium priority (group III) in China, the absolute size of its expected economic surplus would place it near the top of the high priority list in all other regions. For example $10.2 \div 6 = 1.7$ 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 economic surplus to be comparable with high priority commodities in other regions.

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[13] The relativities of 6 in South East Asia and 1 in China imply that the absolute ($) size of the expected economic surplus from research on the highest priority (or numeraire) commodity (rice) in China is six times that from the numeraire commodity in South East Asia (also rice). Hence regions also can be compared in Table 1 by multiplying the commodity relativity by its respective regional relativity (China in this case), and then dividing by the relativity of the region one is comparing.

On observing information such as that in Table 1 many are often tempted to jump to the conclusion that all research funds should be allocated to rice research in China. Such a conclusion might be justified if some of the underlying simplifying assumptions are ignored; for example, that research on all commodities costs about the same and results in a 5 per cent unit cost reduction; also than an unlimited or at least a large number of such projects can be identified at any point in time and that research personnel and facilities are available to undertake the research.

A number of studies in the research evaluation literature have attempted to address this type of issue by collecting detailed information on all possible research projects for all commodities. Armed with this information, relatively sophisticated optimisation models have been developed and used to attempt to identify optimal research portfolios. As far as these authors are aware most of these studies have required substantial amounts of information and very complex mathematical models to achieve results. In all situations the resultant information system has been too demanding and complex to be adopted routinely as an aid to decision-making. In many cases these analyses have attempted to replace the decision-makers with these models rather than generate information which is one input into their decision-making processes.

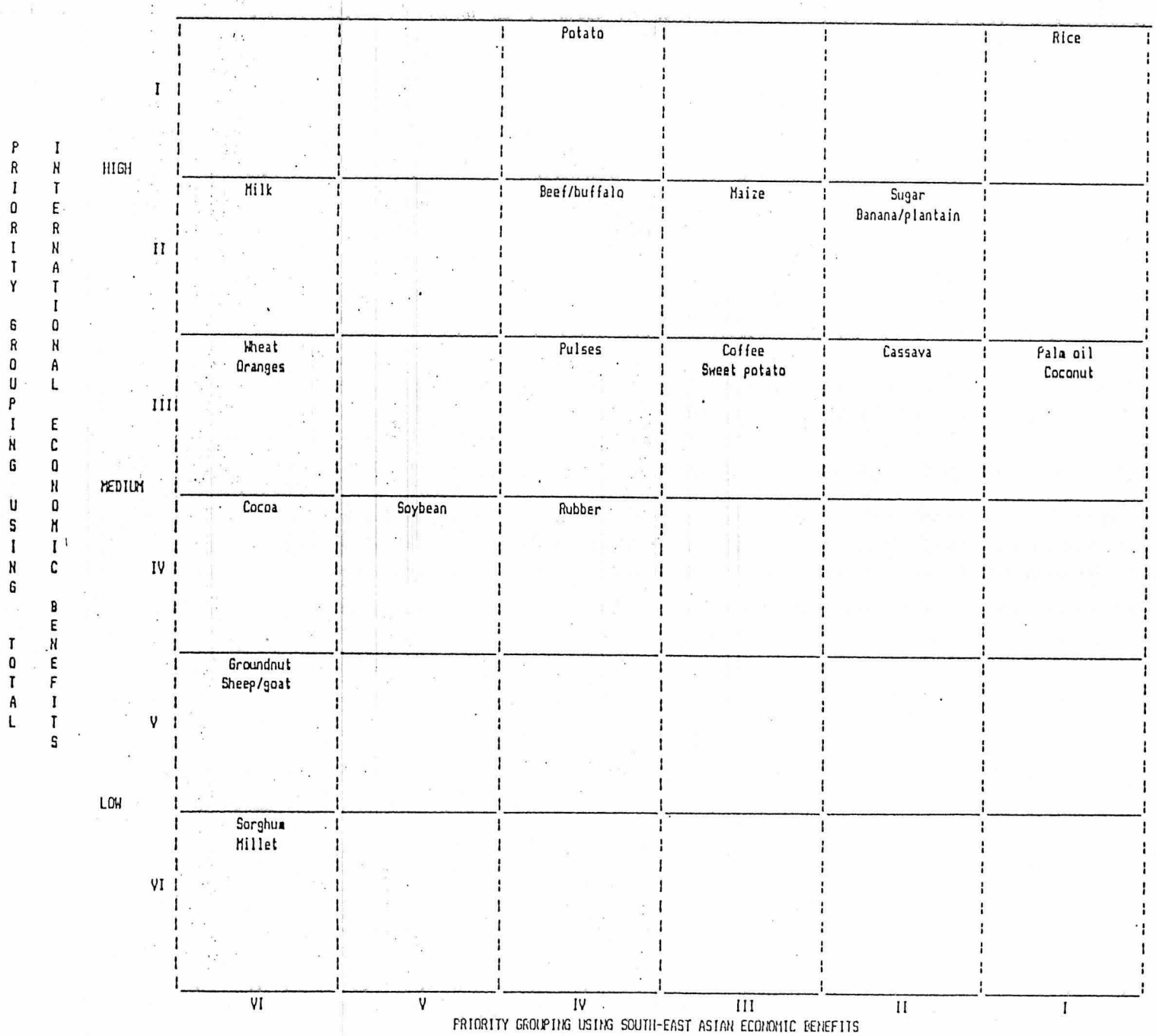
It is contended here that what is required is a set of summary indicators which attempt to alert decision-makers to possible lower benefit trends in research funding, rather than attempting to determine fine-tuned research portfolios. Such indicators may well suggest that closer analyses of certain research proposals or areas is appropriate, rather than detailed analysis of all of these.

Inspection of Table 1 indicates that, although some commodities such as rice and non-coniferous fuelwood are considered to be high priority research commodities for most of the five regions, there is considerable regional variability for most of the commodities. If maximising the total international economic surplus from research (including all developing and developed countries) is the important research policy objective rather than maximising each individual developing region's surplus, a somewhat different commodity ranking emerges.

Using the results of the analysis conducted for the 23 agricultural commodities, it is possible to construct commodity priority groups for a number of institutional objectives. Table 2 provides for South East Asia an illustration of the sensitivity of groupings to the choice of the objective. It illustrates the importance of a clear definition of the CGIAR's objectives as part of its decision-making process.

In Table 2 the South East Asian commodity priority groupings based on potential economic surplus contribution accruing to that region are listed as high (I) to low (VI) in the columns from right to left on the horizontal axis. Thus rice, oil palm and coconuts are expected to generate the largest economic payoffs to South East Asia, and milk, wheat etc. the least. These priority groupings are taken from Table 1. On the vertical axis and rows corresponding to those are listed the commodity priority groupings if the objective was considered to be maximisation of total

TABLE 2 The Congruence Between Commodity Priorities Assessed on an International Versus a Regional Perspective



international economic surplus emanating from international research investments. From the international perspective potato and rice are now the highest priority commodities, with sorghum and millet the lowest.

This tabular presentation has the advantage of revealing at a glance those commodities which have similar priority rankings using either objective. Commodities in the cells along the northwest diagonal, sloping upward from left to right, have this feature. Thus research on rice, sugar, banana/plantain, coffee, sweet potato, rubber, sorghum and millet are ranked the same regardless of which objective is used. The further away from the diagonal a commodity is, the greater the conflict in satisfying both objectives. For example, research on potato and milk are expected to generate relatively large international benefits, but make a small (relative) contribution to economic growth in South East Asia. If both objectives are important, then trade-offs will have to be made by decision makers before these commodities can be allocated a high or low priority status.

Once this important choice of the appropriate objective or set of objectives has been finalised, it is possible to use priority groupings as part of an information system to assist decision-making.

6.2 Research Priorities with Distributive Objectives

As has been mentioned earlier and briefly discussed in Davis and Ryan (1987a), using research investment strategies to achieve income redistribution objectives is a complex issue and it is not difficult to demonstrate in many situations that research funding is an inappropriate policy instrument for achieving these objectives. Nevertheless many government and/or research organisations do adopt these objectives as part of research policy. If this is the case then it is important for policy-implementing organisations to attempt to measure whether research resource allocation alternatives are likely to achieve these objectives. If nothing else, such assessments may provide useful future input into the review and future development stages of the research policy process.

The framework used in this paper can produce such assessments. It first requires a clear definition of the income redistribution objective; in particular, identification of the targeted group or groups. To illustrate how priorities might be developed using these distributive objectives a relatively simple example will be used; that is, that the benefits accrue primarily to producers and consumers in developing countries and not to those in developed countries. Information generated by the framework can be used to define commodity research priority groupings based on this objective (Table 3). This table uses an estimate of the share of the total economic surplus received by developing country producers and consumers to place commodities in different priority groupings. For commodities which result in substantial losses to developed country producers - for example, soybeans, and sheep/goat meat - the simple summation of shares is adjusted to more clearly indicate that developed country consumers receive a large positive share of benefits.

TABLE 3 : PRIORITY GROUPING USING DISTRIBUTION OF BENEFITS TO DEVELOPING COUNTRIES AS PRIMARY RESEARCH POLICY OBJECTIVE.

COMMODITY PRIORITY GROUPING	SOUTH-EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC		AFRICA		W.ASIA N.AFRICA		LATIN AMERICA	
	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)
I	Sweet potato	100	Sweet potato	100	Sweet potato	100	Sweet potato	100	Sweet potato	100	Sweet potato	98	Sweet potato	99
	Sorghum	99	Millet	98	Rice	96	Sorghum	99	Pulses	98	Rice	93	Banana/plantain	95
	Millet	98	Pulses	98	Banana/plantain	94	Maize	99	Rice	98	Millet	90	Coconut	94
	Rice	97	Rice	97	Cassava	93	Rice	99	Millet	98			Rice	93
	Pulses	95	Coconut	95	Millet	92	Pulses	98	Banana/plantain	96			Pulses	93
	Coconut	94	Banana/plantain	95	Pulses	91	Groundnut	97	Coconut	95			Cassava	92
	Banana/plantain	94	Cassava	93			Banana/plantain	97	Cassava	93				
	Groundnut	94	Groundnut	91			Coconut	94	Groundnut	93				
	Cassava	93	Sorghum	90			Cassava	93						
	Palm oil	90												
II	Sugar	82	Sugar	87	Palm oil	89	Palm oil	89	Palm oil	89	Banana/plantain	88	Palm oil	89
			Sheep/goat	86	Groundnut	88	Sugar	88	Sorghum	89	Pulses	84	Millet	88
							Sheep/goat	80			Groundnut	83	Sugar	86
											Sheep/goat	82	Groundnut	85
													Sorghum	84
III	Maize	78	Maize	72	Sorghum	71	Potato	60	Sugar	79	Sorghum	70	Sheep/goat	73
	Milk	77	Wheat	72	Sheep/goat	62			Maize	69	Wheat	62	Maize	71
	Wheat	73	Potato	69	Potato	61			Sheep/goat	66			Wheat	61
	Sheep/goat	69							Beef & buffalo	64				
	Oranges	61							Wheat	62				

TABLE 3 : PRIORITY GROUPING USING DISTRIBUTION OF BENEFITS TO DEVELOPING COUNTRIES AS PRIMARY RESEARCH POLICY OBJECTIVE (CONT')

COMMODITY PRIORITY GROUPING	SOUTH-EAST ASIA		SOUTH ASIA		CHINA		S.PACIFIC		AFRICA		W.ASIA N.AFRICA		LATIN AMERICA	
	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developing Countries (%)	Commodity	Share to Developin Countries (%)
IV	Potato	58	Milk	58	Sugar	53	Cocoa	48	Potato	58	Sugar	47	Potato	53
	Beef & buffalo	55	Coffee	47	Maize	53	Rubber	45	Oranges	57	Potato	47	Oranges	51
	Rubber	47	Rubber	47	Wheat	52	Coffee	43	Milk	49			Cocoa	51
	Cocoa	47	Oranges	42	Rubber	48			Rubber	46			Rubber	46
	Coffee	47	Beef & buffalo	42					Coffee	45			Coffee	46
	Soybeans	45							Cocoa	44			Beef & buffalo	42
													Wool	41
V			Wool	36	Coffee	37			Soybeans	31	Wool	39	Soybeans	27
			Soybeans	28	Wool	36			Wool	24	Oranges	28	Milk	21
					Oranges	31					Soybeans	23		
					Soybeans	27					Maize	22		
											Milk	22		
VI					Milk	11					Beef & buffalo	13		
					Beef & buffalo	11								
VII	Wool	0	Palm oil	0	Cocoa	0	Milk	0			Coffee	0		
			Cocoa	0	Coconut	0	Millet	0			Rubber	0		
							Oranges	0			Cocoa	0		
							Wheat	0			Coconut	0		
							Beef & buffalo	0			Cassava	0		
							Soybeans	0			Palm oil	0		
							Wool	0						

NOTE: Potato and coffee exclude the large distorting negative effects of developed country producers from the totals of distributive share reported.

Six commodity research priority groupings were chosen using this share information:

Priority Group	Percentage Share of Economic Surpluses to Developing Countries
I	100 to >90
II	90 to >80
III	80 to >60
IV	60 to >40
V	40 to >20
VI	20 to >0
VII	No significant production

Inspection of Table 3 reveals similar conclusions to those using maximisation of total international economic surplus as a research objective. Some commodities are consistently in priority grouping I for all regions; examples are sweet potato, rice and cassava. However, some commodities do shift among priority groupings depending on the region considered. Of the twenty three agricultural commodities considered, a large number are in the high and medium priority groupings.

It is important to recognise the limitations associated with using percentage surplus share as a distributive objective. An important one is that the absolute benefits received by developing countries are not obvious. For example, although the share of benefits from millet research to developing countries is high (Table 3), the absolute ($) benefits are low (Table 2). In South East Asia, total ($) benefits to developing countries may be higher for beef and buffalo research as opposed to millet (Table 2), even though the share this represents of total buffalo/beef research benefits is considerably smaller (Table 3).

This highlights the need to be clear on the appropriate distributive objective and the measures of success in meeting these objectives before explicitly embracing them in any priority assessment exercise. The preceding example illustrates that one would establish quite different priorities if the distributive objective was couched in terms of maximising the absolute ($) size of the new income streams accruing to developing country producers and consumers, versus maximising the shares of these they receive. Additionally there is the challenge of deciding how to differentiate among consumers and producers of the various commodities in developing countries. Are the developing country consumers and producers of millet more or less deserving than those of sorghum or cassava? There are no easy answers to these questions. The best that a priority assessment framework can do is to array the likely trade-offs that are implied by alternative decisions.

6.3 A Comparison of Distributive and Growth Objectives

In many situations research policy objectives include both growth and distributive dimensions. As can be seen from Tables 2 and 3 there are often potential conflicts in achieving these multi-dimensional objectives. This issue has been addressed extensively in the literature on research evaluation and priority setting. Methods of including multi-dimensional objectives include mathematically defined social welfare functions,

subjective scoring models and opting to leave these trade-off judgements to research (policy) decision-makers and concentrating on quantifying the contribution of any type of research to each objective separately. In the information system being developed for ACIAR the latter approach is adopted. This way it is felt that decision-makers are encouraged to understand more clearly many of the complex interactions that occur. With other approaches, especially scoring models, decision-makers are often allowed to avoid understanding these complexities by substituting subjective weightings of objectives.

Even if priority groupings and expected impact assessments are derived separately for each objective, it is still possible to summarise them together and provide an overview of the likely trade-offs implied by pursuit of alternative objectives. Tables 4 and 5 illustrate a convenient way of representing growth and distributive priority groupings developed in previous sections. South East Asia and China were chosen to illustrate the differences in implications that can result from the analysis. These tables list the commodity priority groupings using total international (developing plus developed countries) economic surplus maximisation as the objective of funding research in these two regions on the vertical axis and the distribution of benefits to all developing countries on the horizontal axis.

The northeast diagonal of these tables and each of the quadrants gives an indication at a glance of the trade-off that is likely to be required by pursuit of one or other of these objectives for each region. Consider Table 4. For commodities in the northeast diagonal boxes, that is, rice, sugar, wheat, oranges, soybean, cocoa and rubber, either objective gives the same priority ranking. If all commodities were included on this diagonal trade-offs between the attainment of large international benefits and maximising the share accruing to developing countries would not be required. The further away from the diagonal a commodity is the more important the trade-off is likely to be.

Each quadrant also provides useful indicators at a glance. Commodities in the southwest quadrant are of low priority for attaining either objective. Most commodities in the northeast quadrant would be regarded as high priority with a single and/or a joint objectives. Commodities in the remaining two quadrants have a high priority for one objective but low for the other. Thus if more importance is placed on one objective, then attention might be directed to considering commodities in a particular quadrant more closely.

The results for South East Asia and China reveal contrasting patterns of priorities for the preliminary set of commodities considered. South East Asia reveals a concentration of commodities in the joint high priority northeast quadrant. Those outside this have high priority from a distributive view point. On the other hand, the China region has a more even distribution of commodities over all quadrants. Relatively few commodities are included in the joint high priority quadrant. Allocation of research funds within this region would therefore require careful consideration of the importance of trade-offs between the attainment of each objective.

TABLE 4: COMPARISON OF TOTAL BENEFIT AND DISTRIBUTIVE OBJECTIVES - SOUTH EAST ASIA

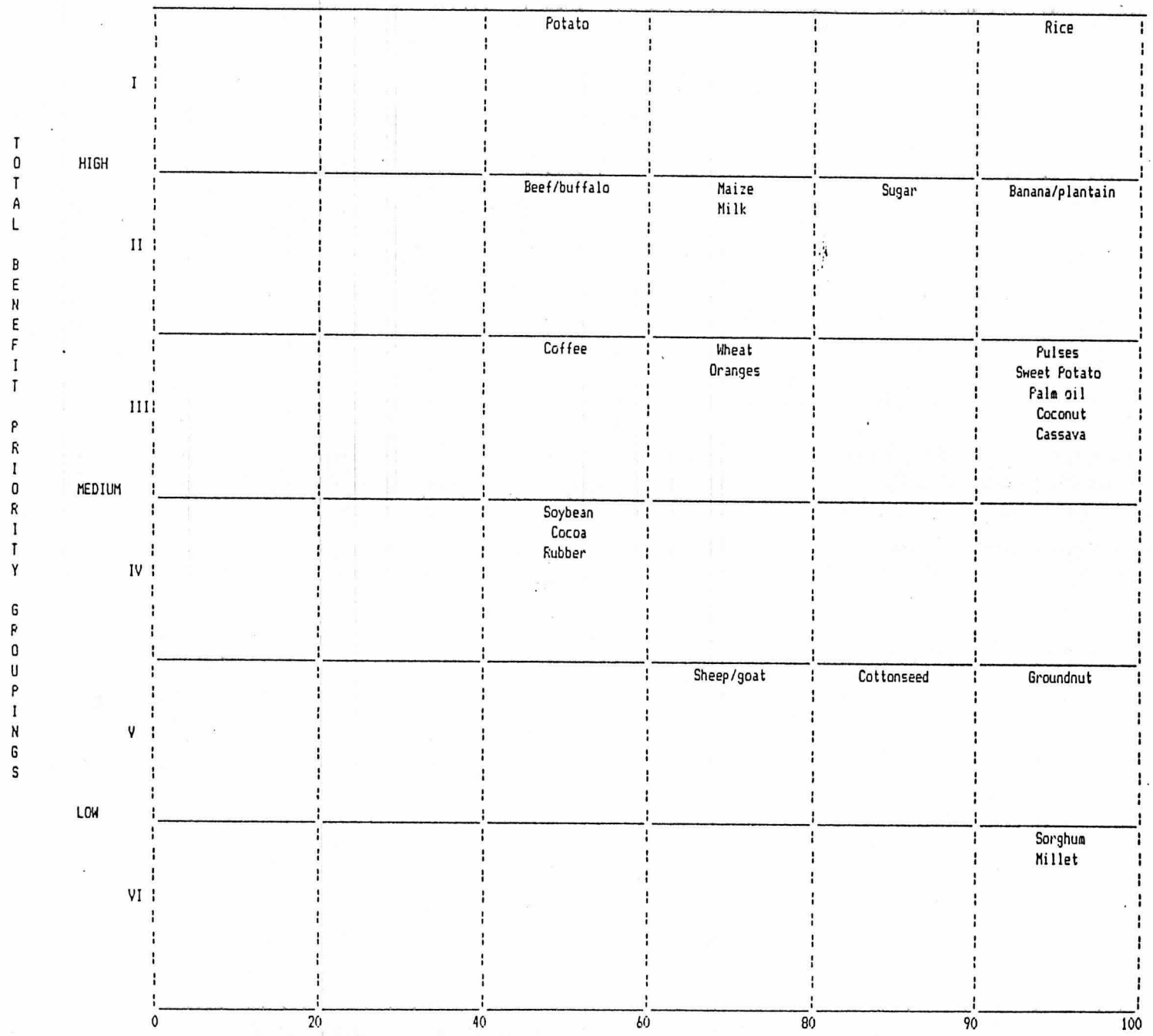
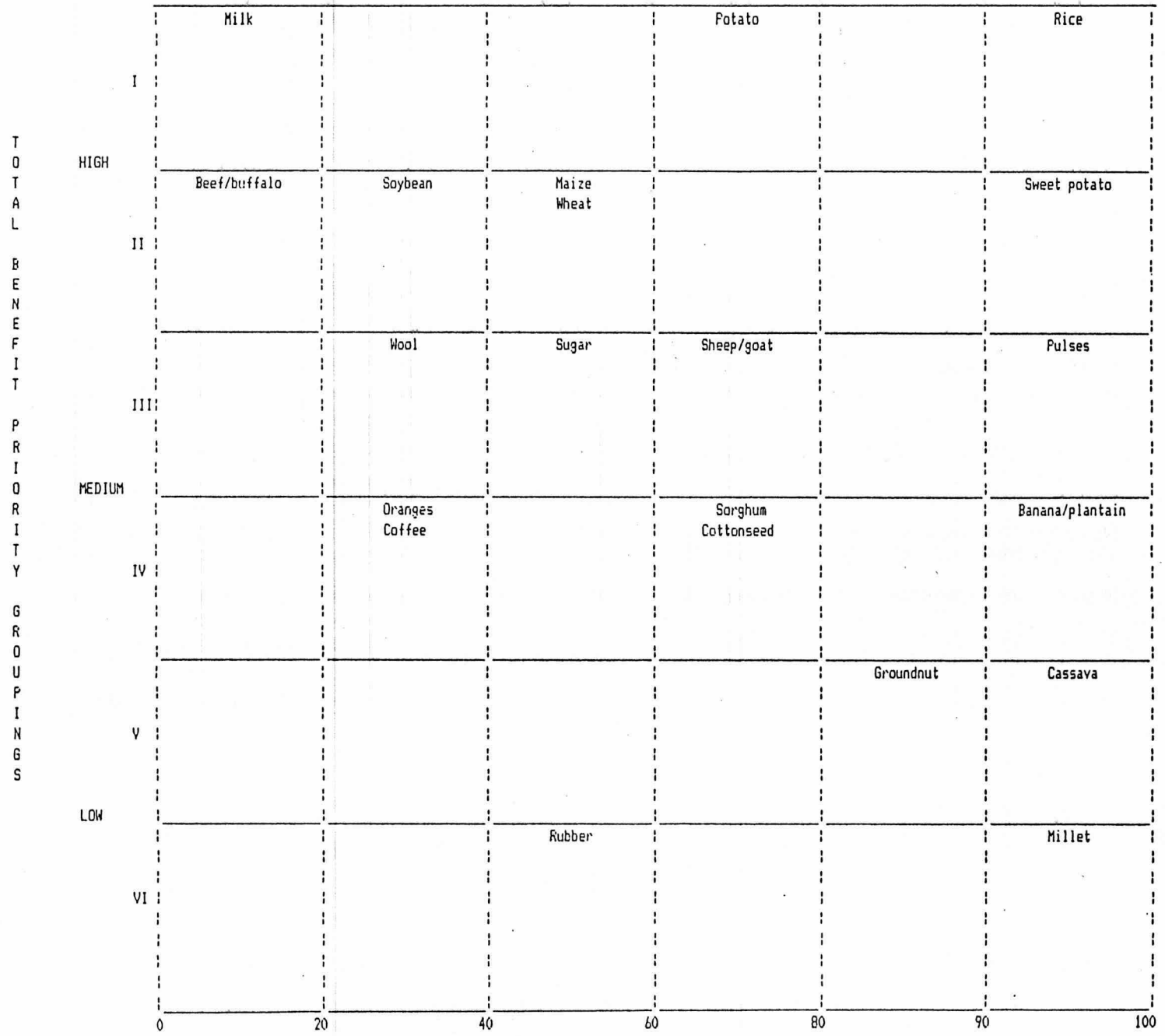


TABLE 5 COMPARISON OF TOTAL BENEFIT AND DISTRIBUTIVE OBJECTIVES - CHINA



6.4 Comparing Current Research Portfolios and Assessed Priorities

The priority assessments developed in this analysis can also be used to generate information regarding the congruence between current research funding patterns and suggested priority research areas. An information database has been developed as part of the priority assessment project which classifies all past and current ACIAR projects on the basis of features such as their commodity, country and program emphases. This information can be used to assess whether ACIAR's actual funding patterns have been consistent with the assessed research priorities. A similar database could be developed for the CGIAR Centres.

The budgets for all past and present ACIAR research projects have been collated and allocated to countries, commodities and program areas. The information can be summarised on the basis of a wide range of possible project characteristics which are discussed more fully in Davis and Ryan (1988b) and Fearn (1988). To illustrate the type of summary information which can be generated, two alternative ACIAR objectives are considered. These are to maximise total economic gains internationally, and to maximise regional economic gains from research. Both were discussed in earlier sections and the sensitivity of priority groupings to the choice of objective highlighted.

Table 6 illustrates the funding patterns for priority groupings consistent with an objective of maximising regional economic surpluses from research for each of the five regions of ACIAR's primary focus. For each region the total funding on all projects (including those completed) is provided, followed by similar information only for current projects. At the bottom of Table 6 the percentage regional shares of total funding are shown and compared with the guidelines established by ACIAR's Policy Advisory Council (PAC).

Several points can be highlighted from this information. For Africa, and to a lesser extent the South Pacific/PNG, funding has emphasised high priority commodities. Although a significant share of funding has been on high priority commodities, for the remaining regions a sizeable share has concentrated on the low priority commodities. Unless more detailed project-by-project assessments reveal special characteristics of these latter projects, this suggests that funding has not been consistent with an objective of maximising regional economic surpluses. Although not developed here, disaggregated forms of this information can provide further insights into the sources of these patterns.

Table 7 provides the same information using maximisation of total (developed and developing country) international economic surpluses as ACIAR's primary research objective. A significantly different set of funding patterns results. With spillover benefits to <u>all</u> countries now of importance (which was not the case in Table 6), ACIAR's funding emphasis has been on the high to medium priority commodities. Slight exceptions are the South Pacific/PNG and South East Asia. The pattern is similar for current and cumulative projects. The change in funding patterns for the two possible ACIAR objectives is illustrated in Figure 4. The low priority shading in the bar charts of funding percentages increases significantly if a regional versus an international objective is adopted as ACIAR's primary objective (the exception being Africa).

TABLE 6: DISTRIBUTION OF ACIAR RESEARCH FUNDING AMONG PRIORITY GROUPINGS DEFINED WITH OBJECTIVE TO MAXIMISE REGIONAL BENEFITS.

COMMODITY PRIORITY GROUP		REGION									
		SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC/PNG		AFRICA	
		ALL PROJECTS[a]	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS
High	I	36	31	43	48	21	21	31	37	61	61
	II	2	1	28	18	12	12	13	15	14	14
Medium	III	5	5	3	3	0	0	0	0	0	0
	VI	15	15	*	*	2	2	0	0	5	5
Low	V	7	9	18	20	35	35	2	1	0	0
	VI	11	11	2	2	3	3	12	7	0	0
	VII	0	0	0	0	0	0	0	4	0	0
Total		76	72	94	91	73	73	58	64	80	80
Other Commodities (not in analysis)		24	28	6	9	27	27	42	36	20	20
Regional Expenditure (%)		53	49	7	8	11	14	13	14	12	14
PAC Guidelines (%)		60	60	9	9	10	10	12	12	9	9

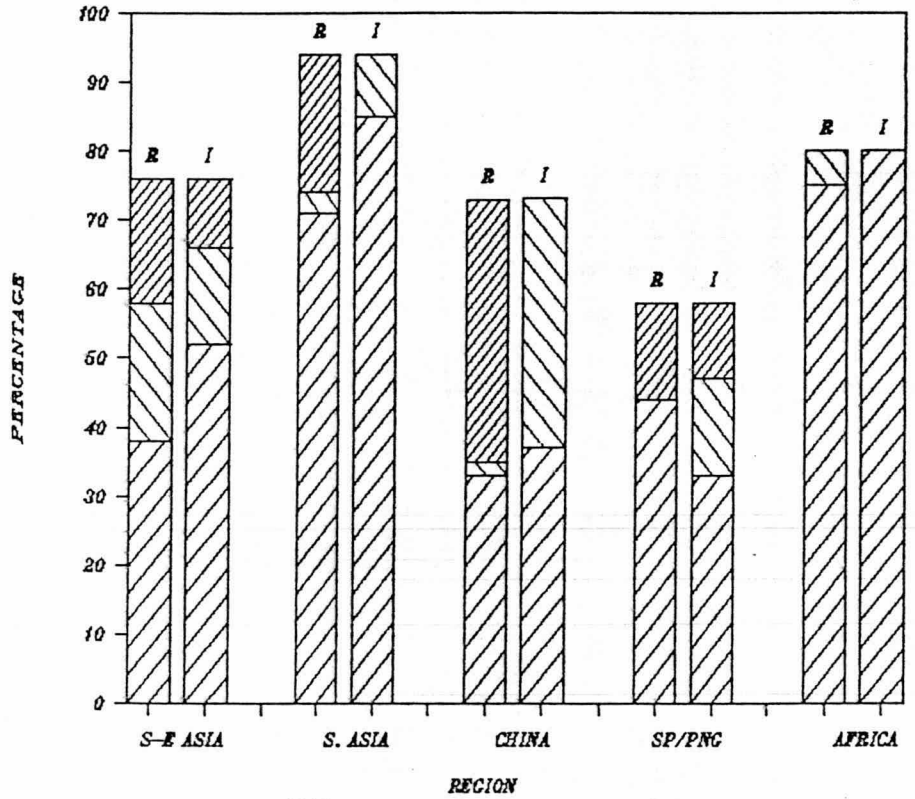
a. Includes current plus completed research projects as at June 1988.

TABLE 7: DISTRIBUTION OF ACIAR RESEARCH FUNDING AMONG PRIORITY GROUPINGS DEFINED WITH OBJECTIVE TO MAXIMISE INTERNATIONAL BENEFITS.

COMMODITY PRIORITY GROUP		REGION									
		SOUTH EAST ASIA		SOUTH ASIA		CHINA		SOUTH PACIFIC/PNG		AFRICA	
		ALL PROJECTS[a]	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS	ALL PROJECTS	CURRENT PROJECTS
High	I	35	30	26	28	21	21	12	14	66	66
	II	17	16	59	60	16	16	21	25	14	14
Medium	III	7	6	7	1	36	36	13	14	0	0
	VI	7	9	2	2	0	0	0	0	0	0
Low	V	10	11	0	0	0	0	0	0	0	0
	VI	0	0	0	0	0	0	0	0	0	0
	VII	0	0	0	0	0	0	14	11	0	0
Total		76	72	94	91	73	73	60	64	80	80
Other Commodities (not in analysis)		24	28	6	9	27	27	40	36	20	20
Regional Expenditure (%)		53	49	7	8	11	14	13	14	12	14
PAC Guidelines (%)		60	60	9	9	10	10	12	12	9	9

a. Includes current plus completed research projects as at June 1988

FIGURE 4: ACIAR FUNDING SHARES BY COMMODITY PRIORITY GROUPINGS USING INTERNATIONAL AND REGIONAL OBJECTIVES.



//// Funding share to high priority commodities.

\\\\ Funding share to medium priority commodities.

//////// Funding share to low priority commodities.

Abbreviations:

R: Funding shares using regional benefit maximisation to set priority groupings.

I: Funding share using international benefits maximisation to set priority groupings.

The information generated by this analysis is intended to raise questions of relevance to decision-making rather than necessarily provide answers to them. Disaggregation of the information can often assist in providing some answers. The main conclusion that stems from this funding analysis is reinforcement of the importance of clear specification of ACIAR's objectives.

7. SOME POSSIBLE REFINEMENTS FOR TAC/CGIAR

This paper has endeavoured to provide TAC with an overview of the framework developed by Davis, Oram and Ryan (1987) to assist in agricultural research priority assessment, and in particular how it has been utilised so far in ACIAR using some preliminary empirical results. In this way it is hoped that TAC will be better able to judge whether it sees merit in making use of the approach in its current priorities and strategies exercise.

We suspect TAC might find it helpful to further illuminate the distributional implications of alternative commodity and regional research strategies. As mentioned earlier in the paper, the framework can readily accommodate this provided there are sufficient data at the level of disaggregation required to incorporate into the analysis. For instance producers and consumers of agricultural, forestry and fisheries commodities in various countries or production environments might be further classified into those who are absolutely poor and those who are not, in order to ensure that commodity and regional choices by TAC/CGIAR are specifically targetted at the poor and in ways that imply as few trade-offs in attaining growth or food self-reliance objectives as possible. The requirements to build in such an explicit poverty objective would be as follows in our judgement.

7.1 Clear Specification of the Poverty Objective

The first and most important requirement is to clearly specify the poverty objective of TAC/CGIAR. Two important questions need to be addressed:

(a) How is poverty defined? Is this a minimum income level for each country?

(b) What level of disaggregation of the 'poor' is required to accurately reflect TAC's objectives? For example, is 'poor' and 'non-poor' sufficient, or will it be important to also know potential differential impacts on poor farmers, the rural non-farm poor, and the urban poor?

Before any data collection commences these two issues need to be resolved. The extent and cost of data collection will be dependent on these decisions. The more disaggregated the focus the more additional data will need to be collected and the greater will be the difficulties encountered.

7.2 Data Requirements

Before discussing possible additional data requirements it is useful to summarise the existing data as available and used by ACIAR/IFPRI. Table 8 provides an outline of this. Data on virtually all items are assembled for

TABLE 8: Data Currently Used For ACIAR's Objectives

Variable or Parameter	Brief Description	Source	Comments
Production	National production for all countries and each commodity	FAO Data Tapes	An important determinant of total benefits. Time Series important
Consumption	National consumption for all countries and each commodity	FAO Data Tapes	An important determinant of total benefits. Time Series important
Prices	National or World Prices	World Bank/FAO	Not a crucial factor unless used to provide an estimate of potential unit cost reductions. Time Series important.
Price Elasticities	National level estimates required of Supply and Demand	World Bank/USDA, plus other studies	When commodities are traded and international spillovers occur these parameter become less crucial.
Relative Strengths of National Research Systems	Required for innovative and adaptive research if different. Previously called probability of success	P Oram/ J Turnbull/ S. Blaber	Can have an important impact on relative benefits, especially if there are large differences among commodities and countries.
Ceiling Levels of Adoption	By commodity for each country	P Oram/ J Turnbull/ S Blaber	Can have an important impact on relative benefits, especially if there are large differences between commodities and countries

TABLE 8 (cont.): Data Currently Used For ACIAR's Objectives

Variable or Parameter	Brief Description	Source	Comments
Adoption and Research Lags	By commodity for each country	P Oram/ J Turnbull/ S Blaber	Will have an important impact on the absolute size of benefits but not on relativities when standard lags are used in the current applications.
Demand and Supply Forecasts	Not currently used but model refinement available.	Not Used Yet	Requires a good forecaster.
SPILLOVER ESTIMATION			
Commodity Production Environments	Uses FAO AEZ's for agriculture, Papadakis for forestry and species and ecological zones for fisheries.	FAO/Papadakis/ S Blaber	Need a classification system with research relevance but manageable for assisting decision making.
Commodity Production Shares	Share of commodity production in each production environment for each country	P Oram/ J Turnbull/FAO	Very important for determining spill-overs among geographic/socioeconomic regions
Spillovers Among Production Environments	Different for each commodity; estimated at a technical level	P Oram/ J Turnbull/ S Blaber	Very important; may ultimately need to develop estimates by type of technology/discipline for each commodity
Commodity Research Focus Proportions	The production environment focus of individual country/regional research on each commodity	P Oram/ J Turnbull/ S Blaber	Currently assume emphasis is similar to production share. If focus is different to these it will affect spillovers

every country of the world. These individual country data are then aggregated into a subset of 70 regions using standardized spreadsheet files. All developing countries of direct importance to ACIAR are included as separate countries. Others are aggregated by major geographical regions and subregions within these. The file storage system has been designed to make alternative aggregations relatively straightforward.

There are two options for providing information using the Davis, Oram and Ryan model to assist in priority assessment with a poverty objective explicitly factored in:

(a) Limited Additional Data Collection.

Some have indicated that it is possible to identify poor people within specific production environments (eg. agroecological zones). If so it is argued that research focused at these production environments might be expected to benefit only the poor within them. If these conditions do indeed hold it is possible to use the "commodity research focus proportions" parameters in Table 8 to incorporate a poverty objective. This would require only minor changes to the ACIAR data files and re-estimation for each commodity.

There are, however, some important limitations to doing this. These include:

- the assumption that the poor are the only ones to benefit in these zones seems strong; as too does the assumption that there are not any poor in other zones;
- the results would not separate consumers into the "poor" and the "non-poor"; thus unless only the poor consumed the commodity, benefits to poor consumers could not be assessed;
- the analysis would implicitly assume that there are no research spillovers to the non-poor production environments; this too is a strong assumption.

In general we would be hesitant to place much reliability on this option in being able to provide realistic indicators of the likely outcomes of alternative research portfolios on the poor.

(b) Disaggregation of Country Data.

The most reliable option would involve disaggregating all (or most) of the country information in Table 8 into the identified categories of the poor. This would need to be done for all developing countries who are regarded as having poor people amongst their populations. Developed country data could remain at the current aggregated level. Table 9 provides an indication of the data requirements to achieve this. In general for each category of poor of interest, the data requirements will increase in multiples for developing countries. For example if one group of poor is sufficient, data requirements will almost double.

TABLE 9: Increased Data Requirements for Explicit Consideration of a Poverty Objective

Variable Name	Importance in Extending the Analysis	Source/Difficulty
Production	Critical to have this disaggregated for each 'poor' group - developing countries only	Not readily available
Consumption	Critical to have this disaggregated for each 'poor' group - developing countries only	Not readily available
Prices	If cost reduction (productivity improvements) are expected to be the same for poor and non-poor farmers national estimates would be sufficient	Use current data set
Elasticities of Supply and Demand	Elasticities could become more important if the focus is on poor. If so elasticities would be needed for the different poverty groups by commodity by country	Difficult to find reliable complete set
Relative Strengths of National Research Systems	May require further refinement if technologies for the poor are different to those for non-poor	Would have to be more subjective. CG Centres may be a good source for refinements to existing estimates
Ceiling Levels of Adoption	Disaggregated estimates would be required since poor farmers may have different levels to non-farmers	Would have to be more subjective. CG Centres may be a good source for refinements.

TABLE 9 (cont.): Increased Data Requirements for Explicit Consideration of a Poverty Objective

Variable Name	Importance in Extending the Analysis	Source/Difficulty
Adoption and Research Lags	Disaggregated estimates would be required since poor farmers may have different lags to non-poor farmers.	Would have to be more subjective. CG Centres may be a good source for refinements.
Demand and Supply Forecasts	Could become more important if growth patterns differ for the 'poor'.	Will be difficult to find.
SPILLOVER ESTIMATION		
Commodity Production Environments	May need to review/refine classification. However existing probably OK.	
Commodity Production Shares	It is critical to obtain this information for each poor grouping.	Will be difficult. CG Centres may be good source of expertise.
Spillovers Among Production Environments	No extra estimates required unless classification scheme changed. May, however, need to get revised estimates from CG centre technical experts.	Revisions to existing data may be required.
Commodity Research Focus Proportions	Depends on research objective. Specification of this to match TAC objectives provides scope for development of important decision support information system.	TAC input

7.3 Possible Outputs

At least two types of information could be generated. These are:

(a) Establishment of Regional Commodity Priority Groupings.

Similar priority groupings to those used in ACIAR could be generated. These would be those relevant to the attainment of the chosen poverty objective or other objectives that are specified. If different groups of poor are identified then box diagrams such as those shown earlier in Tables 2, 4 and 5 in the paper may be useful in discussing and resolving trade-offs.

(b) Consideration of Different Research Foci

It also would be possible to determine the sensitivity of commodity priorities to changes in research foci by the CG system. Benefits to the poor could be influenced by the relative priorities accorded to the various commodity production environments. With disaggregated poverty information, assessments of the impact of a change in the research focus can be made. An important dimension often ignored is that if research is focused on 'poor' farmer production environments, this could have a high opportunity cost for poor urban consumers. That is, if production gains are smaller for these 'poor' production environments (for example because they produce a small share of production), then the price reduction effects of research will be smaller and consumer gains will be reduced accordingly.

8. CONCLUSIONS

The Davis, Oram and Ryan framework could be of use to the TAC/CGIAR as it embarks on another priorities and strategies exercise. For it to be successfully employed would require TAC to begin to institutionalise the framework and the accompanying data base and decision support system within the Secretariat. This would involve dedicating professional staff and financial resources to the task so that it becomes a living operational tool for the TAC, set up in a manner which caters to its specific needs. If this were done it would be available on a continuing basis for refining ex ante research resource allocation strategies and also to assess ex post impacts of its past investments in agricultural research.

We would suggest the following scenario as appropriate for TAC if it considered moving in this direction:

Step	Description
1.	Clearly define the objectives of the CGIAR.
2.	Interpret these objectives in terms that allow quantification of the key variables, eg: whether benefits to all LDC's are the major concern, or total international benefits, or benefits to particular LDC regions.

3. Develop measures for assessing the likelihood of success in attaining these objectives, eg: economic growth contribution, incomes of the poor etc.

4. Assemble relevant data in a form suitable for the analysis.

5. Develop a decision support system to enable assessments to be refined on a continuing basis by linking ex post achievements with ex ante expectations, eg: a variant of the Davis, Oram and Ryan approach.

6. Analyse and array likely trade-offs in achieving various (and possibly competing) objectives.

7. Have detailed scientific discussions of the prospects for sustainable productivity gains in various commodities/regions which might alter the ranking from preliminary analyses in steps 5 and 6.

8. Compare the current CGIAR resource allocations with agreed priorities from step 7.

9. Discuss outcomes of step 8 and make explicit and informed choices.

In step 7 it is not suggested that TAC could or should explicitly evaluate individual research activities or programs of the IARC's or the NAC's. There would be insufficient time and resources to do this in our judgement. Furthermore, past attempts to optimise research portfolios from the project to the program and through to the secondary and then the primary institutional levels, have been fraught with insurmountable difficulties. Not the least amongst these was the inability of scientists to confidently estimate the likely impact of each possible research project on sustainable productivity. Another way of saying this is that the research production functions relating research inputs to expected outputs for all commodities and production environments are unknown.

Instead of TAC explicitly assessing the prospects for success of each possible research activity in existing (and potential) IARC's of the CGIAR, it is suggested that this be done implicitly at the level of the commodity and broad production environment. Inputs into this process would be the strategic plans of the IARC's, the EPR's and EMR's, and the various reports of research progress from the Centres.

ACIAR and IFPRI are presently refining and revising the empirical analyses which have formed the basis of the preliminary results presented in this paper. Peter Oram is responsible for the provision of some of the agricultural commodity data and assessments on which these are based. John Turnbull has provided similar information on forestry and scientists in Australia are in the process of providing similar data for fisheries. In addition to the 31 commodities specified in Table 1, 14-16 fishery products are to be included. There will remain some important gaps in the commodity coverage after this next phase however. For example pigs and poultry still will not be included. With time, resources, and inputs from scientists knowledgeable about such commodities, these and other gaps could be filled.

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APPENDIX A : The Methodology for Estimating Likely Interregional Research Spillover Effects

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. The basis for determining agroclimatic similarities was the set of agroecological zones (AEZ) constructed using methodology developed by FAO (1978a 1978b, 1980a, 1980b).

It was found that production of commodities within an individual country often straddled 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 from FAO 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 the decision-making process. Nevertheless, it is important to build on these subjective assessments over time and ensure that documentation is sufficient to enable replication. In the forestry application an attempt has been made to supplement some of the subjectivity of the spillover estimation used by Davis, Oram and Ryan (1987) with a more systematic procedure. This revised procedure is briefly outlined and then the component estimates discussed.

Revised Spillover Estimating Procedure

The country-level focus of the analysis (rather than sub-regions within a country) means diversity in the agroecological mix within particular countries. Countries such as China, Australia and India include a diversity of AEZ's. The previous assumption that the AEZ with most production of a commodity is the AEZ to use in spillover estimation may be too simplistic. For example, it implies that the direct effect of originating research in a 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 AEZ's this is unlikely to be a reasonable assumption. It would require the notion of a multi-faceted research project which covered all regions. This in turn raises the issue of within-project spillovers, as well as a research cost homogeneity problem among countries. An alternative methodology has been developed to accommodate diversity, in commodity production environments.

A simple matrix representation of the process for each commodity is given as:

$S = P\ C\ F'$

Where:

S is an n x n matrix of potential among-countries/regions spillover estimates for the n countries/regions chosen for the analysis;

P is an n x m matrix of research focus shares; m is the number of agroecological zones for the commodity;

C is an m x m matrix of production environment spillovers among the agroecological zones for each commodity.

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

The elements of S are the equivalent of the potential spillovers estimated by Peter Oram and used in Davis, Oram and Ryan (1987). Each column and row in this matrix represents a country (or sub-region with 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' for a particular commodity.

The introduction of P is required to account for countries/regions with production in multiple AEZ's. The research focus shares included in P_{rt} can be viewed as research emphases by AEZ's in a country. An example is the best way to illustrate. If a country produces a commodity in only one AEZ then it is reasonable to expect any research undertaken to be focused only on technologies for that AEZ. If so $p_{r6}=1$ for AEZ number 6 and zero for $t \neq 6$. On the other hand, if the commodity is produced in five AEZ's then a decision needs to be made regarding whether any research undertaken will be focused on a subset of these zones. If most production is in AEZ number t=10, then it is likely that research will be focused on AEZ t=10 and therefore $p_{r,10}=1$ and the remaining, say t=2,6,25 and 92 zones have $p_{rt}=0$ (along with all remaining zones with no production). Alternatively if production is concentrated in zones 10 and 62, research might be focused equally at technologies for both zones. This being the case $p_{r,10}=p_{r,62}=0.5$ would be the appropriate parameter values (all other p_{rt} values being zero). If research is expected to target a particular zone(s), an alternative parameter structure is adopted.

Elements of C represent estimates of the potential research spillovers due purely to agroclimatic factors, ignoring country production composition. For most commodities it is expected that potential spillovers will be 1 for the same AEZ. The larger the differences agroclimatically among zones the closer c_{xy} is likely to be to zero.

The elements of F represent the shares of commodity production in each zone 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 among commodities and countries a column is included for each possible agroclimatic zone; that is, m is the total

possible number relevant to any commodity. As a result each F (and P) will be a sparse matrix.

In the empirical applications for crops, use has been made of up to seven of the FAO climatic zones and up to seven of the growing seasons within them, making a potential total of up to 49 climate by growing season zones, the precise number depending on the commodity concerned. These are as follows:

Climatic Zones	Growing Seasons
Warm Tropics	Perennially Wet: 365 days
Cool Tropics (Tropical Highlands)	Wet: 330-364 days
Warm Subtropics (Summer Rainfall)	Humid: 270-329 days
Cool Subtropics (Summer Rainfall)	Seasonally Dry: 210-269 days
Cool Subtropics (Winter Rainfall)	Long Semi-arid: 150-209 days
Cool Temperate (Winter Rainfall)	Short Semi-arid: 90-149 days
Transitional	Arid Irrigated: 0-89 days

In the case of forestry, discussion with forestry and climatic zonation researchers led to the conclusion that subjective spillover estimates could be made using the agroclimatic classification developed by Papadakis (1975). For the preliminary results this system was felt adequate. In subsequent revisions more detailed effort will be required to adopt a common classification to ensure maximum consistency between forestry and other products.

Briefly, the Papadakis system separates production environments 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 the forestry study. For this analysis therefore m=72 was used.

APPENDIX B : The Estimation of Research Lags

The time required to consummate a piece of research may vary considerably with the commodity or problem, the objective of the research, the conduct of the research and resources devoted to it. Thus although research on annual crops is often expected to yield a result sooner than that on perennials, examples can be cited where the reverse is the case. Transferring NIF genes from legumes to cereals has proved an intractible problem; reducing costs and raising output from rubber plantations by changing methods of tapping has yielded large benefits in a relatively short time. In the case of livestock, significant improvements in sheep productivity (through crossing and selection) were achieved in seven years in West Asia; and in an even shorter time by changing grazing systems in England. For these reasons we have adopted a standard lag time of eight years for all commodities, based on certain published studies, rather than varying our assumptions from crop to crop with no clear evidence on which to base them. This assumption was based on certain published studies, although possibly a longer average lag time of ten to twelve years might be postulated in the light of the CGIAR impact study estimates. Nevertheless we would still doubt the gains to be achieved from random variations in lag assumptions. The framework does not require this rigidity in lag periods and has been adapted to incorporate different lags for different countries if such data or estimates are available.

APPENDIX C : Some Difficulties in Determining "World Prices" for Priority Assessment.

'World' prices do not exist for several commodities because they are not widely traded on international markets, even though of great importance to domestic food supply in a significant number of developing countries. These include millet, sweet potato, cassava (except for feed and tapioca), most tropical pulses, many tropical fruits and vegetables, and goat meat. Even though national price series are available for several of these commodities there are numerous and unquantified distortions due to subsidies, taxes, etc. which can seriously bias estimation of the benefits from price reductions due to research.

Transportation costs vary considerably among commodities depending on their bulk and ease of handling, perishability, the nature of the products (e.g. ground nuts in shell, shelled, oil etc). Wherever possible this component of costs was based on a transportation cost matrix for shipping between main points of origin and destination throughout the world, using 1979/81 or latest existing data. Freight costs were added to the world price to obtain a regional parity price but land transportation costs are not included in those costs.

Sudden changes in world prices can imply a change in economic surplus estimates, especially if unit-cost reductions are postulated to be directly related to prices. For example, world rice and sugar prices have fallen dramatically since 1982. Thus our 1979-81 'average' prices for those commodities have been criticized as too high. The only answer seems to be to base prices on a longer time series, corrected for inflation and/or to perform sensitivity analyses of the results. The latter is being planned.

Some 'commodities' are really aggregates of several crops (pulses, vegetables, fruit) or livestock (meat), or several types of product (dairy products). Statistics on their production are often incomplete; often only the marketed portion is reported, and in some cases - particularly vegetables and fruits, some species are not cited at all in published data. Thus their value may be under-estimated.