Economic Growth, Technological Change and Priority Assessment in Agricultural Research

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1. INTRODUCTION

Those responsible for the allocation of agricultural research resources are under continuous pressure to do so using multiple objectives, many of which are inappropriate and often conflicting. For example in many developing countries they are asked to target the poor and the nutritionally deprived at the same time as they are expected to enhance export earnings and replace imports. Translating these multiple objectives of national policy into viable research programs is a challenge.

This paper discusses agricultural research in a macroeconomic context, describing its role in the development process. It examines the contention that agricultural research and technological change express their comparative advantage if they are used as engines of economic growth rather than as direct instruments of social welfare policy, and that the resources devoted to them should be allocated against this background.

A research priority assessment framework is described which can facilitate the allocation process for either national, regional or international research agencies. Examples of empirical applications of the framework to Malaysia and South East Asia are presented and inferences are drawn for Malaysian research strategies and regional research cooperation.

The penultimate section of the paper contains a discussion of a number of the common rationales for the allocation of agricultural research resources, which some argue should condition a growth-oriented priority assessment approach.

The paper concludes that agricultural research priorities should be largely set with reference to their expected contribution to economic growth. Due consideration should be given to the likely nature and extent of research spillovers in this process, lest opportunities for regional or international cooperation are missed. By adopting a consistent economic framework for assessing priorities and evaluating achievements, research administrators may be able to harness increased research resources, which seems appropriate in view of the high rates of return evident from past research investments. A proper balance between public and private agricultural R&D is also required, especially with the increased national and international attention being given to the legal protection of intellectual property rights.

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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. This is the case in Malaysia, where in the late 1970's agriculture represented 21% of the gross domestic product, 32% of exports and 36% of employment (Shand, 1984).[1] It remains the largest single sector in the Malaysian economy by all these measures. Additionally, despite significant progress in poverty reduction since 1970, the incidence of poverty remains high at 42% of the households in the rural sector. The poor are concentrated amongst rubber smallholders, estate workers, paddy farmers and mixed farmers (Shand, 1984). Rural poverty eclipses urban poverty. The former represents 86% of the total number of poor households in the country.

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.[2] The initial result of increased productivity is to increase incomes of landowning farmers. In Malaysia these are predominantly smallholders, especially in paddy (100%), coconut (93%) and rubber (69%).[3] Hence productivity growth may largely benefit those landowners at the lower end of the income scale. 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.[4] Production of these goods are generally more labour-intensive than in urban-based large-scale industries. As a result of the increased incomes of landowning farmers, the rural poor are provided with additional nonagricultural employment opportunities. This is in addition to the direct employment - creating effects which adoption of the new technologies by farmers generates. These employment elasticities with respect to output were found to range between 0.15 and 0.80 in India (Tyagi 1981). They depend on the extent of labour-using bias in the new technologies and on the agroecological zones in which the research is conducted.

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1 Agriculture is defined here to include crops, livestock, forestry and fisheries.

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

3 Figures in parentheses refer to the contributions of smallholders to production of each crop in 1978 (Shand, 1984).

4 In the Muda irrigation scheme in Malaysia Alderman (1986) found that

The enhanced direct and indirect employment of 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.

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.

3. THE RETURNS TO AGRICULTURAL RESEARCH AND THEIR DISTRIBUTION[5]

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 23 studies of agricultural research productivity in developing countries reviewed by Ruttan (1980) had an average rate of return on investment of 55%. The studies covered research on food crops, livestock and commercial crops such as cotton and rubber. Over the period 1966-75 international research on rice in Asia showed a rate of return of between 74 and 102% per year (Evenson and Flores (1978) as cited by Ruttan (1980)). Rice research in the tropics over the same period had an annual rate of return in the range 46-71% (Flores, Evenson and Hayami (1978) as quoted in Ruttan (1980)).

In 1970 Judd, Boyce and Evenson (1986) estimate that agricultural research expenditures were $US5.36 billion (in constant 1980 dollars). Twenty eight percent of this was spent in North America and Oceania and another 41% in Europe and the USSR. Developing countries represented 31% of the total. In recent years research investments have grown more rapidly in developing than in developed countries. In 1980 the former's share was estimated by Judd, Boyce and Evenson to be 36% of the total of $US7.39 billion.

The historically high rates of return to agricultural research suggest that current levels of research investment remain well below what they should be

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5 Parts of this section have liberally drawn from Pinstrup-Andersen (1977).

to fully exploit the opportunities for increased agricultural production and enhancement of economic development and human welfare.

Many of the abovementioned studies looked at the distribution of research benefits between the producer and the consumer sector. In most the bulk of the benefits are obtained by consumers. Among producers, those who adopt research findings first - in many but not all cases larger farmers - obtain considerable gains, although with time smaller farmers also adopt and reap rewards. On the other hand, lower income consumers tend to obtain a larger share of the gains from research on basic staples than higher income consumers. The opposite is true for research on higher cost foods such as meats.

Most ex post studies have used closed economy approaches and ignored spillover effects to other countries. It is hence not surprising that consumers are shown to have been the main beneficiaries. The framework described in Section 5 of the paper allows for international market price transmission effects and research spillovers in the assessment of research benefits. In 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. Inclusion of market and research spillovers hence could modify Gardner's (1988) conclusions that price supports and production quotas can help attain socially optimal research spending under certain market conditions, which seem to be predicated on the notion of pervasive producer losses from research.

Those who stress possible adverse distributive consequences of technological change which leads to "growth" imply that by minimising growth the problems of adjustment and income distribution could be also minimised. Few would advocate that approach!

The precise distribution of research benefits depends on whether the increased agricultural output 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. This helps to explain why farmers producing export crops are frequently willing to pay for research on the particular crop, (eg. sugarcane, coffee, oil palm and rubber) while research on domestically consumed agricultural products usually is financed (indirectly) by consumers from their general taxes which are used to provide the research resources.

Private institutions and individuals are frequently unable to capture all the economic benefits from their research activities because the release of research results and related technology cannot be controlled through patents or other arrangements aimed at maintaining exclusive rights. Therefore, while certain research may be highly beneficial to society as a whole or to groups in society such as consumers or farmers, public funds are needed to assure that the research is put into practice. In cases where major economic benefits of research can be captured by private institutions, public funds should not be used. Thus, according to Pinstrup-Andersen (1977), 20% to 25% of all agricultural research expenditures in North America originates in private industry. In contrast, only 2% to 5% of agricultural research expenditures in Asia, Africa, and Latin America originate in the private industrial sector.

Similarly, benefits from publicly funded agricultural research may not be limited to any one country. In such cases, cooperative programs amongst national agricultural research systems and/or international research institutions may have economic advantages. We will return to this theme later in the paper.

In general, agricultural research and the technological changes which it generates have their comparative advantage in contributing to the economic growth objectives of government. 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 Malaysia. Due to the constraints which nature imposes on scientists' ability to predict research outcomes with assurance, and the difficulties of attainment of several 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 existing 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. Ryan (1977) describes these scientific trade-offs in the case of sorghum breeding research, which are similar to those in maize. He shows that 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 welfare goals. To impose on research administrators these social goals and objectives at the outset can lead to a failure of research to realise its full potential as an engine of economic growth. Without sustained growth, most countries find it virtually impossible to achieve social welfare goals such as poverty alleviation, and improved education, health and nutrition.

Acceptance of the proposition that agricultural research is, and hence should be regarded primarily as an engine of economic growth rather than as a direct instrument of social welfare policy, 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.[6] 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. To assess this requires that the commodities which are expected to have their costs of production and/or derived demands 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 in ACIAR for this purpose, and how it relates to the formulation, implementation and review of agricultural research policy will be discussed in the next two sections.

4. THE RESEARCH POLICY PROCESS AND PRIORITY SETTING [7]

The determination of national agricultural research priorities occurs at several stages in the research policy process (Figure 1). At the national policy development level the concern is primarily with the formulation of overall strategies, including the rationale for government intervention in the research process and the consequent balance between public and private support for research. The government's role in the research process is generally justified variously on efficiency and equity grounds (Davis and Ryan 1987b). Intervention by the government can take the form of direct involvement by way of the creation of government research organisations or by the use of indirect measures such as tax concessions and subsidies for private research, establishment of intellectual property rights, or a combination of these. An integral part of these decisions on the extent and type of government involvement in the research process is the choice of funding mechanisms. These can range from general taxation revenue and commodity cesses, to user-pay rules. The decision on which mechanism to use should ideally depend upon the type of research envisaged and the market characteristics of the commodity which will be affected by the

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6 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.

7 [illegible] Davis and Ryan (1987b)

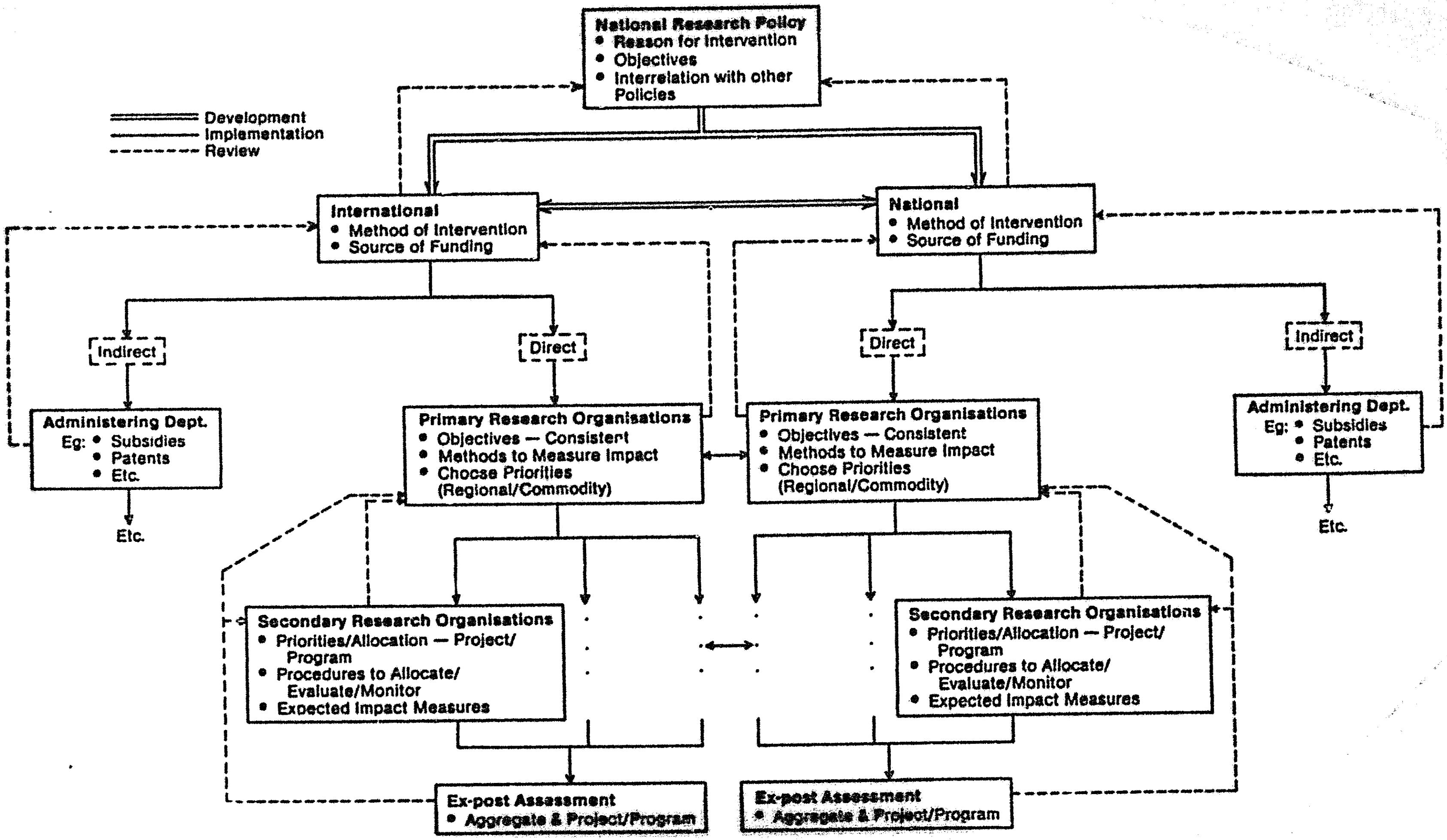

FIGURE 1. Schematic Representation of the Research Policy Process

research. The important interaction between research policy and other government policies also occurs at the development stage of the research policy process.

National research policy increasingly has to embrace international and regional dimensions, involving both the public and private sectors. Exploiting complementarities and opportunities offered by international and regional agencies is an increasingly complex and demanding role for national research policy makers, both in developed and developing countries. This complexity makes it imperative that such international and regional dimensions be consistent with overall national research strategies and policies.

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 organizations who implement national research policy. 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. With direct government interventions, choices of commodity and regional research priorities are translated into decisions about the number and location of primary and secondary research organizations.

Primary research organizations usually have considerable degrees of freedom about the precise balance of resource use among mandate commodities which have been assigned to them by the national agency responsible for policy. As one proceeds further down the research policy process continuum (Figure 1), the scope for choices amongst commodity and regional priorities declines in favour of decisions at the program and individual project levels, within a predefined commodity/region set (Table 1).

Ideally the development, implementation and review stages of the research policy process are complementary and iterative, as suggested in Figure 1, rather than competitive and sequential. This is achieved by continual monitoring and evaluation at the implementation stage followed by <u>ex post</u> review, with aggregate priorities assessed at the primary organisation level being regularly modified and refined based upon information generated from the monitoring, evaluation and review activities.

In the regular assessment of research priorities it is important that a consistent framework be adopted which is relevant at all three stages of the research policy process and which enables an assessment to be made of the extent to which the objectives of national research policy are satisfied by the particular research resource allocation choices that are made.

In subsequent sections, we focus on decisions related to the <u>ex ante</u> choice of alternative commodity and regional research portfolios at the research policy implementation stage, which generally involves a primary research organization. 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

Table 1 The Types of and Levels at which Research Resource Allocation Decisions are made by Research Policy Implementation Organizations.

Levels[a]	Type
Primary	Commodity/Regional Balance. Private/Public Balance. Basic/Strategic/Development/Applied/Adaptive Research Balance. Extent of Centralization/Devolution. Emphasis on Short-/long-run Outcomes. Disciplinary Balance. Emphasis on Training/Manpower Development. Balance of National/International Research.
Primary/Secondary	Balance between Current/Capital Expenditures. Balance between Salary/Non-Salary Expenditures. Location of Research facilities (no. and size). Disciplinary Spread. Allocation of Staff and Non-Salary Expenditures to Commodity/Disciplinary Projects.
Secondary	Balance between On-Station and On-Farm Research Activities. Balance between Research, Monitoring, Evaluation and Review Activities. Balance between Research and Interface with Extension.

a. These are the various levels referred to in Figure 1.

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.

5. A PRIORITY ASSESSMENT FRAMEWORK

Davis, Oram and Ryan (1987) describe in detail a 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 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 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 agrocimatic and socioeconomic environments.

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 has 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 by them into a Fortran computer program adapted for use on an IBM AT microcomputer.[8] These measures assume that supply shifts

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

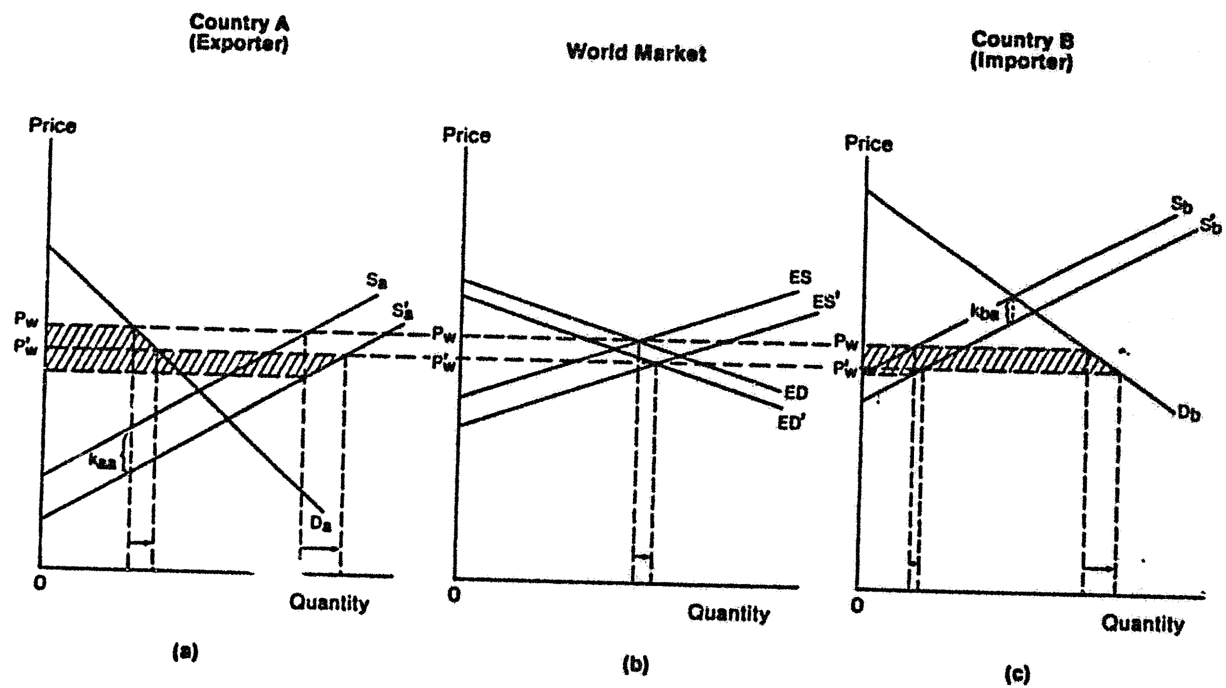

FIGURE 2. Two Country Diagrammatical Representation of the Model.

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.[9]

6. RELATIONSHIP OF FRAMEWORK TO OTHER APPROACHES

The approach to the assessment of agricultural research priorities described in the previous section offers no panacea to policy makers. However, whether it is utilised by 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. (Figure 1).

Seventeen criteria commonly used to justify the allocation of research resources at an aggregate level are examined in Table 2. Some can be regarded as being concerned primarily with the efficient allocation of resources, if this is defined as attempting to maximize economic returns from research investments. These include criteria such as the current gross value of agricultural production, the potential to contribute to export earnings and import savings, current and past research intensities and the urgency of the problem. Others would seem to be primarily concerned with distributional or equity objectives, such as the level and growth of per capita incomes, severity and extent of nutritional deprivation, potential to alleviate human nutritional inadequacies and to enhance rural employment and incomes of resource-poor farmers, and attainment of self-sufficiency. Population size, growth and density would appear to contain elements of both efficiency and equity as rationales for their use in guiding research resource allocation decisions.

All seventeen criteria can be regarded as relevant when decisions about regional and/or commodity balances in research are being made. Some are also pertinent at the level of the research program and/or project. We would contend that, either implicitly or explicitly, the Davis, Oram and Ryan framework currently embraces or can be adapted to embrace all the criteria in Table 2. Rather than devising a multiattribute scoring model which incorporates some or all of the criteria using arbitrary weights as in many past priority studies, it is suggested that the Davis, Oram and Ryan model appropriately integrates these considerations into measures

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9 Davis, Oram and Ryan (1987), drawing on Alston, Edwards and

Table 2 Relationship Between Priorities Framework and Common Criteria Employed to Assess/Justify Aggregate Agricultural Research Priorities

Commonly used criteria	Economic rationale	Relevant allocation	Relevant parameters/variables in Davis, Oram and Ryan priorities framework
Gross value of production	Efficiency	Region/ commodity	Prices, quantities
Population size	Efficiency/ equity	Region	Demand parameters, quantities
Population growth	Efficiency/ equity	Region	Demand parameters, quantities
Contribution to export earnings	Efficiency	Commodity	Demand parameters, prices, exchange rate, supply, supply shift factor "k".
Contribution to import savings	Efficiency	Commodity	Demand parameters, prices, exchange rate, supply, supply shift factor "k".
Growth in gross production	Efficiency	Commodity	Quantities
Extent of population at risk nutritionally	Equity	Region	Demand parameters quantities
Severity of nutritional risk per capita	Equity	Region	Demand parameters
Income per capita	Equity	Region	Demand parameters
Per capita income growth	Equity	Region	Demand parameters
Commodity contribution to diets of population at nutritional risk	Equity	Commodity	Demand parameters
Extent of resource - poor farmers	Equity	Region/ commodity	Supply parameters, levels of adoption.
Scope for enhancing employment/rural incomes	Equity	Commodity/ region/program project	Supply parameters, prices, quantities, levels of adoption, supply shift factor "k".
Person/land ratio	Equity/ Efficiency	Region/program project	Supply and demand parameters, levels of adoption.
Current and past research intensity	Efficiency	Commodity/ region/program	Probability of research success, supply shift factor "k"
Self-sufficiency	Equity	Commodity	Demand and supply parameters, supply shift factor "k".
Urgency of research problem	Efficiency	Commodity/ region	Probability of research success, supply shift factor "k".

which provide policy makers at national and international levels with meaningful information to assess whether research policy objectives are being met by their chosen regional and commodity portfolios.

An important number of the criteria listed concern distributional or equity objectives. While the Davis, Oram and Ryan model provides information on the distribution of total benefits, the applications presented later in this paper limit this information to groups classified as 'producers' and 'consumers'. Many of the criteria listed in Table 2 imply considerably more detailed knowledge of the composition of these groups. For example, on the 'consumers' side emphasis is often placed on the nutritional composition of diets and the importance of certain commodities to this. If all 'consumers' of a particular commodity are considered to be nutritionally at risk then information generated by the framework is directly relevant for assessing the likely consequences of using research policy to overcome this problem. If not, disaggregation is required and target groups need to be clearly defined. The simplifying assumptions regarding the use of economic surplus as a measure of welfare may also require close attention.

On the 'producer' side, not all of those normally regarded as 'farmers' will necessarily receive equal shares of the total producer benefits from research. For example, landless tenants whose labour is in relatively elastic supply may receive a minimal share of these 'producer' benefits. If these distributional consequences are important, again more detailed disaggregation will be required.

The important point of this discussion is that, while the model as developed can be adapted 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. Their input is required in order to assess likely probabilities of research success, ceiling adoption levels, 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).

We proceed in the following two sections to apply the framework to assess South East Asian priorities and to compare them with a preliminary analysis of priorities suggested for Malaysia. We return to a more detailed discussion of common criticisms of the framework we propose for assessing research priorities in Section 10.

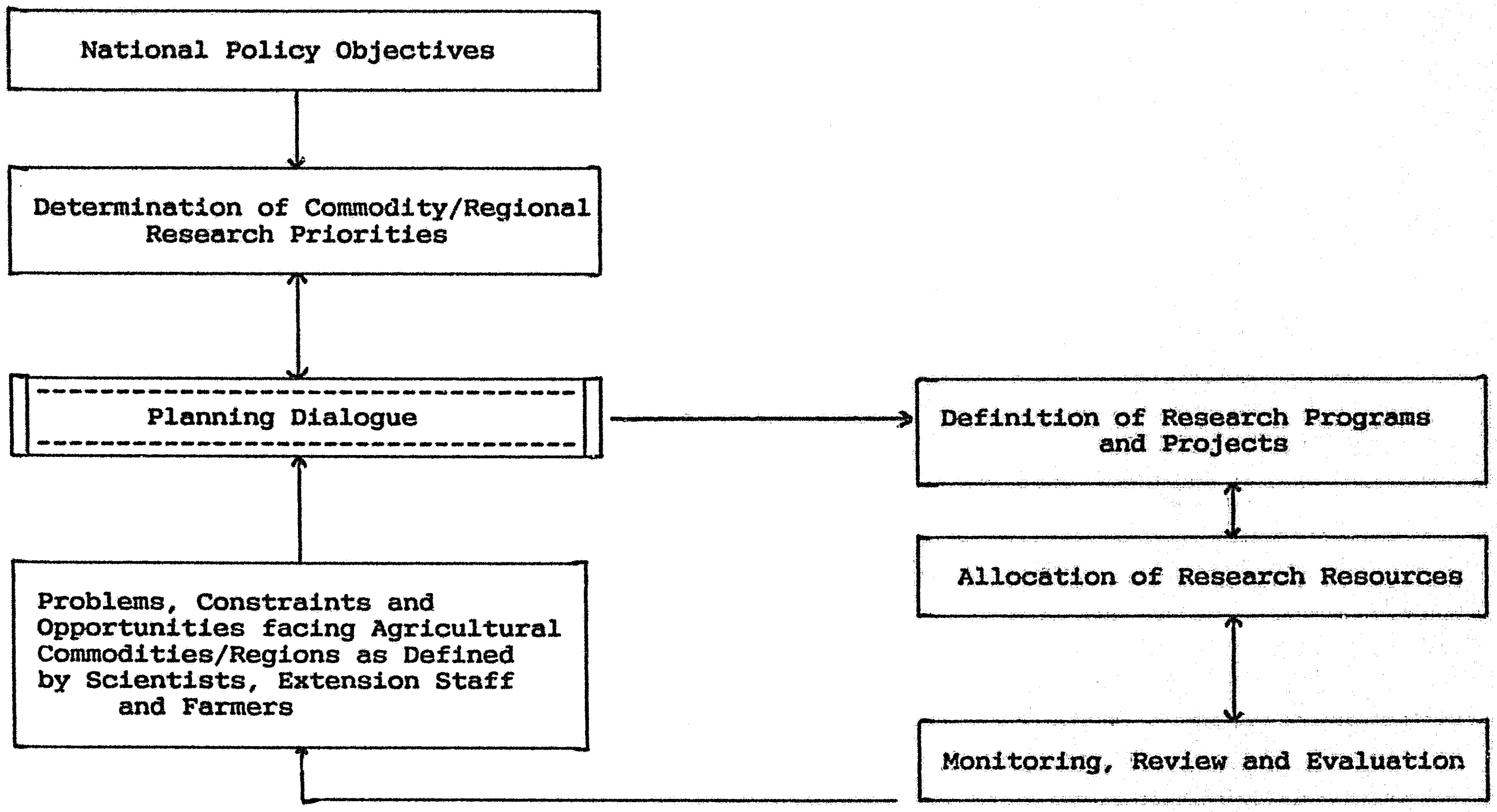

Figure 3 Intersection of National Policy Objectives and Research Opportunities

7. A REGIONAL APPLICATION OF THE FRAMEWORK

A methodology developed for the evaluation of the economic impact of agricultural research is described in more detail in Davis, Oram and Ryan (1987). An important aspect of the framework is its incorporation of research spillover effects. That is, not only can research have an impact on the costs of production of a commodity in the country where it is undertaken, but it also can have an impact on the production and prices of the same commodity in many other countries (Figure 2b and c).

To make effective use of the information generated by the framework on research priorities, clear specification of institutional research objectives is required. After recent discussion it was agreed within ACIAR that an appropriate objective was to choose research projects so as to maximise regional economic gains.[10]

For example, in South East Asia projects would be chosen which offer prospects of providing significant benefits to all countries in South East Asia (as a result of potential spillover effects among countries in the region), rather than relying only on the size of the benefits to the country(ies) where the research is planned to be undertaken.

If maximising regional economic benefits from research is accepted as a primary objective, then a summary of the potential relative economic impact of research has been produced for 23 major agricultural commodities. They have been estimated assuming research on each has potential to cause a 5% reduction in the unit costs of production of each commodity. After adjusting this for subjectively assessed probabilities of research success, ceiling adoption levels and spillovers to other countries using the framework, an assessment of the expected economic benefits from research is arrived at.[11] This information can be used to develop a set of regional commodity priority groupings. Table 3 summarises this information for the five geographic regions of interest to ACIAR.

As well as classifying all 23 commodities into six priority groupings, Table 3 also includes information on the relative benefits for each commodity within each region. These numbers 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 benefits as rice research, it would have to have 87

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10 Of course this is not the only criterion used by ACIAR. Before projects are considered from this perspective they must also satisfy the following criteria: (i) be on a priority problem from the partner country's perspective, (ii) ACIAR has received a request from the country for collaborative research on the problem, and (iii) Australia has acknowledged expertise and comparative advantage in research on the theme.

11 These adjustments represent an attempt to partially incorporate the

TABLE 3 : COMMODITY PRIORITY GROUPINGS WITH THE OBJECTIVE TO MAXIMIZE REGIONAL RESEARCH BENEFITS.

SOUTH EAST ASIA		
	Commodity Ranking	Relative Benefits
I	Rice	1
	Palm-total	5
	Coconut	5
II	Banana/plantain	8
	Sugar	11
	Cassava	11
III	Maize	15
	Sweet potato	19
	Coffee	21
IV	Pulses	30
	Rubber	34
	Beef & buffalo	35
	Potato	40
V	Soybean	70
VI	Groundnut	87
	Oranges	92
	Milk	105
	Sheep/goat meat	138
	Cocoa	189
	Millet	256
	Sorghum	398
	Wheat	393
	Wool	*

SOUTH ASIA		
	Commodity Ranking	Relative Benefits
I	Rice	1
	Wheat	4
	Pulses	4
	Sugar	4
II	Milk	6
	Sorghum	8
	Potato	9
III	Sheep/goat meat	13
	Groundnut	19
IV	Banana/plantain	23
	Maize	23
	Coconut	25
	Millet	26
	Oranges	28
V	Cassava	41
	Wool	50
	Beef & buffalo	57
	Sweet potato	57
VI	Coffee	84
	Soybean	100
	Rubber	226
	Cocoa	*
	Palm-total	*

CHINA		
	Commodity Ranking	Relative Benefits
I	Rice	1
	Potato	3
	Sweet potato	5
II	Wheat	8
	Pulses	10
III	Soybean	16
IV	Maize	25
	Sugar	31
	Sorghum	37
V	Milk	46
	Sheep/goat meat	50
	Groundnut	53
	Wool	54
	Millet	58
VI	Beef & buffalo	153
	Oranges	184
	Cassava	224
	Palm-total	262
	Banana/plantain	537
	Rubber	548
	Coffee	1792
	Cocoa	*
	Coconut	*

S.PACIFIC &PNG		
	Commodity Ranking	Relative Benefits
I	Sugar	1
	Banana/plantain	2
	Coconut	4
	Coffee	5
II	Cocoa	8
	Sweet potato	8
	Palm-total	11
III		
IV		
V	Cassava	43
VI	Sorghum	*
	Rice	*
	Sheep/goat meat	*
	Maize	*
	Potato	*
	Wheat	*
	Pulses	*
	Soybean	*
	Rubber	*
	Oranges	*
	Milk	*
	Beef & buffalo	*
	Groundnut	*
	Millet	*
	Wool	*

AFRICA		
	Commodity Ranking	Relative Benefits
I	Cassava	1
	Banana/plantain	1
	Milk	2
	Beef & buffalo	2
	Rice	3
	Cocoa	3
	Palm-total	4
	Sheep/goat meat	4
	Pulses	5
	Sorghum	5
II	Maize	6
	Millet	6
	Coffee	6
	Sugar	7
	Groundnut	7
	Sweet potato	12
III	Potato	16
	Wool	16
IV	Wheat	26
	Coconut	29
	Soybean	31
V	Rubber	51
VI	Oranges	115

* Not produced in significant quantities in this region.

times the cost reducing effect as any possible rice research. This information can be useful in research resource allocation discussions.

For South East Asia, Table 3 suggests that rice, oil palm and coconut are the highest priority commodities for research. On the other hand, sorghum, millet and wool 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 quite substantial productivity impacts to justify funding if the major objective is to maximise the contributions research makes to economic growth in these developing countries.

Commodity priority groupings such as these can be used in a number of ways. If the economic growth objective is confirmed as appropriate, then a table such as Table 3 might be adopted as a policy guideline for the development of new research project proposals. Any project which considers 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 excluded but would, however, require ample justification.

8. APPLICATION OF THE FRAMEWORK TO MALAYSIA

The objectives of national agricultural research programs are likely to differ from those of international agencies like ACIAR, in particular regarding the importance of international and regional benefits, or benefits accruing to other countries through the spillover effects of research. For illustration here it is assumed that national research systems use the objective of maximisation of national economic benefits from research when determining commodity priorities.

The framework used to help determine regional research priorities can also be used to generate information at an individual country level. Table 4 summarises, in a preliminary analysis, the potential international, regional and national benefits from agricultural research alternatives in Malaysia. In each case the effects of international spillovers have been taken into account from an initial 5% unit cost reduction due to research on the commodities in Malaysia. Table 4 also provide estimates of the distribution of benefits between Malaysian consumers and producers. The Malaysian priority groupings are compared with those for South East Asia and for all countries in Table 4. Although some of the commodities are in the same grouping for both national and international objectives, there are significant differences.

In general this analysis suggests that if Malaysia is concerned to allocate research resources so as to maximize economic growth objectives, then the highest priority should be given to oil palm, followed by rice, rubber and coconut (column 5). Crops such as potato, pulses, sheep and goats, wool and milk should receive the lowest priority. As pointed out earlier, most poverty in Malaysia seems to be concentrated in the rice, rubber and mixed farming sub-sectors. Hence a research strategy which targets such sectors

TABLE 4 : EXPECTED PRESENT VALUE OF NATIONAL, REGIONAL AND INTERNATIONAL BENEFITS TO RESEARCH UNDERTAKEN IN MALAYSIA.

Commodity	National Benefits - Malaysia						Regional South-East Asian Benefits	International Benefits
	Consumer Share		Producer Share		Total	Percent of International		
	($mUS)	(%)	($mUS)	(%)	($mUS)	(%)	($mUS)	($mUS)
Palm Oil	3.3	3	96.8	97	100	69	113	145
Rice	3.2	9	31.2	91	34	6	359	613
Rubber	0.6	4	15.0	96	16	29	20	53
Coconut	2.1	21	7.9	79	10	11	71	91
Banana/Plantain	0.9	16	4.9	84	6	4	39	151
Maize	0.1	4	2.5	96	3	4	21	63
Cocoa	0.1	4	2.5	96	3	5	3	49
Beef & Buffalo	0.1	11	0.8	89	1	1	11	89
Sugar	0.0	0	0.8	100	1	1	21	60
Cassava	0.1	13	0.7	88	1	3	13	31
Coffee	0.2	40	0.3	60	1	1	9	54
Groundnut	0.0	0	0.2	100	0	6	2	4
Sweet Potato	0.0	0	0.0	0	0	0	0	0
Millet	0.0	0	0.0	0	0	0	0	0
Soybeans	0.0	0	0.0	0	0	0	0	0
Sorghum	0.0	0	0.0	0	0	0	0	0
Oranges	0.0	0	0.0	0	0	0	0	0
Wheat	0.0	0	0.0	0	0	0	0	0
Milk	0.0	0	0.0	0	0	0	0	0
Wool	0.0	0	0.0	0	0	0	0	0
Sheep/Goat Meat	0.0	0	0.0	0	0	0	0	0
Pulses	0.0	0	0.0	0	0	0	0	0
Potato	0.0	0	0.0	0	0	0	0	0

Note : All information relates to the expected benefits to research undertaken in Malaysia. National benefits are those expected to accrue to Malaysia itself. Regional South-East Asian benefits are the benefits expected to accrue to Malaysia plus all other countries in South-East Asia after adaptive research. International benefits are the sum of expected benefits to Malaysia plus all other countries in the world as a result of spillover effects from Malaysian research.

offers the prospects of satisfying both growth and poverty objectives at the same time - a pleasing and rare phenomenon. We stress that the results in Table 4 are preliminary and more detailed analysis is required before definitive statements can be made.

9. COMPARING MALAYSIAN AND SOUTH EAST ASIAN PRIORITIES

Table 5 provides a convenient way of examining the extent to which commodity priorities suggested for Malaysia are congruent with priorities established for South East Asia. In both cases the priorities have been assessed using the expected contribution of research to economic growth in Malaysia and South East Asia respectively, as shown in Table 4.

In Table 5 Malaysian priority groupings are listed as high (I) to low (VI) in the columns from right to left on the horizontal axis. Thus oil palm, rice, rubber and coconuts are expected to generate the largest economic payoffs and potatoes, pulses, sheep/goats etc the least. These priority groupings are taken from Table 4. On the vertical axis and rows corresponding to these are listed the priority commodity groupings if an objective was considered to be maximisation of total South East Asian economic growth from a regional or international agency's perspective. From such a perspective, rice, coconut and oil palm are the highest priority commodities, with wool, millet and sorghum the lowest.

This tabular presentation has the advantage of revealing at a glance those commodities which have similar priority rankings, both national and regional. Commodities in the cells along the southwest/northeast diagonal, sloping upward from left to right, have this feature. The more commodities that are included in the upper left (northwest) and lower right (southeast) quadrants, the less consistent are Malaysian and South East Asian priorities from a growth viewpoint. There are clearly a significant number of off-diagonal entries in Table 5, with only three - rice, coconut and oil palm - which represent high priorities for both Malaysia and the region.

Off-diagonal commodities may be of interest from the point of view of research cooperation/collaboration with other national, regional and international research agencies. For example, cocoa is in the medium-high priority (III) group for Malaysia but is the lowest priority (VI) for South East Asia. Hence it could be attractive for other countries in the region to rely on Malaysia for leadership in cocoa research and look to spillover effects from Malaysia's research to be factored into their (much smaller) cocoa industries with the aid of a more adaptive research strategy on their part. The quid pro quo for Malaysia might be for it to do little more than adaptive research on sweet potato and rely on other countries and regional/international agencies for the more basic/strategic/development research from which to draw. These considerations can help to rationalise limited agricultural research resources worldwide, with obvious benefits to all countries. With the pervasiveness of intended or unintended research spillovers among countries resulting from agroecological similarities, more rapid and less costly communications and transport, increased internationalisation of research via the IARC's and networks, and expanded world trade, it is prudent to acknowledge their existence and factor them explicitly into the research planing process. No country can or should

TABLE 5 : COINCIDENCE OF SUGGESTED MALAYSIAN AND SOUTH-EAST ASIAN PRIORITIES.

SOUTH EAST ASIAN PRIORITY GROUPINGS	VI (LOW)	V	IV	III (MEDIUM)	II	I (HIGH)
I (HIGH)					Rice Coconut	Palm oil
II			Sugar Cassava	Banana/plantain		
III (MEDIUM)	Sweet Potato	Coffee		Maize		
IV	Potato Pulses		Beef/buffalo		Rubber	
V (LOW)	Soybean					
VI	Sorghum Millet Wool Sheep/goat Groundnut Wheat Oranges Milk			Cocoa		

MALAYSIA's PRIORITY GROUPINGS

ever expect to be able to mount viable research programs for all commodities of interest to it. There will not be adequate human and physical resources to have the desirable minimum critical mass in all cases. It pays to specialise and concentrate resources on the obvious high priorities, and rely on others for the low priorities.

10. SOME CURRENT RESEARCH POLICY ISSUES

In this section we will discuss a number of the perennial shibboleths which arise in the formulation of agricultural research policies, and in establishing priorities based upon them. The context is the extent to which other considerations such as these ought to condition the use of the foregoing priority assessment framework.

10.1 Need for Research on New Commodities

One criticism often levelled at the use of an economic surplus framework such as that described in Section 5 for establishing commodity research priorities is that, if little or no production of a commodity occurs presently in a country, then it will automatically be accorded a low ranking. Whilst this is true in the sense that the formulae used in such frameworks require non-zero production to obtain a ranking, this is so for a good reason.

Often a new commodity will be available by importing it from countries that currently have a comparative advantage in its production, which usually explains why it may not be produced domestically. Only if by an enhanced domestic research effort it is expected that the domestic industry's cost structure could be improved sufficiently to displace a significant portion of imports is it likely that such a commodity should rate a higher priority than established industries. Even then the projected cost-saving effects of research (below the import price, not the domestic costs of production, which are higher by definition) on the new commodity would have to greatly exceed that expected from the existing major agricultural commodities before this would occur.

We would be surprised if the prospects for productivity gains (cost-savings) from research on commodities with a higher current national resource cost compared to import parity prices are greater than those for the commodities whose cost structures are below import parity, and which are hence largely produced domestically. Only if this inverse relationship existed would there be a case in setting priorities, for special consideration for commodities with little domestic production or which are entirely imported. There would be potential for import replacement to improve foreign exchange earnings but, as discussed later, this does not provide a compelling reason to alter priorities.

10.2 Self-Sufficiency as a Primary Objective

This argument amounts to a strategy of emphasising research on commodities where imports represent a high proportion of domestic utilisation. Often this is rationalised on grounds of foreign exchange saving, but sometimes also for strategic reasons. Again, there may be substantial opportunity costs in devoting scarce research resources to attain this objective, especially if the prospects of successful research on the commodity are low, and the commodity is a minor component of the total domestic utilisation of all agricultural products.

The corollary of this strategy is that often, once countries do become self-sufficient in the production of one or more agricultural commodities, the tendency is to automatically divert research resources out of such commodities into those whose self-sufficiency ratios are less than 100%. Rice in Indonesia is a good example. Over the past 15-20 years Indonesia has moved from being a substantial importer to be virtually self-sufficient in rice. Continued research efforts on rice remain justified, not only to maintain productivity, but to continue to improve it if opportunities remain. These opportunities do not suddenly evaporate because of self-sufficiency. As rice will continue to be a major component of domestic agricultural production, even small productivity gains can generate large cost-savings, with attendant increases in incomes, employment and foreign exchange earnings. These could still dwarf the gains from research targeted at crops in which Indonesia is not self-sufficient.

As long as the commodity remains a significant one and productivity gains are still possible with research, it should continue to be accorded priority, regardless of whether the country is self-sufficient or not. Productivity gains can free resources to produce other commodities if additional production of the commodity in which the country is self-sufficient faces market constraints. If market prices are allowed to convey the appropriate signals, farmers will adjust their production patterns to ensure the freed resources are allocated to the most profitable alternatives. Governments need not worry that an unmanageable surfeit of the self-sufficient commodity will be the automatic result of a continuation of the research effort on the commodity in question, unless it distorts market signals that farmers receive.

10.3 Import Replacement

Import replacement is the mirror image of the discussion of self-sufficiency strategies and the development of new commodities.

Foreign exchange saving is usually the basic imperative underlying this policy. The question is, what are the national resource costs of generating additional foreign earnings, and are there more cost-effective ways of doing it? Perhaps it is preferable to focus research on the export commodities, where by definition the country probably has a comparative advantage? This would be appropriate especially if the export industries are much larger in value than the import industries concerned, and/or the former represent a minor portion of world trade, so additional production would have little effect on world prices.

A preferable alternative to research biased towards either import replacement or export enhancement, is to examine trade and exchange rate policies. It is likely the concern about foreign exchange earnings is a result of the imposition of export taxes, tariff protection and an overvalued exchange rate. Addressing these policy issues is likely to achieve more than targeted agricultural research.

10.4 Emphasis on Food Versus Non-food Crops

The framework described earlier in this paper does not differentiate between food, non-food, commercial or subsistence commodities, except by way of their relative production levels, their prices, and their price elasticities of supply and demand. The fact that a commodity is not traded does not alter the manner in which it is assessed for determining the research priority it should be accorded if economic growth is the primary objective. It is admittedly more difficult to derive the appropriate price to value non-traded goods like subsistence crops to use in a priority assessment framework like that being proposed. But this is their only real peculiarity. In principle they should be treated in the framework in the same way as non-food or commercial crops.

10.5 Sustainability and Environmental Concerns

There is growing concern about the degredation of the environment as a result of population pressure and market failure. Research is suggested as one ingredient in arresting the rate of decline. How do we translate these concerns into commodity research options to compare with other opportunities in a consistent framework?

One way to view research on environmental questions such as soil erosion, is that what is being attempted is the development of technologies that enhance the productivity of soil some time in the future, so that more agricultural commodities of value are capable of being produced than if no research were conducted. Conceptually this is the same question as assessing what is the value of rice breeding research. However, soil erosion research (and indeed all factor research) has an added dimension of requiring the proponents to identify the commodities likely to be affected and to what degree. This is a challenge, but a necessary one.

Because the benefits of this type of research are generally realised further into the future than conventional commodity research, an added difficulty arises. The suggested priority assessment framework uses the standard benefit - cost approach of discounting future benefit streams by an (interest) opportunity cost of capital. This results in benefits received further into the future receiving a much lower weight than those received sooner. Hence long-run sustainability research often fares badly using the framework. Should society be "living only on the earth's interest without encroaching on its capital", to use one commentator's description of the problem? This suggests that in evaluating sustainability or environmental research, one might dispense with discounting on the basis that society is prepared to make current sacrifices on the grounds of intergenerational equity. More research of a socioeconomic and political nature on these issues seems appropriate, as it also raises the question of the proper balance between publicly and privately funded research.

It is also important to recognise as Schuh (1988) does that, whilst more rapid growth can contribute to increased environmental problems, it can at the same time provide additional resources to alleviate them, if the political will exists. Often this requires both institutional and technological innovations.

10.6 Public Versus Private Research

A legitimate role for government in research arises when there are inadequate incentives for the private sector (farmers or industry) to invest in research which has high prospective social returns. This can arise when intellectual property rights to innovations cannot be protected. With the advent of plant breeders rights it may be that the private sector will assume an increasing role in plant breeding research on commodities like food, which traditionally were the preserve of public sector research institutions. This could free public resources to concentrate on research themes like sustainability, where intergenerational equity and lack of intellectual property protection leave no incentive for the private sector and hence may be legitimate candidates for the public sector.

Even when the legitimate role for direct government involvement in research has been established the appropriate source of funding needs to be determined. The framework suggests that with commodities facing elastic demand, such as export crops from countries who are insignificant in world trade, the major beneficiaries from research will be the producers. Under such circumstances it is not surprising to observe that producer groups lobby for commodity cesses or taxes to fund research. The less elastic the commodity demand the larger is the share of research benefits received by consumers, and therefore the more diverse is the group of research beneficiaries. In most of these cases a commodity tax to fund research is also the most effective source of research funding. However, situations will arise when the nature of the commodity and diversity of beneficiaries may result in high transactions costs of collecting and administering commodity research taxes and justify use of general taxation revenue. In these cases the additional social costs of using general revenue taxes to fund research needs to be included in the assessment of the social desirability of the research.

10.7 Post-Harvest Versus Production Research

The priority assessment framework described earlier can accommodate both post-harvest and production research. Essentially what is required is that estimated cost savings be couched in a consistent fashion to enable comparisons to be made. In general terms, the larger the share of the value of production of a commodity represented by post-harvest costs, the more emphasis that line of research should receive, other things being equal.

Post-harvest research could conceivably lead to more innovations which are patentable than production research. To the extent this is true, then there may be less merit or scope for the public sector to be heavily involved. Furthermore, such innovations are likely to be less location - specific (eg. grain dryers), and hence the potential markets for private R&D companies could be large, thus providing considerable incentive for their involvement. Where post-harvest technologies are not expected to be readily patentable (ie. spillover effects are large), there is a convincing case for public sector R&D investment - perhaps more appropriately involving cooperation by a number of countries. A good example of this is the ASEAN Food Handling Bureau.

10.8 Basic/Strategic Versus Applied/Adaptive Research

In general terms, basic and strategic research will not be specific to particular commodities or regions, and hence may not be easily amenable to the type of analysis described in the foregoing priority assessment framework. Basic/strategic research has relevance across many sectors of the economy and internationally. Often the only intellectual property rights available to its scientists are professional publications, which place the information essentially in the public domain. It can then be accessed by R&D institutions involved in applied/adaptive research to develop new technologies and innovations to which they can be assigned patents or other property rights.

Therefore, basic/strategic research should most appropriately be primarily in the public domain. Unless it is, there may be under-investment in it by society if left to the private sector. The current debate in Australia about government funding of CSIRO seems to ignore this implication. Expecting CSIRO to maintain its basic/strategic research profile in the face of a government edict to resort to a more user-pays approach to funding derived from the commercial sector, is heroic at best. This is especially so with CSIRO's agricultural research where a priori there would seem to be even less scope for exploitation of intellectual property rights than in fields such as mineral exploration, materials science and manufacturing technology.

10.9 High Versus Low Potential Regions

Often regions with low and variable rainfall and impoverished soils are targeted for research because a large proportion of a country's poor often reside there. This is a laudable rationale. However nature in these regions is generally more niggardly in allowing science access to its secrets and as a result technological progress can be slow. In such circumstances the question has to be asked as to whether limited research resources might not generate larger productivity gains more rapidly in higher potential environments such as the humid zones and irrigated areas. Some of the additional economic returns from such a diversion could be used to assist in improving the welfare of those residing in the lower potential zones. As Mellor (1986) and Schuh (1988) contend, targeted research again may not be the most cost-effective way to assist them from a national perspective.

10.10 Disciplinary Priorities

The economic surplus framework does not directly provide information which can assist in long-term human resource planning. This can only be adequately done by building up knowledge of constraints to productivity improvements (eg. soils, pests, policies) from below and accordingly designing University training programs with the right balance amongst disciplines.

This long-run task is critical because in the short-run the disciplinary mix available for allocation to problem areas is somewhat fixed. Entomologists cannot become soil scientists overnight! However, entomologists and soil scientists can be moved among commodities and regions in the short-run in response to assessed commodity and regional priorities, along the lines discussed earlier.

10.11 Growth and Equity

To some, the emphasis in the priority assessment framework on the likely contribution of alternative commodity and regional priorities to economic growth might be seen as being at the expense of equity concerns. As explained in the early sections of the paper and in this section, there is no necessary incompatibility in these two objectives, as long as research is not regarded as the only policy instrument available to government to achieve its equity objectives, and it is accepted that research has a comparative advantage in contributing to growth objectives.

For example, the fact that the framework places a significant weight on large industries means that large numbers of consumers and producers are going to be affected by productivity improvements. As both consumers and producers who adopt unequivocaly gain in absolute terms from technological change, when this occurs in large industries more stand to gain. This is an often neglected benefit of a growth - oriented strategy. Of course the relative shares of the benefits accruing to different socioeconomic groups can differ depending on the commodities and regions that are emphasised in the research portfolio.

More of the labour force is generally employed in the production of the commodities which contribute most to the gross value of agricultural production compared to the less significant commodities. Unless research organisations choose portfolios which lend a labour-saving bias to resulting technology options, which would be inappropriate where labour is relatively abundant (Hayami and Ruttan, 1971), there will be widespread participation by the labour sector in the economic gains from a growth-oriented research strategy.

Income is regarded as one of the major determinants of nutritional status, although it is not sufficient to guarantee adequacy. A growth strategy which emphasises the generation of large new income streams from a focus on the major commodities hence should also contribute to social objectives which emphasise improved nutritional well-being of those at risk. If the major commodities in terms of their gross value of production also happen to be the basic food staples of the country (which will be of particular importance to the poor), the equity and nutritional implications will be reinforced at the same time as growth objectives are attained.

10.12 Future Changes in Demand Patterns

If it is expected that future patterns of consumer demand are going to change dramatically from current patterns for reasons other than technological change, then it would be appropriate to factor such projected changes into the priority assessment framework. Davis, Oram and Ryan (1987) describe how this can be done, although in empirical applications, including those in this paper, they have not attempted to explicitly account for these dynamic aspects.[12]

Changes in relative demand patterns in particular countries or regions would have to be dramatically different to those underlying the empirical analyses conducted so far for there to be a significant change in the priorities which have been suggested.

10.13 Agricultural Versus Non-Agricultural R&D

A view which is gaining currency in Australia, not the least by government, is that allocating scarce research resources to "declining" and small industries like agriculture is less attractive than investing them in "sunrise" industries such as superconductors. The rationale behind this seems to be that the latter represent "growth" industries, and unless we develop a niche or special comparative advantage in them from an enhanced R&D effort Australia will be left behind and miss a major growth opportunity. We are not competent to assess the "sunrise" proposition. However it is clear there may be large opportunity costs for Australia if the sun rises at the expense of neglect of those elements of our agricultural sector where we have a demonstrated comparative advantage.

Most of our major agricultural export industries face relatively elastic demand functions and by definition we already have a comparative advantage in their production, in contrast to the so-called "sunrise" industries who are yet to demonstrate this. Furthermore, as we were reminded recently by Allwright (1988) there is a huge potential market for Australia's agricultural products in Asia as income and population growth proceeds apace. Recent analysis shows that developing countries such as Indonesia,

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12 These have been implicitly accommodated in the use of projected commodity prices in 1995 from World Bank estimates in calculating prospective research benefits. These have been estimated by taking into account the effects of income and population trends on commodity

whose own agricultural sectors have grown most rapidly in recent years, are also those whose net imports of agricultural products from developed countries have also grown most rapidly (Mellor (1987) and Anderson (1987)).

Against this background, continuing and growing investment in agricultural R&D in Australia is a wise policy. Agriculture's small share of GDP and employment in Australia belies its potential to continue to grow and contribute to foreign exchange earnings and to fill growing food gaps in developing countries. The lagged supply shifts occasioned by enhanced agricultural R&D efforts in Australia can be expected to impact on relatively price and income elastic markets, which can only be to our economic advantage.

11. CONCLUSION

Agricultural research and technological change should be key ingredients in the development strategies of both developing and developed countries. They provide the stimulus so necessary for economic growth and the realisation of social welfare objectives. Allocating scarce research resources in a manner which emphasises their potential to contribute to economic growth will at the same time facilitate the attainment of social welfare goals. Enhanced growth provides the means whereby other policy instruments can be used to distribute the gains and burdens - according to government policy. It is generally unwise and inefficient to expect agricultural research to directly contribute to the attainment of social welfare objectives.

A framework which allows priorities to be assessed so as to maximise the potential growth contribution of agricultural research has been described in the paper. Although it does not represent a panacea, it does provide a consistent way of comparing research portfolios so as to illustrate the trade-offs which are implicit in alternative scenarios involving objectives other than growth. The framework can be used to develop a data base which can better inform policy makers in decisions about the allocation of research resources, and in evaluating research performance.

In formulating national agricultural research policies the pervasive nature of international spillover effects should be recognised and explicitly factored into R&D strategies. Spillovers present both opportunities and challenges for individual countries. These can often be complementary to those facing other countries and offer advantages to all in strengthening the cooperative and collaborative research arrangements among them. These can take the form of bilateral, regional, or multilateral programs. The priority assessment framework described in the paper can be used to help identify where the best scope exists for such arrangements.

The consistently high rates of economic return to past investments in agricultural research in both developing and developed countries suggests that there is general underinvestment. At least three explanations are possible. One is that agricultural research administrators do not do an effective job of justifying their portfolios to officials in their government treasuries and planning agencies. We contend that the use of a framework such as that described in this paper might provide administrators with a more convincing case to present to treasury officials in a language they understand and appreciate.

The second possible explanation is that spillovers from one country or region to others are prevalent and the benefits they represent are not considered by national policy makers when assessing the prospective payoffs from research investments. This is quite understandable and rational from a national perspective but can lead to foregone international benefits because national programs will reduce their investments below that which maximises total national plus international benefits. Regional and international agencies hence can play an important role in ensuring that national research resources are supplemented so as to fully exploit research opportunities.

Finally, intellectual property rights, especially at the international level, may not sufficiently protect research institutions, be they public or private. If their prospective returns from exploiting innovations are eroded by such a failure it can lead to underinvestment in R&D. This, together with the temptation for the public sector to crowd-out the private sector in agricultural R&D in areas where the former has little or no comparative advantage, imply that more attention to indirect interventions in the research policy process by governments may be appropriate. Whether appropriate or not, plant breeders variety rights is a step in that direction.

REFERENCES

Alderman, H. 1986. The Effect of Food price and Income Changes on the Acquisition of Food by Low-income Households. Washington D.C. : International Food Policy Research Institute.

Allwright, J. 1988. Address to the National Science Forum. CSIRO Canberra, September 29.

Anderson, J.R. and Parton, K.A. 1983. Techniques for Guiding the Allocation of Resources Among Rural Research Projects : State of the Art. Prometheus (1): 180-201.

Anderson, K. 1987. Is Agricultural Growth in Developing Countries in Australia's Interest? In J.G. Ryan (ed.) Building on Success : Agricultural Research, Technology, and Policy for Development. Report of a symposium held at Canberra, 14 May. ACIAR Technical Reports No. 7.

Boyce, J.K. and Evenson, R.E. 1975. Agricultural Research and Extension Programs. Agricultural Development Council, Inc. New York.

Davis, J.S., Oram, P.A. and Ryan, J.G. 1987. Assessment of Agricultural Research Priorities: An International Perspective, Australian Centre for International Agricultural Research, Monograph No.4, Canberra, Australia.

Davis, J. and Ryan J.G. 1987(a). Priority Assessment in Agricultural Research : International and National Perspectives. ACIAR/ISNAR Project Paper, No. 1.

Davis, J. and Ryan, J.G. 1987(b). Institutionalisation of Agricultural Research Priority Assessment : An Application. ACIAR/ISNAR Project Paper No.5, June.

Gardner, B. 1988. Price Supports and Optimal Agricultural Research : Or, Damn Surpluses, Full Speed Ahead. Working Paper 88-1, Department of Agricultural and Resource Economics, University of Maryland.

Hayami, Y. and Ruttan, V.W. 1971. Agricultural Development : An International Perspective, Johns Hopkins, Baltimore.

Judd, M.A., Boyce, J.K. and Evenson, R.E. 1986. Investment in Agricultural Supply : The Determinants of Agricultural Research and Extension Investment. Economic Development and Cultural Change 35 (1): 77-113, October.

Longmire, J. and Winkelmann, D. 1985. Research Allocation and Comparative Advantage. Paper presented at the 19th International Conference of Agricultural Economists, Malaga, Spain, 26 August-4 September, 1985, Economics Program, CIMMYT, Mexico.

Mellor, J.W. 1986. The New Global Context for Agricultural Research : Implications for Policy. International Food Policy Research Institute Report 1986, pp.7-14.

Mellor, J.W. 1987. Links between Technology, Agricultural Development, Economic Growth and Trade Creation. In J.G. Ryan(ed.) Building on Success : Agricultural Research, Technology, and Policy for Development. Report of a symposium held at Canberra, 14 May. ACIAR Technical Reports No.7.

Pinstrup-Andersen, Per. 1977. Selected Economic Aspects of Agricultural Research. Paper prepared for Symposium on The Current Global Status of Food and Agriculture, Ohio State University, Colombus, September 6.

Ruttan, V.W. 1980. Bureaucratic productivity : The Case of Agricultural Research. Public Choice 35 : 529-547.

Ryan, J.G. 1977. Human Nutritional Needs and Crop Breeding Objectives in the Indian Semi-arid Tropics. Indian Journal of Agricultural Economics 22(3) : 78-87, July-September.

Shuh, G.E. 1988. Social, Economic, and Policy Issues in Dryland Agriculture. Paper presented at the International Conference on Dryland Farming, Amarillo, Texas, August 15-19, 1988.

Shand, R.T. 1984. Rural Development in Malaysia. Paper presented at Regional Seminar on Rural Development in Asia, Asian Development Bank, October 15-21.

Tyagi, D.S. 1981. Growth of Agricultural Output and Labour absorption in India. Journal of Development Studies, 18(1) : 104-114.