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Research and Extension Impacts on Food Crops Production in Indonesia

R.E. Evenson¹

Introduction

Indonesia has achieved steady and continuous development and strengthening of its public sector agricultural research program over the past thirty years. In 1960 Indonesian agricultural research institutions had little research capacity. Only a few Indonesian scientists with advanced training were available for research. Expatriate-based research programs were in transition. By 1970 substantial progress had been made in building research capacity. In 1974 a formal research organization was established (the Agency for Agricultural Research and Development, AARD). This agency now encompasses 29 major research centers and over 200 experiment stations. More than 2,400 scientific personnel are employed in the systems research institutes.

The Central Research Institute for Food Crops (CRIFC) is one of the most important of the units within AARD. It has research responsibility for all food crops including research programs on cereals and grain legumes (rice, maize, soybean, groundnut, mungbean) and root crops (cassava, sweet potato). Research is conducted in six research centers located in different regions. Fifteen research stations and 45 experimental farms are included in the CRIFC system. In 1989, 684 researchers (S1, or university graduate, and above) were working in CRIFC.

Staffing and resources in CRIFC and AARD

Prior to 1974 Indonesia supported a number of research centers and institutions. A number of these centers were originally established in the colonial period with a focus on traded commodities. Rice research programs were established prior to 1974, but other food crop research programs were rudimentary at that time.

The AARD, established in 1974, provided the basis for a significant expansion of research in a number of fields. The focus on this study is on the expansion programs of CRIFC, the major research institute in AARD. CRIFC coordinates six research institutes with the following mandates:

- * Bogor Research Institute for Food Crops (BORIF) has a national mandate for conducting pioneering/fundamental research and commodity analysis.
- * Sukamandi Research Institute for Food Crops (SURIF) is responsible for research on wetland areas.
- * Malang Research Institute for Food Crops (MARIF) is responsible for research on palawija, or

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¹Yale University, New Haven, Connecticut, USA.

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non-rice food crops.

- * Maros Research Institute for Food Crops (MORIF) conducts research on dryland areas with a dry climate and on rice tungro virus.
- * Banjarbaru Research Institute for Food Crops (BARIF) has a national mandate for research on tidal swamps and swampy areas.
- * Sukarami Research Institute for Food Crops (SARIF) is responsible for research on dryland areas with a dry climate and on high elevation wetland rice.

Financial resources in CRIFC

Table 1 reports a summary of research expenditures and values of food crops in Indonesia for recent years. Expenditures include routine expenditures and development expenditures. It is not possible, however, to use these categories to assess the relative importance of salary and non-salary support components.

Table 1 Agricultural research expenditures and values of food crops in Indonesia.

	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
A. Total research expenditure (million rupiah)	11.293	11.067	8.583	11.166	12.903	21.898
B. Total value of food crops (billion rupiah)			20.212	21.123	21.898	
Ratio NB			.00043	.00053	.00059	

What is clear from these financial data is that in spite of impressive expansion and growth of the CRIFC research staff, the ratio of research spending to commodity value (i.e., the research investment intensity) is one of the lowest in the world. This is in part because salaries in Indonesia are low making research scientists one of the lowest cost productivity generating activities in Indonesia. Most developed countries have research to commodity value ratios on the order of 0.01, almost twenty times that of Indonesia. About half of this difference is a price differential. Scientists cost only one tenth as much in Indonesia as they do in Europe, for example, while fertilizer and other inputs, except labour, cost approximately as much. Even adjusting for this price differential, Indonesia has research investment intensities that are less than half of those in most other developing countries.

Distribution of expenditures and staff by food commodity

Table 2 reports estimated distributions of budget and staff time within CRIFC by commodity. Approximately twenty percent of staff time and twenty-five percent of budget was allocated to non-crop items. For comparison, staff and value distributions for food crops are also presented.

Table 2 Distribution (%) of CRIFC budget and staff by commodity, 1990.

Commodity	All Food Commodities			Non-Rice Commodities	
	Budget	Staff	Value	Staff	Value
Rice	22.2	31.1			
Irrigated wetland		26.6	71.7		
Rainfed wetland		1.0			
Deep water		0.2			
Tidal swamp		1.1	67.4		
Upland		2.3	4.3		
Other Cereals	17.3	17.8	9.0	35.6	32.1
Maize		16.	8.4	32.0	30.0
Wheat		1.2		2.4	
Sorghum		0.6		1.2	
Legumes	20.5	28.1	18.0	56.3	35.6
Soybean		15.	6.0	30.1	21.4
Groundnut		7.5	3.7	15.8	13.2
Mungbean		4.4	1.3	8.8	4.7
Pigeonpea		.4		.8	
Other		.8		1.5	
Root Crops	3.6	4.6	9.0	9.2	32.1
Cassava		3.0	7.3	6.0	26.1
Sweet potato		1.3	1.6	2.5	5.7
Yam		.1			
Post Harvest	3.8	3.3			
Water Management	1.1	.8			
Soils	.6	1.5			
Engineering	5.2	2.9			
Farming Systems	10.3	4.8			
Socio-Economic	2.4	2.4			
Seed Technology	.9	.5			
Biotechnology	1.4	.5			
Germplasm	.7	.6			

Source: AARD Master Research Plan: Food Crops 1990-1994, Volume 1, CRIFC, September 1990, Agricultural Census.

By comparing the distribution of budget with the distribution of staff one can assess which programs are relatively high cost or low cost. Table 2 indicates that non-commodity research is generally high cost research. Farming systems, engineering, and biotechnology have highest costs per staff member. Rice and legume research is relatively low cost.

Editorial

Farming Systems Research

Seiji Shindo
Director

CGPRT Centre

It is well known that farming systems research is a tool for the testing and introduction of new cultural techniques, crops and post-harvest technology in specific areas. Farming systems research, to use the most general term, has become a very wide stream in agricultural research throughout Asia.

Its continuing popularity is underlined by the recent establishment of the Asian Farming System Association which will hold its third conference in Manila this year. There are a number of important issues facing farming systems research today.

The emergence of farming systems research is explained by the need for

practical and applied research, testing of improvements, varieties and new crops on the spot. In the 1960s and 1970s this type of research was called cropping systems research, and its merit was thought to be that on-farm activities put researchers in direct touch with farmers. In most Asian countries in those years agricultural extension involved crop monitoring and credit supply, while most of the technical attention was directed to rice and its improvement. In due course, researchers developed better insight into various farm activities. One of the major findings of early cropping systems research, which has not lost value, concerns the intensity of Asian agriculture.

It is evident that the first wave of cropping systems research covered primarily irrigated areas, focused on rice and resulted in successful introduction of improved rice varieties and expanded options for second crops. Many situa-

tions permit intensive agriculture, not only for double and/or inter-cropping, but also involving livestock and tree crops.

While there seems no doubt that the farming systems research has brought local conditions into the spotlight and has contributed to fine-tune research to local needs, impacts on local agriculture and farm incomes are difficult to measure. Farming systems research on upland agriculture is not yet well developed and issues of environmental degradation and sustainability add new dimensions to be tackled. Comparison, for instance, of the actual intensity of upland agriculture with irrigated lowland agriculture, is difficult since statistical information does not yet cover upland agriculture in sufficient depth.

This issue of Palawija News reflects the need for institutional as well as economic assessments of investment in R & D on upland agriculture. We look forward to future work in these areas.

In Indonesia there is a concern with diversification both in production and research programs to encompass non-rice crops. It is clear, however, that rice receives the lowest research attention relative to value (probably half of non-rice crops) of any of the commodities. Indonesian rice producers also have the lowest research attention relative to value in the world.

Given this unusual situation, it is useful to compute the non-rice distribution of staff and commodity value. This enables a comparison of research attention to the AARD commodities. For these commodities, legumes receive relatively high research attention and root crops receive relatively low research attention. This is also the case for upland rice.

Staffing history by research center

Historical data on budgets and staffing by center are not directly available. It is possible, however, to "construct" an approximate historical staff series by skill level using the MIS data on staff in 1989-90. These data report:

- * location in 1990 (center)
- * research grade in 1990 (IV, III, II, etc.)
- * degree level in 1990 (S3 - doctorate, S2 - MSc, S1 = BS, other degrees)

- * year last degree obtained
- * year of first hiring in the system.

A historical staffing series by CRIFC center and by skill level was created utilizing the MIS data. It utilized the following assumptions:

- * The 1990 location was assumed to be the staff member's location throughout his career. Only grade III and IV staff were considered as lower grade staff generally do not manage research projects.
- * It was assumed that S3 staff had been S3s since the year of their S3 degree. They were then not included in the staff series for the prior 4 years. They were then treated as S2 staff for the years prior to this (after their initial employment).
- * S2 staff were treated analogously. They had been taken out of the series for 2 years prior to their S2 degree and were assumed to be S1 staff prior to that.
- * S1 staff were treated as S1 staff only after their S1 degree.
- * Other staff include only those staff with less than an S1 degree who have attained a level III ranking. It is assumed that they have attained some research skills although most are older staff with responsibilities for field work, etc. Obviously, the calculated series is subject to

some errors if staff are highly mobile. It appears, however, that staff mobility is quite low and that these series do have a high degree of accuracy.

Table 3 reports the 1989 staff allocation by commodity. Since this distribution were constant over recent years a staffing history by commodity by center series was be created for the econometric analysis.

Table 3 Staff allocation (%) to commodities, 1989.

Commodity	BORIF	SURIF	MARIF	SARIF	MORIF	BARIF
Wetland Rice	35.86	32.23	22.78	15.01	24.39	32.51
Dryland Rice	0.00	0.43	0.00	12.20	5.31	3.52
Maize	18.82	4.74	23.78	6.66	14.75	13.45
Cassava	5.26	0.34	0.00	3.67	0.77	6.24
Sweet Potato	2.16	0.00	0.00	2.97	0.26	0.00
Groundnut	7.12	6.20	9.44	6.72	8.62	6.16
Soybean	15.83	7.50	21.34	8.84	16.09	13.05
Mung bean	4.12	3.96	6.24	3.05	6.03	0.00

Source: AARD Master Research Plan, Food Crops, 1990-1994, Volume 1, CRIFC, September 1990.

Impact assessment methods

Investments in public sector research, extension, and schooling programs have been a primary source of agricultural productivity change, i.e., in increased output per unit of input in many countries. These productivity gains are realized when new products, processes, and practices are invented, developed for farm use, and adopted by farmers. Improved infrastructure and improved markets also contribute to efficiency. Private sector inventions that are made available to farmers at costs that only partially reflect the real value of the inventions also contribute to efficiency (i.e., private firms capture only part of the value of their inventions in higher prices).

Methods for evaluating the specific contributions of public and private sector research programs have been developed and applied in a number of studies. Perhaps the simplest and most direct method was developed by Griliches (1958) in his well known study of hybrid corn. The application of this particular method (the imputation-accounting method) requires that the level of use of technology in question be measured. In the case of crops, the actual adoption and use of specific varieties can be measured, and this information could be used to

compute social benefits. Data for varietal production shifts or impacts are required for this analysis.

Unfortunately, the use of many inventions, particularly minor improvements in practices, is not easily identified. Furthermore, the availability of inventions to farmers causes changes in farm organization, scale, and specialization that take place over time. Thus, the development of improved varieties, for example, may have long-term effects on farm efficiency that are not directly captured in the short-term. Methods have also been developed to deal with cases where technology use is not directly measurable. These methods are statistical methods in which variables based on investments in research, extension, schooling, infrastructure, and farm programs are related to farm efficiency. Data available for Indonesian regions are suited to the use of these statistical methods.

Statistical methods

There are two basic statistical methods available for the study of research program impacts. These are MFP decomposition and meta production function methods. These methods provide means for estimating rather than imputing the contributions of changes in technology, infrastructure, and policy environments faced by farmers to productivity change.

Statistical methods are generally used when no direct measure of the inventions adopted or of the invention-productivity link is available. These methods rely on identifying the link between investments in research, extension, and schooling (i.e. inputs) and productivity rather than between inventions (i.e. research output) and productivity.

The logic of these methods is based on the following concepts. Production, **Y**, can be expressed as a function of inputs, **X**, technology, **T**, infrastructure, **I**, and human capital, **H**.

$$Y = F(X, T, I, H) \quad (1)$$

This is often described as a "meta" production function because it incorporates variables measuring the contributions of **T**, **I** and **H** directly into the analysis. With data on production, **Y** (maize, etc.); inputs, **X** (land, labour, fertilizer); technology, **T** (research, and extension); infrastructure, **I** (roads, irrigation); and human capital, **H** (farmer schooling), it is possible to estimate (1) with appropriate variable specifications.

An alternative method is to first form a "multi-factor productivity" index of production divided by an index of all inputs, X^* . This input index can be computed providing that one has "cost share" data.

$$X^* = E_i C_i X_i \text{ where } C_i \text{ is the cost of the } i\text{th input, } X_i.$$

The MFP decomposition method simply relates MFP to the **T**, **I** and **H** variables.

$$MFP = Y/X^* = F^*(T, I, H)$$

Both methods require careful construction of the **T**, **I**, and **H** variables with the research variable being the most difficult.

Production data and choice of method for Indonesia

Indonesian data were collected at the provincial and regional levels for the following food crops for the period 1971-1990:

wetland rice	groundnut
dryland rice	soybean
maize	mungbean
cassava	

Input data are available on a per hectare basis for these crops for the following inputs:

seed	labour (hired)
fertilizer	other
pesticides	

Inputs per hectare are not available for all provinces. It is, however, possible to obtain such data for the following eight regions:

Sumatra	East Java
West Java	Bali and Nusatenggara
Central Java	Kalimantan
Yogyakarta	Sulawesi

Data on land cost shares and family labour cost shares are not available. However, the advantages of the MFP methods are sufficient to justify the arbitrary specification of these shares to be 0.85. Thus the input index is:

$$X^* = HA.85I.15$$

where **I** is a cost share weighted index of seed, fertilizer, pesticides, and hired labour use.

Family labour is assumed to be proportional to land in this analysis. It was possible to define MFP for each of seven crops studied except for mungbeans where yield is used to approximate the MFP index.

Specifying the research variable

The form of the research variable depends on whether the yield function is in a rate of change per year form or in a "level relative to a base" form. In this study the MFP variable will be indexed to equal 1 in each region for the average of the 1971-75 period. This procedure eliminates all cross-section differences due to soil quality, weather, and other factors in that period. The specification then is one where changes since the base in the dependent variable are being analyzed.

The contributing research activities will have a timing dimension and a spatial dimension. That is, research conducted in time period **t** and targeted to region **i** will have impacts on production in future years. In addition, this research may affect productivity in regions other than region **i** (this will depend on how much research is being done in other regions). The specification of the research variable must thus take both of these factors into account.

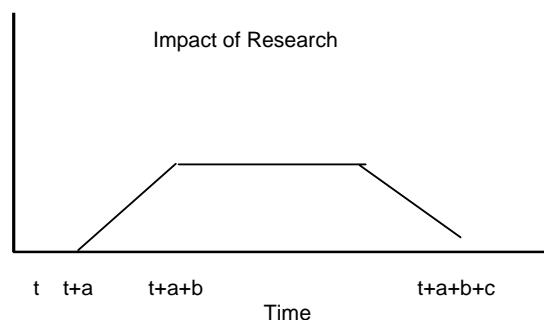
An additional issue that must be faced is the relative weights to place on staff skill categories, **S3**, **S2**, **S1**, and others.

The timing dimensions

Figure 1 depicts the typical time shape or weight distribution over time for a research variable.

Research activity in time **t** may have no impact until period **t+a**. Then it may have a rising impact reaching a maximum at **t+a+b**. The impact may then be constant for a period of **c** years. It is also possible for its impact to decline as disease and pest problems, etc., reduce the value of the original research.

Figure 1 Relationship between time and impact of research



There are several procedures for estimating these time weights. The simplest is to systematically "search" over alternative (a, b, c, d) segments to find the weight configuration that fits the data best. In this study, six alternative weights structures are imposed on lagged staffing activity (note that when one is analyzing productivity in period t, it is past research expenditures that matter and their inclusion in the cumulated researcher stock is based on the (a, b, c) weights). The weight set that had the minimum mean square (MSE) is a non-linear least squares estimate of the actual weight.

The staff skill weights

It is not known a priori how different skill levels should be weighted. Salary weights are probably unrealistic. A large number of studies of research activity have shown that research investment is not in long-run equilibrium where marginal contributions were equated with salary differentials. One of the advantages of staffing data over expenditure data is that this weight can be estimated by interactive procedures.

The procedure for estimating these weights is essentially the same as the procedure for time weights. Three sets of skill weights are estimated. By multiplying these by the six time weight sets, eighteen time-skill weights are created. Again, searching for minimum MSE over these weights provides an estimate of both time and skill weights.

Spatial or regional spill-in weights

Spatial issues are important to research system design. The term technology transfer is used widely in research policy discussion. It is useful to distinguish between two types of transfer. Direct transfer occurs when one region implements technology generated in another region without further modification of the technology. Indirect transfer (or germplasmic transfer) occurs when one region modifies technology generated in another region. The receiving region realizes an improvement in its own research opportunities because of research results generated in another region, and it exploits these opportunities.

It is also useful to distinguish between two further subclasses or sources of indirect transfer, technology and pre-technology. Research findings

in a program outside the region may be in the form of actual technology (e.g. a rice variety) or in pre-technology form (e.g. a genetic resource for a specific trait, a method for identifying traits, improved scientific knowledge of plant growth cycles, etc.). Both forms can expand research opportunities in other regions.

If the region does have a research capacity it may realize transfer, both direct and indirect. If the research unit is a simple regional or branch unit with links to a national or larger center, it may do little more than facilitate direct transfer with some direct-indirect transfer. A more sophisticated research unit will realize more indirect and pre-technology transfer.

The design and location of research centers and stations itself should be responsive to these transfer opportunities. The development of the International Agricultural Research Centers (IARCs) was a response to the perceived need for more institutions with a capacity to transfer technology to National Agricultural Research Center (NARCs). Little formal analysis of the research system design problem has been undertaken. A number of the empirical studies of research impact have examined the role of branch and regional stations, but the topic of research system design is not well researched.

The procedure used to estimate spill-in weights is again similar to that for estimating time and skill weights. Four alternatives were considered: Alternative 1: Centers were assigned uniquely to

regions:

BORIF (Bogor) to West Java
SURIF (Sukamandi) to Central Java,
Yogyakarta

MARIF (Malang) to East Java, Bali
and Nusatenggara

SARIF (Sukarami) to Sumatra

MORIF (Maros) to Sulawesi

BARIF (Banjarbaru) to Kalimantan

Alternative 2: For the four Java regions it was supposed that each benefited from the other Java centers by one-half as much as the origin regions did.

Alternative 3: The same for the Java region. In addition Sumatra benefited by one-half of West Java research and Kalimantan, Bali and Sulawesi each benefited by one-half from each other.

Alternative 4: Java regions benefit fully from each other; the others as in Alternative 3.

Other variables

In addition to the research variables, the following variables are included in the decomposition specification to capture other program impacts. These variables are not commodity specific except for HYV and intensification:

FS: Average farm size in hectares.

Roads: The proportion of villages situated within 2 km of an all-weather road.

HYV: For irrigated rice, the proportion of area planted to modern varieties. This is an index of varietal technology, some of it imported from IRRI.

Intensification: The proportion of cropped area covered under BIMAS, intensification programs of the Ministry of Agriculture,

Extension: A variable measuring extension staff per farm lagged one year. Extension staff include field staff (PPL) and subject matter specialists (PPS) (see Statistic Kelembagaan Penyuluhan Pertanian, 1991, Tables 19 and 20) for 1981-1989 data. Interpolation to 1970 was based on national data. These variables are expected to affect productivity in all crops.

Estimates of time, skill and regional weights

Estimates of time, skill, and regional weights were tested. For time weights a simple set of regressions was applied, ie Fuller-Battese methods to correct for time-series cross-section effects. The maximum 't' ratio provides an estimate of the best time weights.

All research coefficients are positive in this test, but it does not follow that these estimates will survive the addition of extension and intensification variables. For this test a simple specification is best. Time weight set 6 is preferred for irrigated rice, dry rice, and groundnut. Time weight set 4 is preferred for maize. For soybeans and cassava time weight set 1 is preferred and for mungbeans a short time weight (W2) is also preferred. Since time weights longer than W6

were not tested, this is not a full weight test. However, little difference between W5 and W6 exists for the relevant commodities. Weight set 6 is similar to weights estimated for Pakistan and Bangladesh in other studies.

The minimum mean square errors (MSE) provide the best estimate of skill and region weights. In general there are very minor differences between skill weights. In further work SW1, which weights all skills equally, is used. One reason for the lack of evidence that S3 and S2 researchers should be given higher weights than the S1 researchers is that the proportion of S3 and S2 researchers is relatively low. Thus the total number of researchers more accurately measures real research effort. Many S2 and S3 staff are dealing with administrative matters. Finally, many S1 staff are experienced and have developed capabilities to undertake the very applied research programs pursued in these situations.

There are indications that inter-regional spillovers of research contributions are occurring in irrigated rice, groundnut, and mungbeans as indicated by the lower MSE when the research specification allows each region to benefit from research in nearby regions to the extent of 1/2 the benefits occurring to the origin region. In further estimates this regional weight specification will be used for these commodities.

Decomposition estimates

Table 4 reports estimates of the MFP decomposition specification for each commodity. The extension variable is included because the extension program in Indonesia has contributed to productivity growth. This program has probably expended roughly twice as much public funds as have the research programs.

Table 4 estimates utilize time-series cross-section estimation procedures (Fuller-Battese). These estimates differ little from the standard OLS results because all MFP variables are indexed to be equal in the early years so cross-section variation is effectively eliminated. These equations are estimated as single equations. Research variables utilize the estimated timing, skill and regional weights. Specifications including and excluding the HYV and Intensification variables are reported.

Table 4 TSCS runs for individual crops (8/3/92 run); extension = log (PPL + PPS/HH)*.

	Irrigated Rice		Dry Rice		Maize		Soybean		Mungbean		Cassava		Groundnut	
	LTW6SW12	LTW6SW12	LTW2SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW1	LTW6SW12	LTW6SW12
FS	.1366 (4.315)	.1490 (4.471)	.0350 (.869)	-.0225 (.321)	-.0074 (.116)	.0141 (.234)	.0214 (.354)	.0349 (.273)	-.1014 (3.014)	-.0915 (2.606)			.1543 (2.941)	
Roads	.0018 (3.066)	.0015 (2.186)	.0065 (8.955)	.0020 (2.040)	.0017 (1.513)	.0045 (4.403)	.0043 (4.100)	.0003 (.156)	.0042 (4.744)	.0034 (3.555)			-.00002 (.0238)	
Research	.1398 (6.068)	.1409 (4.987)	-.0145 (1.841)	.0797 (5.161)	.0807 (5.257)	-.03139 (.825)	-.0157 (.920)	.2043 (3.692)	-.0119 (1.153)	-.0073 (.693)			.1211 (3.827)	
Extension	.0157 (.356)	.0189 (.433)	.1096 (6.279)	.0226 (.868)	.0184 (.697)	.1082 (3.296)	.1058 (3.133)	-.2113 (3.708)	.0700 (3.251)	.0639 (3.068)			.0626 (1.396)	
Res. x Ext.	-.0016 (.204)	-.0050 (.574)	-.0107 (2.268)	.0277 (3.134)	-.0126 (3.108)	-.0126 (1.251)	-.0151 (1.374)	.0507 (2.745)	-.0199 (3.231)	-.0205 (3.361)			-.0343 (3.179)	
HYV		.0015 (2.095)												
Intensifi- cation		-.0011 (1.064)		.0003 (.520)			.0003 (.526)			.0017 (2.164)				
M.S.E.	.0030	.0031	.0056	.0106	.0108	.0109	.0267	.0095	.0094	.0072				

t ratio in parentheses.

Inspection of Table 4 shows that the addition of the extension variable, a staff/farm variable, changes the results suggested by tests of time weights, which indicated the highest research 't' ratios for irrigated rice, maize, mungbean, and groundnut. These results essentially stand up in Table 4 (and in Table 5, see below) in the presence of the extension variable. For dry rice, soybeans and cassava, the presence of the extension variable effectively eliminates the research impacts.

It is of some interest to note that extension impacts are found in dry rice, soybean, cassava, and in maize and mungbeans as well. Except for maize and mungbeans, the research-extension impact is negative indicating that research and extension are substitutes. This is typical of many such estimates in developing countries. The contribution of extension programs generally appears not to be closely linked to recent contributions to the research system.

The estimates for irrigated rice reflect the dominance of high-yielding varieties and related improvements. However, when the HYV variable is included, the research variable coefficient remains highly significant. The intensification program appears to have been important only in cassava.

Economic implications

Several economic calculations of interest can be made from the estimates reported in Table 4. These calculations are "marginal" calculations because they are based on the coefficient estimates which tell us how much additional production (or productivity) is associated with an increment to a research or extension variable. The calculations are reported in Table 5.

Consider the first calculation, the estimated marginal productivity elasticity (EMPE). This tells us the percent change in product associated with a one percent change in research (or extension). Note that for constant prices this elasticity is the same for value units as for physical units. In Table 4 these estimates for research are computed as:

$$\frac{\delta \ln(\text{MFP})}{\delta \ln(\text{RES})} = C_R + C_{RE} \cdot \ln(\text{EXT})$$

where C_R is the coefficient on the research variable, C_{RE} , the coefficient on the research-extension interaction variable and $\ln(\text{EXT})$ is the mean of the $\ln(\text{EXT})$ variable. Table 6 reports EMPEs for both research and extension based on Table 4 estimates.

Table 5 Estimated marginal product elasticities (EMPEs), estimated marginal product (EMPs) and estimated marginal internal rate of return (EMIRRs).

	Irrigated Rice	Dry Rice	Maize	Soybean	Mungbean	Cassava	Groundnut	All
EMPEs								
Research	.140	(n)	.071	(n)	.188	(n)	.132	.107
Extension	.011	.1091	.099	.071	(n)	.0495	(n)	.0274
EMPs								
Research	91	(n)	10.2	(n)	18.5	(n)	18.9	30.5
Extension	1.0	10.9	9.9	7.1	(n)	4.9	(n)	2.7
EMIRRs								
Research	337		167		204		205	240
Extension	0	173	161	126		92		50

Table 6 Estimated ratio of product value to research expenditure.

Product	Ratio: Value to Research Expense	Ratio:	
		Research Stock to Research Expense	Ratio: Value to Research Stock
Irrigated Rice	.00022	7	.00154
Dry Rice	.00027	7	.00189
Maize	.00099	7	.00693
Soybean	.00126	7	.00762
Groundnut	.00100	7	.00700
Mungbean	.00169	7	.01014
Cassava	.00020	7	.0014

Next consider the conversion of the EMPE into an Estimated Marginal Product (EMP). Since the EMPE can be considered to be a financial elasticity, it is:

$$EMPE = \frac{\Delta V}{V} / \frac{\Delta R}{R^*} = \frac{\Delta V}{\Delta R^*} \frac{R^*}{V}$$

So $EMP = EMPE \times (V/R^*)$.

Thus, by multiplying the EMPE by the ratio of commodity value to the research stock, we obtain the EMP expressed in rupiah of output from a one rupiah addition to the research stock. The research stock is a multiple of the annual spending. This multiple is based on the time weights. The average ratio of research spending to value of crop is taken to be .0005 (Table 1). This is then adjusted for each commodity from data in Table 2. The estimated ratio of product value and the research stock/research value ratio are thus estimated as in Table 6.

The EMPEs are then converted to EMPs in Table 5 by dividing by the value to stock ratios. The next step is to convert these to MIRRs. This is done by multiplying the time weights by the marginal products. Expenditure of one rupiah in year T yields 0 in period t , $0.3 \times EMP$ in year $T+1$, $0.6 \times EMP$ in $T+2$, $0.9 \times EMP$ in $T+3$ and the full EMP in years after this if weight set 6 is used. This is because the expenditure for staff year in T is cumulated forward and is in the research stock in subsequent years with these weights. The same staff member may also move in the year $T+1$ and this year will also be counted in future years.

Thus an investment in time T can be seen as generating an income stream in future years and from this the internal rate of return (i.e. the rate at which the present value of the stream discounted back to period t is equal to one) can be computed. For extension, a simple one year lag is imposed so the marginal product lasts only one year.

Marginal products are relatively high for research and the time weights are relatively short (i.e. relative to other systems). As a result MIRRs are extraordinarily high for research, extension and for the AARD program even when the most conservative EMPs are utilized in the calculation.

Summary

Overall, the investment in CRIFC research has had a very high payoff. This is the case even though no clear impacts have been realized in dry rice, soybeans or cassava. And for these crops, each of which receives relatively little

research attention, there may be impacts in the future. It is well known that productivity gains in dry (upland) rice have been difficult to achieve in other countries and at the International Rice Research Institute. Roughly the same conclusion holds for cassava. Productivity gains have not been widespread although some successes have been obtained in Africa. For soybeans, this is also the case. Soybeans are readily transferred to Latin America where large gains have been made. But this is not the case in Asia, although parts of India have achieved gains recently.

In contrast, many countries have gained from varietal developments in irrigated rice and in maize. Indonesian gains in mungbeans and groundnuts are not widely replicated elsewhere. When one considers the nature of the research potential offered in different crops and the nature of skill levels of scientists in Indonesia, the pattern of productivity gains makes sense. The difficult commodities, such as upland rice, cassava, and to some extent soybeans, do not offer research potential that is easily solvable even by well managed and designed research systems that are skill-constrained in the sense that only a few scientists are trained at the Ph.D. level. The results of the impact study are consistent with this. The results do speak well for the design and management of the system because impressive gains have been achieved in those fields where substantial genetic resources have been developed.

The results for extension also attest to good management of extension where skill constraints are also present. It is especially instructive that extension impacts appear to have occurred for all commodities including those where no research impact was found.

Thus it is reasonable to conclude that Indonesian research programs have performed well over the past 15 to 20 years. They have used staff well and they have accomplished large impacts. They have paid used staff well and they have accomplished large impacts. They have paid huge dividends to the Indonesian public and have enabled Indonesian agricultural sectors to contribute to Indonesian general development and programs.

Policies and Priorities for Farming Systems Research in Indonesia: Lessons Learned from the Upland Agriculture Conservation Project

*H.C. Knipscheer**

Introduction

During the past 30 years, Indonesia and the rest of Asia have made impressive progress in agriculture. Where only 25 years ago, famine was a recurring threat to various areas in the region, now the whole continent, and particularly Indonesia, is largely self-sufficient in food production.

There are, however, several compelling reasons why past success in agricultural productivity may not be a reliable for fortune performance:

- * Because of growth in population and income, the need for increased agricultural production continues.
- * The supply of land, water, and other natural resources for agricultural production is diminishing; incremental responses to fertilizer have declined; the marginal rate of adding irrigated areas has increased; heavily cropped areas are showing increasing evidence of micronutrient deficiencies and build-up of soil-borne pathogens; the industrial and urban sectors compete increasingly for resources such as water.
- * The international food and agricultural system is becoming more complex as interrelationships between national agricultural and trade policies affect development and as farming households become more market oriented and market dependent.

The challenge, therefore, is to find new ways to manage the development process, developing strategies that lead to increased agricultural productivity while maintaining the natural resource base. Attaining the goal of increasing production while protecting the resource base implies the need for new and different ways of farming. Since technologies are the tools of farm management, applying new technologies in

* Winrock International, Arkansas, USA.
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agriculture is what agricultural development is all about. As any introduction of new technologies involves experimenting and testing, it is generally agreed that agricultural research plays a critical component in the process of agricultural development.

Where farming systems research fits

Most research institutes are involved in four types of research: basic, strategic, applied, and adaptive.

- * Basic research generates new scientific understanding, such as through the study of DNA structure by geneticists.
- * Strategic research aims to solve a specific research problem in contrast to a farming problem, such as developing a technique for measuring ovulation rates in sheep.
- * Applied research develops new technologies, such as techniques that help farmers to become more productive.
- * Adaptive research fine tunes development technologies to a specific set of local conditions, such as incorporating a new crop variety into an upland rainfed farming system.

Basic and strategic research are typical on-station activities. The control of variable is essential and farmers' assessment is less important.

Applied and adaptive research are both farmer and client-oriented. They involve the testing, comparing, and refining of agricultural products and practices (technologies), and evaluating them for their usefulness in specific environmental and (or) socioeconomic situations. Such testing and evaluating enable users to select new technologies they would like to integrate into their farming systems.

Applied and adaptive research activities are generally referred to as farming systems research (FSR). Farming systems research methodologies include on-farm experiments, on-farm client oriented research, rapid rural appraisal, formal surveys and regular research field hearings.

Indonesia was one of the first countries to adopt farming systems research programs. With the establishment and growth of the Agency of Agricultural Research and Development (AARD) and under the initial leadership of food crop research institutes, FSR programs gained popularity. Indonesia recognizes the value of

interdisciplinary research, interagency cooperation, and farmers' participation.

However, most of the FSR programs were conducted in the so-called project mode and often with donor support. For example, the first important FSR program was launched with support of the International Rice Research Institute (IRRI) and the United States Agency for International Development (USAID); later the International Development Research Centre (IDRC) and Ford Foundation supplemented these types of research activities. The World Bank provided important donor support for farming systems research in transmigration areas. Various observers have listed the weaknesses of such a project approach; support ends with the termination of the projects and the farming systems research programs were discontinued. Further, by limiting FSR activities to donor-supported projects, the leadership of such programs was often provided by expatriate consultants.

The value of FSR for AARD can be summarized as follows:

- * It has helped by AARD to determine the major farming systems in Indonesia, and subsequently helped them differentiate their client-farmers.
- * It has helped AARD to adapt existing technologies, and develop new alternative technologies.
- * It has promoted farmers' interest in AARD's research program and provided insights to the process of technology transfer.
- It has provided general feedback to research administrators and helped them to set research priorities.
- * It has facilitated collaboration with extension and development agencies.

Lessons learned from FSR/UACP

In many ways, the FSR component of the Upland Agricultural Conservation Project (UACP) was one of the most productive FSR programs in AARD, not only because the program was a multi-commodity and multi-institute research project, but also because it introduced new technologies in diverse, fragile and risk-prone farming systems.

Two main types of systems have been distinguished: transfer of technology (TOT) farming systems and farmers-first (FF) farming systems. TOT farming systems research develops tech-

nology that fits more or less uniform, controllable, high-input, and low-risk conditions. For example, the success of high yielding rice varieties was largely due to the ability of farmers to control the environment by irrigation, fertilizer, and other inputs. Similarly, the tremendous surge in the poultry industry is due to management of the environment for reproducing the new genotype.

FF farming systems address complex (undulating land, variable soils, irregular water supply, intercropped), diverse (cro-livestock-tree, multipurpose), and risk-prone conditions. In such an environment, the farmers are the main experts. The technological innovation has to fit the environment rather than the other way around. The typical technologies for such farming systems should, therefore, be more method-oriented than prescriptions; not a package of practices but a basket of choices. Undoubtedly, Indonesian upland farming systems would qualify as FF. Indeed, not only is the physical environment of upland farming in Indonesia very variable, so is the market environment. The area and location of upland crops change annually as farmers respond to a great variability in market prices for crops such as cassava, soybean, groundnut, and mungbean.

Having worked in a farming systems research program in Indonesia since 1981, I have followed the UACP farming systems research program; initially, with interest, and later, with enthusiasm. Two phases can be distinguished in the program. During the first phase, 1985-1990, scientists focused on technology and data generation, more or less in isolation from local development and planning agencies. In the later phase, the program focused on technology application and information synthesis, and scientists worked more closely with the provincial and local development services. As participant and observer, I learned three major lessons:

- * Information management, though crucial, often has been a neglected element of farming systems research and extension.
- * Working with organized farmers groups is effective.
- * Collaboration with development agencies though essential is cumbersome.

Improving information management

Since its establishment in 1979, AARD has accumulated a rich background of experience and well-trained scientists and administrative staff. A vast amount of reports and articles is produced each year. Most of these describe in one way or another the testing of a new technology.

However, information systems are scattered throughout the research community. Most reports and articles are scientific (i.e. written for peer review) and rarely contain even a full description of the technology to which they pertain. Most users of technologies (extension, development agencies, farmers) have no easy access to AARD's information base, and even if they had, they would not be able to find documents that synthesize research findings in simple terms. Similarly, colleague scientists cannot find documents summarizing the latest information about any particular technology, which understandably leads to duplication of research activities. Consequently, research administrators in AARD will be hard-pressed to answer the question: how many technologies are your staff working on? The main cause of this deficiency is that the research information system is designed for basic research rather than adaptive research; it is not user-friendly.

An inventory of adaptive research technologies is warranted. It should include a comprehensive listing of technologies with a short description of each one's purpose, application, and technical impact indications of economic profitability, farmers' assessment of its social acceptability, and sustainability and a list of relevant references. Such files must be regularly updated.

The FSR project made solid progress towards such as inventory by publishing *Sambung Litluh* or research factsheets. These leaflets aim to summarize key research findings in such a way that extension personnel or farmers can critically select and try out new technologies to see how they perform under the unique ecological and socio-economic conditions in their locality. The framework for compiling a technology inventory can be described as a collaborative effort of scientists, extension personnel, and planning agencies to articulate the state-of-the art of existing and newly developed technologies.

Serving farmer groups

Only in the last phase of the FSR/UACP did scientists start to work with farmers groups when FSR technologies were superimposed on demonstration sites. These demonstration sites consist of organized groups of farmers border each other and are part of a watershed area. For upland farmers, there are many reasons to get organized:

- * Many of the conservation technologies involve waterflow management; the water management practices of one farmer will directly impact the waterflow his neighbor will have to deal with.
- * Many technologies are information-based farm management techniques with limited off-farm inputs. Information can be better transferred and processed by farmers through group discussion than any other way.
- * Some new technologies and new agricultural products, such as growing flowers for export, must be organized to achieve a reliable supply in order to access distant markets. Similarly, the availability of new farm inputs depends on a critical minimum demand or volume of business.
- * As farmers in upland areas rely less on public services because of the great diversity and variability of their needs, and sometimes also because of their isolation, there is need to form self-help groups (so-called grassroots development NGOs). A case has been made for establishing such NGOs with some government members on their boards in order to guarantee optimal collaboration between private and public institutions.
- * The farmer group is an ideal forum to discuss the advantages and disadvantages of new FSR technologies. Prescreening the on-farm testing of technologies through group discussions saves time and resources.

Indeed, working with farmer groups has proved very beneficial for FSR scientists in the UACP. The farmer groups may also be organized as grassroots development NGOs. Especially in complex, diverse, and risk-prone areas, NGOs have successfully applied FSR methods. Grassroot development NGOs help to articulate farmers' needs and their response to alternative technologies.

Collaboration with development agencies

Most institutions harbor disincentives to inter-institutional collaboration. This often manifests itself through procedures and regulations that make collaboration cumbersome. The underlying philosophy of farming systems research fosters collaboration and a sense of mission. AARD recognized FSR as a vehicle for collaborative projects or programs. Not surprisingly, in the FSR/UACP the merits of the FSR program became visible only after a concentrated effort to involve other agencies in the area.

In Indonesia, linkages between agricultural researchers and extension services, information and library services, and farmer/fishermen remain weak. A major factor contributing to this weakness is the lack of systematic monitoring and evaluation of impacts of research activities on user groups such as farmers and development agencies. Some dissemination mechanisms are in place but the feedback is often missing. FSR projects provide some of this feedback, although not in any systematic way.

Implications for FSR policies

Presently, AARD is organized and structured by commodity and discipline. This is an appropriate structure for basic research activities for which subject matter specialization is a major discriminating factor. Such a structure, however, does not encourage adaptive research which is multidisciplinary and multicommodity by nature.

Through its many FSR project activities, AARD has proven that it has the resources to perform applied and adaptive research in Indonesia. The question, therefore, is how to do it. The challenge of balancing the need for adaptive research with the need for basic research is not unique for Indonesia. In recent testimony in the U.S. Senate, a strong case was made to clarify the definition and mission of agricultural research and to earmark government funds specifically for goal-oriented research programs (e.g. for research with the goal to raise soybean yields in any given area by 20%). Successful adaptive research is recognized as being critical for U.S. agricultural research and development institutions as they are steadily losing credibility and, therefore, political support.

Assuming AARD will remain the key agricultural research agency in Indonesia for the next decade, the following strategies are warranted:

- Encourage multi-disciplinary, multi-commodity, and multi-institutional research by reviewing the mandate of the existing research centers and institutes. The number of institutes and scientists devoted to commodity- and discipline-based research should be limited. New programs and/or institutes may be established that have regional mandates. Merging the extension and applied research functions under such decentralized regional research and development institutes deserves consideration.
- Encourage information synthesis and information sharing by reviewing the credit point system used as promotion criteria for scientific staff. The present system leads to piecemeal analysis and disciplinary egoism.
- Develop a comprehensive communication support strategy that is client-oriented and facilitates monitoring and evaluation. Presently, extension services go about their business, and scientists write proposals and conduct their trials, both groups failing to evaluate the impact of their work on their intended clients. Currently, scientists are rewarded for their best proposals (problem statements) rather than for the best solutions (impact).
- * Improve collaboration with other agencies by earmarking funds for adaptive research under development agencies and/or local governments while providing easier mechanisms for multiyear contract research. The terms of such

contracts deserve careful consideration. Depending on the development goals and locations, such funds also could be channeled via grassroots development NGOs.

Conclusions

AARD has the capacity to import, generate, and modify new technologies, and also to help fine tune technologies for location specificity. In order to serve AARD's clients, mandates of institutes and stations, incentives for personnel, and program priorities for scientists should be reviewed. New goal-oriented and time-based development programs may be launched. Such programs would provide technical assistance and monitoring and evaluation services to ongoing development efforts. These would include government-led programs, but could involve programs led by private sector institutions, agribusiness firms, or by grassroots development NGOs. For all these agents of change (government, agribusiness, NGOs), AARD can be the prime source of agricultural information and experimentation, a real promoter of agricultural growth. Such a mission would imply regional decentralization and assumption of an extension function as well; research institutes with a regional (adaptive) mandate would help develop large information centers with strong links to a national and international technology information base. These information centers should be demand-driven and directed by boards where the users of technology information are well represented.

CGPRT Centre News and Activities

Research Projects

Regional Statistical Database System

The Regional Statistical Database System is continuing to show its commitment to providing easy access to reliable data. The computers in the RSDS section are being linked together in a peer-to-peer local area network so that database files, software, printers and other peripherals can be shared by each station, without putting too much strain on any single machine. This

network will also give access to a CD-ROM drive, which has also been installed. CD-ROM titles are still being sought out and assessed, but it is hoped that a library of bibliographic databases (for listings of papers and articles concerned with the many facets of agriculture) will be available soon. The Centre has already acquired the CD-ROM title, Digital Chart of the World, from the US Defense Mapping Agency, and will attempt to integrate the package into its GIS (Geographical Information System) program. These changes, as well other

options presently being explored and implemented, will ensure that the CGPRT Centre continues to be a valuable- source of instant and invaluable information for a broad spectrum of institutions.

Market Prospects of Upland Crop Products and Policy Analysis in Selected Countries in Asia

This two years project funded by the Japanese Government, will start by end of 1994. The objective is to characterize the demand of international markets and the production trends for selected primary agricultural products in different Asian countries, including India, Indonesia, Thailand, the Philippines, China, Pakistan and Viet Nam. These countries have recently undergone rapid changes in food consumption patterns due to rapid economic growth and income increase. Studies will analyze production and consumption of major upland CGPRT crops used for processed food, feed and manufactured materials for export.

Diversification of Agriculture in South-East Asia

The project welcomed Dr. J.M. Boussard, Research Director at the Institut National pour la Recherche Agricole (France) and Associated Professor at the Universite de Paris, for a two-week visit. He assisted Centre staff in improving the supply module and in developing the demand module of a subsectoral model developed by the CGPRT Centre in cooperation with member countries and French scientists to analyze issues related to diversification of food crop utilization in the region.

Sustainable Upland Agriculture in South-East Asia

Recently the Centre initiated a project on sustainable upland agriculture in South-East Asia. The objective of this project is to identify constraints and prospects for development of sustainable resource management of marginal upland agriculture, in particular with CGPRT crops based farming systems. The emphasis of the project will be on methods of economic assessment for this type of agriculture. The study will be guided by the findings from case studies carried out in Indonesia, the Philippines and Thailand. These case studies will be selected from already completed projects which were aimed at development of sustainable upland

agriculture in these countries. The Agency for Agricultural Research and Development (Indonesia) and the Office for Agricultural Economics (Thailand) have agreed to participate in the study.

Synthesis of Soybean Studies of the Centre

In the past seven years a great deal of research has been carried out at the CGPRT Centre concerning the development of soybean throughout Asia. This project aims at succinctly presenting the knowledge accumulated by the Centre to a wider audience. The synthesis of the studies will indicate constraints and prospects of soybean development, and suggest priorities and options for further research and policies for individual countries and the region as a whole.

20 Years of Horticulture in Indonesia: The Vegetable Subsector, Maria F. Ferrari. CGPRT Centre. Working Paper No. 15. 1994. 148p. ISBN 979-8059-54-9.

This study presents an overview of recent developments in the vegetable subsector in Indonesia. It analyzes production, demand and markets. The study is presented in two parts; the analysis in the first part is highly aggregated in terms of species and geographical location. In other words, it refers to the vegetable economy at national, regional and provincial levels. Chapters in the first part cover markets, area and production, domestic consumption and external trade.

However, different vegetables have different environmental responses, cultural requirements and growth and harvesting periods. Preparation for the market and storage requirements are also commodity specific. This is the reason for breaking down the analysis to the commodity level in the second part. The vegetables selected are cabbage, potato, shallot and chili, based on extent of area harvested, magnitude of production and availability of data.

Replete with 44 tables, 48 figures, 4 maps and 13 appendices, this volume accurately describes the role of horticulture, especially the vegetable subsector, in the agricultural economy of Indonesia.

CGPRT Centre

The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre) was established in 1981 as a subsidiary body of UN/ESCAP.

Objectives

In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

Programmes

In pursuit of its objectives, the Centre has three programmes which are mutually supportive:

1. Research, which entails the preparation and implementation of studies covering production, utilization and trade of CGPRT crops in the countries of Asia and the South Pacific.
2. Training of national research and extension workers,
3. Information and documentation which encompasses the collection, processing and dissemination of relevant information for use by researchers, policy makers, and extension workers.

Palawija News

Contributors are invited to submit concise summaries of significant social research related to CGPRT crops for publication. Figures (graphs or tables) may accompany the article. All articles are subject to editing to meet space limitations.

Please send all queries relating to articles in *Palawija News* to Publications Section, CGPRT Centre, Jalan Merdeka 145, Bogor 16111, Indonesia.

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CGPRT CENTRE
Publications Section

Editor: Douglas R. Stoltz
Production: Deddy Subandi M.
S. Tayanah (Yayan)
Distribution: Fetty Prihastini
Deddy Subandi M.
Printer: SMT Grafika Desa Putera



CGPRT Centre
Jalan Merdeka 145,
Bogor 16111, Indonesia
Telephone: (0251) 336290, 343277
Fax: 62-251- 336290
Cable: ESCAP CGPRT Bogor

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