ASSESSMENT OF THE ECONOMIC IMPACT OF AGRICULTURAL RESEARCH: SUMMARY OF STUDIES CONDUCTED BY MICHIGAN STATE UNIVERSITY

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Objectives

This presentation has three main objectives:

1. To summarize briefly the objectives and methods of studies conducted by MSU on the impact of agricultural research in Africa.

2. To present and interpret the principal results of these studies. What can be concluded from these results? What are the key factors which seem to determine the impact of the agricultural research programs?

3. To draw some lessons from these studies in order to improve the effectiveness and efficiency of agricultural research, and methods for evaluating the impact of agricultural research.

Context and Justification of Studies Conducted by MSU

Seven studies were commissioned by USAID, with the principal objective of providing empirical evidence of the performance of their investments in agricultural research programs in Africa. Within USAID, there was a feeling of disappointment concerning these projects. It was thought that the agricultural sector was not dynamic, and that USAID's investment in agricultural research projects had not proven successful. Consequently, USAID (and other donors) had reduced their support for agricultural research.

In this paper, I will focus on six of the seven countries where MSU conducted studies (Cameroon, Kenya, Mali, Niger, Uganda, Zambia), the seventh country being Malawi. Two other studies, not financed by USAID, were conducted by MSU researchers in Kenya and Senegal (see table 1).

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[1]Paper presented at the regional workshop entitled "Développement et Transfert de Technologies dans un Environnement en Mutation Rapide: Implications pour la Recherche Agricole au Sahel," Bamako, Mali, August 30 to September 3, 1993. Paper also available in French.

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Two main objectives were the focus of these studies:

1. Calculation of the rate of return to investments in agricultural research.

2. Analysis of the factors which have affected the rate of return, including institutional factors. Knowing the "why" and the "how" of the rate was also important, perhaps even more important than the rate itself.

The choice of countries and crops to study was made jointly by the staff of USAID-Washington and researchers from MSU. The studies needed to cover West Africa as well as East Africa, and also a sample of crops for which agricultural research programs had been at least partially financed by USAID.

The studies were conducted in the field by M.S. and Ph.D. students or recent graduates in agricultural economics from MSU. In each country, at least one local researcher was chosen to assist with the study as a collaborator. The collaborating national organizations were the following:

Kenya:	KARI (Kenya Agricultural Research Institute)
Niger:	ISNAR and INRAN
Mali:	IER (Institut d'Economie Rurale)
Senegal:	Bean CRSP/Cowpea (Collaborative Research Support Program)
Cameroon:	IRA (Institut de Recherche Agronomique) and NCRE Project (National Cereals Research and Extension)
Zambia:	Ministry of Agriculture, Makerere University, and MFAD (Manpower for Agricultural Development) Project

Method Used

The length of the field studies varied between three and twelve months. In Mali, Uganda, and Zambia, the analysis of the impact of agricultural research constituted the first phase of a more ambitious subsector study.

Many types of impacts were evaluated. Impacts that were quantified included: (a) the economic impact (increase in agricultural productivity), estimated by comparing the "with research" and "without research" scenarios; and (b) the contribution of improved technology to food security (example: Senegal).

Other impacts were the object of qualitative analysis: (a) the reinforcement of human and institutional capacity; (b) the distribution of benefits between producers and consumers (to be quantified in the Zambia case); and (c) the impact of new technology on women.

TABLE 1. Results of the MSU Studies on the Impact of Agricultural Research in Africa

Author(s)	Year	Country	Crop	Period	Rate of Return (%)
Karanja	1990	Kenya	Maize	1955-1988 [b]	40-60
Mazzucato[a]	1991	Kenya	Maize		58-60
Mazzucato	1992	Niger	Cowpea +	1975-1991	<0
& Ly[a]			Millet\Sorghum	1975-2006	2-21[c]
Boughton &	1992	Mali	Maize	1969-1991	135
Henry de Frahan[a]				1962-1991	54
Schwartz, Sterns	1992	Senegal	Cowpeas	1981-1986	31-92[d]
& Oehmke					
Sterns & Bernsten[a]	1992	Cameroon	Cowpeas	1979-1992	3
				1979-1998	15
			Sorghum	1979-1998	1
Howard et al.[a]	1993	Zambia	Maize	1978-1991	<0[e]
				1978-1991	90-103[f]
				1978-2001	96-106[f]
Laker-Ojok[a]	1993	Uganda	Sunflower	1985-1996	31
				1985-2006	38
			Maize	1985-1996	<0
				1985-2006	33
			Soy	1985-1996	<0
				1985-2006	6

Source: See references:
[a]Study financed by USAID.
[b]Parameters estimated for the period 1955-1988; rate of return calculated assuming that the research was initiated in 1978.
[c]Depending on assumptions about yield, rate of adoption, etc.
[d]The 92% rate was obtained when including the value of the early cowpea variety as a contribution to household food security.
[e]Including the costs of seed multiplication, production, research, extension, and the real costs of maize program subsidies.
[f]Without the real costs of maize program subsidies.
[g]All rates include the costs of research, training, extension, and rehabilitation of research stations attributable to the product concerned.

It was not possible to evaluate the impact of agricultural research on employment or on the environment.

Two methods were utilized to assess the economic value of these impacts. Production functions were estimated in the Kenya study. This was the only country where a long enough series of data was available to allow the use of this method. In the other countries, the concept of economic surplus was used in estimating the benefits of agricultural research.

The rate of return was calculated according to several definitions of "investment":

1. Agricultural research alone (Kenya).

2. Research + transfer of technology (other countries).

3. Research + transfer of technology + agricultural policy (Zambia).

The question that arises here is, "Why estimate the impact of research plus . . ."? First, the observed impacts--adoption of new technologies, yield increases, etc.--stem from many factors other than agricultural research, such as input distribution (better seeds, fertilizer), extension, processing, and marketing. Since these complementary interventions help collectively to produce the impacts and benefits of agricultural research, it was necessary to incorporate the costs associated with implementing these interventions on the ground.

Secondly, it is difficult, from an analytical point of view, to separate the effect of agricultural research from that of other complementary factors. The impacts of agricultural research must therefore be evaluated as a whole.

Only the costs of the national agricultural research programs were incorporated. The cost of activities conducted by the International Agricultural Research Centers (IARCs) was not taken into account. This was in part because we were interested in knowing the return to the investment made at the national level, and also because we lacked the necessary data. The results obtained (rates of return) therefore represent the return to national investments, given the present level of IARC activities.

All studies included an *ex post* evaluation; that is to say, we examined the costs and benefits from the onset of the program until the date of the study. In many cases, we also conducted *ex ante* analysis; that is, we incorporated a projection of costs and benefits for at least several years into the future. The assumptions used in these projections are described in detail in each report.

Particular emphasis was placed on understanding and interpreting the results in a *filière* or subsector perspective. This was done not only in order to account for all the factors that have affected the observed impact, but also to better identify research priorities for the future. The development of a given subsector may be limited by constraints at levels other than the production level, for example at the processing or final demand level.

By the same token, the analysis of institutional factors was emphasized in order to better understand the context in which agricultural research and complementary interventions exerted

their impact on agricultural production. By institutional factors, we mean economic and agricultural policy, and the efficiency of public or private organizations that serve different functions in the subsector.

Results--General Discussion

In general, the rates of return obtained in the studies that appear in table 1 are acceptable, in terms of being higher than a typical target rate of 10-12%. From this result, we can conclude that agricultural research is profitable in economic terms. This same result has been found in many studies conducted outside of Africa. The implication is that additional agricultural research investment would be justified.

This conclusion must be qualified for two reasons. First, the conditions that contributed to the impact of previous investment may not recur in the future. For example, in some cases (as in Zambia), the economic impact stemmed from the development and transfer of hybrid varieties, which contributed to a considerable gain in productivity. It is not certain that the next advance in technical progress will be as significant. Secondly, in order for investment in agricultural research to have an ultimate impact, the agricultural research system must be effective. We observe that many agricultural research institutions are currently confronted by severe financial and human constraints, and by problems of an administrative nature.

The results presented in table 1 also show that the rates of return vary depending on many factors, such as:

1) *The period evaluated (Niger, Uganda, and Mali cases).* If the study perspective is *ex post*, or if the benefits are not projected for more than a few years into the future, then the rates of return can be very low, if not negative.

2) *The assumptions used (Niger and Senegal cases).* The values used for rate of adoption or the yield gain (or other cost and benefit elements) have a critical effect on the rate of return.

3) *The crop studied (Cameroon and Uganda cases).* The role of the crop in the household's food strategy and in the national economy influences the price and therefore the economic value of the good. We also found that maize research programs often had substantial impact, which is probably attributable to the capacity of maize for genetic improvement and to the responsiveness of maize yields to conditions of good fertility and improved cultivation practices.

4) *The types of impacts quantified (Senegal case).* Including impacts other than agricultural productivity gains adds to the economic benefits. In Senegal, the rate of return was increased considerably by taking into account the value of the early cowpea variety as a contribution to household food security.

5) *The types of costs incorporated* (Zambia and Mali cases). In the Zambia study, the return on investment in agricultural research was shown to be

either negative or very positive according to whether the economic costs of policies and subsidies aimed at the development of the maize sector were taken into account. In Mali, the rate varied considerably according to whether the analysis began in 1962 (more costs incorporated for the same level of benefit) or in 1969 (fewer costs incorporated). It is well known that a subsidy policy, or the implementation of a production support program, can stimulate the adoption of new technology. However, it must also be recognized that these interventions carry economic costs that must be accounted for in the analysis.

6) *The price adjustments incorporated in the economic analysis.* The economic analysis must be based on prices that reflect the real value of outputs or inputs. These prices are not necessarily the prices observed in domestic markets. Domestic market prices do not represent the economic value of outputs or inputs on which the government has placed a tax or subsidy, or in cases where the output concerned can be purchased or sold in the international market. Additionally, the value of goods bought or sold in the international market and converted using the official rate of exchange may be incorrect from an economic point of view if the national currency is overvalued. The studies conducted in Cameroon and Niger incorporated fewer adjustments of this kind than the studies in Mali, Senegal, Zambia, and Uganda. Even if one assumes that this variation in the application of the economic analysis methodology is justified (which we hope is true!), these special features of the analysis must be recognized by the reader in order to correctly interpret the results of the different studies.

Results by Country

Kenya

This study provides an example of the production function analysis approach. This method becomes feasible when a long series of data is available. In principle, the method allows one to isolate the contribution of agricultural research from that of extension, seed distribution, and other complementary interventions. The rate of return calculated with this method is a marginal rate, which expresses the benefit obtained from the last monetary unit invested in agricultural research. In his base scenario, Karanja found that an additional KSh. invested in agricultural research brought 0.48 KSh. in economic benefits. (In contrast, the other MSU studies calculated the average rate of return, which expresses the average benefit obtained from all invested costs.)

The Mazzucato study refined the analyses made by Karanja, and examined the effect of agriculture policy (restriction of fertilizer imports, and subsidies of fertilizers to producers) on the return to agriculture research. Mazzucato found a 60% rate of return to maize research in the absence of fertilizer policies, and a 58% rate of return in the presence of these policies. This modest decline in rate results from the opposing effects of restrictions on fertilizer imports (negative effect on the return to research) and of the subsidies (positive effect, if administrative costs of subsidizing are not taken into account).

Niger

Low or zero rates were obtained depending on the period and the scenario examined. The results showed important constraints with regard to development, transfer, and adoption of new technology.

Technology development. First, Niger has a difficult climate, with limited and variable rainfall even in the arable zone. Finding varieties or agronomic practices capable of raising agricultural productivity considerably in such conditions represents an enormous challenge. In addition, the focus and objectives of the research constituted an obstacle. The initial priorities (monocropping of cowpeas) were determined by researchers in terms of their scientific concerns, and not in terms of the needs expressed by the farmers (millet/sorghum/cowpea intercropping). It was not until the 1980s that the orientation of research was changed to focus on millet/sorghum/cowpea intercropping.

Transfer of technology. The production and multiplication of better seeds proved to be inefficient and costly because of the size of the institutional infrastructure created relative to the limited demand for improved seeds. The extension department was weakened by insufficient education and financing, and by the lack of a consistent extension approach in the field.

Adoption. The rate of adoption of technologies developed by research has been held back by many factors, including farmers' limited interest in monocropping of cowpeas, the weak producer price of cowpeas, and an underdeveloped infrastructure which made transportation quite costly.

The Niger study suggests that it may be appropriate to reconsider existing research priorities. What priority should be given to varietal improvement relative to crop management research? What priority should be given, in a country as arid as Niger, to research on plant production versus animal production?

Mali

The rates of return obtained in the Mali study were high but sensitive to the assumptions adopted. Many reasons can be cited for the high rates, such as:

Modest costs of research. The improved variety was selected by French-funded researchers prior to 1969, the beginning of the research program evaluated in the MSU study. Also, the variety was identified by simple screening. Extending the period of analysis back to 1962 added to research costs and considerably diminished the calculated rate of return.

High product value. Maize was considered a substitute for imported maize, which led to a higher economic value than financial value.

Rapid adoption. Complementary investments (infrastructure, support services, price policy) gave rise to rapid adoption.

Transfer of technology. Input distribution and product marketing was assured by a regional development agency that was already established and well run (CMDT).

The Mali study highlights the critical role of agriculture policy. Pricing and support policies in the maize sector increased the rapidity of adoption of improved seeds and cultivation practices, and consequently boosted the impact in terms of agricultural production. However, this policy was ultimately not sustainable because of its budgetary cost. Liberalization and privatization of the maize sector reduced these costs, but at the same time they presented new challenges for subsector coordination.

The study is also particularly interesting because it demonstrates how the development of the maize sector is limited by off-farm constraints. Constraints at the demand level (type of product preferred) and processing level (technology for processing maize into flour remains costly) should be the subject of further research in order to realize the potential for expansion which maize offers in principle.

Zambia

Research on maize has been quite successful in Zambia, thanks in part to complementary interventions which, unfortunately, were not sustainable in the long run. Nine improved varieties were developed during the 1980s, seven of which were hybrid varieties and two of which were open-pollinated varieties. The improved varieties were adopted on 60% of the maize area, which itself increased 40%. Maize production doubled, with the majority of growth coming from small producers. Expansion of the maize sector was supported by agricultural credit and subsidies on fertilizer, producer prices, transportation, and maize milling.

Several problems were evident near the end of the 1980s, namely:

1) Maize expanded into zones where it was not well adapted.

2) The subsidy burden became unbearable. The level of subsidy reflected in various interventions was considerable, up to 80%.

3) The rates of return cited in table 1 show that development and transfer of new maize varieties was not economically profitable when the real costs of subsidies were included in the calculation.

Cameroon

Improved varieties of sorghum and cowpeas in Cameroon were developed by screening varieties obtained from IITA. The cost of research activities at the national level was therefore modest, and IITA's contribution was considerable.

The cowpea research program had a greater impact than the sorghum program. Why? The improved variety of cowpea was an early-maturing variety, which contributed to household food security. Cowpeas also provided a source of household cash revenue, as an alternative to cotton.

Technical improvement of sorghum consisted of adding drought resistance. This aspect of the improved variety provides benefits only one year out of three, when rainfall is insufficient. This is in contrast to the improved cowpea, which provides benefits every year. The choice of

problems to study through research, is therefore crucial. The solution to a serious problem can bring more benefits than the solution (even more dramatic) to a minor problem.

Other lessons worth noting include:

1) The importance of links between national and international research organizations (in order to facilitate exchanges of knowledge and scientific materials), and links between research and producers (in order to ensure the pertinence of research programs to the problems faced by producers).

2) The choice of SODECOTON as the technology transfer agency brought both advantages as well as disadvantages. SODECOTON handled the distribution of better seeds, chemical inputs, agricultural equipment, and farmer training regarding the use of cultivation practices. This strategy was successful because of SODECOTON's well-established structure and effective procedures. The drawback to this strategy lies in the fact that SODECOTON's programs did not extend beyond its traditional target group, made up of cotton producers. Consequently, the transfer of new technologies only reached 40% of the total population of producers.

Uganda

The period evaluated in the Uganda study was very short, due to the recent re-establishment of USAID's program in Uganda--in 1986 after the end of the civil war. The effort was concentrated on the reconstruction of the capacity for research on food cultivation through refurbished research stations, short-and long-term training, and technical assistance. This reinforcement of human and institutional capacities entailed considerable costs.

The maize program was re-established in 1987, and the first new variety, Longe 1, was distributed in September 1991. Distribution of other, more improved varieties is expected in 1994.

A research program on sunflower was launched in 1988, resulting in the distribution of a new variety, Sunfola, to farmers in 1991. In 1992, Sunfola represented more than 11% of sunflower production.

The research program on soybeans, re-launched in 1988, also saw the distribution of a new variety in 1991. The distribution of a second variety was proposed for the end of 1992.

The development of oilseed crops was encouraged by programs in addition to agricultural research. Other programs were aimed at the reinforcement of cooperatives, and the development and distribution of improved oilseed presses.

The particular interest of the study in Uganda is, first, its subsector approach to examining the oilseed industry. Identification of constraints to the expansion of edible oils was done with a subsector perspective. The study provided some insights concerning the impact on women of new oilseed production and processing technology. Women participate fully in the production, processing, and marketing of the three crops studied--maize, sunflower, and

soybeans. Improved technology for procession grains into oil (more efficient and easier-to-handle manual presses) was particularly valued by women.

Several observations arise from this study, including:

1) Consumer preferences should have constituted an important criterion in the choice of agricultural research priorities. A case in point is soybeans, where consumers prefer grains with a white color, while the variety produced through research yielded red grains.

2) The oilmills' revenues are limited by the small quantity of sunflower seed marketed. At the same time, the quantities marketed are limited by the small returns obtained by farmers. Thus, a classical vicious circle exists, which suggests the need for research on selecting varieties with a greater yield.

3) The potential of new varieties distributed by research cannot be realized due to several problems: an insufficient capacity for seed multiplication, particularly for hybrids (sunflower), and for the production and distribution of rhizobium (soybeans), and inadequate extension services.

These problems are aggravated by constraints at the national level, including the recent history of political instability, limited national revenues due to the weak price of coffee in the international market, and economic policies which discourage the participation of private agents in the agricultural inputs sector.

Key Factors

This brief summary of studies conducted by MSU has brought to light several important factors which influenced the observed results. These factors include the following:

1) *Agroclimatic potential.* The Niger and Zambia cases illustrate how this factor can facilitate or impede the success of an agricultural research program and its subsequent impact on agricultural production.

2) *Agricultural policy.* Policy plays an important role in providing incentives for the adoption of improved technologies, as illustrated by the Zambia and Mali cases.

3) *Continuity and stability of organizations and development policies.* The important role of this factor is illustrated by the Uganda case, and also by the Mali and Zambia cases, where radical agricultural policy changes have had a strongly negative effect on trends in maize area and yield.

4) *The performance of agricultural research and other organizations involved in development and transfer of new technologies.* It is necessary for research to generate improved technology, and then for effective input distribution, extension, and marketing to be assured. The crucial role of multiplication and distribution of improved seeds is illustrated by the Zambia, Mali, and Cameroon cases (success), and the Niger and Uganda cases (failure). The ability of well-

established development agencies to carry out these functions can be seen in the case of Mali (CMDT) and Cameroon (SODECOTON), while only in Zambia was this function filled by a quasi-private agency (ZAMSEED).

5) *Market performance.* Well-functioning markets are important, both for agricultural inputs and for agricultural outputs.

Conclusions

In conclusion, the following points can be emphasized:

1) Economic impact studies "plus" (i.e., those conducted from a subsector perspective and taking into account institutional factors and complementary interventions) can help agricultural research services to justify investment in agricultural research, and to identify the constraints which influence the performance of particular subsectors.

2) In order to reinforce the performance of agricultural research, it is necessary to:

   a) Place a high priority on important crops (in order to realize a significant impact), and on producers' problems (in order to maximize the eventual adoption of possible improved technology);

   b) Define the research focus and objectives using a systems perspective, understanding the "systems" concept in two ways:

      - subsector: the subsector focus reflects a vertical perspective that encompasses all economic agents in the subsector, and thus allows the identification of constraints beyond the farm level;

      - farming system: this focus reflects a horizontal perspective that encompasses all household production activities, agricultural and non-agricultural, each of which competes for its share of common household resources (land, labor, and capital).

3) In order to reinforce technology transfer, availability of improved seeds must be assured.

4) In order to strengthen the analyses of the economic impact of agricultural research, we must:

   a) Carefully define the "without research" scenario;

   b) Ensure that the costs of all complementary interventions (including agricultural policies) are incorporated;

   c) Improve the collection of critical data, such as data on:

- adoption of particular varieties, not simply data on the general category of "improved varieties"; the data must allow tracking the adoption of whatever specific innovation is the focus of the impact assessment;

- the yield gain due to research.

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