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BUILDING AGRICULTURAL RESEARCH CAPACITY: INDIA'S EXPERIENCE WITH THE ROCKEFELLER FOUNDATION AND ITS SIGNIFICANCE FOR AFRICA

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ABSTRACT

Technical change in agriculture has frequently been explained as being induced by relative factor scarcities or the organized efforts of vested interests. Public sectors, however, often have to play an important role in the development of agricultural technology because of the small and dispersed nature of the production units, the large costs of investments in research, the gestation lags in reaping the benefits of research and the free rider nature of those benefits. Successful development of research systems have often involved research organizational decisions, human capital development and an incentive system requiring a complex coalition of political and scientific elite who are not necessarily the direct beneficiaries of such improvements. Models of induced innovation or interest groups do not adequately explain the genesis of technical change through such reorganizations.

By drawing on the diaries of scientists in the Rockefeller Foundation who assisted India in developing its research system in the 1950s and 60s this paper outlines the process by which research reorganization was achieved the external factors which induced the reorganization and its relation to the growth in productivity of the Indian system and the role that the Foundation played in that process. It stresses that external factors may frequently be critical in developing coalitions of elite needed for policy reform. It nevertheless contrasts the experience of the Rockefeller Foundation in India with that of the donors currently attempting to build the systems in Africa. It stresses the preconditions needed to achieve a successful donor recipient collaboration in both donor and recipient countries including the need for a long term perspective, political support at the

highest levels of the government, the quality and the length of service of the donor and recipient scientists and a wholistic approach to organizational improvement which simultaneously addresses the problems of human capital, institutions, incentives and administrative procedures.

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I. Introduction

Rapid agricultural growth typically results from rising factor productivity generated by improvements in the quality of inputs (material or human), which are in turn made possible by technical change, among other developments. International agricultural research institutions may initiate much of the necessary scientific work, but reaping the benefits of technical change also depends critically on a country's ability to "borrow" from the existing stock of relevant international knowledge, to conduct adaptive research and farm level tests, and thus to tailor techniques discovered in the laboratory to the specific requirements of different farming locations (Evenson and Kislev 1973).

Because agricultural research requires lumpy investments, involves externalities, and is subject to long gestation lags, it must often be conducted by the public sector. Multilateral and bilateral official donors have therefore invested heavily in national and international institutions for agricultural research (Anderson and others 1985): as a measure of the scale of this effort, the Consultative Group on International Agriculture Research (CGIAR) spent $163 million world-wide in 1985.

Despite these expenditures, the process of developing national agricultural research capacity is little understood, as are the links in the long chain of research, experimentation, adaptation and dissemination. Theories of induced innovation (Hayami and Ruttan 1971) explain technical change as the result of relative factor scarcities, but leave the process of national capacity building opaque. Interest group oriented explanations of technical change (de Janvry 1977) are equally unsatisfactory. It is clearly

important that interested parties define and demand the technical knowledge they need so as to get the most out of the work of domestic and international research institutions; nevertheless the fact is that interest groups are often not well organized in countries at early stages of development and are not able to express their preferences for technology -- and yet technical change still takes place, even without the prior existence of an organized interest group of likely direct beneficiaries. For instance, the development of the US land grand system involved relatively little grassroots pressure (Hadwiger 1982). Rather, it was the result of collective action by a complex coalition of scientific, administrative and political elites, whose share of the total benefits from new technology was relatively small. Most of the bottom-up demand occurred later, as the result of ex post perceptions of the benefits of technical advancement.

We will demonstrate in this paper that in India, as in the US, the emergence of a coalition of bureaucratic and intellectual elites led to "top-down" pressure for research that would develop local technological capacity for new sources of agricultural productivity. Even this pressure only bore fruit, however, after it had received support at the highest levels of government, and in the context of a specific crisis in agriculture that lent political urgency to perceptions of India's technological needs. Finally, the availability of "miracle" Mexican wheat and Taiwanese rice varieties made improving the nation's scientific and technical capacity in agriculture a feasible and politically attractive option.

Demand articulation, political will, and promising international research are only partial preconditions for developing a viable indigenous research capacity, however. Knowing the factors that help and hinder the

process of generating such capacity is equally important.[1]/ In the sections that follow, we will show how India obtained access to high quality knowledge about how to generate national research capacity, and will suggest why it is that most African countries have hitherto been unable to replicate India's success in this area, despite the growth of international and national expenditures on agricultural research. India was selected for study because its agriculture is frequently cited as an example of a hopeless situation turned into a success that ought to be emulated in Africa, and because the Indian experience offers directly relevant lessons for the development of national agricultural research systems in Africa.

Material for the Indian case study comes from previously unavailable internal documents of the Rockefeller Foundation (especially from the diaries kept by key Rockefeller staff when they were involved in building the Indian research system, but also from memoranda, letters, and reports contained in project and general correspondence files).[2]/ The material vividly documents one of the most effective institution building programs in the developing world. It was carried out by the Foundation in India between 1953 and 1974, cost an extremely modest $7.9 million (about $23 million in current prices)

1/ Generating capacity must be distinguished from generating research results, a function which has predominated in the CGIAR system. The recent establishment of the Special Program for African Agriculture Research (SPAAR) may mark a beginning of an effort to correct this bias. SPAAR will try to coordinate donor research support, serve as a clearing house for information on new technology, and develop national and regional research programs and networks.

2/ Our review of foundation documentation had been preceded by Lele's conversations with M.S. Swaminathan, O.P. Gautam, Ananta Rao and several others then involved on the Indian side, and were followed by intensive interviews with Ralph Cummings, Albert Moseman and W. David Hopper on the US side.

over the entire period[3/], and never involved more than a dozen expatriates at a time; nevertheless, it had a very high payoff, in terms of both enhanced institutional capability and the transfer of technological information. It is one of the outstanding instances of catalytic aid, where a donor stimulates improvements in recipient institutions that enable them to develop the indigenous capacity to adapt more productive technology. While the United States Agency for International Development (AID), the Ford Foundation, and the Agricultural Development Council (ADC) also played important roles in establishing agricultural universities, supplying training, and supporting research, the Rockefeller Foundation's central role in India is recognized even in prestigious Government of India reports.[4/]

We will argue that at least four critical factors underlay the Rockefeller Foundation's ability to help India to develop an effective research effort. First, the Foundation was simultaneously involved in upgrading several interrelated activities that were crucial for building India's agricultural research capacity. These included the development of graduate education in agriculture, the setting up of coordinated research for commodities, the reorganization of the agricultural research system, and the introduction of imported high yielding varieties (HYVs) of wheat and rice for diffusion at the farm level. The second important factor was the long term nature of the Foundation's program in India, involving the same individuals (in particular the program's Director Ralph Cummings, but also his associates)

3/ The current figure was obtained by converting Rockefeller's outlay each year to 1983 prices by using the implicit US GDP deflator.

4/ See for instance the report of the National Commission on Agriculture (India 1976).

for a decade or more. Third, the demand for Rockefeller Foundation assistance was not the result of an aid donor's initiative; rather, it originated in India's own perceived need for help and its search for high level expertise. This contrasts sharply with the situation in Africa, where the impetus for agricultural research all too often stems from a donor's conception of a recipient's technical assistance needs. The fourth critical element was the fact that the "message" about how to proceed may not have been the only possible one -- but it was always coherent and consistent.

The comparative material for Sub-Saharan Africa comes primarily from a major current research project directed by Uma Lele on "Managing Agricultural Development in Africa"(MADIA). The project includes studies of the political and institutional environments in each of six African countries, of the effects of domestic economic policies on their agriculture, and of eight donors' foreign assistance programs for those countries since the mid-1960s.

The thirty-five countries of Sub-Saharan Africa spent a total of $385 million on agricultural research in 1983, while donors contributed another $307 million for international and national research systems in the region that year.5/ Nevertheless, apart from a few countries (such as Zimbabwe, Kenya, and the Ivory Coast) that have done well with selected crops, most countries of Sub-Saharan Africa have been unable to borrow from the accumulated stock of scientific agricultural knowledge or to articulate clearly their needs for developing location specific scientific knowledge to

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5/ Personal communication with Peter Oram. The data are in 1980 dollars and should be interpreted cautiously because of variations in donor and national government reporting procedures.

suit their particular resource endowments. Inadequate national research and inability to adapt technology to diverse local conditions -- especially to the needs of small farmers -- are major reasons for the poor supply of new technology for agriculture in the region. In turn the lack of suitable technology holds back productivity and constrains rural development generally.

There is as yet little sign of the emergence in Africa of coalitions of bureaucratic and political elites of the kind that were instrumental in developing India's agricultural research capability. The current weakness or absence of such groupings helps to explain the ineffectiveness of research systems in much of Africa, despite massive expenditures on research. In addition, with the partial exception of maize, there have been no dramatic laboratory breakthroughs resulting in comparable "miracle" varieties for food crops that might stimulate political demand for adaptive research in Sub-Saharan countries.

Finally, much of the current agricultural research effort in Africa is being undertaken at the insistance of different donor countries or institutions, and consequently suffers from major weaknesses. It is inevitably piecemeal (in contrast to Rockefeller's holistic approach in India), and is all too often modelled on a donor's idea of what a recipient needs. It is generally short-term in nature, which militates against the development over time of close and effective interactions between donor and host country personnel. The resulting fragmentation of (frequently unsolicited) expert views among myriad donors can end up by confusing rather than co-opting policy makers in Africa.

In the sections that follow, we will outline India's experience with the Rockefeller Foundation from the 1950s onward and will note some of the

main ways in which this experience differs from that of African countries. The paper concludes with a summary overview of the lessons to be drawn by donors and African recipients alike from the India/Rockefeller interactions that we describe in earlier sections.

2. India: Defining Research Priorities and Approach

When it achieved independence in 1947, India inherited a research system that was reasonably sophisticated for its time, but offered a relatively poor payoff in terms of new technology.[6/] Some breakthroughs had occurred with sugar and other cash crops, but critics at the time, such as A.B. Stewart (1947), argued that the overall system of research was unduly fragmented. Separate commodity committees studied the major cash crops, and the Indian Council of Agricultural Research (ICAR) did not exercise the kind of effective leadership needed to focus research on pressing problems or promising opportunities.

Overemphasis on basic over applied research, a legacy other countries (such as Kenya) have also inherited from Britain (Jamieson 1981), was another problem. This theoretical orientation was partly the result of the British style of higher education, which neglected the practical application of technical knowledge. In contrast to Africa today, there were already seventeen degree granting agricultural institutions in India at independence,

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6/ Pray (1984) estimated the internal rate of return was no higher than 22 percent, a respectable figure compared to many public investments, but low compared to what is usually found in agricultural research programs.

but only five offered advanced training as of 1951.[7/] The National Commission on Agriculture noted that agricultural education "was generally formal and bookish rather than seeking to develop practical skills and ability to solve field problems" (India 1976, pp. 185-86).

2.1 Institution Building

Post-independence awareness of these shortcomings led civil servants, scientists, and some political leaders in India who had the necessary long-term vision to seek to improve the way in which their research system was organized, by drawing on the experience of more advanced countries. Lacking multilateral sources of assistance, they turned to the United States out of a perception that it was the world leader in science based agriculture.[8/]

The US had much to offer Indian agricultural science in the early 1950s.[9/] The basic organizational principle followed by the Americans was to unify teaching and research so as to force attention onto practical problems. They had also had considerable success with adaptive research that

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7/ Kenya (population of six million) had no degree granting agricultural institutions at the time of independence. Given India's population of 300 million at the comparable stage of political development, this was not as glaring a disparity as it may at first seem. Nevertheless, India did benefit from the consequent trained manpower availability because of, inter alia, a long-time horizon needed for building research and scale economies in the planning of research reform.

8/ Impressed by advanced US agriculture, Jawaharlal Nehru visited the United States in November 1949 and asked to visit farms in the Midwest to see what technology might be relevant for India agriculture (personal communication from T.W. Schultz, who accompanied Nehru on a tour of Iowa farms and shared the briefing notes he had prepared for the visit).

9/ It should be emphasized that the US pattern that interested Indians was the one that has blossomed from about 1920 to 1940. Since that time, American society and the associated research system have evolved in ways that have tended to weaken the links between farmers and the educational and research establishment (Bonnen 1985).

used interdisciplinary teams to develop "packages" of improved farming practices (Moseman 1970). Of particular relevance to a large, federal system like India's was Washington's use of grants to subsidize research at state agricultural stations. Coordination at the federal level enabled plant breeders to exchange information and planting material regularly, and to identify the most promising crop combinations in specific regions by adopting uniform trials throughout the country. This arrangement gave the US research system the unity of purpose associated with administrative centralization, while simultaneously giving field level scientists the autonomy needed to conduct research under diverse conditions, and thus to determine the comparative advantage of different crops and regions, which is so crucial in developing an efficient agricultural sector.

The lack of alternative sources of assistance may have been a blessing in disguise. It concentrated India's attention on a single set of institutional models, while still permitting reliance on different sources within the US as appropriate -- i.e., on the Rockefeller Foundation for help with the development of the national research system,[10/] on AID for investment in land grant type agricultural universities, and on the Ford Foundation for assistance with farm extension work. It greatly reduced the search cost typically so high for developing countries with limited trained manpower and diverse sources of supply.

10/ Not surprisingly, Rockefeller was later to play a crucial role in the establishment of the CGIAR system.

2.2 Adaptive Research

In addition to its interest in institutional reform of the country's research system, the post-independence Indian government made an early decision to promote adaptive research on hybrid maize, a crop that had experienced outstanding technical breakthroughs in the US and had spread to Europe and elsewhere.[11/]

At least three factors prompted the initial emphasis on maize rather than rice or wheat -- a superficially surprising choice given that only about 3 percent of India's gross cropped area was under maize in the 1950s, compared to 30 percent under rice and 10 percent under wheat (see section 4 below for discussion of later work on wheat and rice). First, the Indian Agricultural Research Institute (IARI) believed that programs for the latter crops were well underway and therefore needed no external assistance. Second, should better varieties of maize fail to materialize, the loss to India would not be excessive, making initial experimentation less risky than in the case of rice or wheat. Third, maize was the subject of little ongoing work in India; there were thus fewer scientists and administrators who might feel threatened by new approaches to maize research.

The leading repository of knowledge about maize in developing countries was the Rockefeller Foundation, which had been running maize programs in Mexico since 1943 and in Colombia since 1950. Vishnu Sahay, India's then Secretary of Agriculture contacted the Foundation for help in 1953, seeing no reason to go over ground already covered in Latin America.

11/ According to an historian of the crop (Crabb 1947: xv) it "is truly one of the most important advances made in all the thousands of years since man first began cultivating special food-bearing plants."

But Rockefeller officers expressed concern that India might be rushing into commercial maize production without doing sufficient adaptive research. Two Foundation experts invited to India in 1954 confirmed this judgement, citing the lack of adaptability of American hybrids to Indian conditions and the need for crossing with local material. These recommendations led to a formal request (in 1955) that Rockefeller help the Ministry of Agriculture with the necessary hybrid maize research.

Rockefeller officials decided that the most useful way to proceed in India would be to replicate the approach to adaptive hybrid maize research that had been successful in the American South during the 1940s. This meant continuing experimental work at existing state research facilities, but coordinating it from the center to avoid duplication and oversights. This in turn required setting up uniform crop trials, a consistent record system, and means for unrestricted exchange of seed material. American experience had also proved the value of interdisciplinary research for developing ways of controlling disease and pests, and for building a base of information on cultural practices to complement new strains of maize; Rockefeller therefore wanted to ensure that the Indian program would involve team work among scientists from different backgrounds.

One key decision was to cooperate with existing Indian institutions rather than to build new ones.[12]/ Despite delays and administrative conflicts of various kinds, the project soon found varieties that had test yields of up to 140 bushels per acre, versus an average yield in India of about sixteen

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12/ U. J. Grant, who initially ran the maize project, did not agree with this approach and left the Indian program in 1959 to take a post in the Colombia Agricultural Program.

bushels. By 1960, it proved possible to recommend four double cross hybrids for release to Indian cultivators. The diffusion of these varieties was slower than anticipated, however, partly because net returns for rice, which competes with maize, turned out to be far higher. Hybrid maize accounted for only one-quarter of maize acreage in 1980-81, after twenty years of use.13/

The maize project also had important organizational fallout. The relatively rapid development and release of new varieties proved to many Indian experts the advantage of central-state cooperation and interdisciplinary research -- although the vested interest of researchers in other organizational models meant that the All-India coordinated system of research was not used for other crops until the mid-1960s.14/ The maize model looked especially effective when compared to the relatively slow progress of sorghum and millet research. In fact the pace of research on these two crops was also hindered by the need to collect indigenous specimens for breeding, but the speedier progress made with maize reinforced the impression that Rockefeller organizational techniques were superior to traditional ones.

13/ Similar patterns are observed in Africa. In Kenya, for example, hybrid maize had achieved adoption rates of 50 to 100 percent in humid areas by 1983, but adoption was much spottier in transitional and semi-arid areas (Jha/MADIA 1986). Consumer resistance has also been a problem. In many African countries national scientists still have only a limited capacity to develop the characteristics in maize demanded by consumers (e.g., the highly prized white maize compared to the imported yellow maize). They have also failed to improve sufficiently the milling and storing qualities of maize (e.g., in Malawi). The resulting consumer resistance to hybrid maize in Africa has reduced its marketability and slowed its adoption -- an outcome that is frequently but mistakenly ascribed to "the absence of a technical package."

14/ Central-state conflict is endemic even in the American system (Knoblauch and others 1962). Bonnen (1985) actually suggests that such tension is a source of strength for the American research system, because it forces it to confront new problems.

2.3 Rockefeller's Approach

Simultaneously with its approach to Rockefeller for help in hybrid maize research, the Indian government had begun to explore the possibility of obtaining the Foundation's help in setting up a graduate program in agricultural sciences (see below, section 3). Meanwhile, Rockefeller's managers had their own objectives in becoming more extensively involved with India, and their own conditions for participation. First, they were interested in working in India because of the challenge (and potential prestige) of working in a large country; they also expected to achieve scale economies in their provision of technical assistance to India. Second, the Foundation wanted to make the most of its own comparative advantage. It was better able than official donor agencies to work on long term institutional problems, because it was unconstrained by the vagaries of annual donor government budgeting processes, or by changing degrees of political support for particular recipient countries (both of which plague official bilateral aid programs and planners). Moreover, as an endowed philanthropic agency with no need to show immediate success in order to continue projects with long gestation periods and/or uncertain prospects (such as adaptive research on maize), it could afford, and wished, to take a long term approach. Therefore, the Foundation's interest in helping India with graduate education and maize research depended on whether it could expect to be involved in long term programs of ten years' duration or more.

Third, senior Rockefeller officers always required that their resources be concentrated on major ongoing schemes that could ultimately have significant payoffs, and not be diluted over many small "starter" projects. They saw the Foundation's role as providing the marginal input needed to raise to very high standards programs to which the national government had already committed itself.

Fourth, and of special importance, was the Foundation's insistence on participating in all relevant aspects of developing indigenous agricultural research capability and adapting new crops to local needs. Its involvement thus ranged very widely -- from designing aspects of the education system and the maize research program, to training Indian professionals in scientific and pedagogical techniques, and to implementing an "action program" over which it initially insisted on retaining managerial authority. Furthermore, it also tried to ensure that the same individuals who helped India design programs were also involved in training nationals and grooming them for line management positions.

Fifth, the Foundation was determined that its senior staff working on India should be individuals whose credentials would ensure that their advice carried weight with their Indian counterparts. The key Rockefeller, Ford Foundation and US government personnel involved in India at that time -- Ralph Cummings, U.J. Grant and Albert Moseman (Rockefeller), Douglas Ensminger (Ford) and Frank Parker (US Technical Cooperation Mission) -- were men of recognized stature in the US agricultural community; they had all also been extensively involved in working with large scale agricultural development programs in developing countries, and/or in operating national agricultural research programs. Moreover, they had a common background in science-based agricultural research: this homogeneity meant that the Indians received consistent advice, both from the representatives of the individual assisting institutions at a given point in time and from the institutions as a group over time.

Sixth, senior Rockefeller advisers were seconded to work on Indian programs for extended tours of duty (ten years in Cummings' case, five in Moseman's). This helped them with the crucial task of creating a constituency of supporters within the cadres of the Indian government concerned with

agricultural research. Coalition-building of this kind is crucial to the long term success of efforts to develop new institutional capabilities in developing countries. Without it, the new institutions tend to last for little longer than the secondment tours of expatriate personnel.

Finally, the long term time frame within which Rockefeller staff were able to operate, together with their freedom from yearly budgetary pressures, meant that they had no need to point to immediate dramatic results. Senior managers of the Rockefeller Foundation were willing to judge the administrators of their Indian Agricultural Program on their ability to help the Indians to establish and operate over time an effective agricultural research system -- not on the speed with which they could point to completion of particular project components.

3. India: Human Capital Development and Institutional Reform

It would seem intuitively obvious that a program for creating or upgrading a national research capability should begin by concentrating on human resource development (in terms of projects for skill enhancement) and institutional change: in fact, however, a persistent flaw in efforts of this kind in developing countries has been undue donor emphasis on investment in "bricks and mortar." The Rockefeller Foundation's approach in India avoided this trap, spending less than $1 million (only 12 percent of total expenditures) on buildings and equipment (Table 1). The Indian government was also independently determined to ensure that the Foundation not be diverted by capital projects. A request from IARI for the construction of a student hostel by the Foundation was actually turned down by the Prime Minister, out of concern that this would distract the Foundation's attention from the more important task of transferring knowledge.

Rockefeller's contribution to building India's agricultural research capacity took three direct forms:

(i) Human capital investment through grants and fellowships;

(ii) Planning the reorganization of the higher education programs at the IARI; and

(iii) Helping the Indian government to reorganize the Indian Council of Agricultural Research (ICAR)

Each of these activities is briefly examined below.

3.1 Investing in Human Capital

Few Indians knew how the American research system worked: in 1957, therefore, Rockefeller began to send key personnel to the United States for a first hand look at agricultural schools and experimental stations. Over the next dozen years, ninety short-term travel grants were awarded to Indian leaders at a cost of $400 thousand (Table 1).

Table 1
Rockefeller Foundation Expenditures for Agriculture
India (000$)

	1951-55	1956-60	1961-65	1966-70	1971-75	Total
Agricultural Program a/	--	1,111	1,640	2,578	501	5,830
Bldg., Equip. & Books	197	435	252	63	--	947
Experiment Stations	--	--	560	--	--	560
Travel Grants	--	69	188	148	--	404
Other Grants b/	100	36	18	--	--	154
Total	297	1,651	2,658	2,788	501	7,895

a/ Includes support for IARI Post-Graduate School and All-India coordinated foodgrain projects. In-country cost of Rockefeller Foundation staff not included for all years.

b/ Includes $100 grant for rural training institute at Etawah Project (Lucknow).

Note: Totals may not sum due to rounding.
Source: Rockefeller Foundation, Annual Report (various years).

The Foundation also provided a long-term fellowship program to upgrade the formal skills of Indian researchers and students. Rockefeller solicited a limited number of nominations from official organizations each year for graduate or postdoctoral training overseas, usually at US land grant schools. One hundred and fifteen trainees finished their course of study between 1956 and 1970 (Table 2). 15/ Rockefeller's commitment to formal high-level education of agricultural scientists contrasts with the World Bank's current approach to research, which its Operations Evaluation Department (World Bank 1983) has criticized for underemphasing formal training and relying excessively on on-the-job training.16/

One of the most frequently heard objections to investing in formal skills upgrading (especially through degree courses at higher education institutions in the developed world) is that the individuals concerned will come home to inadequate opportunities and/or compensation -- or perhaps never return from their studies at all. While this problem may have been less critical in India than in most other developing countries, Rockefeller's involvement in promoting several aspects of agricultural research gave it a number of ways in which it could protect its investment in human capital.

15/ The fellowship program was not officially part of the Indian program. The Foundation awarded fellowships on an international basis, with candidates from India competing with those from other countries outside the US. The competition, which involved no national quotas, was not generally advertised. Instead, Rockefeller staff tried to use their contacts to identify promising individuals who might benefit from a fellowship, using the international award procedures to avoid the danger of influence peddling in selection of awardees that a purely national program might present.

16/ In six out of ten countries studied, fewer than 10 percent of research staff had doctoral degrees; in eight countries, at least 40 percent of the staff had bachelor degrees or less.

These included (i) awarding scholarships to job-holders in Indian institutions with guaranteed positions upon completion of their education; (ii) supporting several candidates from the same institution to build up an indigenous staff with a shared background of expatriate training; and (iii) making small grants of critical equipment and facilities to the institutions in question. More generally, Rockefeller's role in reformulating the Indian research system allowed it to help create an overall environment in which Indian scientists could operate effectively. Three-quarters of former holders of Rockefeller grants reported working at Indian agricultural schools or research organizations at the end of the 1960s. Only five percent were working outside of the country. (See Table 2).

Table 2
Indian Recipients of Rockefeller Fellowships & Scholarships, 1956-70

Institutional Affiliation a/	Degree Received				
	Ph.D.	M.S.	Postdoc.	None	Total
Within India					
College/University	39 b/	12	13	8	72
Government	9	2	1	4	16
Research Institutes	8	4	2	1	15
Non-government orgs.	3	1	--	1	5
Outside India	5	--	--	1	6
Total	64	19	17 c/	15	115

a/ Reported as of 1969 or 1970.
b/ Includes one Ed.D.
c/ Includes one person for whom no institutional affiliation was reported.

Note: The data cover only persons who had completed their study programs by 1968.

Source: Rockefeller Foundation (1972).

3.2 Reorganizing Agricultural Education

A major post-independence concern of the Indian government was the need to strengthen higher education generally, and rural and technical education in particular. The Radhakrishnan Committee, the first of a series of blue-ribbon panels that would examine the issues involved, was set up in November 1948. The prestigious nature of its membership (both the chairman and another member were later to become Presidents of India) indicates the importance attached to its subject matter -- a sense of priorities for which it would be hard to find a parallel in Africa today. Nevertheless, the Committee's proposals for reform took 15 years to get under way.

Meanwhile, by the early 1950s, the government had begun to take steps to promote technical higher education in agriculture through institutions such as the IARI Post Graduate School.[17/] Institution-building efforts of this sort typically need careful preparation and substantial local commitment and input if they are to take root. Thus when the Rockefeller Foundation undertook to help the government to set up the Post Graduate School, a key element in the project was the joint preparation and execution of plans by Foundation staff and Indian counterparts. After Ralph Cummings took up his post as the Foundation's Field Director, he was careful not to rush into the IARI project with preconceived ideas: instead, he devoted a six month stay in India in 1957 simply to learning about the country, before developing proposals for the educational program at IARI. This approach is very

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17/ Frank Parker was instrumental in a major parallel effort to develop state agricultural universities on the land grant model. For a review of this experience from a comparative perspective see Goldsmith (1987).

different from the current tendency among donors to try to address long term needs through short-term project preparation missions.

Set up in 1905 at Pusa (Bihar), the IARI was primarily a research institute, though it provided non-degree training in agronomy, botany, chemistry, entomology, and plant pathology. Its established status had both benefits and costs in terms of institution-building. On the one hand, a reform program could move quickly by building on existing facilities; on the other, reorientating professional staff to new patterns of behavior was a considerable problem. Once he had sufficient information to begin making proposals, Cummings suggested that graduate education at IARI adopt the American pattern of major and minor fields of study, written and oral comprehensive examinations, and theses supervised by an advisory committee.

These innovations required major adjustments on the part of IARI staff. Instead of the familiar system of standardized curricula and external examinations, instructors would now become responsible for developing their own courses and measuring students' performance. The curriculum was also expected to change, with a new emphasis on deductive reasoning, problem solving, and a broad grounding in science. Finally, the teaching and research staff at IARI were now expected to be chosen on the basis of merit rather than seniority, as was the common Indian practice.

These were radical proposals. The existing staff were wary of many of them, although they broadly accepted the basic principles involved. In the event, active collaboration between the relevant institutions and individuals -- Indians at IARI, the Ministry of Agriculture, the Ministry of Finance, the Planning Commission and the University Grants Commission, together with their

Rockefeller counterparts -- made it possible to adapt Cummings' blueprint to suit Indian conditions, and the new school was inaugurated in October 1958. Its short (one year) gestation period is a good indicator of the high degree of Indian commitment to reorganizing the system of agricultural education -- and reflects special credit on the University Grants Commission, which had been expected to object to handing over responsibility for graduate education to IARI.

The issue of how to adapt US organizational structures to Indian conditions remained, however. Division heads at IARI were reluctant to change completely to the US committee-based system of postgraduate examinations proposed by Cummings. They preferred retaining some external examiners to avoid favoritism and ensure the objectivity of committee members. The refusal of Indian administrators to delegate decision powers and their insistence on making seniority a primary consideration in personnel matters were seen as problems by Cummings, who had become the school's first dean (on an acting basis in the absence of a suitable Indian candidate). Cummings also had reservations about the admissions process at IARI, which was adjusted to favor government personnel already working in agriculture but lacking a degree. In Cumming's view this reduced the competition for admissions to the graduate program (and consequently the research system's ability to draw on the best students from the widest possible pool). The issue prompted his resignation as dean in November 1960. He was suceeded by A. B. Joshi and, in 1965, by M. S. Swaminathan.

The performance of the IARI Post-Graduate School is not easy to measure. Certainly, the output of the program grew rapidly. Within a decade the number of students grew to roughly 400, half of them at the doctoral

level: the school accounted for about one out of six graduate degrees in agriculture awarded in India each year, and there were typically ten applications for each available place. On the other hand, critics have complained that the administration of IARI pays too little attention to the running of the school, and that seniority and connections still play too prominent a role in personnel matters.

3.3 Reorganizing the Research System

Reforms of higher education institutions and curricula can improve the availability and qualifications of potential research personnel, but if the institutional framework for the research effort is itself flawed, the ultimate output will be less than optimal. In this section we briefly explore the history of proposals to reorganize India's agricultural research capability, some of the obstacles to reorganization, and how they were overcome.

Proposals for reforming India's agricultural research system had been discussed since 1947. Critics had repeatedly suggested that the ICAR was too tied to civil service regulations to be effective, that the pay and job conditions of agricultural scientists were poor, and that the work of the major agricultural research facilities was weakly coordinated. By the early 1960s, despite the consensus among administrators that the research system needed revision, the reforms proposed by successive committees of experts (most recently by a US-sponsored team of Indians and Americans that had reported in 1959) had been shelved on the ground that they were politically

sensitive.[18] Nevertheless, in 1963 the Vice President of ICAR, A.D. Pandit, requested the Rockefeller Foundation to put together yet another Indo-American committee to study the problems of agricultural research.

The report of this team (Parker and others, 1964) repeated many earlier proposals. It laid out two main objectives: creation of an incentive system that would encourage more research from professional personnel, and establishment of an organizational framework that would enable them to focus on the most urgent problems. Specific ideas included freeing agricultural scientists from the constrictions of civil service regulations and pay scales, abolishing the commodity committees, and eliminating the ICAR itself and starting again with a new central organization to coordinate research at the state level.

There was still no political support for administrative reform when the Research Review Team submitted its report in March 1964, and the Indian government made no effort to implement the group's proposals. It is probable that nothing would have been done, but for the fact that Chidambaram Subramaniam, then Minister for Steel, Heavy Industry and Mines, was appointed Minister of Food and Agriculture in June 1964 to deal with India's

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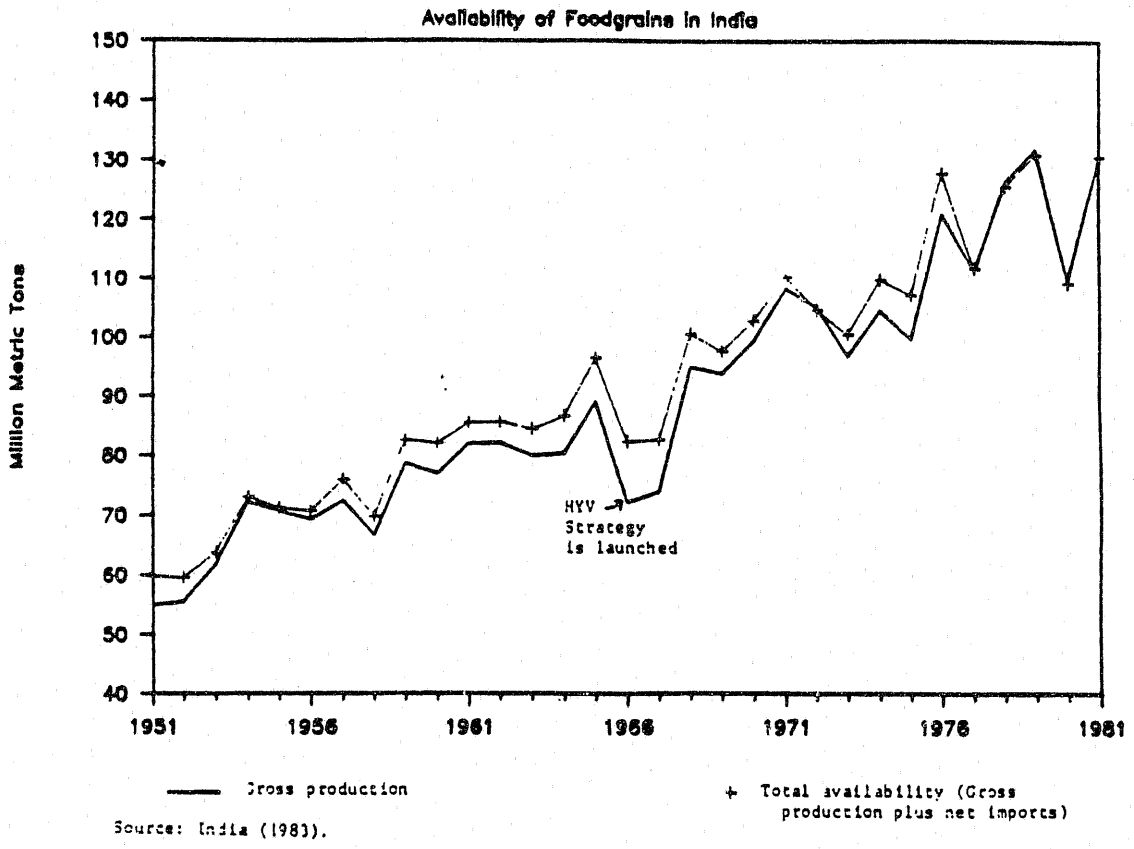
18/ This cycle of proposals for reform being followed by political inaction is familiar in Africa. (Lele forthcoming). It could produce near-immobility in India: the first Five Year Plan (India 1953), for instance, had challenged the "compartmentalization" of the crop-wise studies carried out by commodity committees. It proposed setting up a research center for each crop region, and strengthening the ICAR so it could review and approve the research programs being carried out by subordinate institutions. Ten years later, the system remained the same.

agricultural crisis. Foodgrain production was stagnant and grain imports had risen to equal 8 percent of the Indian output of these crops (Figure 1).

FIGURE 1



Source: India (1983).

India's dependence on concessionary supplies provided under US Public Law 480 was becoming a troublesome feature of international politics. Along with a devaluation the prestigious Bell mission from the World Bank had stressed the need for pro-agriculture policies as a condition of program support, while President Johnson had made PL 480 shipments conditional on agricultural reforms.

Subramaniam recognized India's need to deploy its scientific resources with the utmost efficiency to boost food production. Meanwhile, his lack of strong ties to the agricultural establishment put him in a better position than his predecessors to experiment with basic reforms in the structure of agricultural research. He therefore eagerly seized on the Parker Committee report.19/ Working with an advisory group of Indian scientists, he adjusted the latest proposals to fit political realities. He chose not to abolish the ICAR in favor of a stronger body, though he achieved virtually the same result by giving it direct control of national research institutes such as IARI, together with greater funding power so that it could more actively coordinate research undertaken by the states.

To give agricultural sciences prestige in a status conscious Indian bureaucracy and society, the position of Director-General of ICAR (occupied traditionally by the civil service) was turned over to professional scientists. B.P. Pal -- the first scientist to hold this office -- subsequently developed the Agricultural Research Service, an elite corps with clear career paths, pay scales that could be supplemented for outstanding work, and the possibility of promotion irrespective of vacancies at higher levels (Pal 1974). Subramaniam (1979, p. 29) argues that the primary gain from these reforms was the ability of Indian administrators to redirect

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19/ In his authoritative account he recalls (Subramaniam 1979, p. 13): "My first concern was how to make agricultural science in India more effective and efficient so that it might contribute to greater production. I therefore tried to find out the state of the organization of agricultural science because that mattered most." Subramaniam's account was made possibly by Sir John Crawford, a member of the Bell mission who later invited him to deliver a series of lectures at Australian National University.

research priorities, turning scientists toward specific, nationally determined goals as opposed to ad hoc projects formulated on an individual basis.

Did the reorganization of ICAR succeed? Cost-benefit analysis shows the research system to have had high returns, though these are not all attributable to the reorganization.[20/] The post-1965 system has been able to develop and release a large amount of genetic material, especially for rice (see section 4 below). The status of agricultural scientists improved greatly although they are still said to have lower status than nuclear scientists within the Indian scientific community (Anderson 1983). Putting a scientist in charge of ICAR is also not necessarily a step in the right direction, if more professional administration and dynamic leadership is what is needed.[21/] Also, new structures and procedures do not by themselves guarantee changes in the behavior of individuals within an organization.[22/] Not surprisingly, the ICAR underwent a further restructuring in 1973. According to the Vice President of ICAR, M.S. Randhawa (1979), the objectives were again

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20/ See Evenson and Jha (1973), Singh (1974), Mohan (1974), and Kahlon and others (1977).

21/ Appointment of civil servants may also give agricultural research a broader constituency and a hearing in the Indian government --something that may now be desirable, given the need to revitalize Indian agricultural science so that it can absorb and build on recent biogenetic breakthroughs. The low current level of support for Indian agriculture from the donor community suggests that India should autonomously reorganize itself so as to catch up with the newest technological innovations.

22/ A report from the Centre for Management in Agriculture (Chowdhry and others 1972) came to the conclusion that the reorganization of ICAR did not work as expected because there was no retraining of personnel. Changes in formal organization apparently failed to change informal behavior patterns.

to give it greater autonomy, decentralized decision-making, and a more flexible personnel system.

4. India: Foodcrop HYVs and Adaptive Research

One of the important issues facing technical assistance personnel in developing countries is the resistence of local nationals to changes that undermine their own position. We noted earlier that Indian agricultural experts in the 1950s assumed they had enough knowledge about wheat and rice for external advice on these crops to be unnecessary. As with the reorganization of ICAR, high level political pressure was needed to change their minds. The role of the Rockefeller Foundation, and of Ralph Cummings in particular, was significant in this process, as we shall show below.

4.1 The Background

In 1962, Indian researchers successfully tested two Mexican semidwarf varieties of wheat, which they had acquired through the US Department of Agriculture's international rust nursery system. This led to a tour in 1963 of the wheat growing regions of India by Norman Borlaug from Rockefeller's agricultural program in Mexico. He dispatched 400 kilograms of four varieties for trials in India, two of which -- Lerma Rojo and Sonora 64 -- outyielded domestic control varieties by 30 percent.

An exciting rice variety was also identified -- a semidwarf called Taichung Native 1 that originated in Taiwan. In 1964 the general manager of India's National Seeds Corporation obtained some TN-1 from the International Rice Research Institute (IRRI) in the Philippines (which had been set up with Ford and Rockefeller funds). It had good results, and the next year the Ford Foundation purchased one ton of the seeds for wider trials in India.

In contrast to their inclination in the 1950s to move quickly into commercial production of hybrid maize, Indian scientists and administrators were very cautious about the Mexican wheat and Taiwan rice varieties. The political costs of failure with commodities of supreme importance in Indian diets were great at a time when import dependence had become a national issue. Also, Indian scientists had a greater professional stake in wheat and rice research than in maize, and wanted to generate their own varieties suited to local conditions.

By 1964, Ralph Cummings felt that sufficient testing had been done in India to begin releasing the imported wheat and rice varieties to Indian farmers, especially given the impending food crisis (see Figure 1). His evaluation was based on longstanding knowledge of Indian agricultural conditions, but his ability to make an effective recommendation also depended on his credibility at the highest levels of the Indian government -- at a time when the official Indo-US dialogue was strained and US popularity in India was low. (The US was perceived as putting pressure on the IMF and the World Bank to press conditionalities with regard to devaluation and giving priority to agriculture, to which it was not only tying its own aid but also the levels approved by the IMF and the World Bank).

Cummings' generally low profile in India, his tendency to give credit to Indians for all accomplishments, and his silence about his interactions with Indians now paid off. He approached Subramaniam to see if the new agriculture minister would be willing to throw his weight into accelerating the process of introducing the HYVs. Subramaniam (1979, p. 23) acknowledges that he decided to follow Cummings' advice quickly, and began to formulate a

strategy for using the new varieties to combat India's increasingly desperate food situation.

4.2 The 1965 Food Crisis

In the summer of 1965 matters came to a head: the worst drought in memory led to a 20 percent decline in grain production. US President Lyndon Johnson believed that India was not serious about policy reform and held up food aid to get India to commit itself to what he called "self-help."23/ Meanwhile, the Bell Mission from the World Bank was looking into program support for India to help meet its critical balance of payments needs, but the support of both the Bank and the US government was contingent on India's willingness to undertake policy reforms -- including a devaluation and a reorientation of economic strategy, away from import substituting industrialization and towards accelerated agricultural development.

The Indian situation in the mid 1960s differed from the current difficulties in Sub-Saharan Africa, in several major respects. First, world food stocks were much lower than they are today, so that India could not count on continued food aid to bail it out -- a point that was underlined by President Johnson's "short-tether" policy regarding PL 480 shipments. Second, the Mexican wheat, and to a much lesser extent the Taiwanese rice, could be taken "off the shelf" and applied to India's immediate food problems. Third, despite President Johnson's perceptions to the contrary, India was fully able by 1965 to put its political and administrative machinery into gear to make use of the new varieties and to put in place a sophisticated agricultural

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23/ In his study of this incident, Paarlberg (1985) concluded that Johnson's effort to exercise power over food was largely ineffective.

policy on fertilizer distribution, price supports, storage, market development, etc. in addition to research.

Even so, Subramaniam (1979, pp. 23-8) faced an uphill battle in convincing his countrymen to move ahead quickly with the semidwarf varieties. Not being certain about the returns, the Planning Commission was concerned about the foreign exchange costs of importing the additional fertilizer needed for application to the HYVs in a period of a severe balance of payments crisis. State governments worried that adoption of HYVs would reduce their autonomy in agricultural research and extension. Leading statisticians such as B.S. Minhas and T.N. Srinivasan (1966) questioned the shape of the fertilizer response function and hence the returns on intensive fertilizer use in limited areas as opposed to its wider geographical spread. Sociologists argued that the new varieties would harm small farmers and the landless, and communists worried about the implications of shifting to the HYVs for future dependence on "western" scientists and fertilizers. Senior agricultural scientists objected to the new varieties because of their likely susceptibility to disease. Of all the groups Subramaniam consulted, he felt that he had the support of only the younger agricultural scientists, who thought introduction of HYVs should occur quickly and on a large scale.

While the debate raged, the Indian cabinet initially avoided taking a position for or against the new strategy. However, the food emergency enabled Subramaniam to prevail on Prime Minister Shastri, and on his successor Mrs. Gandhi after his death in 1966, to support the strategy on two main grounds: (i) continued dependence on foreigners for food imports was risky in the extreme, and (ii) semidwarf wheat and rice were the only realistic short term options for attaining domestic food self-sufficiency. Working with the key

support of the Secretary of Agriculture, B. Sivaraman, Subramaniam was able to announce plans in December 1965 to introduce HYVs on 12 percent of India's cultivable land over the next five years. 24/ In the summer of 1966, India bought 20 thousand tons of Mexican wheat seed with Rockefeller help, the largest single seed transaction in history. 25/

4.3 Adaptive Research and HYV Adoption

Subramaniam's gamble had slim chances of long term success in the absence of extensive adaptive research. Breaking the resistance of domestic pressure groups to the large scale importation and introduction of the HYVs was only a first step. The political and economic success of the new strategy depended on the acceptability of the new varieties to Indian consumers -- and the high-yielding hybrids were not fully acceptable in their initial form owing to their cooking quality and color. Problems of disease and pest resistance, particularly for rice, also necessitated continuous development of a large number of area specific varieties. The new responsiveness of the national research system to these requirements was critical to the continued spread of new varieties. Meanwhile, the HYVs in turn gave a boost to reform of the research system -- by providing a

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24/ Subramaniam (1979, pp. 45-6) reports that even experts from the Rockefeller Foundation thought he should not push events so fast. "After all [they argued] it had taken the United States more than a generation to spread this new technology and make it acceptable to the farmer, even though their farmers were so much better educated. .. I [thought] that we should set out sights fairly high and have an ambitious but achievable task."

25/ According to Subramaniam: "The stakes were so high it was just like gambling... In retrospect, it was historical compulsion, compulsion of circumstances, which enabled me to force through in one month critical decisions which might otherwise have taken years." Quoted in Johnson (1972, p. 173).

justification for extending the coordinated maize crop research model, for developing a time-based program of research, and for focusing efforts on concrete problems like grain color and pest and disease problems.[26/]

The research system was able to deliver successfully. Indian scientists quickly identified two Mexican wheat lines that performed better in the field and the kitchen than the imported varieties, leading to the release of the Kalyansona and Sonalika varieties in 1967. Fifteen years later, these remained the most popular wheat varieties in India (Dalrymple 1986c). Semidwarf wheat spread very fast, accounting for about one-third of total wheat acreage after only three years and for more than half the acreage after seven years. In 1983-84, 76 percent of the land under wheat was using semidwarfs. Equally important was the absolute growth of acreage under wheat, owing to shifts away from competing but lower yielding crops.

A much more extensive improvement effort was needed in the case of the imported IRRI rice varieties, which had poor cooking quality and were susceptible to disease. As of 1983, Indian rice research had resulted in the release of 221 varieties (Dalrymple 1986b); the need for so much adaptive research reflects the many adoption problems encountered with rice (in contrast to experience with wheat, which has more homogeneous growing conditions). Nonetheless, in 1983-84, eighteen years after the first

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26/ ICAR set up All-India projects (patterned after the Rockefeller-backed maize project) for wheat in 1964 and rice in 1965. Over the next several years some seventy projects were launched using this same organizational model. A recently funded World Bank project has helped India to move to a more decentralized research system. The new arrangements are intended to be more responsive to the different growing conditions in particular states, but it is not yet clear whether they retain the benefits of a nationally coordinated research program.

semidwarf rice was released, Indian farmers were planting 54 percent of their rice area in high yielding varieties; this proportion would unquestionably have been far lower without an effective research program.[27/]

The overall impact of the new varieties on the agricultural sector can be assessed by analyzing sources of growth in aggregate productivity (measured in value terms on the basis of constant crop prices). Bindlish has decomposed this growth among five components, which are summed over individual crops.[28/] As Table 3 shows, wheat alone accounted for an astonishing 99 percent of the increase in aggregate productivity between the 1956-69 and 1969-82 periods. Along with yield increases, changes in cropping patterns away from less productive crops explain most of the gains attributable to wheat. Rice contributed 15 percent to the increase in aggregate productivity over the same period. Because the contributions of other crops were marginal or (as in most cases) negative, the combined contribution of wheat and rice accounted for over 100 percent of aggregate productivity growth.

27/ The adoption of modern varieties of rice in India is about average for Asian countries. In 1978-79 the adoption rate in the Philippines (72 percent) and Indonesia (56 percent) were higher, but in Bangladesh (18 percent) and Thailand (12 percent) rates were lower (Barker, Herdt, and Rose 1985).

28/ Dalrymple (1986a) notes that agricultural economists usually estimate the technology variable in production functions indirectly, by looking at fertilizer use or a time variable. Rarely do they treat the introduction of new varieties as a variable. In the case of India, however, it is clearly possible to attribute technological change directly to the dramatic shift in varietal use that took place in the mid-1960s.

Table 3
Crop-Wise Contributions of Individual Effects to the Change in Aggregate Productivity, by Period
(Rupees per hectare)

Crop	1956/57 to 1968/69							1968/69 to 1981/82						
	Pure Yield Effect	Pure Location Effect	Location Interaction Effect	Pure Cropping Pattern Effect	Cropping Pattern Interaction Effect	Sum of Effects		Pure Yield Effect	Pure Location Effect	Location Interaction Effect	Pure Cropping Pattern Effect	Cropping Pattern Interaction Effect	Sum of Effects	
Bajra	3.53	-0.23	-0.03	-2.09	0.14	1.37	(0.78)	0.72	-0.24	-0.45	-6.65	-0.17	-6.80	(-2.57)
Barley	1.54	-0.06	0.20	-10.03	-0.97	-9.32	(-5.33)	1.10	0.21	-0.14	-15.37	-2.45	-16.66	(-6.29)
Cotton	2.81	0.05	-0.07	-33.44	0.55	-30.10	(-17.20)	3.77	1.08	0.20	-4.64	-2.63	-2.23	(-0.84)
Groundnuts	-1.36	0.16	0.18	14.48	-2.57	10.89	(6.22)	2.66	-0.06	0.83	-9.50	-0.39	-6.46	(-2.44)
Jowar	-0.16	0.18	0.01	-4.15	-0.17	-4.29	(-2.45)	6.69	-0.31	-0.11	-7.46	-1.66	-2.86	(-1.08)
Maize	1.17	0.09	0.19	19.39	2.29	23.14	(13.22)	0.07	0.20	0.20	-9.31	0.09	-8.74	(-3.30)
Pulses	2.11	1.40	-0.68	-15.87	0.20	-12.83	(-7.33)	-1.15	-1.88	0.69	6.23	0.44	4.33	(1.64)
Ragi	0.03	-0.01	0.01	-3.68	0.10	-3.54	(-2.02)	2.05	-0.09	-0.03	-1.61	-0.20	0.11	(0.04)
Rice	25.45	0.88	0.00	16.24	7.71	50.09	(28.62)	20.41	3.51	1.50	10.88	3.01	39.30	(14.84)
Sugarcane	0.77	0.37	0.00	-1.03	0.15	0.25	(0.14)	0.56	0.17	-0.01	12.33	0.51	13.57	(5.12)
Small Millets	-0.09	-0.01	0.02	-6.49	0.09	-6.48	(-3.70)	0.30	-0.22	0.08	-10.25	-0.16	-10.25	(-3.87)
Wheat	20.05	1.23	1.42	95.12	38.00	155.82	(89.05)	32.07	2.93	0.40	206.01	20.11	261.51	(98.75)
Total	55.86	4.04	1.12	68.45	45.52	174.99	(100.00)	69.24	5.28	3.15	170.65	16.49	264.83	(100.00)
	(31.92)	(2.31)	(0.64)	(39.12)	(26.01)	(100.00)		(26.15)	(1.99)	(1.19)	(64.44)	(6.23)	(100.00)	

( ) Indicates percent of the sum of the effects for the period.

Source: Bindlish (forthcoming)

Finally, it should be noted that the success of wheat and rice HYVs in India stemmed from both domestic and external sources. The research that produced the new wheat varieties (for which Norman Borlaug was to win a Nobel Peace Prize) had originated at what is now called the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in Mexico, while the rice varieties had been developed at IRRI in the Philippines -- in both cases with the support of the Rockefeller Foundation. But these exogenous breakthroughs could not have been so successfully translated into staple foodcrops for India, had it not been for the indigenous ability of the Indian research system to borrow the new technologies and adapt them to Indian conditions. The story of the wheat and rice HYVs is thus a prime example of mutually reinforcing foreign and local research efforts. The development of the new varieties overseas provided an opportunity for solving India's chronic food problem relatively quickly -- and this in turn gave added impetus to efforts to build an effective indigenous agricultural research capability.

5. Africa and India: Some Comparisons and Lessons for the Future

We have shown how the the Indian government and the Rockefeller Foundation were able to collaborate in a uniquely beneficial partnership for developing an effective Indian research system. By comparison, the relations between the nations of contemporary Africa and the many donor agencies involved with them have been much less productive. In this section, we will outline some of the ways in which Africa's experience with building agricultural research capacity has fallen short of India's and will try to

identify some of the causal factors involved. We will conclude by listing a number of crucial lessons for the future, derived from India's and Africa's contrasting experience.

5.1 Africa's Comparative Disadvantages

Some of the ways in which Africa has been less fortunate than India are independent of donor/recipient behaviors and relationships -- for example, the scale difference between Indian agriculture and that of individual African countries, or the absence from the African scene of new "miracle" food crop varieties. But many other disadvantages faced by African countries in building agricultural research systems are causally linked to the history of their relationships with donors: it is these with which we shall be concerned here.

We have seen that the post-independence Indian government had the capacity to diagnose its needs in terms of building research capability. This capacity for competent self-diagnosis differentiates India from many of contemporary African governments: in the latter, the lack of scientific manpower (and of trained manpower in general) at independence has meant that technical considerations and long time horizons have often carried less weight than political imperatives and short-term results in defining research needs or prioritizing investments in agriculture. Anthony's (1986) review of research in East Africa for the MADIA project shows that the UK had trained few African researchers before independence, with the result that the research system was staffed by expatriates in long term employment conditions. This scientific workforce did excellent work on cash crops during the 1940s and 50s; when the UK began to withdraw its personnel in the 1960s, however,

serious staffing gaps opened up.29/ Former French colonies in Africa have hitherto suffered less from the loss of personnel, because French expatriates have continued to dominate agricultural research in Francophone African countries for a much longer period after independence. On the other hand, this has meant that indigenous research capacity in these countries has remained even weaker -- with the result that their ability to mount autonomous programs of adaptive research may well be behind that of Anglophone countries.30/ The poor tradition of education and scientific enquiry also means that elites in African governments have simply not accorded development of sciences and technology, the priority and the social esteem necessary to build indigenous capacity.

Contemporary African governments are also far less fortunate than India in another important respect. Because diagnoses of research system shortcomings and needs have typically been made by expatriate advisers or middle level research staff (who lack the high level political support needed to achieve effective reform), even well-conceived reform programs may languish for many years before being taken seriously. In Kenya, for example, the Rodenhiser Committee Report identified weaknesses in the research system in

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29/ The British did provide budgetary aid to maintain the research system but (partly due to political pressures from African governments) began to withdraw these funds too early and too quickly. Further, the research supported by the UK since independence has tended to have a much more short-term orientation than earlier research work. Between 1970 and 1984, 55 percent of the British man weeks spent on research and advisory visits to Kenya, Tanzania, and Malawi involved assignments of less than four months (Anthony/MADIA 1986).

30/ For example in Senegal in 1979, only 26 percent of the scientists engaged in agriculture and livestock research were Senegalese (World Bank 1981).

1968; serious consideration of the proposed reorganization did not begin until 1984.

Moreover, even when a decision is finally taken to act on a proposed program, African countries are often hampered, in a way that India was not, by the diversity of aid sources and the consequently high search cost of obtaining suitable expertise. Recipients tend to accept a particular official donor institution's technical assistance regardless of whether the concerned institution is best placed to provide appropriately qualified staff (Johnston and Hoben/MADIA 1986). In the case of official bilateral aid, recipients may also find it hard to obtain certain kinds of agricultural knowledge, because aid-giving countries' governments tend to avoid future competition from aid recipients in the relevant crop(s) and activities. Considerations of potential competition have prevented the US from helping with cotton, palm oil, and citrus and the Danish government from the development of livestock industry in Africa and have led the CGIAR to emphasize work on foodcrops -- despite the fact that the donor community's advise to Africa has focused on the region's need to exploit its comparative advantage in export crops (Lele 1986).

African countries' experience with technical assistance has fallen short of India's experience with Rockefeller in other crucial respects. For example, we have noted the Foundation's determination to make a long term commitment to its India Agricultural Program. This is in marked contrast to the high degree of instability in aid commitments to Africa associated with the changing political importance of individual recipient countries to aid givers. Johnston and Hoben/MADIA (1986), for instance, report that AID's staff in Kenya and Tanzania fell sharply during the presidencies of Richard

Nixon and Gerald Ford (by 53 percent and 22 percent, respectively), only to rise again (by 65 percent and 43 percent) under President Carter.

The long term tours of duty of individual Rockefeller personnel and the relative homogeneity of views among Rockefeller, Ford and US Government officials in India is another factor that differentiates India's early experience from contemporary Africa's. It meant that advice tended to be more consistent over time and among individuals than is generally the case in Africa.31/ Thus India avoided the Balkanization of agricultural research that has occurred in many African countries as a result of different donors offering mutually contradictory recommendations and procedures.32/

These contrasts between Indian and African experience with regard to developing research capability are compounded by the fact that there seems to be much more turnover of research staff in Africa than there was in India. For example, 51 percent of researchers in Kenya in 1984 had been on the job less than two years. Only 9 percent had more than ten years experience (Jha/MADIA 1986). In the case of trained national personnel, this is simply because investment in human capital in Africa by donors and national government is far below the region's needs, especially given its low initial base and in comparison with the emphasis placed in financing on physical

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31/ Rockefeller, Ford, and the US collaborated on several projects in Indian agriculture. The coordination was by no means smooth; nevertheless, the small number of agencies and the underlying consensus among their key staff enabled the problems to be surmounted.

32/ The dispersal of research resources and failure to assemble a critical mass of personnel is a particular problem in Kenya, with its eleven national stations, eight regional stations, ten substations, and fourteen other research facilities (Jha/MADIA 1986). Some 53 different research programs are currently being backed by donors in Kenya.

capital. In the case of expatriate personnel, official bilateral donor agencies in Africa do not encourage their technical assistance staff to take up long term residence in individual countries. On the contrary, they appear to promote diversity of country experience. The CGIAR's international centers may provide some incentives to build up single country expertise, but their contribution to improvements in national research systems (as distinct from carrying out their own coordinated trials) is limited. None of the CGIAR research institutions that have practical experience in carrying out actual research have the mandate to develop national research system. Shortages of qualified personnel, combined with rapid turnover of seconded staff, can make it difficult to build up effective national research program. In Senegal, for instance, 46 percent of expatriate researchers in 1985 had been in the country less than three years (Jha/MADIA 1986). Whether the size-based advantages of a country like India in attracting and retaining quality can be duplicated in Africa is an issue that needs more international attention. It is worth noting, however, that even a large country like Nigeria has not devoted the resources and the political priority needed to developing a national agricultural research system.33/

Two more general factors inhibit the effectiveness of current donor programs of research capacity development in Africa. First, donors tend to separate their training programs from both institutional development and actual research projects rather than integrating the three. The US, for

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33/ The US withdrawal of bilateral aid to Nigeria after Nigeria's joining of the OPEC set back the Nigerian agricultural research effort as much of the earlier US effort in training of Nigerians and establishing institutional capacity was lost even though Nigerian expenditures on agricultural research increased until about 1981.

instance, has been effective in establishing agricultural universities in Africa but has paid little attention to the development of agricultural research institutions. (Johnston and Hoben/MADIA 1986). In Malawi, the UK maize breeding project has done good work, but left a gap when finished because of its failure to provide training. Formal training has been supplied, but only recently and by the US (Anthony/MADIA 1986). Even within the CGIAR system, different agencies are often responsible for preparation and implementation of projects, with a corresponding loss of conceptual continuity. For example, the International Service for National Agricultural Research (ISNAR) may design proposals for reorganization which may be put into effect by a group of aid donors.

Second, the growth of disciplinary specializations has pushed scientific enquiry in the developed countries into more esoteric problems, so that Africa today has generally less immediate use for the "cutting edge" knowledge now being provided in laboratories in the developed world than India did for the new findings of the 1950s and 1960s. Thus, an alternative source of assistance to that provided by the CGIAR is not available to most African countries especially with the attrition of the traditional British and French technical expertise on African problems.

Another difference between India's experience and Africa's stems from Rockefeller's determination to limit its involvement to major research projects with large identifiable payoffs rather than spreading itself over many smaller projects. This approach resulted in an investment portfolio that was very different from those of most donor agencies in Africa to-day -- which usually consist of large numbers of relatively low priority including isolated "island" projects on individual crops and regions mostly with an extension

focus that deplete rather than enhance national technical capacity (Lele 1986).

Finally, donors in Africa have simply not been as effective as the Rockefeller Foundation in assessing the adaptability of imported farm technology to local conditions despite Africa's widely varying and often unique physical and environmental conditions. The result has been premature investment in production and extension programs. The US/North Cameroon Seed Multiplication Project, for example, wrongly assumed in 1975 that sorghum and groundnut seed could be tested, extended, and multiplied among farmers within five years. After ten years the project had still made only limited progress toward this goal. Yet American officials continued to misperceive the sequencing issue between research and seed multiplication as they planned additional agricultural research activities (Jaeger/MADIA 1986). Having said this, however, AID in Cameroon has been at the forefront in getting IITA involved in developing Cameroon's national agricultural research system, one of the few examples of an effective collaboration between an international and a national research system for the purposes of building national research capability.

5.2 Some Lessons for the Future

The donor community's growing interest in the development of national agricultural research capacity in Africa is encouraging. Less encouraging is the fact that many of the preconditions for technological change that existed in India in the 1950s are absent in Africa in the 1980s. To begin with, the continent's agricultural research problems are far more complex and harder to solve than India's. Africa's soils are more diverse, its climate more varied, its pest and disease hazards more pronounced. Moreover, the scale and the

complexity of the scientific and technical problems contrasts sharply with the small size of many African countries compared to India, a fact that in turn militates against scale economies in agricultural research and technical assistance. The obvious solution of creating regional agricultural institutions for Africa has been hampered by international rivalries and domestic political instability, with a great loss of learning by doing.

The Indian case nevertheless suggests five broad lessons for improving the odds for successful research in Africa. The first is that political will at the highest level is required to build an effective science and technology capacity, and (as in India) that severe external shocks are more conducive than tranquil times in facilitating the resolution of many controversial questions that are frequently needed. The droughts, global economic trends, and donor disenchantment of the 1970s and early 1980s have already had a consciousness raising effect. Yet many of the types of decisions that India made in the mid-1960s to build its research system are yet to be forthcoming in most African countries.

Second, African countries and donors need to adopt a holistic approach to developing national research capacity, by achieving a better balance and interaction between the development of scientific manpower and the provision of physical capital (which usually takes precedence in donor financing of research); another prerequisite for success will be better integration of the planning of research efforts and the responsibility for their implementation. While the latest agricultural research projects designed by ISNAR and funded by the World Bank are more comprehensive in theory than in the past, in practice donors tend to divide up the "pie" between planners and implementors as well as by crops, regions, stations, or

scientific disciplines or subject matter -- thus making it impossible to develop a coordinated research program.34/

Third, donors need to reduce the "noise" of competing projects and research designs. While it may not be possible to achieve the homogeneity of advice supplied to India, more interagency coordination is certainly essential. This may require untying technical aid to ensure that assistance is forthcoming from both the most qualified and the most cost effective sources. It may also require development within the CGIAR system of the capacity to help developing countries select the most competent bids. This may frequently involve choosing proposals that keep physical hardware to the absolute minimum in the initial stages of research development.

The fourth general lesson is the need for long term commitment of personnel -- both by African governments of their own nationals in key technocratic positions and of their expatriate counterparts. All too often, inexperienced or short service technical assistance personnel have been expected to work with middle level technocrats to develop new institutions. CGIAR and governments may need to devote greater attention to long term career

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34/ In Kenya for instance, eight to ten donors have expressed in financing the new research program. It is also important for donors to avoid situations of the kind that arose in Kenya, where requests to the United Kingdom to develop maize research capacity in the 1970s resulted in the Overseas Development Administration splitting the work artificially between basic and adaptive research and setting up a single research station in Kitale, an area not typical of maize growing conditions in Kenya. The Maize Agronomy Research project led to many useful publications and an excellent seed production program, but the evaluation of the project (Gibbon and others 1983) found it to have left very little national research capacity behind. Even reports and other scientific papers were no longer readily available at the library of the National Agricultural Research Center at Kitale, because expatriate researchers had removed some of the working files and primary data to the U.K. to prepare their own reports.

opportunities for seconded personnel to maximize the institutional effectiveness of their work.

This raises the fifth, and perhaps the most important lesson: it is fundamental for African elites to recognize the long gestation lags involved in the creation of a national scientific research capacity in agriculture. In India, a decade of cooperation between the same Indian and American officials eventually made it possible to focus national political energy on improving this capacity. Only a similarly long term commitment by African policymakers can hope to promote and sustain appropriate research institutions in the unique environment of Africa, whose future development will depend critically on scientific advances in agriculture adapted to African conditions.

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