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EXTERNAL REVIEW
OF THE
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
MARCH 1990

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ABBREVIATIONS AND ACRONYMS

AID	(U.S.) Agency for International Development
AFTMIN	African Fertilizer Trade and Marketing Information Network
ANDA	*Associaçao Nacional para Difusao de Adubois* (Brazil)
BADC	Bangladesh Agricultural Development Corporation
BCIC	Bangladesh Chemical Industries Corporation
CGIAR	Consultative Group for International Agricultural Research
CIAT	*Centro Internacional de Agricultura Tropical*
CIMMYT	*Centro Internacional de Mejoramiento de Maiz y Trigo* (Mexico)
CIP	*Centro Internacional de la Papa* (Peru)
CSR	Crop Soils Research (Indonesia)
DAP	diammonium phosphate
DGIS	*Directorate Generaal voor Internatinal Samenwerking* (Netherlands)
FADINAP	Fertilizer Advisory Development and Information Network for Asia and the Pacific
FAI	Fertilizer Association of India
IARC	International Agricultural Research Center (USA)
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer Project
IDRC	International Development Research Center
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics (India)
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture (Nigeria)
INSURF	International Network on Soil Fertility and Sustainable Rice Farming
IRRI	International Rice Research Institute
LDCs	lesser developed countries
MAP	monoammonium phosphate
NIFTAL	Nitrogen Fixation by Tropical Agricultural Legumes Project

OAU/STRC	Organization for African Unity/Scientific Technical and Research Commission
PAPR	partially acidulated phosphate rock
PR	phosphate rock
SAB	sulfuric-acid based
SSP	single superphosphate
TSP	triple superphosphate
TVA	Tennessee Valley Authority
S&T/AGR	Science & Technology/Agriculture
TAC	Technical Advisory Committee of CGIAR
UNIDO	UN Industrial Development Organization
UNDP	UN Development Programme
USAID	U.S. Agency for International Development
USDA-ARS	U.S. Department of Agriculture, Agricultural Research Service
USG	urea supergranules
WAFMEN	West African Fertilizer Management Evaluation Network
WARDA	West African Rice Development Association
WB	World Bank

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IFDC SUMMARY SHEET

- A strategic plan for changes in mission emphasis and organizational structure has been presented to the IFDC Board. These changes are appropriate and should be implemented under the new Director.

- Almost all aspects of the Center's work received favorable assessments from the Review Team.

- No other institution offers the range of resources in dealing with fertilizer issues in LDCs.

- The Center's staff has an excellent reputation with LDCs and the organizational climate of the Center is good.

- The Center has been well managed. Although, some procedures and practices should be strengthened and formalized.

- Redirect the emphasis of the research programs to account for new strategic emphases, emerging needs, and maturity of programs.

- Seek more donor funding for core. Solicit funding for a wider range of research from a larger number of donors.

- Improve relations between headquarters and the Togo Center. Establish the roles and relationship of each regional center with the headquarter's Center.

- Develop a continual strategic planning process.

- Continue the Center's broad-based approach to fertilizer development.

- Tie more closely to the IARCs and FADINAP.

- Encourage privatization of fertilizer marketing and distribution processes.

- Document results when doing policy making and implementation.

- Continue to work on fertilizer policy research, recommendations, and implementation.

- Seek membership in the CGIAR.

- Do more modeling in collaboration with IARCs. Do more modeling.

- Work on fertilizer use for drip irrigation systems.

- Maintain a multidisciplinary staff. One of Center's main strengthens.

- See if block dollars can be used by IFDC.

- The Board should be more independent of top management.

- Include land preparation techniques in fertilizer research.

- Use the regional centers for training.

- Share agronomic work with the IARCs.

- Use the Bangladesh marketing and policy reform project as a prototype for privatizing other agriculture input sectors.

- Document Indonesia's large-scale experience on briquetting and hand deep placement of USG.

- Evaluate the IFDC's rice fertilizer application techniques.

- Follow-up with training program graduates.

EXECUTIVE SUMMARY

This report describes the external evaluation of the International Fertilizer Development Center (IFDC) carried out for the U. S. Agency for International Development (USAID). The evaluation was done in January and February, 1990.

The basic mission of the IFDC is to help improve fertilizer effectiveness and food production in the tropical and subtropical developing countries. More recent emphases are on economic development, sustainable agriculture, and environmental concerns pertaining to fertilizer. To accomplish it's aims, the IFDC engages in research, develops technologies for making and using fertilizers, and provides training and technical assistance. Some recent tasks have been performing policy studies and implementing policies, primarily concerned with fertilizer distribution and marketing.

Most of the IFDC's 149 staff are located at the headquarters in Muscle Shoals, Alabama. At any time a number of the staff are on overseas assignment in the developing countries. About 20 staff members are on long-term assignments overseas. The 106 scientists, engineers, and professionals are from 25 countries.

The IFDC is organized into four divisions and a management and support unit (Office of Managing Director), although the Center's proposed strategic plan recommends a revision in the structure. The Agro-Economic and Fertilizer Technology Divisions are mainly involved in strategic and applied research, the Outreach Division in adaptive research, and the Africa Division in applied and adaptive research. The Fertilizer Technology Division develops products and processes of fertilizer manufacturing and does pilot work. The Outreach Division is responsible for training personnel working with fertilizers in the developing countries. It also supports the technology assistance activities of the IFDC. These and other functions of the divisions overlap, and on specific projects the organization is in a matrix form. The Africa Division is the newly formed

West Africa Center in Lomé, Togo.

The review team's overall evaluation of the IFDC is very positive. The IFDC is seen as a trusted and objective resource on fertilizer questions involving developing countries. The quality of work of the staff is excellent. The Center has taken initiatives to provide useful services to a wide variety of clients. The staff models good professional practice for host country counterparts. The funds given to the IFDC have supported efforts directly related to its mission, although an increasingly greater portion or their funds are from restricted core funds.

The IFDC has been limited in covering a more complete spectrum of developing countries' needs, because of funding constraints. The Center has placed a strong recent emphasis on Africa, which is appropriate, but there are still needs in Asia and Latin America.

The staff has been good at cooperating with donors, Consultative Group for International Agricultural Research (CGIAR) centers, national programs, and other organizations involved in fertilizer development, but this is still an area requiring some improvement.

The management of the Center has been very good. The executive leadership communicated their vision of the IFDC and the staff has responded well. Much of the credit should go to Dr. Donald McCune, who until February 1, 1990 was the only Managing Director the Center has had. The rest of the staff is strong and devoted to doing quality work. There truly has been a sense of striving for excellence at the Center.

The Board is well-qualified, but it probably should be more independent of the Managing Director in its review and policy direction roles.

In general, the organizational climate of the Center is very good. Some conflict and ambiguity about roles exists between the headquarters and the West Africa Center.

The IFDC is at a turning point in its history. Several

transitions are occurring and their outcomes will influence the future direction of the Center. A new Managing Director, Dr. David Parbery, is now in place. The African centers are just taking shape. Membership in the CGIAR is to be decided. Funding patterns are changing. New initiatives have been proposed in the recently prepared long-range plans. Most of the IFDC's long-term research and development programs have been successful, and it is time to consider how some of them fit in the competition for funds.

The IFDC is not an old organization, but it faces a dynamic future. The mission that propelled it so far has to be re-examined to fit changing prospects in fertilizer use. Expected changes in fertilizer demand and population pressures will influence distribution, marketing, and farmer use practices. Work on problems of importance in this changing world will require the whole spectrum of IFDC's skills to devise effective research technology and policy approaches.

The attached report provides a description of the IFDC and it's work. Evaluative comments are included in most sections. Section V includes answers to the questions from the review team's terms of reference and contains much of the evaluations of the report. Section VI is a summary of the conclusions and recommendations.

The review team accepted their task seriously. As with projects of this sort, we were always left with the feeling we should know more before reaching our conclusions. Our task was made possible by help from many people, most notably the IFDC staff. They helped us accurately understand the Center with diligence and goodwill, and we believe that is how they go about much of their work.

I. THE REVIEW

A. Reason for the Review

In late 1989, AID's Bureau of Science and Technology, Office of Agriculture (S&T/AGR) requested an external review of the IFDC. The review was to cover the progress since the last review in 1983-84, the ongoing activities of the IFDC, the Center's effectiveness in fertilizer development, and other questions involving its work.

AID was interested in doing a review at this time for several reasons. It is customary to review international agriculture research centers about every five years. More importantly, in 1990 the funding from AID's Science and Technology/Agriculture (S&T/AGR) for the IFDC's core grant is being considered for renewal. These monies have provided stability and flexibility to the IFDC, beside being its single largest source of income.

At the time of the review, the Managing Director who had started the IFDC, Dr. Donald McCune, was retiring and Dr. David Parbery was coming in as the new Managing Director. This review was timed to give Dr. Parbery information that might be useful in his transition to leadership.

Other changes made the timing of this review more important than it might otherwise be. The West Africa Fertilizer Center in Togo was recently started and the African Fertilizer Development Center in Zimbabwe is expected to start soon. Both these centers have somewhat destabilized the IFDC's organizational structures and processes, and created shifts in funding that have strong implications for the IFDC. Another contributing activity has been the establishment of a national fertilizer development center in Egypt with possible affiliations to other countries of North Africa and the Middle East. The IFDC is in an awkward phase of adjustment.

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Other changes important to the review are the 2- and 10-year plans recently written by the IFDC, suggesting mission and organizational changes that could shortly go into effect.

Some of the Center's research and development programs have reached maturity, and as a result, questions should be asked if changes in the IFDC's program should come about. New programs are becoming important and are competing for a shrinking pool of core funds.

A final major issue concerning the timing of this review is the potential membership of the IFDC as a Center in CGIAR. The IFDC has been considered a likely member of the CGIAR since 1975, when the IFDC first started, but for various reasons it has not been invited to join. The last serious consideration was about 10 years ago. This review and the Technical Advisory Committee (TAC) of CGIAR review of the IFDC in the summer of 1989 and will be used by the CGIAR to reconsider the IFDC as a member.

B. Review Team

Brief bigraphical sketches of the four-person team follow:

1. **Dr. Jacob Hautaluoma** is an Associate Dean, College of Natural Sciences, and Psychology Professor at Colorado State University. He is an organizational psychologist with extensive experience as a management consultant with businesses and government agencies, including AID, the World Bank, and the Peace Corps. He has worked and taught overseas on a number of assignments. He was a member of the last AID external team reviewing the IFDC for AID. He went to Asia for this review.

2. **Dr. John Coulter** of East Sussex, England recently retired from the World Bank. He is an agronomist with a wealth of international experience. He has been involved in agriculture research management and research center development. He was a scientific advisor to the CGIAR secretariat. Before this review, he was the chairman of the TAC review team for *Centro Internacional de Agricultura Tropical* (CIAT), the CGIAR center in Colombia. He went to Africa for this review.

3. **Dr. Luiz Marzo** is the Managing Director of Espindesa, an engineering consulting firm in Madrid, Spain. He is an engineer specializing in fertilizer technologies and has been a long time visitor to the IFDC. Dr. Marzo was a member of the TAC review team that examined the IFDC in the summer of 1989.

4. **Dr. Edguardo Moscardi** is the Director General of INTA, the National Agriculture Research Organization of Argentina in Buenos Aires. He is an agricultural economist with experience in the CGIAR system. He served with Dr. Coulter on the TAC review of CIAT.

The review team assembled at the AID offices, Washington, DC, on January 22 and 23, 1990. They were briefed by Dr. John Malcolm and other officials of the Office of Agriculture. From January 24 through 27, the team was in Muscle Shoals, Alabama to hear reports from the IFDC headquarters' staff and to prepare the outline of this report. On January 28, Dr. Hautaluoma left for Indonesia, Bangladesh, and Thailand, and Dr. Coulter went to Togo and Niger to review IFDC work in those places. The team members returned to their respective countries to write their parts of the report. This report is an amalgamation of contributions from each member.

The report borrows heavily from a variety of sources. Because the TAC review of IFDC had been done so recently, the team did not attempt to duplicate many of its evaluations. We did borrow from the TAC report as needed. We also had the IFDC Muscle Shoals' staff respond to the questions in our terms of reference. Their responses were liberally utilized, but we are responsible for what was used, changed, or omitted. We conducted numerous interviews, listened to many presentations, observed, read reports, and visited field and project sites to collect the data for this report. We must thank the IFDC staff, especially Dr. Paul Stangel; the AID/Washington staff, particularly Dr. John Malcolm; government officials of countries hosting IFDC projects; and unnamed farmers, fertilizer dealers, and others for helping us. The IFDC headquarters and outposted staff were professional and gracious in facilitating the review.

C. Organization of the Report

In the main body of the report are the review team's observations and evaluations of the IFDC. The first part of the report is devoted to examining the IFDC's programs. The research programs receive the most space. The next large section of the report is a listing of the questions from the review team's terms of reference and our responses to these questions. The last section summarizes our conclusions and recommendations. Appendix A is the trip report for the visits to the Asian locations of IFDC's work. It is important, because it refers to suggestions for needed work in Indonesia, particularly in reclaiming deforested lands that have gone to infertility. The Appendix also describes the successful policy reform and marketing project in Bangladesh and the issues associated with this kind of project for the IFDC.

II. INTRODUCTION

A. Role of Fertilizer in Development

The primary mission of the IFDC has been to help increase food production and rural income through the development of new and improved fertilizers and fertilizer use and distribution, mainly for the lesser developed countries (LDCs) in the tropics. The IFDC came about when the world energy crisis and food shortages in the LDCs were of great concern. During the last several years these issues have not been as potent, but they are still important in thinking of IFDC's mission.

The proper application of chemical fertilizers to the soil is a relatively easy adjustment in agricultural procedures and it leads to increases in food production. Nevertheless, inadequate fertilizers and application practices are often used in the LDCs. To achieve the proper use of fertilizers requires advances in scientific, logistical, and management knowledge, and the acceptance of the knowledge by persons involved with agriculture in the LDCs.

In the Western World, advances in fertilizer use were preceded by a history that may be hidden to the casual observer, but much of it must be understood and/or to help the LDCs utilize fertilizer correctly. In the developed countries is a large body of agronomic work on crop responses to various fertilizer practices. From this knowledge, manufacturers were able to make fertilizers containing high concentrations of elements in proper proportions to get the desired crop responses. Manufacturers also tried to make fertilizers with good storage, transportation, and application properties, all at a low cost. The manufacturing practices took advantage of indigenous raw materials as much as possible. Intricate transportation, storage, handling, distribution, and marketing systems were established to meet each country's needs. Farmers, dealers, and others were educated about using fertilizers. Feedback systems were set up so farmers and others could let the manufacturers know how their products

were working. Finally, credit arrangements were established to allow farmers and dealers to purchase fertilizers. When thinking of fertilizer development in the LDCs, all of these components and others must be considered, and they should all be within the IFDC's span of interest.

B. Development of IFDC

1. *Background*

In 1974, AID drew up plans for an International Plant Nutrition Institute to cover three program areas:

(a) chemical fertilizers;
(b) biological nitrogen fixation; and
(c) improved utilization of organic matter.

This proposal took place against a background of substantial fertilizer shortages with prices (in 1974 dollars) in excess of $300 per ton. Production costs at new factories were predicted to be more than $200 per ton and a new ammonia plant to cost over $150 million. Furthermore, it was thought current fertilizers, designed almost entirely for temperate country agriculture, were not totally suitable for tropical agriculture, and new materials tailored especially for such conditions were needed.

The proposal emphasized the importance of environmental considerations, stressing the need for fertilizers to replace the nutrients removed by crops, thus preventing soil deterioration. Increased yields on better lands would lessen pressure on the erodible lands. Nitrate leaching was a concern, as was pollution caused by the processing of ores. In the 15 years that IFDC has been operating there has been a spectacular growth in world fertilizer use (Table 1), most importantly in the tropical regions (Table 2). At the same time prices have decreased to approximately one quarter of those in 1974, but capital costs have moved up relentlessly.

Table I. Global Fertilizer Consumption (million tons)

	1975	1980	1985	1987
N	38.5	57.2	70.5	72.4
P_2O_5	22.9	29.9	33.0	33.8
K_2O	19.5	24.0	25.9	26.1
Total	80.9	111.1	129.4	132.3

Table II. Regional consumption of NPK (thousand tons)

	1975	1980	1985	1995 (projected)
Sub-Saharan Africa	651	728	992	1,566
Central America	1,665	2,057	2,727	3,886
South American	2,577	4,545	4,489	7,061
East Asia	10,332	19,092	27,019	32,312
South Asia	3,399	6,609	10,297	18,226

Growth in fertilizer use averaged about 2.6% per year in the 1980s, compared with over 5% in the 1970s, and more than 8% in the 1960s. However, there were vast regional differences. Growth was negative in Western Europe and North America, but reached 9.3% in South Asia and 5.3% in sub-Saharan Africa. Thus Asia, which accounted for only 16% of global NPK fertilizer consumption in 1970, used 31% of the world total in 1987, while Africa's share was only 2.7%. Sub-Saharan Africa with generally the poorest soils, uses an average of only 7 kg/ha of NPK and 2 kg/capita compared with per ha and per capita figures of 47 and 10 for South Asia, 100 and 17 for East Asia, and 32 and 17 for South America.

These figures indicate that agricultural production in the tropics has become more and more dependent on the use of

fertilizers, but that sub-Saharan Africa, with the worst production record, lags badly behind other regions in its use of inputs. Development of the fertilizer sector is a long-range process and it is likely to take more than a decade for many countries in Africa to develop an efficient sector.

The increases in fertilizer consumption since 1975 have been due, almost entirely, to increases in production of the standard fertilizer types, urea, superphosphates, and muriate of potash. There has been a negligible consumption of non-traditional fertilizers. Biological nitrogen fixation and organic matter re-cycling have remained the major sources of nutrients in African agriculture, especially for the non-cash crop sector. But, as mentioned, there will have to be great increases in fertilizer use in Africa for it to reach desired levels.

Not all of Asia has benefited from increased productivity. In Nepal, for example, yields of rice, maize, and millet in the Hills region have dropped by 25% over the past decade, and fertilizer use will have to increase from 120,000 tons in 1988 to around 400,000 tons by the year 2000 to regain the losses.

2. *Emerging Issues*

Since the foundation of IFDC, two major issues of increasing concern, both globally and in the tropical countries, have emerged: sustainability and pollution.

a. Sustainability. The TAC has defined sustainable agriculture as "the successful management of resources for agriculture to satisfy changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources." Within these broad objectives, the IFDC's role is directed at maintaining and improving the resource base--the soil--in both its nutrient supply and its physical condition. In the absence of nutrients from extraneous inorganic sources, the only natural sources for replenishing those removed by agricultural production are weathering of soil minerals and additions from the atmosphere. In most cases, these natural contributions are small and much less than those removed in crops, even if all residues are returned. As agriculture

intensifies, the rate of nutrient removal increases, so under present and projected population densities, sustainable agriculture will be impossible without the addition of major elements like nitrogen, phosphorus and potassium, as well as calcium, magnesium and sulfur from extraneous (mineral) sources.

Additions of plant nutrients improve the soil structure as they increase the amount of organic matter which can be added to the soil. For example, doubling the yield of millet grain in the Sahel from 200 kg/ha to 400 kg/ha, doubles the amount of straw from 800 kg/ha to 1600 kg/ha. The root mass is also substantially increased.

Fertilizer will play an essential role in developing sustainable agriculture. In the absence of inorganic fertilizers, productivity will inevitably fall and even more fragile areas will be developed for agriculture.

b. Pollution. Pollution from fertilizers is usually associated with nitrate entry into the ground water, but this will remain only an isolated problem in tropical agriculture. In temperate lands, where most of the problems occur, leaching takes place in winter when there is a surplus of water draining through the soil and when crop growth has ceased. In the tropics, when there is rain there is vegetation growth and consequently nitrogen uptake. Considerable losses of nitrogen have been measured in both rice and upland cultivation in the tropics, but most of these losses are in a gaseous form.

Environmental contamination can also take place through the addition of heavy metals, e.g., cadmium in phosphate rocks.

The problems of environmental damage and loss of sustainable agricultural systems in the tropics will be insurmountable in the absence of a supply of plant nutrients from mineral sources. The lack of fertilizer applications will be far more damaging than their use.

C. IFDC's Organization and Programs

The IFDC is currently organized into three Headquarters Divisions and the Africa Division in Lomé, Togo (Figure 1). The Office of the Managing Director coordinates these activities and provides support services. The Headquarters units are the Agro-Economic, Fertilizer Technology, and Outreach Divisions. The first two are oriented toward research and the development of fertilizer products and use practices. The Outreach Division is primarily engaged in technology transfer through training and technical assistance. It helps implement national field programs of adaptive research. The Africa Division is relatively new. It has elements of all of the other divisions in it, but its work is concentrated on needs of Sub-Saharan West Africa.

The IFDC's administrative functions and overall managerial responsibilities are covered by the office of the Managing Director. The IFDC has had only one Managing Director, Dr. Donald McCune, until February 1, 1990 when Dr. David Parbery took over. For policy and program direction guidance, the IFDC has a 14-member Board of Directors organized according to the standards of the CGIAR. The Board currently has seven members from developing countries, three from the United States, and four from other developed countries.

The IFDC staff numbers about 150, recruited from over 25 countries. This total number is down from 194 in 1985. The reduction occurred because of a serious budget shortfall. About one-half of the staff are senior scientists and professionals in chemical engineering, chemistry, economics, agronomy, soil science, geology, marketing, and sociology. Their specialty skills cover almost all facets of fertilizer production, marketing, and use. Approximately 20 IFDC specialists are outposted in Asia, Africa, and Latin America. They work with international, regional, and national institutions with which IFDC has linkages. The IFDC employs a number of host country nationals on its projects overseas.

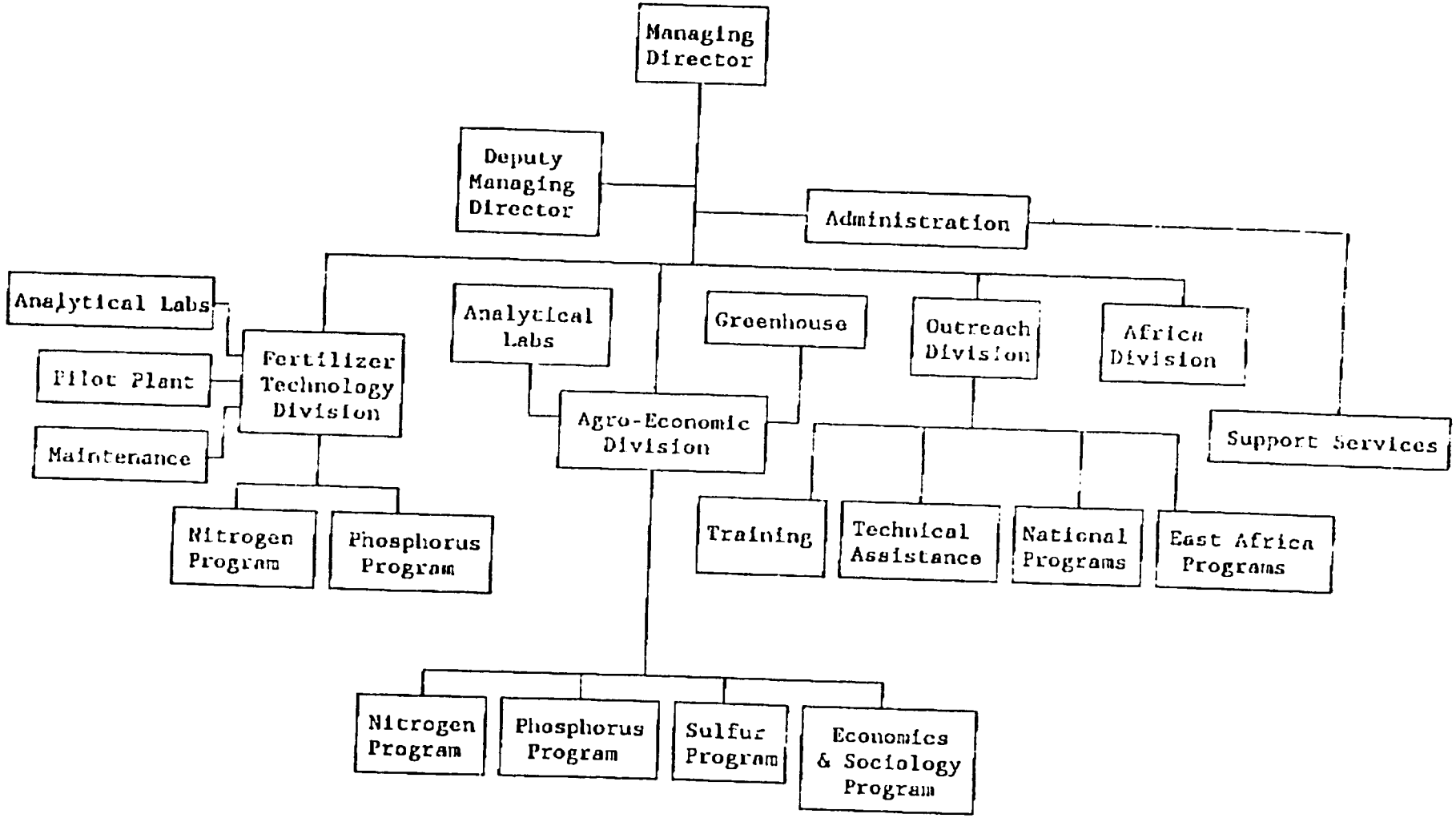


Figure 1. Present Structure of IFDC.

D. IFDC's Funding

The IFDC's funding is divided into funds for unrestricted use (core), funds for restricted use, and funds for special projects. Core funds, given for basic research, pilot projects, and administration, made up over half of the revenue of the IFDC until 1982, (Table 3). Since 1986 the proportion of budget from core monies has decreased. The core budget has stayed at close to $4 million per year. Until 1986 the IFDC received about $4 million per year for core funds from AID, and then it dropped to about $3.4 million per year (Table 4). With the establishment of the West Africa Center, some additional core funds are being donated by the UNDP and the German and Dutch governments. The proportion of unrestricted core funds in IFDC's budget for 1989 was 36% of a projected income of $12,246,092.

Table 3
IFDC Revenues and Expenditures (1976-1988)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	(million US $)												
Revenue													
Core	1.9	2.1	3.9	4.1	4.0	4.3	4.2	4.2	4.9	4.4	4.2	3.8	4.1
Restricted core/ special projects	0.4	0.3	0.4	1.9	3.1	3.7	5.1	4.3	4.5	3.7	4.3	4.6	7.4
Total	2.3	2.4	4.3	6.0	7.1	8.0	9.3	8.5	9.4	8.1	3.5	8.4	11.5
Expenditures[a]	2.0	2.1	4.2	5.5	7.2	7.7	9.3	8.6	10.1	9.2	7.5	8.9	10.9

a. Expenditures include fixed assets less depreciation.

Table 4 - Income by Source

Income by Source (1984-1989)
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1984

DONOR	U.S. $ TOTAL
CORE	
USAID	4,662,830
MISCELLANEOUS INCOME [1]	302,233
	4,965,063
RESTRICTED FUNDS/ SPECIAL PROJECTS	
ADAB	656,434
FORD FOUNDATION	7,600
IFAD	900,000
IDRC//PHOSPHORUS	90,834
IDRC/WEST AFRICA	141,165
UNDP	710,000
USAID/NIGER	27,171
MISCELLANEOUS	1,889,563
	4,422,767
TOTAL INCOME 1984	9,387,830

[1] MISCELLANEOUS INCOME INCLUDES; INTEREST, PUBLICATIONS, AND TRAINING FEES.

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1985

DONOR	U.S. $ TOTAL
CORE	
USAID	3,794,968
ISRAELI CHEMICAL COMPANY	45,000
MISCELLANEOUS INCOME [1]	345,763
	4,185,731
RESTRICTED FUNDS/ SPECIAL PROJECTS	
ADAB	589,330
FORD FOUNDATION	22,800
IFAD	200,000
IDRC//PHOSPHORUS	155,624
IDRC/MALI	16,636
IDRC/WEST AFRICA	58,669
UNDP	710,000
USAID/ACFD	15,879
USAID/CAMEROON	129,532
USAID/NIGER	5,672
MISCELLANEOUS	2,070,872
	3,975,014
TOTAL INCOME 1985	8,160,745

[1] MISCELLANEOUS INCOME INCLUDES; INTEREST, PUBLICATIONS, AND TRAINING FEES.

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1986

DONOR	U.S. $ TOTAL
CORE	
USAID	4,022,259
ISRAELI CHEMICAL COMPANY	45,000
MISCELLANEOUS INCOME [1]	443,669
	4,510,928
RESTRICTED FUNDS/ SPECIAL PROJECTS	
ADAB	218,318
IDRC//PHOSPHORUS	224,826
IDRC/WEST AFRICA	142,424
PHILPHOS	555,485
UNDP	796,633
UNDP/SE AFRICA	240,000
USAID/ACFD	126,246
USAID/BANGLADESH	274,142
USAID/CAMEROON	117,961
USAID/NIGER	17,797
WORLD BANK-NIGERIA FOOD CROPS	108,100
MISCELLANEOUS	1,188,069
	4,010,001
TOTAL INCOME 1986	8,520,929

[1] MISCELLANEOUS INCOME INCLUDES: INTEREST, PUBLICATIONS, AND TRAINING FEES.

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1987

DONOR	U.S. $ TOTAL
CORE	
USAID	3,687,935
DGIS - AFRICA CENTER STARTUP	91,029
GTZ-DONATED VEHICLES	130,751
MISCELLANEOUS INCOME [1]	340,378
	4,250,092
RESTRICTED FUNDS/ SPECIAL PROJECTS	
ABOCOL - COLOMBIA	133,828
AQUANOVA - BRAZIL	9,757
BADC - BANGLADESH	1,124,114
CMDT - MALI	17,465
ENICHEM - ITALY	36,600
FEECO//TVA	5,893
FERTISA	7,021
FFDI	25,979
GEASA - ARGENTINA	11,920
GOVERNMENT OF BURUNDI	86,535
GTZ - GERMANY//UREASE INHIBITORS	61,250
IICA//HENAO	11,676
IDRC//MALI	93,072
IDRC//PHOSPHORUS	81,089
IDRC//NETWORKS//WEST AFRICA	133,646
ICI - ENGLAND	29,867
INTEVEP - VENEZUELA	33,818
JORDAN DCP	79,800
KELLOGG FOUNDATION	500,000
KISR - KUWAIT	21,084
KREBS	14,990
MCI//TVA	8,684
OTP - TOGO	104,513
PHILPHOS - PHILIPPINES	25,741
ROCKEFELLER	50,000
SECID - BURMA	42,473
TEXASGULF	25,000

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1987

DONOR	U.S. $ TOTAL
TVA	62,478
UNDP//NITROGEN AND TRAINING	371,542
UNDP//CIAT//FIXATION PJT	47,191
UNDP//SE AFRICA	180,000
UNIDO//LIVINGSTON CONSULTANCY	10,200
USAID//ACFD	57,576
USAID//NIGER	46,938
USAID//RICE MODEL	5,336
USAID//POLICY RESEARCH	2,534
USAID//SOIL RESTORATION	75,364
WORLD BANK//CLAYTON CONSULTANCY	13,600
WORLD BANK//VLEK CONSULTANCY	7,960
WORLD BANK//STANGEL CONSULTANCY	21,375
MISCELLANEOUS SPEC PJT	(51,296)
	4,126,612
TOTAL INCOME 1987	8,376,704

[1] MISCELLANEOUS INCOME INCLUDES; INTEREST, PUBLICATIONS, TRAINING FEES.

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1988

DONOR	U.S. $ TOTAL
CORE	
USAID	3,574,975
BMZ - AFRICA CENTER STARTUP	166,766
DGIS - AFRICA CENTER STARTUP	187,642
UNDP-AFRICA CENTER STARTUP	141,051
MISCELLANEOUS INCOME [1]	513,326
	4,583,759
RESTRICTED FUNDS/ SPECIAL PROJECTS	
ABOCOL - COLOMBIA	221,963
AMERICAN PHOS INSTITUTE (APF)	10,000
BADC - BANGLADESH	1,244,750
BMZ//GEOLOGY VOLTA BASIN	198,253
CHILEAN NITRATE CORP.	5,365
DEAD SEA WORKS - ISRAEL	10,425
DGIS//AFTMIN	244,398
ENICHEM - ITALY	44,792
FORD FOUNDATION	21,069
FINNIDA	50,626
FPM - MALAYSIA	18,455
GSFC - INDIA	34,577
GTZ-UREASE INHIBITORS - GERMANY	29,600
HAIFA CHEMICALS - ISRAEL	6,943
IBSNAT/RCUH	62,930
ICA//HENAO	12,819
IDRC//PHOSPHORUS	89,453
IDRC//WEST AFRICA	139,635
IRAT - FRANCE//SOIL RESTORATION	22,465
JORDAN DCP	17,488
KELLOGG FOUNDATION	487,500
MANAH, S.A.	26,395
MINISTRY OF AGRIC. - MALAWI	84,844
M.W. KELLOGG//NAFCON	22,208
OHIO STATE UNIV.	5,194
OPEC///ACFD	20,000
OTP//BENEFICIATION	5,333

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
STATEMENT OF INCOME FOR CY 1988

DONOR	U.S. $ TOTAL
ROCKEFELLER//SOIL RESTORATION	120,000
SECID - BURMA	16,595
SOQUIMICH	13,177
TEXASGULF//GRESIK	12,981
TEXASGULF	100,000
TOGOLAIS DES PHOSPHATES	23,300
TVA//USGS - SAUDI ARABIA	128,943
UNDP//NITROGEN AND TRAINING	985,861
UNDP//CIAT//FIXATION PJT	26,809
UNDP//SE AFRICA	180,000
UNDP//STANGEL CONSULTANCY	10,003
UNDP//CHINESE DRIP IRR	8,137
UNIDO//POLO CONSULTANCY	29,700
UNIDO//MCCLELLAN//CHINA	5,335
USAID//IGADD	37,804
USAID//UGANDA	65,932
USAID//EAST AFRICA	75,000
USAID//RICE MODEL	86,201
USAID - NIGER	147,725
USAID//POLICY RESEARCH	641,534
USAID//SOIL RESTORATION	739,368
WORLD BANK//SOIL RESTORATION	270,000
WORLD BANK//CLAYTON CONSULTANCY	15,913
WORLD BANK//ALLGOOD CONSULTANCY	11,550
MISCELLANEOUS SPEC PJT	(5,650)
	6,883,704
TOTAL INCOME 1988	11,467,463

[1] MISCELLANEOUS INCOME INCLUDES: INTEREST, PUBLICATIONS, TRAINING FEES.

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
INCOME STATEMENT FOR CY 1989 (PRE-ADJUSTED)

Donor	U.S. $ Total
GRANTS	
IFDC Hdqt.	
USAID/DAN	3,320,000
USAID/Ceres Rice Model	18,026
World Bank/Core	100,000
World Bank/East & SE Africa	600,000
Africa Center	
USAID/Niger	29,771
USAID/Policy Research	635,000
USAID/Soil Rest tion	1,277,204
TOTAL GRANTS	5,980,000
RESTRICTED FUNDS	
IFDC Hdqt.	
UNDP/Nitrogen & Training	523,147
IDRC/Mali	501
Africa Center	
American Phos Inst(APF)	0
DGIS-AFTMIN	323,624
DGIS-CORE	96,939
IDRC/West Africa	67,919
IDRC/West Africa III	55,920
IDRC/Evaluation & Adoption	225,509
IMPHOS	49,991
IRAT	44,985
Kellogg	475,000
BMZ	158,396
Rockefeller-Soil Rest.	120,000
World Bank-Soil Rest.	270,000
Miscellaneous	12,118
TOTAL RESTRICTED FUNDS	2,424,049

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
INCOME STATEMENT FOR CY 1989 (PRE-ADJUSTED)

Donor	U.S. $ Total
SPECIAL PROJECTS	
ABOCOL	10,941
ACIAR/Friesen	234
AGRI-CHEMICAL	5,286
AIDAB-Kenya Workshop//P Modelling	15,462
AMOCAR	16,559
Auburn University	1,200
Bariven-Pequiven	19,909
Egypt Peace Fellowship-Gadalla	5,000
BMZ-Geology Study	127,588
EniChem-Urease Inhibitors	14,572
EniChem-Material Preparation	15,000
EniChem-Degr. N-(n-butyl)	39,542
Erkki Matikainen	8,950
FINTRA	72,301
FPM	3,400
Gubre-Turkey	5,050
HAIFA Chemical	223
IAEA-Puga	7,000
IBSNAT/RCUH	56,713
IFIA-Christianson	3,281
INTEVEP	27,398
IRRI	1,739
Jordan Phosphates Mines	26,600
KUWAIT Institute	21,084
MANAH.S.A./FOSMAG	10,500
MANAH.S.A./TVA	0
Maxi Tecnica de Venezuela	2,000
Min. of Public Works-Burundi	159,561
Min. of Agric.-Malawi	21,211
Ministry of Energy -Bolivia	21,058
Monomeros	75
M.W. Kellogg--T 15 Study	13,818
National Chemical Corporation	9,800
OTP/Benefication	17,822
PAS-Gregory	29,614
ROFOMEX	8,000
SECID//BURMA	(17,039)
SOQUIMICH	9,064
Texasgulf	116,527
TVA-MSM	1,234
TVA-USGS	0
UNDP-Parish, Algeria	13,423
UNDP/Stangel	18,103
UNIDO-Opportunity Study	234,104
UNIDO-Equipment Purchase	105,150
University of Hawaii-travel	7,474
USAID/Bangladesh	1,716,079
USAID/IGADD	34,057

Table 4 - Income by Source (continued)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
INCOME STATEMENT FOR CY 1989 (PRE-ADJUSTED)

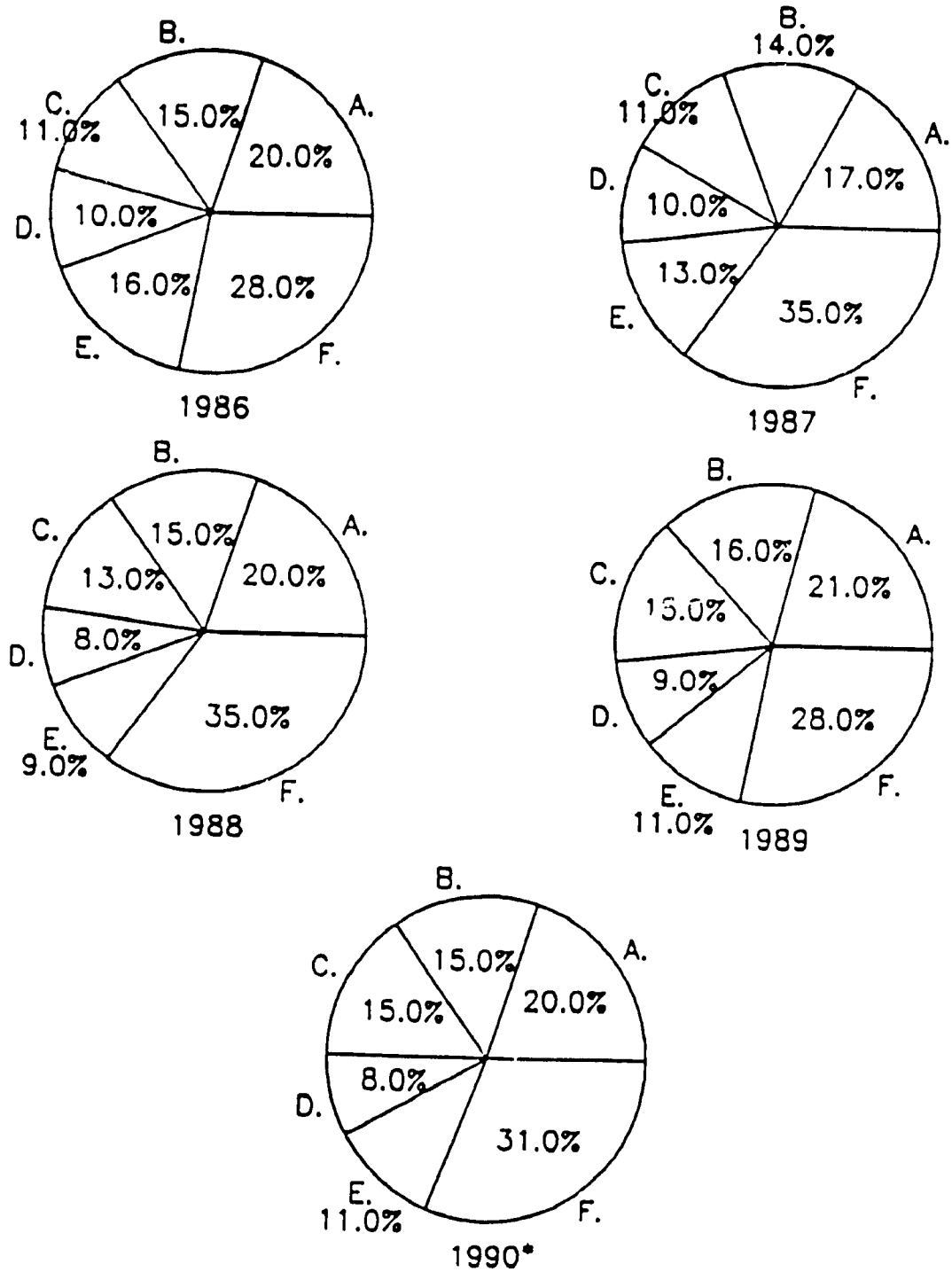
Donor	U.S. $ Total
USAID/Kenya	44,171
USAIS/Zambia	82,897
USGS-Saudi Arabia	113,912
USGS-Roy	1,010
USGS-Lawendy	815
World Bank-Clayton	5,000
Miscellaneous	36,807
TOTAL SPECIAL PROJECTS	3,321,278
TRAINING	
Training General	21,760
Data Collection	33,380
Mod. Tech in F Dis & Hndl	33,000
Fert Mkt Manag.TP	51,750
Fert Mkt TP	17,100
Tech Manag.of F Pro Units	33,600
Relev Fert Supply Strat.	10,982
Computer Sim.for C Growth	17,500
S&E Anal. of F Exper Data	11,778
Purdue Univ TP	22,400
Finance for N-Finance Man.	7,175
FADINAP	19,500
TOTAL TRAINING	279,925
Discounts Earned	3,537
Interest Earned	151,885
Publications	17,434
Fertilizer Manual Royalties	181
IIE Insurance Refund	67,803
TOTAL INTEREST & PUBLICATIONS	240,840
TOTAL INCOME 1989	12,246,092

Restricted and special project funds are given for particular projects and often for specific countries or regions. The monies come from donors and other organizations, including government units and fertilizer companies. The largest amount for 1989 was $1,716,079 from AID/Bangladesh for the marketing and policy reform project. Other funding sources over $200,000 for 1989 were the International Development Research Center (IDRC), Kellogg Foundation, World Bank, the United Nations Development Programme (UNDP) (nitrogen and training), DGIS-AFTMIN, and the United Nations Industrial Development Organisation (UNIDO). The duration of the restricted funds projects varies depending on the services provided by IFDC. In 1989 these funds were expected to be $2,424,045 for restricted funds and $3,321,278 for special projects.

IFDC's expenditures can be divided into the following categories:

- research and development (covering plant nutrition, fertilizer production methods, and socioeconomic/policy);
- technical assistance;
- training; and
- administration.

Research and development from core, restricted core, and special projects accounts for the majority of the budget (Figure 2) and has ranged between 42% (1987) and 52% (1989). In 1990 it is projected to be about 50% of the total budget. Of this amount, about 35% is allocated for agronomic and technology research and the rest for socioeconomic/policy research. Next to research and development, administration takes up a sizable amount and has ranged between 28% (1986) and 35% (1987 and 1988). The higher figures in 1987 and 1988 were because of the formation of the West Africa Division in Togo. The other categories of expenditures are training and technical assistance. Training averages about 10% while technical assistance ranges between 9% and 16%.



RESEARCH AND DEVELOPMENT:

A. Plant Nutrition Research
B. Fertilizer Production Methods Research
C. Socio-Economic and Policy Research
D. TRAINING
E. TECHNICAL ASSISTANCE
F. ADMINISTRATION

* Projected

Figure 2. Allocation of Funds by Category.

E. Physical Plant

The IFDC headquarters is on a 13-hectare area next to the National Fertilizer and Environmental Research Center of the Tennessee Valley Authority (TVA) in Muscle Shoals, Alabama. The IFDC has most of its own facilities, but it shares the TVA's cafeteria, medical center, library, and some warehouse space. The IFDC pays for support service provided by the TVA.

The West Africa Center is temporarily housed in rented buildings in Lomé, Togo. The IFDC was given 12 hectares, near Kpeme and next to *Office Togolaise de Phosphates* production facility outside of Lomé, for a permanent building site.

The IFDC headquarters facilities were completed in 1977 and they include about 80,000 ft^2. Its two buildings include the main building, which houses the administration offices, laboratories and greenhouses, a data processing center, shops, and storage. Its second structure, the pilot plant building, consists of laboratories, pilot-scale granulation plants, a wet-dry beneficiation plant, a warehouse and storage areas, a controlled temperature-humidity room, shops, a conference room, and other work areas. A settling pond is located near the pilot plant building.

The pilot plants--beneficiation, wet acid (both dihydrate attack and concentration to merchant-grade acid) and two granulation/bulk blending units--form a unique, integrated facility. They are important in the IFDC's research, development, and technology transfer activities, and clearly differentiate the IFDC from other international centers. The smaller granulation plant (about 25-30 kgs/hr) has been used for evaluation of indigenous phosphate rock for fertilizer production, development of new processes, and preparation of experimental materials for greenhouse and field trials (up to about 500kg). Over the past five years, this unit has been used on an average of about 11 months/yr with about 1 month/yr allocated for maintenance and overhaul. Replicas of this unit are being made available to India and Egypt.

The large pilot plant (750-1000 kgs/hr) has seen only limited utilization. From 1983-1986, on an average, it was used about 20% of the time. Since 1987, this unit has been utilized more because of the need for experimental materials for field trials in West Africa. In 1989, about 100 tons of materials were prepared. The utilization rate of this unit is now about 40%. In 1990, the IFDC is planning to use the large pilot plant for at least two "hands-on" group training programs. The IFDC expects utilization of this unit will increase to 60%-70% as more training programs are scheduled.

The pilot plant staff was severely reduced in 1986-1987, due to budget problems. Its five-person work force is considered small. If the pilot plants are used more, more staff will be required.

The review team recommends the IFDC promote the use of the unique facilities by:

1. Identifying industry needs, in the LDCs and elsewhere,

2. Marketing IFDC capabilities in response to those needs and,

3. Integrating IFDC pilot plant/process development capabilities into the total fabric of project development on behalf of potential clients (fertilizer manufacturers and engineering companies) who need pilot plant data. Such data, to support process design and operation, is likely to become more important as manufacturers and engineering firms begin to work with new and unfamiliar raw materials. Information will be needed on phosphates and unconventional NPK process technology, such as urea-based NPKs, compaction-granulation, and partially acidulated phosphate rock-based NPK.

4. Include pilot plant data in the modeling efforts of the IFDC.

III. RESEARCH PROGRAMS

The IFDC's research mandate has been to develop appropriate fertilizer technologies and know-how to increase food production and to promote the use of indigenous resources in tropical and subtropical LDCs. In this context, IFDC research programs have focused on: improving nitrogen efficiency, particularly in lowland rice; identifying technologies that will lead to the development of indigenous deposits of agrominerals, specifically phosphate rock; developing and identifying fertilizer policies that will increase food production and support an equitable and sustainable agriculture; increasing the quality and size of the manpower base related to fertilizer; establishing the data base and information networks necessary to operate an efficient fertilizer sector; and carrying out technical assistance that will address the conception of proper investment strategies.

A. Method of Implementation

Historically, IFDC scientists have done their R&D, training, and technical assistance using multidisciplinary task teams. For example, problems related to improving nitrogen efficiency may include a soil scientist, engineer, agronomist, economist, and modeler.

IFDC programs range from basic research on formulating fertilizer materials and the mechanisms of nutrient reactions in the soil, to applied research on fertilizer interactions and management within diverse agroedaphic and climatic regions, to research on methods for extrapolating research results and socioeconomic constraints to adoption of fertilizer practices. The IFDC has developed a family of technologies that fit specific agroclimatic or socioeconomic areas.

With respect to agronomic efficiency, the standard research approach employed by the IFDC in a given agroclimatic zone follows the sequence described below:

1. IFDC scientists conduct research with regional or national institutions to determine the efficiency of fertilizer materials and practices used within a region. This evaluation includes (a) complete chemical and physical characterization of fertilizer materials, (b) farm surveys to determine management practices, and (c) experiments using labeled fertilizers to determine the fate of applied nutrients.

2. Based on the findings of the fate of the nutrients and the pathways of nutrient loss, soil scientists and chemical engineers work together to formulate experimental materials. Preparation of bench-scale quantities of experimental materials takes place in IFDC laboratories, followed by chemical and physical characterization as appropriate.

3. These experimental fertilizers are screened in IFDC greenhouse or growth chamber facilities to determine which of the alternatives are effective in achieving the desired results.

4. If promising results are obtained with one or more of the modified products (or practices), production of the materials with greatest potential is scaled-up to simulate commercial production conditions in IFDC's pilot plants. Optimization of the process parameters and preliminary estimates of production costs can be determined during the preparation of sufficient quantities of the fertilizers for field evaluation.

5. Field evaluation of product management and effectiveness is conducted by IFDC staff members outposted in LDCs or by national institution collaborators participating in an IFDC research network (i.e., no field research is conducted at the IFDC Headquarters in Muscle Shoals). At the conclusion of the research, all data are entered and stored in IFDC's fertilizer efficiency computerized data base.

6. Concurrent with the execution of the field experimentation

on fertilizer management and effectiveness, socioeconomic studies are conducted to identify potential constraints to future adoption of proposed technologies and to estimate potential impacts if the technologies are adopted.

7. In some settings policy research is done to be able to make proposals to national governments on distribution and marketing practices.

8. Modeling of crop growth, nutrient movement, and other processes is done where applicable.

B. Nutrient Programs

Three nutrients (nitrogen, phosphorus, and sulfur) have received primary attention in the IFDC's research program, and, in general, the IFDC has concentrated on solid forms of fertilizer rather than liquids or suspensions. Liquid or suspension fertilizers are usually applied on big farms, which are not common in the LDCs. It is recognized that research on other nutrients (especially those compatible with irrigation systems) is required. The selection of the IFDC's priorities was based upon the original mandate to focus on technology with the potential for maximum benefit to resource-poor farmers of LDCs who have little experience with the use of fertilizers. Expansion of research into new areas (e.g., sustaining soil fertility, minimizing environmental pollution, adapting practices for crop diversification, agroforestry, etc.) is now receiving new priority, but is limited by the need for additional funding.

1. Nitrogen Research

The nitrogen program focuses primarily on improving the crop-use efficiency of urea, the most common N source in developing countries. Due to basic differences in the pathways of N loss, attention has been split between a wetland and an upland N program.

Work initially focused on (1) verifying the reportedly poor efficiency of N utilization, and (2) identifying the causes for

poor performance of commercial N sources. Currently, additional emphasis is on developing technologies and management techniques to improve the efficiency of applied N and developing crop-growth simulation models to assess the agronomic and economic risks associated with management modifications.

Research on N-use efficiency in the wetland program is split between laboratory, growth chamber, and greenhouse experimentation at the IFDC headquarters, research station experimentation by IFDC staff outposted at IRRI, and field testing by a network of national institution collaborators.

The IFDC's research has given major emphasis to N, because of its importance in crop production and the great potential for improving the efficiency of its use. In temperate agriculture, a 50% efficiency has been regarded as the average, but in paddy rice the efficiency may be as low as 20%. In dry lands losses can also be high, especially from urea on sandy soils. The incremental yield responses to N usually diminish as the rate of application rises. With low rates of fertilizer application, a 30% increase in recovery of N would give a substantial increase compared with a similar increase in efficiency at higher rates. For the small farmer in the tropics who normally uses low rates of fertilizer, increases in efficiency are particularly important.

a. Research Program.

The IFDC has been a leader in research on losses from N fertilizers in tropical farming systems. Using ^{15}N measurement techniques, scientists from the Center have been able to quantify the losses from N fertilizers under different systems and to determine the mechanisms causing these losses. Urea is the most widely used fertilizer for rice and significant losses can occur via ammonia volatilization when urea is applied to the flood water. These losses are especially severe when urea is applied at, or just after, transplanting when the plants are small and when the surface water is turbulent through wind disturbance. The work on losses of N in rice farming systems has been done in collaboration with IRRI. Work on dryland agriculture, e.g., millet cultivation in Niger, has shown that l[illegible]es by

volatilization of ammonia are also high on sandy soils, if the fertilizers are not incorporated into the soil.

The approaches to solving the problem of low N uptake by the crop consist of altering the methods of applying N fertilizer or modifying the materials, so the N supply matches N demand by the crops. One approach is to apply N fertilizer to match the stages of plant growth, i.e., by split applications. Experimental evidence shows that this can be effective, but there are several constraints to farmers using this technique. These include lack of information for the farmers, lack of fertilizer delivery at critical times, and the need for additional labor to apply fertilizer efficiently. Incorporating fertilizer into the soil to prevent losses through volatilization of ammonia requires considerable additional labor. Sometimes when soils are too sandy for upland rice, incorporation does not prevent N loss.

Farmers can generally minimize the losses from urea in rice paddies by placing the fertilizer in the soil to a depth of 10-15 cm. A frequently recommended practice is to drain the water from the paddy field, apply the fertilizer, and incorporate it thoroughly. However, the farmer has often little control over the water supply, and might not have the tools for thorough incorporation into the soil. Consequently, he usually broadcasts the urea into the standing water with the ensuing losses described above.

The IFDC has used several approaches to the problem of N losses, particularly in rice paddies. They include:

1) *Deep placement.* A solution to the problem of ammonia volatilization is to keep the urea out of the floodwater by incorporating it into the soil. Once the urea is deeply incorporated, little diffusion of urea or ammonia to the floodwater will occur. One method has been tested by IFDC and IRRI to remedy some of the problems. Urea supergranules (USG) have been made to facilitate deep placement. They are large 1- to 2-g granules of urea that are placed into the soil. Using this technique, N is made available to the plant with little risk of loss by runoff or volatilization. Additionally, because the ammonia produced by the hydrolysis of urea is kept in the soil,

where oxygen is absent, nitrification is minimized. Because oxidized forms of N are precursors for denitrification, USGs achieves protection from this loss mechanism as well.

Results from numerous field evaluations have shown that using USGs is an effective means of reducing N losses, consistently doubling N uptake by the rice at sites where low rates of application were used. However, a problem is the requirement for line-transplanted rice and the labor associated with hand placement of the granules. The extra yield associated with USG may be outweighed by the extra labor for placement. No machines have yet been developed which can economically apply USG to the correct depth in a farmer's field. IFDC scientists have recently developed a dispenser with a cheap transplanting guide made of bamboo to facilitate USG placement. Limited field trials to evaluate hand deep placement have been conducted in India showing that use of the line transplanter required only 25-30% more labor than conventional broadcasting of urea into the floodwater. A new project with PhilRice in the Philippines will try to determine under what conditions the combination of village-level briquetting of USG and hand deep placement will lead to adoption.

2) *Urea supergranule production.* Two methods for making USG have been tested by the IFDC--briquetting and melt granulation. The second seems of little interest for LDCs and most of the work has centered on briquetting.

Briquetting is done as urea in crystals, dust, or prills is fed to a roll press which compacts USG briquettes. The shape of the USG depends on the roll pocket configuration. It is a dry process requiring only electricity. Machines are available to produce about 0.25-10 mtph. At this time there is no commercial production of USG by briquetting.

To test the potential demand for USG, the IFDC conceptualized a village-level supply scheme. Under IFDC supervision a Chinese briquetter was modified and demonstrated for USG production in Indonesia. The machine needed improvements for sustained production. The machine is fed with locally made prills. It is planned that over 2000 of the machines will be

manufactured and used in Indonesia. This program will allow a large experiment in the manufacture and use of USG briquetting and in implementing this technique. Approximate unit cost for the machines is $1500 to $2000 with a production capacity of 200-250 kgs/hr. So far, the method of the deep placement of USG is hand placement by farmers, one granule for every four rice hills. This fertilization needs to be done once per planting, while broadcasting requires 2-3 applications. Hand deep placement is being mandated by the Indonesian government for its farmers.

The use of USG containing diammonium phosphate (DAP) to improve N and P efficiency in rainfed transplanted rice has been tested. The results suggest that enrichment of USG with DAP in proper ratios can be agronomically superior to traditionally applied prilled urea and single superphosphate in rainfed transplanted rice with modified spacing, especially on soils with high P-fixing capacity.

3) *Coating for controlled release.* IFDC scientists have investigated methods to achieve an effective, economical coated urea for rice farmers. Compared with deep placement, this method does not involve changes in the farmer's practice and, therefore, could spread rapidly if a cheap, coated urea could be obtained. The initial objective of the coated urea was to match the N release rate with plant uptake--a low initial release followed by a gradual increase and the N total release at crop maturity. Coatings hold the promise of decreasing ammonia volatilization, leaching, and runoff losses, and show potential in both flooded and upland conditions. The release rate of N from coated urea is dependent on: (1) quality (size and smoothness) of urea prills; (2) characteristics of the coatin;, and (3) coating thickness.

IFDC has used sulfur-coated-urea as a standard for coating research, but has tested other coaters like lignin, starch, natural and synthetic latex, natural rubber, and polymers. All of these materials make coated urea much more expensive than non-coated urea and, therefore, limited application can be expected at this stage of the research.

4) *Inhibitors.* Two types of inhibitors for controlling N

transformations in soils are of known agronomic importance. A urease inhibitor will deactiviate the soil enzyme urease for a time, thus delaying the decomposition of urea to ammonia and carbon dioxide. A nitrification inhibitor delays nitrite and nitrate formation from ammonia to reduce leaching and denitrification losses. Emphasis at the IFDC has been on urease inhibitors, because ammonia volatilization is a primary loss mechanism.

With partial funding from West Germany, a 4-year project has been completed on urease inhibitor synthesis, pH-stat evaluation, soil evaluation, and greenhouse and field trials. The IFDC's program objectives are to identify urease inhibitors that are effective, stable, and cost effective. Recently over 40 compounds were synthesized at IFDC's laboratories or procured for evaluation. This work covered several classes of compounds. It resulted in a better understanding of inhibition mechanisms and identification of promising inhibitors. The project led to a patent.

5) *Urea substitutes.* Limited research has been conducted on producing urea derivatives, which are more slowly mineralized in soils to reduce N losses and sustain availability. The work was to determine if use efficiency over urea could be achieved. Urea formaldehyde, guanylurea sulphate, and metal salt urea complexes were tested.

b. Achievements.

1) *Nitrogen (Lowland).*
IFDC researchers have made major advances in identifying the causes and magnitudes of fertilizer N loss in lowland rice and have developed technologies that can curb these losses. Following are some specific accomplishments:

a) Greenhouse and field trials have determined that farmers lose up to 60% of the fertilizer N applied to flood water. About 30% of applied N for wetland rice remains in the soil, while crop recovery varies between 20% and 50% of applied N depending upon fertilizer application method, water management, soil, and weather conditions.

b) Laboratory, greenhouse, and field trials have highlighted the importance of ammonia volatilization in total N loss from wetland rice and identified factors contributing to this loss.

c) Denitrification in tropical paddy soils, when directly measured with a new IFDC technique, is generally less than 3% of the applied N. This is a much lower figure than current estimates. This information has important implications about the contribution of NO_x emissions to global warming estimates.

d) Urea deep placement, use of inhibitors, and coating of urea to curb N losses and improve plant uptake efficiencies have been studied and found to be effective under specified conditions.

e) The important technical and economic parameters of processes for producing urea supergranules to facilitate deep placement have been studied to determine the relative merits of each.

f) The use of a small village level briquetter for converting urea prills into USG near the place of use appears to be practical. The IFDC has redesigned and fabricated a small urea briquetting machine for using prills available from local markets.

g) A USG dispenser with a transplanting guide has been developed and tested. This device appears promising for decreasing labor requirements for deep placement of USG.

h) Numerous materials, including polymers, have been studied for coating urea to retard release. None have yet been found to be cost-effective for LDC farmers.

i) A number of possible urease inhibitors have been synthesized and evaluated to determine their effectiveness. One product, in particular, has provided effective delay of urea hydrolysis and resulted in greater rice yield in greenhouse tests. Field trials and economic analysis of this and other

products are needed to fully evaluate the inhibitors for improving N efficiency. Again, cost-effectiveness is a detriment in using these products.

2) *Nitrogen (Upland).*

a) Considerable data to aid national researchers in planning strategies have documented N recovery and losses for various agroclimatic areas.

b) The effects of soil moisture and water additions upon urea hydrolysis and ammonia volatilization has been further defined to allow national scientists and extension workers to formulate recommendations.

c) IFDC research has revealed that N efficiency for upland crops is not as serious a problem as for lowland crops, although studies are being continued to identify conditions under which N efficiencies are poor in upland crops.

c. Future Plans.

In its two-year plan for 1990-91, the IFDC proposes to continue work on the deep placement of urea, and to develop agronomically and economically viable coated urea products with slow release properties. Development of effective chemical soil urease inhibitors for improving efficiency of broadcast prilled urea in transplanted rice will have lower priority. The Center plans to evaluate the use of the briquetters in Indonesia, Bangladesh, and the Philippines.

d. Assessment.

IFDC's work on determining the mechanisms for N losses and quantifying these losses has been very good and has been done in close association with the other international centers. Most of the research has been confined to relatively few sites, so there is much to be learned about how losses vary from site to site. Losses of ammonia from rice paddies can be high. Losses by run-off may also be considerable. There are as yet no satisfactory methods for measuring losses by denitrification. Vast quantities of nitrogen fertilizers are used in rice paddies,

so the losses from these are likely to be large. Still needed is a better understanding of how these losses take place and of the soil and water conditions influencing such losses. This work would be long term research on methodology and studies on loss mechanisms, and field work in Asia on the conditions influencing such losses. The review team believes it would be worth continuing support for this research.

Work on slow release N fertilizers has a long history. Research on sulfur-coated urea predates the establishment of the IFDC. Coating is effective in reducing losses, as has been proven by widescale testing in many Asian countries, but production costs are still too high to make the materials suitable for widespread use.

The work on urease inhibitors has given some interesting results, but the IFDC is unlikely to have the resources to match those of large chemical companies who can invest in such projects. Because of the growing emphasis on the detrimental effects of nitrate leaching, this work may receive increased industrial emphasis. The IFDC could then have a role testing products in tropical agricultural systems.

Supergranules perhaps present the best opportunity for applying urea below the soil surface. Most of the technical problems of making supergranules, including small village level machines, appear to be near solution. The main problems are social and labor difficulties. Hand placement is tedious, and the simple placement machines that have been designed appear to have cost problems. The plans in Indonesia to manufacture over 2000 of the village-level briquetters will provide an experiment in the use of supergranules. If the farmers find the granules useful, they will come up with novel ways of using them. However, the farming practices of the Indonesian (i.e., straight rows) and the ability of the Indonesian government to mandate deep placement by hand may make the experiment unfair for generalizing acceptance of the practice elsewhere. The review team believes that work by the IFDC, in collaboration with national programs, on the adaptive research necessary to get this technology used by farmers is worth continuing support, but this work needs to be done mainly in the rice fields of Asia.

It appears there is limited scope for improvements in N fertilizer efficiency in rainfed upland crops, although there are some conditions where losses are very substantial. A modest program investigating these conditions would encourage agronomists in national programs to look for ways of improving the efficiency of nitrogen fertilizers.

e. Recommendations.

The review team offers the following recommendation on the IFDC's N research program.

1. No major additional efforts in further technical development are suggested in USG production, because melt granulation is already offered in the market, and concerns with briquetting are not with the technical side but with required changes in farming practices.

2. Some additional research is suggested to develop better USG dispensers. A few more trials should help to make a decision on continuing or abandoning research on deep placement. Mos of the technical research seems to be already accomplished.

3. A small research component is suggested to resolve the issues regarding polymer-coated urea, namely: urea substrate, cost and availability of casting materials, percentage coating, and post-production handling.

4. The same is suggested for a few of the urease inhibitors, mainly triamide, which appear promising. Field trials and economic analysis are needed to evaluate their role in improving N efficiency as well as evaluating methods of adding the inhibitors to urea and determining the stability of the most promising inhibitors when mixed with urea. Additives should be included that may improve stability at elevated temperatures encountered in storage. Some tests are needed to improve the stability of the most promising inhibitors.

2. *Phosphorus Research*

Large areas of sub-Saharan Africa, South and Southeast Asia, and South America are very deficient in phosphorus. In the absence of fertilizers, P for crop production comes from the recycling of organic matter, crop residue and animal manure, and the very small pool of weatherable P minerals in the soil brought to the surface by deep rooted plants. Animal manure and crop residue application may be used to concentrate P from a wide area into a small space for crop production, but the system is not closed: some is lost through crop removal and soil erosion, although virtually none is lost by leaching.

Total P consumption for sub-Saharan Africa has grown from 180,000 tons of P_2O_5 in 1975 to 357,000 tons in 1987. Comparable data for South Asia are 617,000 and 2,866,000 tons. These amounts will need to grow substantially in the future as agricultural production intensifies and farmers turn to new high value crops. All of this increase must come from P fertilizers. In their absence, soil fertility and productivity will fall. Historically, phosphate fertilizers have been made by processing phosphate rock from a limited number of sources suited to large-scale exploitation by well-established methods.

Perhaps it is P research in which the IFDC has obtained its most valuable results. As a consequence of this research, the IFDC's reputation has increased in the fertilizer world, and LDCs trust and see the IFDC as an independent, skilled center which can provide immediate advice. This is one of the IFDC's major assets.

Phosphate rock (PR) deposits exist in a large number of tropical and subtropical LDCs. A major focus of IFDC research has been providing an understanding of the agronomic and economic alternatives for the use of this natural resource within developing countries. These alternatives range from direct application of finely ground PR to conventionally processed soluble P fertilizers, and include intermediate alternatives such as partially acidulated phosphate rock (PAPR), PR cogranulated with other more soluble or acidifying materials (i.e., sulfur, organic materials, etc), or thermalphosphates.

IFDC's advantage in this endeavor is its multidisciplinary capability to evaluate a given deposit on the basis of the combined influence of rock mineralogy, chemical and physical characteristics of the rock, solubility in diverse soil environments, availability of the P from the rock or its modified products to the plant, technical and economic parameters related to production of fertilizers, energy needed to grind a particular particle size, potential for beneficiation, farm-level management of the fertilizer material, economic efficiency of the alternatives, and socioeconomic constraints to its production and/or adoption. This approach ensures that the options from which the developing countries base their decisions are technically sound rather than just intuitively attractive.

This research approach requires active in-depth basic research at the IFDC headquarters, as well as experiment station and farm-level research in the tropics, augmented by collaboration in regional networks. Research of this type on P is ongoing in Latin America, Asia, and Africa.

The research aims at a basic understanding of P minerals, determined through their characterization. The characterization of a P mineral (ore or concentrate) consists of information on chemical analysis, mineralogical analysis, reactivity, grinding energy, assessment of impurities, particle size analysis, and potential for beneficiation (upgrading). This information is needed to plan a strategy for processing the material into a P fertilizer. Chemical analyses quantify the elements that are of value, such as P_2O_5 and CaO It also identifies the elements that are undesirable, such as Fe_2O_3, Al_2O_3, Cl, and MgO, which interfere with chemical processing. Ore texture indicates if the ore is amenable to upgrading by removing impurities. Reactivity is a useful indicator of potential for using the materials as a direct-application fertilizer on acid soils and for chemical processing. Energy for grinding indicates the relative hardness of the minerals. IFDC has established a computerized raw material data file on about 1,200 P ore samples from 75 developing countries. New samples are continually added, many from Africa. To our knowledge, no other comparable database on P minerals exists in the world.

The work of IFDC on P has been important. Prior to IFDC's research, P minerals were only analyzed for Fe% and Al% to decide its future use in phosphoric acid production. The IFDC has shown that the form in which the undesirable impurities appear in the mineral is more important than the quantity. This has led to processing of phosphates that in the past were rejected.

IFDC has the capability to convert ore or concentrate into phosphoric acid, nitric phosphates, ammonium phosphates, superphosphates, thermal phosphates, direct application products, and multinutrient products. In addition, ores can be upgraded by flotation, calcination, and magnetic separation, including crushing and grinding.

The usefulness of any particular P product depends not only on its properties, but also on soil properties, crop species, and time and method of application. The IFDC's research program is designed to understand and define the conditions under which different kinds of phosphate fertilizers will be best suited.

a. Single-Nutrient Fertilizers

1) *Direct-application products.* The IFDC is a leader in assessing P minerals for direct application to acid soils. The neutral ammonium citrate (NAC)-soluble P_2O has been determined in numerous samples and correlated with P recovered from soils after incubation. The NAC-soluble P_2O also been correlated with yields in numerous greenhouse and field trials. Rocks ranking medium to high in reactivity can be recommended for direct application on acid soils with a high degree of confidence. Ultimately, agronomic tests are needed to confirm the potential.

The rocks can be applied either finely ground or granulated. The IFDC has developed techniques for manufacturing conventional granules or minigranules.

2) *Partial and full acidulation.* For those rocks or soil conditions not suitable for direct application, some type of acidulation must be considered. The most common process is full acidulation using phosphoric acid to make triple superphosphate

(TSP) or sulfuric acid to make single superphosphate (SSP). These processes are well known and widely used.

For LDCs the IFDC has concentrated its efforts on partial acidulation in order to reduce product cost by lowering the quantity of sulfuric or phosphoric acid for acidulation. The products may be granular or semigranular. Sulfuric acid has been used predominantly by the IFDC, because many developing countries do not have or cannot economically make phosphoric acid. The level of acidulation is 25% and 50%, indicating one-fourth or one-half of the sulfuric acid for full acidulation. This type of technology is aimed at small countries having a limited demand for P and expensive raw materials. Sedimentary rocks low in reactivity can be used for this purpose. There is less experience in using low-reactivity igneous rocks for partial acidulation. A cost comparison of the alternatives of ground rock, sulfuric-acid based (SAB) PAPR (50%), and SSP on a P205 basis, shows the cost effectiveness of the PAPR. Brazil has adopted the PAPR process. Seven other countries are in various stages of evaluation.

b. Multinutrient Fertilizers.

Multinutrient fertilizers encompass all those products containing more than one of the major nutrients N, P, or K. They may also contain micronutrients. IFDC is conducting agronomic evaluations on NPK multinutrient fertilizers produced by different processes, such as bulk blending, steam granulation, and dry compaction.

1) *Phosphoric acid.* A basic building block of multinutrient fertilizers is wet-process phosphoric acid. The IFDC has contributed much information regarding the suitability of P ores for the process. The Center has not attempted to develop new technology for wet-process phosphoric acid, because there is enough proven technology, and it is available to any fertilizer producer in the world.

2) *Ammonium phosphate.* Monammomium phosphate (MAP) and DAP products have been made using many of the phosphoric acid sources described above. The IFDC's work has mainly been to determine acid suitability and physical/chemical characteristics of MAP/DAP

in contrast to developing a new process. The preneutralizer process is simulated. The MAP and DAP are made in a rotary drum granulator. Some limited tests have been made employing a pipe reactor. As in the case of phosphoric acid there exists a considerable array of technology in the market, and the IFDC has not considered it worthwhile to develop a new one.

3) *Nitric phosphate.* Nitric phosphate involves the reaction of P ore or concentrate with nitric acid and further processing to a solid fertilizer. The final product may be NP or NPK.

A major IFDC project in Colombia updated an old nitric phosphate plant to improve efficiency and reduce pollution. A preliminary package was supplied based on pilot-plant tests to produce the nitric phosphate slurry, which was not granulated. Six grades of NP or NP slurry were tested which would be fed to a spherodizer-type granulator om tje Colombian plant. Also, some tests where done at the IFDC to determine if local Sardinata rock could be substituted for Florida rock in a particular type of nitric phosphate process.

Only a few technologies exist for fertilizer producers and some of them are not licensed. It is likely there will be a shift towards nitric phosphates in the future, due to their lower cost, and a willingness by users to accept non-100% water soluble P_2O_5 fertilizers. As environmental issues become more important, developing nitric phosphate technology for the use of indigenous reserves of P rocks may be a promising line of research for the IFDC to follow.

4) *Urea-based NPK.* Although there are few new plants being built for NPK, some are being considered for producing NPK in plants originally designed for DAP. Over the years the IFDC has studied the use of urea in NPK fertilizers. Two main problems have been studied. Incompatibility of urea with superphosphates, and hygroscopicity of urea and urea mixtures.

5) *Compaction.* Developing countries are often restricted to only using solid, single nutrient materials applied individually to supply N, P,and K. To make NPK granules,

steam/water granulation is used along with energy for drying. The IFDC has demonstrated a compaction process, which is an attractive alternative for granulation of solid materials. It appears to have several advantages: (a) no drying/cooling, (b) good for urea-based NPK, (c) good for micronutrient additions, and (d) adaptable to a small scale. The IFDC recently prepared a technical/economic assessment on bulk blending, compaction, steam granulation, and chemical granulation which indicates that compaction for NPKs should be considered along with other alternatives.

A variation of acidulation is to mix a solid P source, such as SSP, triple superphosphate (TSP), DAP or MAP, with the ground rock to provide varying degrees of P_2O_5 water solubility. This may have application where a sulfuric acid plant cannot be justified. Further, those PRs not suitable for PAPR production (because of high Fe_2O_3 and Al_2O_3 content) can be compacted for direct application. The IFDC has evaluated various compacted products using PRs for Togo, Colombia, Brazil, and Zimbabwe.

The IFDC has a compaction machine that is used to supply N, NP, and NPK products for agronomic testing. A range of products have been made.

c. Achievements.

IFDC geologists, engineers, chemists, and soil chemists have mounted a major program to find ways to make effective use of local agrominerals, with an initial focus on phosphates. As a result, developing country planners have a much better understanding on how to use their resource base.

The IFDC is well equipped to perform research on P raw materials, intermediates, and to do suitability studies of processes to manufacture phosphoric acid, MAP, or DAP. This capacity contributes to the uniqueness of IFDC.

Below is a summary of achievements of the IFDC on P research.

1) About 200 phosphate deposits covering 75 countries have been catalogued by the IFDC in a raw material data file

containing information on location, size and quality of deposits, exploitation methods and uses, and published references. This unique computerized data file on about 1200 phosphate ore samples serves as an excellent reference source for scientists, planners, and policy makers from developing countries, and for funding agencies.

2) About 50 non-commercial phosphate rock deposits from Latin America, Africa, the Middle East, and Asia have been characterized to determine their potential as fertilizer raw materials. Potential routes for their processing have been identified.

3) New beneficiation methods have been developed to upgrade ores with high levels of impurities in actual or planned beneficiation plant situations, e.g., Jhamarkotra, India (dolomite); Guizhou, China (dolomite); Leyte, the Philippines (iron/aluminum); Sukulu, Uganda (iron); Hahotoe, Togo (cadmium); Chilembwe, Zambia (silica); and El Hasa, Jordan (silica).

4) Research on the benefits of blending a local ore with an imported phosphate concentrate to improve performance, and on the tolerance of an acidulation plant to slimes addition has been demonstrated. The results were put into commercial use in the Philippines and Senegal, respectively.

5) For low-reactivity rocks, some type of acidulation is needed. Significant improvements in the technology for partial acidulation, developed by the IFDC, have allowed several developing countries to reassess the economic potential of their indigenous phosphate deposits, especially those that are not suitable for the manufacture of conventional products and intermediates (single superphosphate, triple superphosphate, and phosphoric acid). Semigranular versus granular means of production have been investigated to find low cost methods of production.

6) The database on the effects of impurities in igneous and sedimentary phosphate rocks, on process performance, and product quality has been significantly expanded. This development has allowed some countries to utilize their indigenous phosphate

rocks. Examples are in Brazil and Colombia.

7) A novel method for soil testing for plant-available P has been developed and is in the advanced stages of development. This test has worked well in acid as well as alkaline and calcarious soils, and the technology is appropriate to soil testing institutions in developing countries. The method has to have use in measuring phosphate levels in lakes, streams, and groundwater. The test is sensitive to low available P levels, common in low input systems.

8) Laboratory test methods to determine the agronomic potential of direct application of finely ground and granulated phosphate rock with different characteristics have been developed to guide field trials in Asia, Latin America, and sub-Saharan Africa.

9) Field trials have generated excellent data on the potential effectiveness of phosphate rock and partially acidulated or extended phosphates of varying characteristics for a number of edaphic, climatic, and crop conditions, resulting in a renewed interest in exploiting indigenous phosphate deposits.

10) The IFDC data base on the effectiveness of direct-application rock and modified phosphates will serve as a guide for developing countries in their examination of promising indigenous deposits, particularly for land-locked countries with small deposits.

11) The IFDC has developed technologies and gained expertise in utilizing difficult and/or low-grade ores.

12) The IFDC has erected a phosphoric acid pilot plant to determine the suitability of P ores or concentrates in contrast to developing a new process. Most of the tests simulate the dihydrate process.

13) A second pilot plant has been erected to test the suitability of MAP/DAP with some of the phosphoric acids made at the IFDC. A preneutralizer process is used. Some experience has been gained with the TVA pipe reactor process.

14) IFDC has used its pilot plant to simulate several types of nitric phosphate processes to test the suitability of P ores and had helped to modernize some industrial plants.

15) Use of urea for NPK in chemical granulation creates problems. The IFDC has performed tests to define the parameters to evaluate NPK production.

16) The IFDC has developed technology for compaction to make granular NPK, plus micronutrients. The technology has advantages for certain developing countries and the cost appears favorable.

17. A new slurry production process permits phosphate rock to be a carrier of rhizobium inoculum. If viable in field tests, this combination could be useful for low-input systems in legume growing acid soils of the tropics.

d. Future Plans.

The IFDC envisions the following work in P research.

1) Emphasize characterization of minerals from developing countries, particularly in Africa and the Middle East, because of the activation of two regional centers. A few samples will come from Latin America as new deposits are found and assessed.

2) Further investigate the option to mix ore plus soluble P by compaction in lieu of acidulation.

3) Work on an improved method to make semigranular PAPR or SSP (not involving recycle) to reduce costs. Determine the suitability of rocks for these processes and the agronomic performance of the products.

4) Conduct tests on certain P ores for use in the wet-process phosphoric acid method and assess additives that act as crystal modifiers to improve filtration.

5) Evaluate phosphoric acid for use in making NP and NPK fertilizers.

6) Evaluate combinations of raw materials for NPK in chemical granulation. Urea will receive primary attention as most of the countries want to use it. Better methods are needed to combine urea to make NPK.

7) Test a wide range of raw materials, applicable to small countries, in the compaction process. Use local rock where appropriate.

8) Prepare experimental products for agronomic testing.

9) Continue mapping potential areas for alternative P sources.

Much of this work is expected to be performed on a cost-reimbursable basis.

e. Recommendations.

1) Keep updating the data file for P minerals and extend it to other agrominerals, such as potash, limestone, and the heavy metal content of ores (i.e., Cd).

2) Develop nitric phosphate technologies to enable the use of indigenous P minerals. Test nitric acid/phosphoric acid mixtures. Better knowledge on the caking of nitric phosphates is required.

3) Compaction techniques for world-scale commercial plants are available to any user. However, substantial R&D is recommended bor developing compaction units to be used at the village level. Existing technologies need further evaluation.

4) Drip irrigation fertilizers are important for semiarid areas (e.g., Egypt, Saudi Arabia, etc). Good P ores are required or purified phosphoric acid must be used. Solvent extraction techniques should be developed to purify the acid and to remove undesirable heavy metals.

5) The influence of micronutrients at large crop levels is

far from understood. Industry does not seem interested in micronutrients, because they are not big volume money-makers. Nevertheless, they should be of interest for some LDCs for some crops. Any research on micronutrients would need research on physical properties of fertilizers.

6) Environmental concerns with P fertilizers are increasing. Work should be devoted to develop technologies that decrease or eliminate the production of phosphogypsum.

The review team believes the research on developing local phosphate deposits is an essential element in providing P for agricultural development in sub-Saharan Africa. So far, however, there has been little progress in persuading industries in those countries to take up any of the technologies developed at the IFDC, and it will require a major effort among country planners, industries, and donors to further this aim.

3. Sulfur Research

Large areas of tropical soils are low in S, so low in fact that they can only support modest level of crop production, especially legumes. Fertilization with P and liming increases sulphate losses by leaching. Moves toward high analysis fertilizers deprives some soils of the S they previously received as a byproduct. In contrast to industrial countries where large, indeed excessive quantities of S, are added through rainfall, the lack of industrialization in most tropical areas means that only 1 or 2 kg/ha of S is added by rain. This amount is insufficient to replace losses through crop removal and soil leaching.

The research program on S started after that on N and P. One of its objectives was to develop analytical methods to determine S deficiencies. A second objective was to identify soil and climatic factors that contribute to S deficiency and influence the effectiveness of S sources.

^{35}S has been utilized to trace the fate of S applied either as elemental S or as sulphate in the form of gypsum or ammonium sulphate. In West Africa, both kinds of materials have been used in experiments on millet, sorghum, and maize. Elemental S can be

incorporated into other fertilizers, but it has to be oxidized to sulphate before it can be taken up by plants. If used with urea, which is then incorporated into the reducing zone of the soil, the elemental S might not be oxidized in the first season and will not benefit the rice crop in that season.

The philosophy and objectives of the IFDC's S program are based on two premises: understanding the S transformations and loss mechanisms in various soil-plant systems to be able to optimize S use efficiency and design more efficient S fertilizers; and knowing that nutrient S will in most situations be applied in combination with other nutrients (N, P, and K), rather than as a straight-grade fertilizer. Consequently, IFDC's sulfur program focuses on:

a) The study of S dynamics in the soil-plant system as they affect the fate and efficiency of S-containing fertilizers. Work is focusing on organic-S pools, absorbed sulfur, leaching losses, immobilization/mineralization, and volatilization. Both greenhouse and laboratory studies have been done on factors affecting S leaching losses.

b) Developing and evaluating S fertilizer sources and management strategies in which S occurs (but not exclusively so) in combination with other nutrient ions. Greenhouse evaluation is being done of various S sources (primarily sulfatic) under a range of imposed water regimes, both aerobic and flooded.

a. Achievements.

1) The IFDC monograph on *Fertilizer Sulfur and Food Production* demonstrated the widening gaps between aggregate S requirements and supplies in developing countries, and it outlined research priorities and policy measures required at national and international levels.

2) Field studies conducted in S deficient areas of South and Southeast Asia highlighted the importance of placement method (broadcast, mixed incorporation, and point deep placement) on the effectiveness of S-containing fertilizers (urea, TSP, and partially acidulated phosphate rock).

3) Field studies in West Africa on cropping systems and agroclimatic zones have shown substantial responses to S-containing fertilizers, confirming the importance of S in that region.

4) Field research has shown elemental S is not readily available to the first crop of lowland rice, but is a good source of S to the second and following crops.

5) Variables for production of S-fortified TSP have been established, and the process is being considered for commercialization by a company in Australia.

b. Future Programs.

The 10- and 2-year plans of the IFDC do not set out a specific program for S research, although indications are that agronomic research will continue along the same lines as at present. Some plans appear to be:

1) Study fertilizer dynamics as a whole, making use of radioisotope-labeled materials to follow the fate of S in soil-plant systems.

2) Headquarters research will focus on the evaluation of multinutrient sources in which S is present in a reduced form (initially as elemental S or pyrite).

3) Examine the interaction in products of other nutrients (N or P) in products with S.

4) Develop management strategies to enhance the availability and efficiency of insoluble S sources.

5) Through collaboration with the N and P programs, seek to identify areas where S deficiency is or may become a problem. In areas where S deficiency is documented, establish experiments to assess its magnitude. Identify the causes for deficiency and evaluate means of correcting them.

c. Recommendations.

S deficiency is becoming evident as a limiting factor to crop productivity in extensive areas of the tropics. The IFDC's research on ways of supplying S to tropical soils will become more important. Partially acidulated rock phosphate will supply S, for example, in West Africa. Gypsum, from the manufacture of phosphoric acid, is presently an unwanted by-product in parts of Asia, but is a potential source of S for rice lands. Work by the IFDC on using these and other materials is worth continuing support.

Other recommendations of the review team are these:

1. Develop processes which produce less phosphogypsum.

2. Test elemental S by adding it directly to fertilizers. LDCs are geared to the production of N and P, and elemental S does not excessively dilute the grade. Care should be taken to avoid explosion risks when handling elemental S.

3. Evaluate appropriate S-containing products to identify options for various agroclimatic zones and cropping systems. Specify options that could feasibly be incorporated into fertilizer production facilities in developing countries.

4. *Organic Fertilizers*

Research on organic matter was part of the original brief when forming the IFDC was discussed. The benefits of organic matter, whether in temperate or tropical agriculture, have long been evident. Not all the reasons for such benefits are completely understood, but the major problems have been and will continue to be its availability and the economics and labor in utilizing the material. While disposal of organic matter, in the form of animal manure, has become a major problem in parts of Europe and a source of serious pollution, most tropical farmers are aware of its advantages, but the material is both scarce and of poor quality. Manure from animals fed on crop residues with low levels of nutrients will be poor in plant nutrients. It is generally seen as an extremely bulky product of low value, which

may have to be carried considerable distances by the farmer who has no other means of transport. The use of organic matter in its many forms is an agricultural, cultural, and social problem, subject to many local constraints. The IFDC's role, therefore, should be to ensure that, in its cooperative agronomic research with national programs, due recognition be given to the value of organic matter in conjunction with inorganic fertilizers, and research should seek to optimize the returns from combinations of organic matter with chemical fertilizers.

5. *Liming Materials*

As productivity improves, calcium and lime requirements of the soils increase. The IFDC should continue to identify, analyze, and establish data base information on limestone deposits, especially in Africa. The agronomy programs should emphasize the need for lime and the role of organic matter in soils with high exchangeable Al.

6. *Economic and Policy Research*

From the beginning of IFDC, the need for economics and policy research was apparent. Skills in the IFDC staff were slowly acquired, but they were not always valued as much as the more traditional skills associated with fertilizer research. Effective research on agronomy, chemistry, and production is necessary to fulfill IFDC's mission, but they are not sufficient. Policy and economics research has an important bearing on rates of economic growth and well-being in the IFDC's client countries. Government policies shape the behavior of consumers and producers through prices for foods, commodities, export crops, and factors of production.

A controversy exists about how much the IFDC, or possibly any international center should be involved in suggesting policies to an LDC, and, therefore, how much and what kind of economics and policy research should be conducted and by whom. An issue behind the controversy refers to the value premises supporting various policies. One value issue concerns the interest in privatizing sectors in economies versus a value that certain sectors of economies should be controlled by the public sector to ensure the

greatest public good. AID has been interested in "privatizing," and there is a strong trend to do so in the world today. The Bangladesh marketing program is an example of a successful IFDC project success in privatizing the marketing of fertilizer (see Appendix A for a further discussion of this project).

Review team members discussed among themselves the desirability of the IFDC, or any international center, doing policy research and attempting to implement broad policies that the IFDC supported. The argument centered on the International Food Policy Research Institute (IFPRI) in the CGIAR system who had as its mandate policy research. It has expert staff and resources to do policy research. Therefore, it should have a comparative advantage over other centers on that topic. Countering this point, it was argued that a center like the IFDC should be involved in certain kinds of policy research and implementation, if its targets gave it an expert advantage over a more general policy-making organization. On the review team trip to Asia, we were told that IFPRI specialized in food policy questions and not fertilizer, and that IFPRI was usually not involved in implementing complicated policy reforms, such as was done in Bangladesh.

The review team recommends that the IFDC remain involved in policy reform programs, such as the one in Bangladesh. It has now developed expertise for doing these kinds of projects, including implementing them. The concerns about setting straight the value premises from which policy reform is done have to be weighed on a case by case basis. If a center has specialized expertise about a commodity, such as fertilizer or a nation or region, then the center should be encouraged to work on policy questions. If, however, the policy questions fall more appropriately into the province of centers especially skilled at policy research, then we would encourage their lead while working in collaboration with national or international organizations that might be more able to implement and shepherd policy reform. In the current instance of IFDC and IFPRI collaboration in West Africa, however, there have been serious problems of lack of teamwork, and this should be dealt with.

The review team recommends that the IFDC attempt more

projects of the type in Bangladesh, but we caution that this project had a fortunate mix of project and donor leadership skills, and government officials willing to try to improve their country's economic condition. If those assets are not present or developed, such projects can be quite risky. Another secret of the Bangladesh project appears to be the development of an exceptional project monitoring system that produces convincing data on the results of each step of implementation. These data led to converts for the policy reforms at all levels from farmers, to fertilizer dealers, to the country's highest executives, and to the donors.

7. *Modeling*

Modeling is a relatively recent addition to IFDC's repertoire of activities. It is still not a large emphasis, but it has increased markedly since the last review. Some of the IFDC'S effort may decrease, because a key staff member was leaving to return to Australia shortly after the review team's visit to the headquarters. The Center has had difficulty retaining good modeling staff.

This topic was controversial among the review team members. Some of the team had been used to working with modelers and seeing models as examples of scientific theories or as means of summarizing many principles into one dynamic picture. Other team members believed the enterprise was best left to other centers who should develop a rice model, a wheat model, etc. The main point was the comparative advantage of having modeling at the IFDC versus some place else, but there was also a question about how useful each member found models to be in general.

The review team did not reach any consensus on the modeling activity at the IFDC. What work we saw presented at Muscle Shoals appeared to be competently done. The modeling staff had used as resources many of the prominent agricultural or ecological models and the Center's models were working. Modeling is more attractive to basic scientists than to persons mainly interested in applications, but models are a basis for producing expert systems and other devices that promise to aid practical applications.

We recommend that the IFDC continue its modeling work, but that it attempt to coordinate with the international centers when working on various crops.

IV. OUTREACH PROGRAMS

The distinction between research and technical assistance is not clear at the IFDC. This ambiguity is not a problem: It simply means that these two areas are intertwined in much of the Center's work. Organizationally, research has primarily been assigned to the Agro-Economic and Fertilizer Technology Divisions, and the Outreach Division has covered technology transfer. In truth, many efforts of outreach involve all three divisions. The Outreach Division is mainly responsible for training and technical assistance and implementing national field programs of adaptive research.

A. Training

If the LDCs are to attain the recommended levels of fertilizer production, UNIDO estimates that an additional 6,400 technical and 2,200 non-technical people per year will have to be trained. When fertilizer marketing and distribution are included, these manpower needs double. Recognizing these needs, the IFDC has committed itself to helping build a pool of trained professionals capable of operating all parts of the LDC's fertilizer sectors.

IFDC training programs are aimed at developing junior through senior level managers and professionals. The Center offers both general and specialized training. Programs having general interest are usually given at the headquarters; programs of regional or national interest are often done in other locations. General courses can be group training or workshops that last between 1-6 weeks. A description of the 1989 training calendar is in Table 5. The list of all general IFDC training program titles, including new programs planned for 1990, is in Table 6. In Table 7 are the names of the specialized training programs for 1988-89. Table 8 shows the number of participants in general or specialized programs by year since 1975. In Table 9 is the average faculty composition for courses at headquarters or

overseas. Table 10 describes the participants' ratings of the 1988 courses, which is a representative year. Table 11 lists the cosponsors of general training programs.

Table 5

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
1989 Training Calendar

Program	Duration	Dates	Location	Fees (US $)
Fertilizer Marketing				
FADINAP/IFDC Regional Training Course on Port Handling of Mineral Fertilizers in the Asian-Pacific Region	3 weeks	April 10-28, 1989	Singapore and Bangkok	-
Data Collection, Analysis, and Projections for Fertilizer Sector Studies	3 weeks	April 17-May 5	IFDC, Muscle Shoals, Alabama, U.S.A., and other locations	1,350
Modern Techniques in Fertilizer Distribution and Handling	3 weeks	June 12-30	United Kingdom, Ireland, Netherlands, Belgium, West Germany	1,500
Fertilizer Marketing Management Training Program	6 weeks	August 14-September 22	IFDC, Muscle Shoals, Alabama, U.S.A., and other locations	2,250
Fertilizer Marketing Training Program	2 weeks	December 4-15	Singapore	900
Fertilizer Production and Technology				
Technical Management of Fertilizer Production Units	3 weeks	October 16-November 3	IFDC, Muscle Shoals, Alabama, U.S.A., and other locations	1,600
Supplying Quality Multinutrient Fertilizers in the Latin America and Caribbean Regions	1 week	October 10-13	Guatemala	560
Fertilizer Supply Options and Constraints in Developing Country Agriculture (French and English)	1 week	November 21-24	Lomé, Togo	950
Fertilizer Use Efficiency				
Computer Simulation for Crop Growth and Fertilizer Responses	2 weeks	May 15-26	IFDC, Muscle Shoals, Alabama, U.S.A.	1,250*
Statistical and Economic Analysis of Fertilizer Experimental Data (French and English)	2 weeks	April 17-28	Lomé, Togo	900
IFDC/Auburn University Soil Testing, Classification, and Fertilizer Management Training Program	1 week	July 17-20	IFDC, Muscle Shoals, Alabama	-

(Continued)

Table 5 (cont.)

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

1989 Training Calendar

Program	Duration	Dates	Location	Fees (US $)
Fertilizer Sector				
IFDC/Purdue University Training Program on Fertilizer Sector Development in Tropical and Subtropical Countries	2 weeks	July 24-August 4	IFDC, Muscle Shoals, Alabama, U.S.A.	950
Finance for Non-Finance Managers in Fertilizer Sector	2 weeks	November 20-December 1	Singapore	900

*Includes needed software.
Dates and locations are subject to change.
Fees do not cover travel expenses or living expenses.

Table 6 IFDC Training Program Offerings

Fertilizer Marketing

Fertilizer Marketing Management Training Program
Fertilizer Marketing Training Program
Fertilizer Distribution and Handling Training Program
Modern Trends in Fertilizer Distribution and Handling Training Program
Data Collection, Analysis, and Projections for National Fertilizer Sector Studies Training Program
Use of Microcomputers for Fertilizer Sector Personnel Training Program
Fertilizer Quality Control Training Program

Fertilizer Production

Fertilizer Factory Maintenance Training Program
Maintenance and Production Management Training Program
Fertilizer Granulation and Bulk-Blending Seminar
Fertilizer Production Training Program
Development of Indigenous Phosphate Deposits Training Program
Fertilizer Process Economics Training Program
Technical Management of Fertilizer Production Units

Fertilizer Use Efficiency

Fertilizer Efficiency Research in the Tropics Training Program
Soil Testing and Soil Fertility Management Training Program
Fertilizer Use Efficiency Research and Technology Transfer Workshop in Africa
Statistical and Economic Analysis of Fertilizer Experimental Data Training Program
Research on Effective Fertilizer Use Training Program
Computer Simulation for Crop Growth and Fertilizer Response Training Program
Development of Effective Fertilizer Recommendations

Fertilizer Sector Development

Advances in Fertilizer and Irrigation Technology in the United States Training Program
Advances in Fertilizer Technology, Marketing and Use in the United States Training Program
Caribbean Workshop on Fertilizer Technology and Marketing Systems
Fertilizer Sector Development in Tropical and Subtropical Agriculture Training Program
African Workshop on Fertilizer Sector Development
Investment Analysis and Decisionmaking--Fertilizer Sector Projects Training Program
Finance for Nonfinance Managers in Fertilizer Sector Training Program
Relevant Fertilizer Supply Strategies Training Program
Workshop on Fertilizer Sector Development and Agricultural Production for Selected Countries in the Mediterranean, Middle East, and North Africa
Fertilizer Sector Development for Graduate Students Training Program
International Workshop--NPK Fertilizer Production Alternatives

Table 7 IFDC Specialized Training Programs, 1988 and 1989

Program	Participants	
	Country	Number
	1988	
Fertilizer Production		
Phosphate Rock/PAPR Production and Use	United States	1
Phosphate Rock Beneficiation	China	1
Phosphate Mineralogy	China	1
Urea Granulation/Sulfur Coated Urea	China	1
Phosphate Fertilizer Production	China	1
Fertilizer Marketing		
Fertilizer Distribution/Handling	Kenya	3
Fertilizer Distribution/Handling	Nigeria	5
Fertilizer Use Research		
Use Efficiency Research Techniques	China	1
Rice Modeling	Philippines	1
Use Efficiency Research Techniques	India	1
Micronutrients	Pakistan	1
Soil Fertility/Fertilizer Use	Madagascar	1
	1989	
Fertilizer Production		
Analysis of Phosphate Rock	Venezuela	1
Phosphoric Acid Production	China	1
Phosphate Rock Characterization	Venezuela	1
Nitrogen and Phosphate Production Technology	Brazil	1
Fertilizer Marketing		
Fertilizer Database Systems	Egypt	5
Development of Computerized Fertilizer Database	Egypt	4
Fertilizer Marketing System	Bangladesh	2
Fertilizer Use Research		
Fertilizer Use Efficiency Research Techniques	China	1
Agronomic Effectiveness of Zimbabwe Phosphate Rock	Zimbabwe	1
Efficiency of Nitrogen Use on Flooded Rice	Egypt	1
Biological Nitrogen Fixation Research Techniques	Panama	1

Table 8 IFDC Training Programs, 1975-89

Year	General Programs		Specialized Programs		All Programs	
	Number	Participants	Number	Participants	Number	Participants
1975			11	20	11	20
1976			19	39	19	39
1977	1	21	17	29	18	50
1978	2	47	13	292	15	339
1979	1	24	16	142	17	166
1980	6	207	18	97	24	304
1981	5	145	16	164	21	309
1982	9	206	17	191	26	397
1983	6	133	12	101	18	234
1984	9	179	13	71	22	250
1985	11	251	15	134	26	385
1986	11	188	27	279	38	467
1987	10	170	16	59	26	229
1988	13	281	12	18	25	299
1989	13	311	11	19	24	330
TOTAL	97	2,163	233	1,655	330	3,818

Table 9. Average Faculty Composition Training Programs (1978-88)

	IFDC Headquarters (%)	Overseas (%)
IFDC staff	50	40
Developing country experts	15	35
International agencies	10	10
Private sector	25	15

Table 10 Participants' Ratings[a] of 1988 General Training Programs

Training Program	Number of Responses	Number Responding: Poor (1)	Fair (2)	Good (3)	Very Good (4)	Excellent (5)	Overall Rating (Mean)
Research on Effective Use of Fertilizers	14		4	7	3		2.93
Fertilizer Distribution and Handling	16				12	4	4.25
Mercadeo de Fertilizantes	14				8	6	4.43
Advances in Fertilizer and Irrigation Technology in the United States	10				6	4	4.40
Investment Analysis and Decisionmaking for Fertilizer Sector Projects	16			3	8	5	4.13
Analisis Estadistico y Economico sobre Uso de Fertilizantes	17				3	14	4.82
Soil Testing and Soil Fertility Management	6				5	1	4.17
Fertilizer Sector Development for Graduate Students	13				8	5	4.38
Fertilizer Marketing Management	30			3	16	11	4.27
Technical Management for Fertilizer Production Units	24			4	13	7	4.13
Fertilizer Marketing (Asia)			1	2	25	10	4.16

a. Participants' responses to question "In general, I would rate this program poor (1), fair (2), good (3), very good (4), and excellent (5)."

Table 11 Cosponsors of IFDC General Training Programs

International Agricultural Research Centers

Centro Internacional de Agricultura Tropical
International Center for Agricultural Research in the Dry Areas
International Institute of Tropical Agriculture

United Nations Agencies

Economic and Social Commission for Asia and the Pacific
Fertilizer Advisory, Development, and Information Network for Asia and the Pacific

National Governments

Ministry of Higher Education and Scientific Research--Cameroon
Ministry of Agriculture and Cooperatives--Thailand
Ministry of Agriculture (Institut d'Economie Rurale)--Mali
Ministry of Agriculture (Centre for Soil Research)--Indonesia
Ministry of Agriculture, Kenya

National Universities

University of Ibadan--Nigeria
University of Nairobi--Kenya
University Pertanian Malaysia--Malaysia
Purdue University--U.S.A.

Fertilizer Industry Associations

Centro de Estudos de Fertilizantes--Brazil
Fertilizer Association of India
Asosiasi Produsen Pupuk Indonesia

National Government Organizations

Bangladesh Agricultural Development Corporation--Bangladesh
Bangladesh Agricultural Research Council--Bangladesh
Farmers Association of Malaysia
Fertilizer and Pesticides Authority--Philippines
National Fertilizer Development Center--Pakistan

The Outreach Division includes training personnel, but it uses all the kinds of specialists of the IFDC staff in training. The specialists are a major source of ideas for training courses. So far, the IFDC has conducted 97 general training sessions for 2,163 participants from 114 countries (Table 8). The IFDC staff forms most of the core faculty for the courses, but the Center draws heavily on expertise from many other organizations (Table 9).

Trainees leave their courses with a mini-library of the latest literature and sometimes with computer software.

Because the IFDC charges for its courses, some potential trainees may be excluded. However, the IFDC works to get donor or organization sponsorship of trainees, and the real loss of trainees who should attend is probably low. About two-thirds of the training programs are funded by LDC organizations, and other donors and cosponsors are supportive (Table 11). The training is often done in concert with with the IARCs, national governments, or industrial institutions.

The IFDC's training was evaluated by the UNDP (a main sponsor of IFDC training) in 1986, and it gave the Center's programs a favorable assessment. Our review team also commends the IFDC's training efforts and encourages its continuation and even expansion.

B. Technical Assistance

Technical assistance is a general term covering a family of activities but mainly referring to the transfer to LDCs of knowledge about fertilizer use, production, supply, and marketing to improve national fertilizer sector operations. Technical assistance is provided in the form of consulting, preparing technology transfer publications, doing economic and policy option studies, demonstrating fertilizer use practices in fields, and other approaches. The targets of technical assistance can be government decision makers, fertilizer manufacturers, parastatals involved in fertilizer distribution, farmers, farmers' cooperatives, fertilizer dealers, bankers, and anyone else in the

fertilizer sector.

The IFDC's general task in technical assistance is to either come up with solutions to problems defined by others or to anticipate problems that need working on. The Center must devise practical solutions that usually require change on the part of some target persons or groups. The solutions must be technically sound, economical, feasible, usually as simple as possible, acceptable by the targets, and associated with good results. Most of the solutions require the help of several disciplines at the IFDC, because solutions usually affect technical, economic, and social systems.

Almost all of the IFDC's technical assistance is done on a cost reimbursable basis, although much of the background information to do good technical assistance is funded by core monies. Technical assistance is usually handled on a project basis, requiring proposals, budgets, and statements of anticipated results. Much of the work is done by senior IFDC staff members. Almost all projects involve collaboration with host country counterparts. It is reasonable to think of these projects as another form of training for the recipients of the service. They learn how to do what the consultant does as a result of working on the projects.

Technical assistance is commonly done in the following areas: fertilizer production, fertilizer marketing and distribution, fertilizer use, and sector planning and institutional development. Many projects involve several of these areas at a time.

Since the IFDC started, about 300 technical assistance projects have been done. Over one half of the total were in fertilizer production. The smallest number of projects were on fertilizer use (10%). Services have been provided to over 150 clients, benefiting about 80 countries. About two-thirds of the projects have been located in Africa and Asia. Over the 15-year life of the IFDC, the greatest involvement has shifted from South America to Africa. The most projects in any year was 39 in 1988.

The IFDC has had good success in getting its projects

implemented in the LDCs. Examples of success in improving fertilizer plant operations are in Brazil, Colombia, Venezuela, Malaysia, Nigeria, and Indonesia. Assistance in improving fertilizer use has been effective in Colombia, Venezuela, Senegal, Thailand, and Egypt. Improvements in marketing and distribution systems have led to important changes in about 10 countries.

The need for IFDC technical assistance should increase. Substantial progress has been made in the fertilizer sector in Asia, but the advances were not uniformly spread across the continent. Some of the more developed countries need less help, but they still request IFDC services (see Appendix A, Asia Trip Report). The IFDC has had to limit its technical assistance because of available staff, but probably the major constraint has been funding for the projects. The Center only does projects for which it can get paid, and there are many potential projects for which no funding has been available.

The type of assistance required from the IFDC will vary depending on the stage of development of the fertilizer sector in a country or a region, but it should be expected that with the increasing maturity of the fertilizer sector in the LDCs, the nature of the technical assistance needed from the IFDC will change. Also, with the new mandates of the IFDC to work on environmental issues and sustainable agriculture, the Center will have to revise some of the premises of its technical assistance.

The review team finds little to criticize about the IFDC's technical assistance. The staff is competent and is seen as a valued resource by LDC clients. The demand for the Center's technical assistance has grown and the reports we received about it on visits with clients indicated that good work was being done. The IFDC is being forced, more and more, to count on technical assistance funding to support its staff, and this can be a source of worry. In Section V, 12 of this report, we discuss this topic.

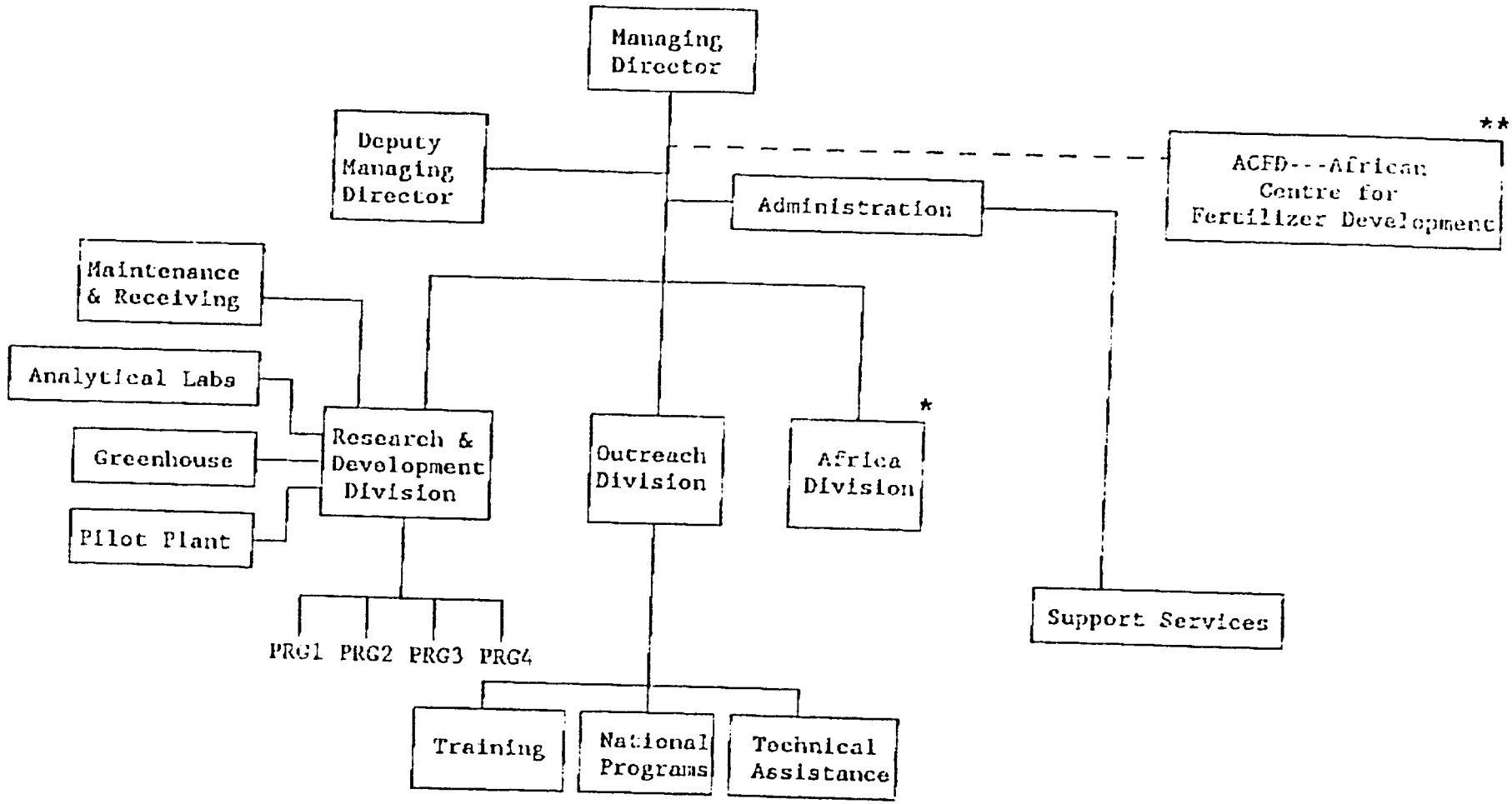
C. African Programs

In 1985 the IFDC Board decided to intensify program efforts

in the region and instructed the center's Managing Director to establish a permanaent presence in the subregion. This resulted in the establishment of IFDC-Africa with offices located in Lome, Togo. For administrative purposes, it is referred to as the West Africa Division (Figure 3). The Division consists of 21 professional staff and about 30 support staff, and is recognized by the Government of Togo as an international institution. The Division is semi-autonomous, but the degree of autonomy has not been clearly defined, and this has caused debate between its Director and the management at headquarters. There is also some discord over funding: the Division claims it has to pay for any services it receives as well as contribute to the overhead of the parent institution. More important than these administrative irritations is the lack of a clear plan for the future operations of the IFDC in Africa, particularly with the advent of the African Center for Fertilizer Development, to be located in Harare, Zimbabwe under the auspices of the Organization for African Unity/Scientific Technical and Research Commission (OAU/STRC). The IFDC aims to serve as the executing agency for the Harare Center for the first 5 years at least.

UNDP through UNIDO is also providing funds for an Egyptian Fertilizer Development Center and the IFDC has been working with this concept since 1987. This center is designed to develop more cost effective fertilizer products suitable for Egyptian farmers. The IFDC will be responsible for providing technical services to determine the feasibility of producing the products. Among the Egyptian Center's equipment, will be a pilot plant designed by the IFDC for making experimental products for market testing. Because this center will be geared primarily for work on the irrigated agriculture of Egypt, it is unlikely to spin off much experience or information that will be useful in sub-Saharan Africa. It is, however, likely to be of major value for serving the developing countries in North Africa and the Middle East.

There is substantial justification for a major effort on fertilizer research in Africa. As pointed out in Section II, B, the continent has fallen far behind Asia and Latin America in its use of fertilizers. Because most of the Africa's agricultural production is non-irrigated, it is exposed to higher risks and is



PRG1 - Natural Resource Development for Fertilizer Production and Sustainable Agriculture
PRG2 - Nutrient Efficiency
PRG3 - Economics, Marketing, and Policy Analysis
PRG4 - Fertilizers and the Environment

* Would carry out activities of IFDC in West Africa.
** Would include East Africa programs. Specific activities of ACFD is yet to be defined.

Figure 3. Suggested Structure of IFDC.

not very productive. Supply and marketing of fertilizers is particularly important, because many of the markets are small and far from ports. In West Africa, for example, only Niger uses more than 50,000 tons of fertilizer per year. At present about 80% of Africa's fertilizer needs are financed on a concessionary basis (soft loans and grants), so donors and suppliers control to a certain degree the kinds of fertilizers made available. The African countries themselves confuse the supply situation, for example, by specifying six different kinds of cotton fertilizers for six countries in West Africa. The differences in the fertilizers are agronomically insignificant, but to require different blends to satisfy the contractual arrangements, substantially adds to the costs. These problems and many others lead to inefficiency in procurement, port handling, storage, transportation, and distribution, and are major factors contributing to the high farmgate prices of fertilizer.

1. Research Programs

IFDC-Africa receives core funding from French, Dutch, and German donors as well as from UN agencies (UNDP and WB). Approximately $400,000 is received annually from these donors for use of core activities of the West Africa Division. These include:

a. *Fertilizer Policy Research Project.* This project, funded by AID, is executed by IFDC with strong participation by IFPRI. An IFPRI economist serves as the leader of a team of three IFPRI and two IFDC staff. Work started in 1988 with a workshop and a review of the literature on fertilizer policy matters. The team is collecting data on the responses of various crops to fertilizers across the different agro-ecological zones and is carrying out economic analyses.

b. *Dissemination of Fertilizer Market Information.* This program, set up the African Fertilizer Trade and Marketing Information Network (AFTMIN). A monthly fertilizer market intelligence bulletin, African Fertilizer Market, has been published since 1988 to provide background information on fertilizer trade and marketing for 40 countries in sub-Saharan Africa. The bulletin is published in English and French.

c. *Communications, Documentation and Training Program.* This program, funded by the Kellogg Foundation, has three main objectives: 1) to improve fertilizer information dissemination in the region; 2) to train national extension personnel in developing fertilizer extension support materials; and 3) to develop pilot projects in using media such as video to increase awareness of soil fertility needs and fertilizer use in the region. Radio Netherlands Television is collaborating with the IFDC in the production of a video on soil fertility and resource conservation.

d. *West African Agrominerals Research and Development Program.* This program is supported by the Federal Republic of Germany and aims to evaluate some of the many phosphate and other agromineral deposits that have not yet been studied in the West African region. Information is exchanged among scientists working on these deposits. This network will start a systematic process that will assess the potential of these deposits for fertilizer use. The network will help develop the geological skills to locate and evaluate the deposits. The network is developing a data base on raw materials and deposits with a potential for fertilizer use. The data base will be a part of the IFDC's regional information service.

e. *Soil Fertility Restoration Project.* This project, funded by several donors, is planned to determine the agronomic, economic, and social benefits of fertilizers and associated soil amendments in three countries of West Africa, Ghana, Togo, and Niger. It will assess the potential of fertilizers to increase and sustain food crop production and farm incomes under contrasting agronomic, climatic, and socioeconomic conditions. The project will cover five years and the villages have been selected to cover three agroclimatic zones. The first year of the project (1988) involved collecting baseline data in the pilot areas. These included information on the farmers, their farming systems, and the perceptions of farmers about constraints to fertilizer use. The surveys in the Ashanti region of Ghana showed that lack of knowledge and costs were constraints to using fertilizer. There was a strong aversion to using organic manure, even though low soil fertility is perceived as the most important

constraint to agricultural production. Trials were conducted in Ghana and Niger to evaluate up to five fertilizer treatments in the villages. In Ghana, a combination of urea, muriate of potash, and single superphosphate appeared to be the most promising fertilizers for food crops, while urea and single superphosphate gave the best results in Niger.

f. *Agronomic Research Program.* The IFDC established a sub-Saharan Africa research network and by 1984 collaborative trials at more than 30 sites were carried out jointly by the IFDC staff and national research staff in 14 countries. The program now consists of the West African Fertilizer Management Evaluation Network (WAFMEN) with 18 participating national institutions from 14 countries in the region. The research program involves on-station fertilizer trials. Meetings are held annually to review and plan the research program. The 7th annual meeting of this group was held in 1989. There are benchmark sites at five stations in Togo (representing different ecological zones) and two in Niger.

In an on-farm fertilizer adoption program, funded by AID and IDRC, results from the on-station research program are verified on farmers' fields. Simple trials with four treatments are conducted over a period of years. The trials are farmer managed, but fertilizer is applied according to the instructions of the researcher. In one village in Niger, fertilizer use increased from 1 to 100 tons in the period 1981-86, without assistance from the government or the IFDC.

2. *Future Plans*

The Africa Division originally planned to have its own buildings. It was given 12 ha of land by the Togolese Government in 1987, but funds for capital development have not been forthcoming and the Center works out of rented buildings. It is converting space in one of these into a small service laboratory. Originally the Division proposed that a pilot plant be included in the capital plans, but wiser counsel prevailed and the idea was dropped. There is already a nearby pilot plant belonging to the Togolese Phosphate office. This plant is under-used because of lack of funding for long term research.

Although the Division is handicapped because it does not have unrestricted core funding, it has been successful in attracting project funding. However, it is almost impossible to develop a long-term strategy with such funding.

From its beginnings, the IFDC has suffered from the perception that the location of its headquarters in the USA biased its program towards the fertilizer industry in that country. At the same time it was always understood that it would have major programs in the LDCs, possibly through the establishment of regional centers. IFDC management is opposed to the idea of granting complete autonomy to these centers and believes that the Africa Division, as well as other outposted personnel, must see themselves as part of IFDC's global strategy of international development. In view of the limited financial and human resources available for fertilizer development, IFDC management believes it is essential that all of these efforts including that of the ACFD in Harare, Zimbabwe, be coordinated and managed from a central location.

One problem with outposted staff is the costs per staff per year. The disadvantages of cost must be balanced with the advantages that outposted staff have in developing local knowledge and contacts and of gradually being accepted as partners in the local research scene.

In its shorter-term plans the Africa Division proposes to:

- Conduct area-specific agronomic research as part of a regional network;

- Conduct agronomic and socioeconomic research to enhance the use of indigenous resources;

- Conduct socioeconomic research to identify constraints to fertilizer adoption, including government policy measures;

- Disseminate relevant fertilizer market information to decision makers; and

- Intensify technology transfer in the areas of agronomics and marketing.

3. Achievements and Their Assessment

Since the IFDC started its agronomic work in West Africa, its research has added considerably to knowledge about fertilizer responses and how different kinds of fertilizers respond under West African conditions. It has to be recognized that many fertilizer trials had been conducted over many years in the region, so there was already a considerable amount of information about fertilizer responses. The IFDC's program has expanded on this knowledge, quantified some of the losses (e.g., from N fertilizers), and widened the range of phosphate fertilizers (ground rock, partially acidulated, and super phosphates) for which information is now available. Perhaps even more important has been encouraging the agronomists of the region to work together, exchange ideas, and improve the standards of agronomic research. While other international centers have given a high profile to plant breeding, and have become role models for the national programs in the field, the IFDC has strengthened national programs in fertility management and has demonstrated its importance in increasing productivity.

The communications, documentation, and training programs of the Africa Division have ambitious, but well thought out, plans. As in most of Africa, library systems are in poor shape in West Africa, and the scientists in the region appreciate the information provided by the Division. Some innovative ideas, such as the use of video for conveying information on soil fertility management to farmers, have considerable potential. The IFDC has a comparative advantage in this area as it is involved in both "R" and "D" and the "D" side of its program encourages work with the end users of the IFDC's knowledge. Farmers need more than instruction about using fertilizer--they need education in the various ways of managing and improving soil fertility.

The IFDC emphasizes policy research in the fertilizer field. While government policies on fertilizer pricing, delivery systems, and advisory programs are important, programs on policy

research seem to be driven more by the ideas and interests of the international institutes, in this case IFPRI and IFDC, than by the interests of the recipient countries.

Because of the role of outside agencies in the funding and supply of fertilizers in West Africa, research into marketing and the elements that make up the costs in delivery to the farmgate is particularly useful. IFDC has built up good expertise in this area through its work in both Asia and Africa and is in a position to supply information about fertilizer supply systems to interested parties.

Visits to the national program in Togo and Niger confirmed that the IFDC programs had worked well with them. In Togo, the IFDC has made small grants to the national program to pay for labor, transport and small items of equipment. These were vital to the national program, but IFDC finds itself walking the very fine line between being regarded as a collaborator in research and being looked upon as a donor. The latter raises expectations of ever increasing help in a number of areas. Relationships between the IFDC staff, International Crop Research Inststitue for the Semi-Arid Trops (ICRISAT), the national programs, and the Tropsoils program have been particularly good in Niger, with ICRISAT providing the laboratory space, the national program the land and staff for collaborative work, and Tropsoils some of the research inputs. This has led to joint publications by staff of all the organizations. Relationships with International Institute for Tropical Agriculture (IITA) appear to have been less good; personalities having played a role in the less than enthusiastic collaboration

Work on new product development for West Africa has been confined to rock phosphates. Partially acidulated rock phosphates have proved efficient in supplying P on West African soils, but their manufacture still requires sulfuric acid, albeit in smaller quantities. This means transporting and setting up the acid plants in areas with a poor industrial infrastructure, if such PAPRs are to be manufactured locally.

The review team supports the IFDC management's stance that the activities in Africa should remain part of the overall

Center's program. The exact roles of the West Africa Center and the proposed African Fertilizer Development Center in Zimbabwe needs to be defined. It is recognized that the West Africa Center has political support at the country level, but ill defined donor financial support at the moment. Whether it will be able to mobilize the essential core support is problematical. Ideally, the Zimbabwe center should constitute part of the African program, but its eventual independence seems to have been underwritten already.

The proposed IFDC management structure of the Africa Division in parallel with the other two divisions, Research and Development, and Outreach, should be operable, but there will need to be a substantial delegation of authority to the Africa Division and a clear definition of the program. The Division will need additional core funding for longer term work. With an assured core, even of modest size, it can continue a substantial program with special project funding.

The AID missions in both Togo and Niger were very supportive of the IFDC's work. The staff there said similar good relations existed with the other missions in the region. The missions would like to give stronger support to the work of IFDC, but are short of funds. The missions would like to know how to follow up the work of the Division. For example, its work has proven that phosphate fertilizers can substantially increase yields of cereals in the Sahel and enhance the productivity per mm of rainfall. Developing an input system to supply the needed fertilizers at the right time and price is a challenge to which the missions would like to find an answer.

D. IFDC in East Africa

In addition to several special projects in East and Southeast Africa, a continuing activity is entitled *Fertilizer Research Program in East Africa.* This research program was initiated in 1987 in 11 East and Southeast Africa countries. The ojective of the program is to find ways to use the indigenous agromineral resources in the region for the manufacture of fertilizers needed to sustain and increase food production. A regional network of geologists and agronomists was formed in 1987 to identify

potentially beneficial agrominerals and to test them for agronomic benefits. A Fertilizer Management and Evaluation Network Workshop with an identified collaborator from each country was held in Nairobi, Kenya in May 1987. A Geology Workshop on Fertilizer Minerals was conducted in Lusaka, Zambia December 8-10, 1987. Proceedings from these workshops contain some of the most current information on fertilizer research and geology, exploration, mining, and processing of agromineral deposits for potential fertilizer use for the countries reporting within the region. The proceedings are making a significant contribution to the knowledge of the region.

Field trials utilizing indigenous phosphates for direct application, acidulated phosphate fertilizers, and partially acidulated phosaphate rock (PAPR) with sulfuric acid are presently underway in eight countries in East Africa. The countries are Burundi, Uganda, Kenya, Ethiopia, Tanzania, Malawi, Zambia, and Zimbabwe.

Field trial results in 1988 and 1989 indicate that the agronomic effectiveness of sulfuric acid-based PAPR compares favorably with other phosphate fertilizers. If these results continue after additional agronomic evaluations, significant savings on importing phosphate fertilizers in those countries with phosphate deposits will be possible. The project was originally funded by UNDP and the World Bank, current funding is from World Bank and USAID/S&T.

E. IFDC in Asia

This section of the report will be shorter than that for Africa for two reasons. First, the IFDC is currently not heavily involved in Asia. Second, these two sections were written by two different team members, and Dr. Hautaluoma, who went to Asia, put many of his comments in a trip report (Appendix A). There is no need to duplicate what is said there, so this section will be a brief summary of IFDC's work in Asia.

In general, the IFDC's presence in Asia is not great. The main work in Indonesia involves experiments on the use of untreated, crushed rock phosphate, primarily on lands destined

for reclamation. The work is being funded by an American company, and is being done in collaboration with the Crop Soils Research unit of the Indonesian Ministry of Agriculture.

Another influence of the IFDC in Indonesia is the USG briquetter, designed for use by farmers' cooperatives. The briquetter will produce super granules of approximately 1 gram urea for hand deep placement by the farmers in rice fields. The use of the briquetter and the deep placement technology, which had been introduced by the IFDC, has been mandated by the highest levels of the Indonesian government, and the practices are currently being implemented. It is expected that over 2,000 briquetters will be manufactured and used by the farmers' cooperatives within a short time.

The IFDC project in Bangladesh is a very successful policy reform effort aimed at fertilizer marketing. Its main thrust has been to design and implement policy reforms in marketing and distribution leading to private enterprises selling fertilizer. The project has existed for several years, but recent changes have led to remarkable results in fertilizer use and price, and consequent increases in food production. The project was recently nominated by AID/Bangladesh to receive The Seventh Annual Presidential End Hunger Award.

The last visit in Asia was with the FAO's Fertilizer-Advisory, Development and Information Network for Asia and the Pacific (FADINAP) representative in Bangkok, Thailand. He said favorable things about the IFDC and acknowledged that more cooperation between the IFDC and FADINAP on training and regional and national program development would be good for both institutions.

Overall, it is not surprising how little IFDC work is going on in Asia, in view of the fact that the IFDC board decided, in 1985, that the Center would focus a major portion of its resources on sub-Saharan Africa. In Indonesia, the research is managed by Indonesian counterparts and a member of the IFDC staff who visits tow to three times a year. In Bangladesh are two outposted IFDC headquarters staff persons and an IFDC Chief of Party, contracted for the job, plus about 100 Bangladesh staff.

In Indonesia, and again in speaking with FADINAP, requests were heard to have a semi-permanent IFDC staff person posted in Asia.

The IFDC has a staff member outposted at International Rice Research Institute (IRRI) in the Philippines, and this has been a long-term relationship. The review team did not have a chance to see the work there, but in the past it has produced important information on N losses on lowland rice.

V. TERMS OF REFERENCE QUESTIONS

Although many of the Terms of Reference questions to the review team are touched on in the rest of this report, this section will directly respond to each question. The answers will be brief and reference will be made to other parts of the report for augmenting information.

1. Is the general mandate "To assure a dependable supply of better fertilizers at a lower cost to farmers in LDCs' still valid today? In general, the mandate is still valid. The review team recommends that a greater emphasis in the mandate be placed on sustainable agriculture, soil fertility in a broad sense, and environmental concerns. Dealing with these points should make the Center more attractive to donors and the CGIAR system. These points have already been highlighted for future attention in the IFDC's strategic plan.

To account for some of the inherent inconsistencies of providing a dependable supply of fertilizer with issues such as environmental concerns will require new means of calculating long-and short-term costs and benefits. These costs should include social costs that should not necessarily be borne by the farmers alone.

Additionally, an assumption about agriculture sustainability is that inputs should be low, which means low use of inorganic fertilizers among other things. But lower inorganic fertilizer use usually means lower food production. Organic materials have desirable attributes, but they are not always easy to obtain or to use for LDC farmers, and by themselves do not satisfy concerns about sustainable soil fertility. These issues from incorporating the new emphases in IFDC's mandate will be difficult to deal with, but they suggest many different kinds of topics and approaches for the IFDC to use in its research.

The review team recommends that the IFDC include in its mandate a concern for restoring poor soils to fertility. These

lands are in most of the LDCs, but noteworthy examples are in Africa and the Alang-Alang lands in Indonesia. The lands targeted for restoration should not currently be forested or have environmentally sensitive ecosystems. The TAC recommends examining intermediate input lands that could be adopted to crop varieties with some use of biocides and simple improvements in water control. The recommended fertilizer needs for such lands would be about 50-100 Kg of N + P_2O_5 + K_2O per ha per year. Rates in the U.S. and Europe exceed these numbers, and rates in Asia are within these bounds. The rates for Latin America are a little short of the desired minimum and African rates are well below it. Some of the work on restoring lands should be done in cooperation with the International Agricultural Research Centers (IARCs), but the IFDC can make unique contributions by generating fertilizer research and innovative use practices.

The appropriateness of the IFDC's mandate and mission should be periodically reviewed through comprehensive strategic planning exercises.

2. How has the program been adjusted to address recommendations made during the last in-depth review? The last AID review was done in 1983. That review included the following recommendations. The Center's responses and the present review team's recommendations are described.

a. Shift more budget to upland crops and vegetables. This has generally been done for upland crops. The Center has not done much on vegetable crops. The review team recommends additional work on crops, including vegetables, that can generate cash income for small farmers.

b. Include soil characteristics in fertilizer evaluations. The IFDC has always done this and it is now doing it more completely than before.

c. Do more planning in fertilizer product evaluation. The Center has paid greater attention to farmers' reactions to specific fertilizers and to product responses in specific agroclimatic zones. Crop models have been

used to identify information gaps and to synthesize knowledge.

d. Have greater focus on modeling. The Center has become active in modeling (see section III, 7 of this report). As mentioned in that section, the review team is not of one mind about recommendations for modeling.

e. Expand economics research activities. This has been done (see section III, 6 of this report). The Center plans to increase this function further.

f. Staff (especially Technology Division) should have more contact with international companies. With the increase of reimbursable project funding, the staff have increasingly met more people from other organizations. The IFDC has encouraged specialists from Europe and other places to take sabbaticals at the Center. Some of the review team still thought the IFDC staff should attend and present more papers at international fertilizer conferences and publish more in professional journals.

g. Continue to do reimbursable projects if they are consistent with the IFDC's mission. The proportion of funding for the IFDC from these kinds of projects has been increasing (see Section II, D of this report). The work on these projects is consistent with IFDC's aims. Nevertheless, the IFDC staff should continuously try to increase core funding.

h. Repair and replace equipment. The Center has done as much of this work as the budget will allow, but they have large needs for updating their scientific equipment and for maintenance on their buildings. The Center is 13 years old and much of its equipment is not current enough. The staff described a need for $2 million to replace analytic equipment and research equipment. An additional $1 million is needed to replace much of the heating, air-conditioning, and distilled water equipment in the main building and to

repair the roof and continue sand blasting and painting the pilot plant building. These are serious needs and they will start to adversely affect the Center's productivity if they are not dealt with in the next few years.

i. Develop new production technology. Limited core funding has precluded much work on this recommendation. The Center has worked on briquetting and compaction, partially acidulated and other beneficiating methods for phosphate rock, and other significant projects.

j. Offer more non-English courses. This has been done, especially in South America and Africa. English is still primarily used for training in Asia and at headquarters.

k. Increase activities of the Outreach Division. Technical assistance and training are the fastest growing programs at the IFDC. The capacity of the present staff is almost completely taken up with current activities.

l. Conduct more outreach activities overseas. Over one-half of all training is now done overseas. The number of staff posted abroad has tripled since 1983.

m. Do more technical assistance and training on lowering costs of marketing and distributing fertilizer. Most of the technical assistance and much of the training is on this topic. Courses have been added since 1983.

n. Help needy participants to receive training. The IFDC offers 3-7 scholarships per course, but is financially limited in its ability to do more. The IFDC offers some scholarships per year, but its finances limit its ability to commit major funds. The Center rotates countries in which courses are held, so participants can more easily attend. The Center has sought financing from external donors for students.

3. Have less productive activities been dropped or given less resources? How have the changes been initiated? Work has been dropped on S-coated urea, research on phosphate mini-granules using the pinmixer, and investigations on phosphate processing using the Clinker process. The work on basic N transformations and loss mechanisms has been reduced, although this work certainly has been productive. Resources have been shifted from Latin America and Asia to sub-Saharan Africa. Availability of donor funds has been a driving force in many of the decisions. The Center's management has chosen to focus its limited resources to obtain the largest effect and to not attend to other more developed topic areas, although these still have work to be done on them.

4. What are the IFDC's most significant accomplishments? What are their likely effects in 5, 10 and 20 years? The IFDC produces information. It attempts to be a catalyst and to present information in systematic ways. It has earned a reputation as an honest broker and a credible source of expertise. LDC and fertilizer researchers worldwide rely on the IFDC for trusted information on fertilizer technology, use, marketing, and policy. The Center has helped find deposits of fertilizer materials, designed ways of using the materials, determined economical fertilizer use practices for specific conditions, assessed users' responses to fertilizers and practices, and helped design and implement policies. Most of these kinds of information and activities have been used by national, regional, and donor decision-makers to obtain gains that would not have occurred without the IFDC's help.

Examples of influential work are many and include: (a) economic studies in many countries that give policy makers options about uses of mineral deposits, start up of new plants, production practices, farmer use practices, etc.; (b) lowland N research on losses and ways of curbing the losses have had strong implications concerning foreign exchange; (c) work on finding and characterizing phosphate rock, and determining ways to best process it for use in local areas, should have a profound effect on LDC economics; (d) building data networks about phosphate rock will improve knowledge for the whole world about this resource; and (e) the relatively new S and micronutrient research promises

to influence food production. The micronutrient work would probably not be done elsewhere, because it is not likely to lead to a high volume of sales for private industries.

The IFDC is one of the main organizations most interested in objectively representing the needs of the LDCs in the fertilizer world. The Center continues to look for questions and answers about fertilizers relevant to LDCs' needs. No other organization includes the spectrum of research, consulting, training, maintaining information repositories, and disseminating information that the IFDC does. Fertilizers will continue to be an important input in increasing food supplies, and questions surrounding their use will become more important as population pressures increase and environmental and agriculture sustainability questions become more difficult to deal with.

Many of the long term effects of IFDC's work are in the person of their trainees: the Center has conducted over 330 training programs for about 3,700 trainees in over 120 countries. These trainees are multipliers of the information available from the Center, and some of the review team heard many positive reports about the IFDC's training programs. The IFDC will continue to have about 10-12 training programs for about 250-300 trainees per year.

Some of the technical and other advancements of the IFDC show promise of having a long-term effect in many countries. The small scale briquetters used to make USG are already being implemented nationwide in Indonesia, and this program will be watched with interest by other countries. The research on S is likely to lead to legislation requiring S in NP and NPK fertilizer in some countries. The phosphate rock research has wide ranging implications for much of Africa and other countries as well. The work on heavy metal contaminants in phosphate rock will influence decisions on acceptable manufacturing technologies. The Bangladesh marketing and policy reform project has been so successful, that it will probably be used as a prototype for similar efforts elsewhere. The IFDC main effort will be concentrated on Africa, but the review team recommends continued attention to Asia and Latin America too. Although progress in fertilizer has been great in Asia, it still is the

part of the world where improvements affect the most people.

The IFDC staffs' estimates of the impacts of IFDC programs in different areas over the next 10-20 years are seen in Table 12.

Table 12
Anticipated Long-Range (10-20 years)
Impact of IFDC Programs

Area of Impact	Impact		
	Asia	Africa	Latin America
Fertilizer Supply Aspects			
Improvements in:			
▪ Fertilizer production/efficiency			
nitrogen	H	L	M
agrominerals	H	M	M
▪ Fertilizer production/environment			
nitrogen	H	L	M
agrominerals	M	H	M
▪ Fertilizer marketing assessment (imports, storage, distribution, and policies)	H	H	M
▪ Fertilizer pricing policies	H	H	M
▪ Fertilizer AID policies	L	H	L
▪ Balanced fertilization	H	M	M
Fertilizer Use Aspects			
Improvements in:			
▪ Nitrogen efficiency/environment	H	L	M
▪ Use of agrominerals (P and S)			
--In general	M	H	M
--In connection with environment	L	H	M
▪ Fertilizer adoption and use	L	H	M
▪ Fertilizer policy - general	M	H	M
▪ Modeling	H	M	M
▪ Institutional assistance/development	L	H	M
▪ Training			
--Fertilizer use efficiency	L	H	M
--Product decisions and environment compatibility	H	L	M
--Policy issues in fertilizer-sector development	M	H	M
--Efficient fertilizer market development	M	H	M
--Strengthening women's role in sustainable agricultural development	M	H	M

a. L = low; M = medium; H = high.

5. What is the contribution of the S & T/AGR core grant to the IFDC program? These funds have been instrumental in helping the IFDC follow a consistent strategic course. They have given stability and flexibility to the Center's work. In research, the Center has been able to initiate research that has global or regional implications. This research is often followed by reimbursable projects in specific countries. Core funds were used to fund the phosphate rock data base, to develop new phosphate rock characterization and processing techniques, to improve physical properties of fertilizers, to do agronomic and economic studies on non-conventional fertilizers from indigenous resources, to collect information on world and regional fertilizer supply and demand and prices of raw materials and fertilizers, and to study farm-level constraints to fertilizer usage. For technical assistance, core monies have been used to maintain databases at headquarters. The information in the databases is transferred to the LDCs. Core monies help maintain the library and to produce publications and visual aids. The training facilities and supplies are funded by core funds. The networks of IFDC, primarily in Africa, are partially funded by core dollars.

6. In which countries supported by AID has the IFDC had the greatest impact? The IFDC has worked in some way with nearly 100 countries, but the greatest impact has been in Bangladesh, Indonesia, Colombia, Brazil, Kenya, and Cameroon. The large economic and food production benefits for Bangladesh are described in Appendix A, as are some of the effects on Indonesia. The work in Indonesia has led to a large national briquetting program. The Colombia work has been long term and mainly on phosphate. The IFDC helped assess local rock, did pilot tests, designed production plant modifications, and evaluated local rock for direct application. Similar work was done in Brazil, and the IFDC also helped establish a national fertilizer research center (CEFER) there. In Kenya, several IFDC technical assistance missions led to a transition from a public to a privately controlled fertilizer marketing system. The IFDC also helped train fertilizer marketing people and establish a data collection and analysis unit in Kenya.

7. <u>What is the interaction with other programs sponsored by S&T/AGR? Is the IFDC program aimed at sustainable agriculture?</u> The IFDC researchers have made strong efforts to interact with researchers from Tropsoils, IBSNAT, and NIFTAL. The interaction with Tropsoils has occurred primarily in Indonesia, Peru, and Niger. In Indonesia the interaction took place through the Center for Soils Research. Similar interactions occurred about phosphate trials in Peru and Niger.

The interaction with IBSNAT took place about modeling research. The IFDC also collaborated with the USDA-ARS crop modeling groups in Texas and Michigan State University on this effort.

The IFDC has had some, but only a limited, interaction with NIFTAL about fertilizer to serve as carrier of the rhizobium inoculum. The IFDC probably dropped this work too early.

Many segments of the IFDC program are aimed at sustainable agriculture. The work on N losses and ways to curb them is an example. The studies on finely ground indigenous rock phosphate in the Soil Restoration Project in West Africa is another example. Recently, the Center increased its work on the impact fertilizers have on the environment. Investigations on nitrates in groundwater in India, Pakistan, Indonesia, and Egypt will start in 1990. In addition, assessments will be made on the importance of fertilizers relationships to greenhouse gases. The presence of heavy metals in fertilizers will also soon receive attention.

8. <u>What is the interaction of IFDC's program planning and AID bureaus and missions, particularly the Africa Bureau?</u> The IFDC's senior management has regular and frequent contact with the African and Asian Bureaus, and less contact with the Latin American Bureau. It makes regular contact with missions in countries where major projects are underway. Currently, IFDC works most closely with the Africa Bureau on the IFDC/IFPRI Fertilizer Policy Project and the Soil Restoration Project, both funded by the African Bureau. Regular contact with AID mission staff takes place in Kenya, Mali, Niger, Togo, Zimbabwe, Zambia,

Malawi, Bangladesh, Pakistan, the Philippines, and Guatemala.

9. What is the interaction of the IFDC with the CGIAR centers? A central part of the IFDC's strategy in developing new or improved fertilizers and practices is to work jointly with the IARCs on the crops within the IARCs' mandates. The IFDC has approached IRRI, CIAT, *Centro Internacional de Mejoramiento de Maiz y Trigo* (CIMMYT), IITA, ICARDA, ICRISAT, CIP, and West African Rice Development Association (WARDA) about this interest. Early, the IFDC started working with IRRI on N research for rice and this work has had good consequences. A similar relationship was struck with CIAT on phosphate research for pasture and bean crops. Then the IFDC started working with ICRISAT in Hyderabad and in its subcenters in Niger and Zimbabwe. The IFDC has permanent staff posted at IRRI, CIAT, and ICRISAT, and their staff are usually melded into the host centers' staffs. There have been many joint publications with these three centers, and IFDC headquarters staff visit the centers often. In the past the IFDC has had staff posted at ICARDA and IITA.

10. How has the IFDC shaped or been shaped by national programs? What networks have been created or employed to strengthen national programs? IFDC researchers and consultants work closely with national programs and networks, and the Center places major importance on developing strong national programs. It works with only a few national programs at a time because of limited resources. The most successful work with national programs has been in Bangladesh, Indonesia, and Colombia. The work just starting is mainly in West Africa. A prior network on utilization of agrominerals in Latin America is no longer active, due to lack of funding. The IFDC supplies materials for testing to the International Network on Soil Fertility and Sustainable Rice Farming (INSURF) in Asia. Some of the networks in Asia and Latin America are connected to other international centers.

11. Is the balance of efforts allocated to research, technical assistance, training, and information appropriate, considering the available resources? Are economics, policy, and social issues adequately covered? The percentage allocation of core funds by category for 1986-90 are shown in Figure 2 in Section II, D of the report. The largest portion, 28-35%, is for

administration. The next highest 17-21% has been for plant nutrition research. The amount for technical assistance is 8-10%, but much of the expenditures in the total budget for this item comes from reimbursable projects. Socioeconomics research is increasing from a low of 8% in 1984 to 15% of the core budget in the last two years. According to the IFDC's strategic plan, more effort will be devoted to economic, policy, and social issue work in the future.

12. Are the current sources of funds permitting a cutting edge program, or has the program been pressed to yield certain successes? Is the funding pattern similar to the CGIAR IARCs? Is the IFDC presenting itself adequately to donors and users of its services? These questions are complicated, and they are partially dealt with in Sections II, D., and V, 5, 11, 14, 16, 17, 19, 20, and 30. The increasing use of restricted or special project funds to maintain the Center's staff can cause problems, but the difficulties are not pronounced yet. Should the proportion of core funds drop too much, however, the Center could be driven off its strategic plan by its primary need to perform services as required by clients. Fortunately, this has not yet been the case, and the restricted projects the Center has taken fit within its aims. The problem is that restricted funds are less predictable and are not consistently available. This can lead to demands for staff that vary greatly and could make it difficult to keep critical expertise at the headquarters.

The review team does not know the funding pattern of other IARCs, so we are not able to evaluate how the IFDC's funding pattern compares to theirs.

The issue of how well the IFDC is doing in its public relations function is discussed in section V, 14.

13. Has the impact of IFDC's research, development, and technical assistance been adequately measured? In general, because of limited core funds, a low priority has been given to evaluation studies of programs. Also, because many IFDC studies have very long-time effects, after projects are finished, the impacts are often difficult to measure.

One example of good program assessment is the Bangladesh policy reform and marketing project. It was especially praised by the AID mission and Bangladesh government officials for the comprehensive data supporting its changes. The effects were in tons of fertilizer used, fertilizer availability, prices to farmers, money saved for Bangladesh, and, indirectly, food production. The work in Colombia produced a cost-effective phosphate rock, leading to use of the rock by farmers, with attendant food production increases.

IFDC's research has been widely cited and used, especially on N losses and phosphate characterization. This citation and use is an indicator of successful research.

Work on technical assistance is hard to evaluate, and the market place is often the best evaluator: if you are asked back or if your advice is increasingly sought, you are probably doing a good job. It is fair to say that one of the outstanding assets of the IFDC is the credibility it has earned among knowledgeable professionals and LDC clients. The Center's staff members are seen as trusted experts who do good, objective work. The IFDC has had to earn acceptance by producing thorough and important evidence. It does not have the advantage of being a donor who can encourage LDC clients to accept ideas for fear of losing a funding source.

The training by IFDC is well-evaluated. The trainees' attitudes toward the training are measured shortly after their attendance and almost all the indices are favorable. Assessments are also made of the impacts of training after the trainees have had a chance to use their learning. The IFDC received high marks on the evaluations and information that the training had led to career progress and to other positive changes affecting fertilizer use and practice in the trainees' countries.

The evaluations of the effectiveness of the IFDC's publications revealed that the LDC clients placed the highest value on IFDC publications of any from the IARCs. In 1989, over 600 additional persons asked to be added to the list to receive the *IFDC Report*. Over 8,000 names are already on the list.

14. Has the IFDC adequately presented its programs and capabilities to donors, LDCs, and potential cooperating institutions? Numerous presentations have been made to a broad range of donors, LDC officials, and potential cooperating institutions. The senior staff has as a major part of their job making contacts with potential enablers of the IFDC or users of IFDC information. The Managing Director and others have made special presentations at many conferences.

The Center has an extensive list of public relations pamphlets and other materials it liberally dispenses to advertise itself. Visitors to the Center are usually shown an audio visual presentation on the IFDC and its capabilities.

Despite serious efforts and good intentions, the activity in dealing with certain donors, country officials and others has not been as effective as might be hoped. The Managing Director in the last several years began to feel frustrated in dealing with certain groups in the network of contacts he should maintain, and he neglected some of them at the expense of dealing with more promising and responsive groups. Some of the lack of receptiveness to IFDC, has to do with the IFDC being seen as an American Center, funded primarily by AID, and having too close ties with industry. Donors of certain kinds were not interested in treating the IFDC as if it was a true international center, and this made contacting these donors an unfruitful experience.

The review team recommends the IFDC attempt to communicate itself differently from what it has been able to do in the past. It has to change its image in key ways. Although the Center's work has been good, and even outstanding, there have been strong perceptual biases against it, which have prevented the IFDC's easy acceptance into the family of other international centers and donors.

15. Are the IFDC publications appropriate for their purpose? The IFDC is aware that its most valuable product is disseminated information. The Center has a well-established communication unit, which is fully capable of publishing useful and timely literature. The publications include technical bulletins, reference manuals, annual reports, proceedings of symposiums and

workshops, a paper series, promotional booklets, and fertilizer situation reports. IFDC publications are entered in the "Books in Print" database and are cataloged by the Library of Congress. A brochure listing of all of IFDC's publications is distributed to each entry on the mailing list and any one else requesting a copy.

IFDC's publications are distributed to a wide audience, including scientists, fertilizer industry executives, donor representatives, educators, extension representatives, government officials, the media, and libraries. The IFDC quarterly newsletter, the publications list, and all promotional booklets are distributed to approximately 6,500 entries on the mailing list. The annual report is received by a select group, numbering approximately 2,000. The scientist or engineer who authors a special publication, such as a technical bulletin, determines the distribution of that publication. In addition, IFDC exchanges publications with more than 95 libraries.

Since its inception, the IFDC has produced 396 publications, including 34 technical bulletin, 7 reference manuals, 12 annual reports, 11 special publications (including proceedings), 11 paper series, 6 promotional publications, 4 fertilizer situation reports, 127 professional journal articles on nitrogen, 81 on phosphorus, 13 on sulfur, and 94 journal articles on miscellaneous subjects. These publications are important resource materials for LDC researchers, policymakers, extension workers, and others. The communication unit also prepares slide presentations for professional conferences, poster presentations, and training or resource material in fertilizer, technology, marketing, and use. The unit prepares news releases for mass media coverage.

The target audiences of IFDC's communications program include a wide variety of donor representatives, scientists from other research institutions, fertilizer industry executives, educators, extension representatives, government officials, and the media.

An audience's preference for publications depends on its particular expertise and background. Donor representatives and

government officials may be most interested in the annual report or newsletter. Scientists and fertilizer industry executives are more interested in technical bulletins, reference manuals, proceedings of symposia and workshops, and the paper series. Among the most popular publications are the technical bulletins, with fertilizer supply and demand studies attracting the greatest interest. *Energy and Fertilizer: Policy Implications and Options for Developing Countries*, has been especially popular. Among the reference manuals, the *Fertilizer Manual* has received the highest rating. The most popular reprints on N have been those relating to N transformations and for P those concerning the use of indigenous resources.

A recent survey by the Aspen System Co. indicates that IFDC information is the most desired of any of the IARCs potential LDC users. In addition to print publications, the IFDC has assisted organizations in developing countries in acquiring translations of the film, *Making the Most of a Miracle*, which was produced by the Fertilizer Institute.

Although it is expensive to produce high-quality videotape programs like that produced by the Africa Division, video represents another excellent medium for the transfer of technology to the developing countries, especially via state-owned television stations.

Because of the easy access to radio in the LDCs, the IFDC should investigate using that medium to transfer its technology.

Whenever possible, the IFDC should work in collaboration with organizations in the developing countries to avoid misunderstandings and to ensure that the communication products meet the needs of the client and do not offend any particular culture.

Audiovisual programs can be useful. The IFDC's activity in this area has been limited to the more inexpensive slide/tape modules. Presently, the IFDC has for sale 20 slide modules of training resource material on fertilizer technology, marketing, and use. These modules cover subjects such as the functions and sources of fertilizer nutrients and other topics of interest to

fertilizer-sector personnel of developing countries.

16. Are the 2- and 10-year strategic plans valid for what needs to be done in the LDCs? In 1986 the IFDC Board of Directors asked that the Center develop a 10-year plan of priorities. The Board was responding to its sense that the Center should account for changing emphases and needs in agriculture in the LDCs. The Managing Director appointed a Center-wide committee to prepare the plan. The committee was made up of staff below the executive level. It worked diligently.

The committee determined that the general mandate of the IFDC was still effective, but that several issues should be considered in the IFDC's projected work. One condition they accepted in their plan was that the land available for farming in the LDCs was limited and, therefore, more food production had to come from existing lands. This point enhanced the importance of fertilizer effectiveness research and increased concerns about sustainability. Salinization and erosion of soils become more critical issues than they have been in the past.

Additionally, the economics of most of the LDCs include serious problems of unemployment and limited foreign exchange funds, so efforts to aid national self sufficiency in fertilizer and food production will be important. These concerns highlighted the need for more complete economic analyses of options to be considered by the IFDC in relation to national programs. The plan mentions the need to expand IFDC's work on cash and nonfood export crops.

The planners saw an increasing need for work on supply and demand constraints to fertilizer use, and the need to design policies to relax those constraints. They thought it important to target certain countries having special problems of adjusting to changes in the world and regional economics, especially in Africa.

The plan considered how to use the rapidly advancing communication technology to train, transfer technology, and disseminate information.

The plan recommended work on all these issues along with changes in organizational staffing and structures, and increased links with other international centers, national programs, financial institutions, donors, and others.

The pattern of funding will determine what the IFDC can do about the plan. If the Center becomes a member of the CGIAR, core funding should stabilize and may even increase over current IFDC projections. If the Center follows the current trend toward a higher proportion of its budget in reimbursable income, some of these aims will be driven by what the donor or user will pay. Primary reliance on reimbursable funds could change the nature of the Center to look more like a consulting firm than it is now. The proportion of core funding probably has to be higher than it is likely to be for the IFDC to do work that is more directed by the strategic plan than the market. Reimbursable projects with relatively long lives (3-5 years) offer some of the stability associated with core monies, and they allow more stable projections of needed staff levels.

The Center itself, and the review team concurs, that the IFDC should: (a) seek renewal of key projects early enough to help organizational planning; (b) seek funding from donors for at least three years at a time; (c) aggressively seek funding to fill in gaps left by terminating projects; and (d) maintain financial control to improve planning and promote funding stability. The IFDC staff also must do more marketing of its capabilities, hire needed staff from reimbursable funds even if they are not covered by core monies, and use more consultants to deal with short-term needs. The expansion of the regional centers in Africa are going to strain the IFDC's budget and may influence some of the strategic initiatives the Center would like to accomplish.

The two-year plan has some interesting points, including a change in the organizational structure of the Center (see Figures 1 and 3). The Board of Directors has deferred its approval of the plan until the new Managing Director has had a chance to influence it.

The review team appreciates the planning effort of the IFDC

staff, but the work has not been done without the advice of planning professionals. Some of the aspects of planning that should be covered in planning by the top staff are (a) descriptions of the Center as a part of a system, including its enablers, users of its products, competitors, and detractors. The system should be examined to learn of the expectations these key groups have for the Center. These expectations should be assessed to see if they are being dealt with by the Center: (b) the mission of the Center should be described, including the results of step (a) above and the conceptions of the Center held by the IFDC's staff themselves; (c) an assessment should be made of whether the IFDC is fulfilling its mission. The review of this team can be part of that assessment; (d) the strengths and weaknesses of the Center should be determined, relative to its competitors; (e) the opportunities and threats to The Center's existence in the future should be assessed; (f) the vision of the best possible IFDC should be created; and (g) from each of these steps should come potential action steps describing a strategic plan. Although, the planning committee did good work, it did not truly produce a strategic plan. The plan they made is a good effort and the review team found little to criticize about it. The next cycle of planning should include more of the steps described above, and should include representatives of donor groups, IARCs, and national programs to help in the planning. Appointing working groups that would concentrate on specific topics of the plan, and who would report back their proposals for action to the rest of the staff, would also be useful.

17. Is the IFDC operating within its budget and income? In general, yes. The Center has to live within its means, because it has little capacity to carry a debt. The annual budget is based on expected income. Because the Division Directors have to estimate incomes, there are times when expenditures have not matched incomes. Expenditures are carefully monitored to minimize this problem. The accounting department tries to get monthly reports out by the 10th, so the remainder of monthly expenditures can be controlled accordingly.

Adjustments to expenditures have not often affected staff, but a serious income short-fall in 1985 led to salary cuts and a 10% staff reduction as well.

18. Is there adequate financial, facility, and inventory control? The IFDC generally uses standard CGIAR accounting and financial practices, but because the former Managing Director and his Administrative Director had worked together for many years, they developed some personalistic budget management approaches. There is not a hint of a problem with what was done, but the approaches seem very dependent on the personal knowledge that these two persons had about the financial management at the Center. The former Managing Director is not now available, and the Center is almost too reliant on the expertise of the Administrative Director. She has done a fine job, but having this expertise concentrated in one person, rather than more widely shared, puts the Center in jeopardy. The review team believes this situation should be corrected. Even other top-level staff professed a lack of knowledge of how certain financial matters were handled at the Center, and this signaled a need to change the practices so they can be followed by other persons should the Administrative Director leave the Center. Again, we want to reiterate that there is no suggestion of wrong doing, only evidence of the lack of a sound financial management practices. The IFDC is regularly audited by an independent accounting firm.

19. Are there any problems created by special record keeping requirements of Donors and Contractors? The IFDC is geared to dealing with donor and contractor requirements. For reimbursable projects, the project proposal process usually covers record requirements, and expected records are discussed. Although requirements vary among donors, this is not a problem for the IFDC.

20. How much support has been provided by various donors over the last five years? What funding pattern is anticipated over the next five years? The income sources of the IFDC for 1984-89 are in Table 4, Section II, D. The S&T/AGR, AID was one of the original sponsors of the IFDC, and provided the bulk of funds for the original physical facilities and equipment, as well as yearly contributions to operate the core programs. Multinational organizations, such as the Australian Development Assistance Bureau (ADAB) and the International Fund for Agricultural

Development (IFAD) have been major contributors. The UNDP has been a continuing donor since 1979 to the IFDC's N research and training work. Other multinational donors are the World Bank, The Kellogg Foundation, and the Rockefeller Foundation.

It is expected that the IFDC's funding level will grow over the next five years, and unless there is a change in pattern, the reimbursable projects portion will grow the fastest.

21. Are all the IFDC's activities self-supporting? Is the cost of publications covered by the charges for them? Is full cost recovery of publications desirable? Could other service charges be increased without hurting the program? Technical assistance projects are done on a full cost recovery basis. This recovery includes an administrative fee. On projects where the scope of work is relatively indefinite, an actual cost approach is used. In other cases, the project's budget is based on the estimated costs of a specific service. The IFDC refuses projects on which it cannot expect to recover its costs.

The IFDC charges a fee per participant for training. The UNDP and other donors help support training costs, and the IFDC training is generally self supporting. Core monies allows the IFDC to maintain and operate the training center, the costs of which are not fully covered by training fees.

Publication fees depend on the individual publications and mailing costs, so the developing countries often pay more for publications than the developed countries. The Center needs to resolve the unfavorable impression of charging the people of its mandate area high rates for information that is intended to serve them. IFDC should re-examine its policy on pricing of publications and consider adopting a pricing policy similar to other IARCS, that is, assessing a lower fee for developing countries than that charged to developed countries. In cases where the LDC professionals do not have the foreign exchange to pay for publications, the IFDC occasionally tries to supply these free of charge. However, because of scarcity of funds at the Center this is becoming increasingly difficult to do. This policy has become an issue particularly when joint publications are developed with the CGIAR centers. This problem needs to be

resolved. As pointed out in the 10-Year Plan, another possibility is to distribute IFDC's publications through regional distribution points, such as Fertilizer Association of India (FAI), Bangladesh Chemical Industries Corporation (BADC), CSR, ANDA, etc.

It is difficult to predict the demand for a publication, so it is not easy to know how much to charge. Attempts are made to recover some costs, but the loss of knowledge transfer from withholding publications, or even discouraging requests from LDC clients, is probably worth more than what would be gained from charging more money for the publications.

22. Is the organization of the Center adequate to meet program needs? Recent changes affecting the IFDC have led to changes and proposed changes in the IFDC's organizational structure. The two-year plan of the Center proposes a revised structure (see Figures 1 and 3). The primary change is that there would be three revised divisions; Research and Development, Outreach, and Africa, versus the four present ones, Fertilizer Technology, Agro-Economic, Outreach and Africa. The main change is the merger of the current Fertilizer Technology and Agro-Economic Division into one division. The Research and Development Division would have new programs under it pertaining to natural resource development and sustainable agriculture; nutrient efficiency; environment; and economics, marketing, and policy analysis.

The Africa Division would be only for the West Africa Center. Additionally, in the proposed plan, there would be an African Center for Fertilizer Development, also reporting directly to the Managing Director. It would deal with East Africa Programs, but would not be called a Division. This split in Africa programs seems unnecessary in the long term.

These changes in proposed structure of the IFDC came about because of (a) the establishments of the West African Center in Togo and the anticipated center in Zimbabwe; (b) the expansion of programs in Bangladesh and ICRISAT; and (c) the reduction in staff from 194 to 150 in 1985 for budget reasons. The changes also account for new directions in the strategic plan. The

structure is unusual in mixing major units according to function and geography. The Africa Division is partly an attempt to demonstrate to donors the seriousness of IFDC's interest in West Africa. Having a separate identification for the Zimbabwe center is partial recognition of the impending center there, but it is an empty box at present.

The proposed structure is acceptable to the review team, but it is apparent that the relationship between the headquarters and the Africa Division must be specified much more carefully. The relationship is unclear and even conflictual at present and it should not be allowed to remain that way. Almost more than structural descriptions, what is needed are specifications of roles of the headquarters and the African Division and the Zimbabwe Center relative to each other, clearer authority relationships, coordinating mechanisms, and understandings of which functions should be only at the headquarters or the African centers and which should be duplicated at the different locations.

23. <u>How does the present organizational structure encourage or discourage cooperation between the Divisions?</u> There is a high degree of cooperation and interaction at the headquarters, and we do not see this as a problem. Some disciplines (e.g., economics) have been somewhat neglected in the past, but that is reasonable in a situation where other disciplines would be defined as the leading systems of the IFDC. This problem is not major.

The main issue of cooperation is between the headquarters and the Africa Division, and it has been discussed above. Communication is a problem with the Africa Division and from that Division to national programs within Africa. Some suggested steps to facilitate cooperation between the Africa Division and headquarters are (a) clarify the relationships described above, and (b) frequently rotate staff between the two locations. The same problems are not anticipated with the Center in Zimbabwe, because its strategy is clearer and the headquarter's staff has been more involved in defining that Center's program. The former Managing Director of the IFDC is expected to direct the Zimbabwe Center and this should help with coordination issues to headquarters.

24. Should the center in Togo have more independent status, or should it be more closely tied to headquarters? This topic has already been touched on in items 22 and 23 above. Also see Section IV, C of the report on Africa programs. The headquarters staff believes a strong bond should exist between the headquarters and the Togo Center. They believe the Togo center should be responsible for identification of problems, proposing strategy, and implementing action. The headquarters staff would maintain responsibility for major program aims (some of which should involve the Togo Center), and final decisions on program content and direction. Headquarters thinks the Togo Center should see itself as part of an international development network and be aware that it would most likely suffer if it tried to be too independent from the IFDC's resources of money, library, staff expertise, and strategic planning. The headquarters would be responsible for keeping broad concerns about regional and international development in view, and would be able to influence the Togo Center to fit into strategic aims of headquarters. The review team did not take a considered position on this issue.

25. How does the present organization coordinate with the international agricultural research centers, donors, and the private sector? This item was covered under 9 above. The Center maintains regular contact with the IARC's, donors, and relevant private sector persons.

26. Does the staff, considering its areas of specialization and competence, meet program needs? Will changes be necessary over the next five years? The staff is especially experienced and competent, and carries out its work professionally. The new emphases on environment and sustainability, coupled with the likely retirements of 6 to 8 key people, will require staff recruitment soon. Some of the younger staff should be trained for increasing leadership roles. Areas in which staff should be recruited are: fertilizer policy, modeling, market research, fertilizer distribution, chemical engineering, geology, and environmental research.

27. Are the lines of communication and authority clearly defined and functioning? Refer to items 22, 23, and 24 above for a

discussion of this topic. Work is handled in a variety of ways at the Center. Some projects are managed by Division Directors and some by project leaders from among the staff. All projects are approved by the Managing Director, and on some projects his office is the main contact with a client. Most projects are managed in a matrix form with necessary staff seconded to work on project teams. Although this kind of organization can cause communication and authority problems, this generally has not been the case at the IFDC. The review team did not hear of communication problems other than with the West Africa center, and with some of the outposted staff. The project staff in Bangladesh, for instance, cited a relative lack of contact with headquarters, but they did not necessarily want more control by headquarters either.

In general, communication at the headquarters up, down, and laterally has been good. The Center demonstrated good teamwork and the review team did not discern signs of discontent, lacks of job satisfaction, or poor support for the organization.

28. Is the record keeping and documentation complete and addressable so financial and technical histories can be easily recovered? Financial records are kept at headquarters on a computerized accounting system. The IFDC, uses the Institute of International Education, as do the most of the IARCs for payroll, retirement, insurance, and other services. Records are maintained for at least five years. Accounting records are audited annually by Price Waterhouse.

The IFDC's accounting program covers most of the intricacies required by different donors.

Project reports have been kept in central files since the Center started and are easily accessible. These hard copy records are starting to take up a large amount of room and alternative storage means should be investigated.

29. Has adequate provision been made for the transition to the new Managing Director? Dr. Parbery took over as Managing Director on February 1, 1990. On his own initiative and funding he visited the headquarters in mid-1989. He then came to the

annual Board Meeting in October, 1989, and again visited the headquarters. He stopped in Washington, D. C. before the meeting to visit with the Board Chairman. He had continually been provided with materials by the Center.

The headquarters staff attempt to make his visits useful. The review team, however, is concerned that there had been little contact between the outgoing Managing Director, Dr. McCune, and Dr. Parbery. It would have been advantageous for Dr. Parbery to learn about some of the ways of managing that had been practiced by Dr. McCune, especially concerning financial matters. Dr. McCune would have been useful in linking Dr. Parbery to any informal networks Dr. McCune used. The review team was concerned that much of the organizational history that necessarily had to be Dr. McCune's was not used by Dr. Parbery. We can appreciate Dr. Parbery's interest in starting fresh and without undue historical encumbrances, but it does appear that not enough had been done to create learning for someone who was not very familiar with the IFDC before taking the central leadership role.

30. Has the IFDC determined its role in starting up the African Center for Fertilizer Development (ACFD) in Zimbabwe under the auspices of the Organization for African Unity? Does creating this new center have implications for agencies of the U.S. Government? The IFDC sees its role for the next 5-10 years to be the managing agent for the ACFD. This means helping the ACFD develop and establish a program, create an organizational structure, build a human resource base, and establish linkages with national and international institutions, so the ACFD will be able to assume its place as the leading fertilizer center for sub-Saharan Africa. This implies that the ACFD will be in a subordinate position relative to the current West African center. The goal is to eventually have the ACFD's technical and management staff be primarily made up of African nationals.

The ACFD's relationship long-term to the IFDC is less clear. The review team recommends that the IFDC define its strategic plan more clearly, outlining its own objectives, priorities, and programs in a global context to ensure preservation and sustainability of the national resources on which the present research system of the IARCs is built. Within the strategic plan

should be described the role of the regional fertilizer centers. This strategic thinking is necessary soon to prevent confusion and commitments that might not be best for the IFDC or the ACFD.

The benefits of the ACFD for AID and other donors would be as a regional source of fertilizer expertise for the AID supported SAADAC group of southeast and southwest Africa. IFDC staff outposted at the AFDC would be a close source of expertise for AID and other donor programs.

31. <u>What advantages would be realized by the IFDC if it were accepted as an associated center by the CGIAR? What are the potential disadvantages to the IFDC?</u> From its inception, the IFDC was considered a potential member of the CGIAR system. That it has not officially become associated with the CGIAR, has been due to a number of factors, the importance of which have varied from time to time. The most consistent negative perceptions influencing a formal association appear to be: (a) the location of the IFDC in Alabama and the United States, where it is not seen as an international center; (b) its relationship with the private sector, particularly fertilizer companies in the U.S., (c) its concentration on both the development and research sides of R&D, because development is a less prominent part of most IARC's roles; (d) the belief that fertilizers are associated with high-input agriculture, while research on plant breeding, which is a usual activity in the IARC's, is associated with low-input agriculture; and (e) the IFDC does not have a commodity or a regional emphasis, but deals with a specific agricultural input, which made it hard to place in the CGIAR's strategic pattern. Most of these issues can be countered by the IFDC, but they have contributed to the Center being not quite acceptable to the CGIAR in the past.

The main advantage for the IFDC in joining the CGIAR should be to obtain a more stable funding base, with a higher proportion and possibly a larger amount of the anticipated funding in unrestricted core. This stability would allow the IFDC to carry out more long-term research and development. A disadvantage for the IFDC might be some loss of freedom in determining its own programs.

There are strong potential advantages to the CGIAR and the IARCs in having the IFDC as an associated member. Questions about soil fertility, effective and efficient fertilizer use practices, sustainable agriculture, and environmental issues associated with fertilizer should be of concern to almost every IARC. The IFDC could be an important research and development asset in almost all IARC's programs, and broadening the IFDC's scope of attention to the various IARC's crops and topics of interest would lead to greater generality of fertilizer principles derived by the IFDC. The IFDC has a tightly integrated and focused organization that can conduct research and provide assistance in all aspects of the fertilizer sector, from raw materials to farmer attitudes. Most companies the IFDC works with in the LDCs also handle other agriculture products, such as seeds and irrigation equipment; the IFDC's experience in marketing, distribution, and marketing policies should be useful in dealing with these inputs as well as fertilizers. By joining the CGIAR, the IFDC could help in building stronger information and technology transfer links involving the IFDC, the IARCs, and national programs. The IFDC can help deliver IARC technologies to the farmers.

The review team recommends that the IFDC become an associated member of the CGIAR.

The research and related activities of the IFDC are relevant to the goals of the CGIAR. The IFDC is uniquely qualified to develop innovative fertilizer products, processes, and uses for the LDCs. It does work that most likely will not be done by fertilizer industries. Fertilizer industries can benefit from the IFDCs work and vice versa, and the industries should be considered as donors and allies in helping the IFDC accomplish its goals. The technical assistance side of the IFDC is stronger than in most other IARCs, and it is an advantage of the IFDC.

Conclusions and Recommendations

The IFDC is at a crucial point in its existence and it is in a time of transition. A new Managing Director is replacing the only one the center has had since its beginning. The Center's

staff has presented a strategic plan to the Board, with suggestions for changes in mission emphasis and organizational structure. The Center is being considered for membership in the CGIAR system. The growth of the regional centers in Africa is both a challenge and a problem. The proportion of the budget in core monies has been decreasing and it could change dramatically for the worse if AID were to withdraw much of its support. All of these issues will shape the future of the IFDC, and they beg for attention. The review team was struck with both the promise anf the potential threats in the IFDC's future.

Conclusions

The performance of the IFDC since the last AID review has been very good, especially considering some serious problems with funding in 1984-1985. Almost all aspects of the Center's work received favorable assessments, and there were notable spikes of excellence, such as the Bangladesh marketing and policy-reform project.

There is no other institution offering the IFDC's range of resources for dealing with issues of fertilizer use in the LDC's. Although the Center does not have a high profile image everywhere, it is widely respected as a developer of high quality research and technology and an objective source of advice. The IFDC has established a solid research program to support its technical assistance. It has devoted its attention building infrastructures and skills in the LDCs to make fertilizer use effective for farmers. It has helped LDC decision-makers assess their countries' own materials and potentials for making fertilizer. It has, and will increasingly continue to do so, consider fertilizer as part of agricultural, ecological, economic, and social systems, and not just as an input in a small closed system. The IFDC's increasing emphases on sustainable agriculture and sound environments will take advantage of these system skills. The IFDC has shown care in trying to improve the lot of farmers in the LDCs.

The Center's staff has an excellent reputation for being skilled, experienced, diligent, and honest broker of ideas and suggestions, and for having the interests of the LDCs at heart.

They have been doing state of the art research, but some of that research has reached maturity and should give way to other pressing demands. It will pay to redirect efforts away from topics that can be done well at other IARCs or by industry, and to concentrate on other needed programs. It is easy to try to continue everything and respond to initiatives too, but that is not possible under present funding levels.

The Center has been well managed. Dr. McCune should be given much credit for being a strong leader and propelling his vision of the IFDC into action. The Center is a success largely as a result of his efforts. He has been fortunate in having a solid, devoted staff who have served the Center well. Dr. Paul Stangel is a strong Deputy and he guided the preparation for this review. Good management practices have been followed at the Center, and the only issues the review team raised was about some small financial control procedures followed by the former Managing Director and the Administrative Director. The procedures occurred because these two people had worked together for a long while. Our criticism is that there is not an adequate information back-up if both of these people left the Center.

The review team was also concerned that the Board was not more independent of the Managing Director. The Board is made up of qualified members, but almost all of them had been nominated by the Managing Director, and their election had the appearance of a rubber stamping of his choices. We do not criticize the Board's general work, only that it should be more autonomous in its review and policy direction prerogatives.

The general feeling tone of the Center's staff was positive. The staff has high energy and supports the IFDCs programs and each other. They are interested in service and doing good work, and, in general, they like working for IFDC. The field projects we visited communicated a strong IFDC work and service ethic to host country nationals. The organizational climate of the Center is good.

Recommendations

1. Redirect the emphasis of the research programs to account

for new strategic emphases, emerging needs, and maturity of programs. Reduce the research on N losses in lowland programs. Continue the work on P, but attempt not to overlap on good industry programs. Continue the S work. Increase work on micronutrients and on low-input fertilization, but not at the expense of developing innovative fertilizers that will minimize environmental degradation or economic advantages for farmers. Emphasize upland crops and new crops that will bring income to farmers. Increase research on reclaiming lands. Initiate more research on sustainable agriculture and environmental issues. Decrease production research, except where it is needed and different from industry work. Concentrate on Africa, but do not neglect issues in Asia and Latin America.

2. Seek more donor funding for core. Work on the IFDC's image. Do better public relations work. Solicit funding for environmental research and desired practice changes in the LDCs.

3. Improve relations between headquarters and the Togo Center as part of the next phase of strategic planning. Determine the roles and relationships of the headquarters, the Togo Center, and the Zimbabwe Center. Specific attention needs to be directed toward clarification of such issues as delegation of authority and responsibility as well as procedures to follow in allocating core funds to Division.

4. Develop a continual strategic planning process. Have standing topic committees that generate and implement strategic initiatives.

5. Continue the Center's broad-based approach to fertilizer development. Emphasize economic analysis even more. Take more of a farming systems approach to include work on different inputs of materials.

6. Develop closer ties to the IARCs and FADINAP.

7. Encourage privatization of the fertilizer marketing and distribution processes. (This point is not without controversy. See Appendix A, Bangladesh, for a discussion of some of the issues. The review team was not settled on how much the IFDC should be involved in policy research. The matter of the comparative advantage of the IFDC in doing policy research over professionals dedicated to the task was an issue.) Where feasible, help develop and implement policies that lead to the reduction subsidies.

8. Document results when doing policy making and implementation. Evaluative data are very influential in gaining support for the projects. Portray fertilizer use changes on economic development and improvements in foreign trade.

9. Continue to work on fertilizer policy research, recommendations, and implementation. Do this work in concert with IFPRI, where possible. Develop a more positive relationship with IFPRI.

10. Seek membership in the CGIAR.

11. Do more modeling in collaboration with IARCs. Demonstrate uses of the models.

12. Work on fertilizers use in drip irrigation agriculture.

13. If the core budget percentage is reduced, still try to maintain the present mix of staff specialties. Use consultants to cover short-term needs on projects.

14. See if blocked dollars in the LDCs can be used of IFDC projects.

15. The Board should be more independent of IFDCs top management. They should be stronger in their program review and policy suggestion. They should still work cooperatively with the management.

16. Include in the research questions of how soil is handled

e.g., till vs. no-till.

17. Use the regional centers to train national fertilizer sector persons.

18. Try to share more of the IFDC's agronomic work with the IARCs.

19. Document the steps and principles of the Bangladesh marketing and policy reform project, and use it as a prototype for privatizing other agriculture input sectors.

20. Document the results of Indonesia's large-scale experience the briquetting and hand deep placement of USG.

21. Evaluate the IFDC's rice farming method using bamboo guides, dispenser deep placement, and placement in well-laid out rows.

22. Do follow-up contact with training program graduates.

APPENDIX A

ASIA TRIP REPORT

Dr. Hautaluoma, of the review team, went to Indonesia, Bangladesh, and Thailand to review IFDC work in Asia. What follows is his trip report.

IFDC Work in Indonesia

My companion in Indonesia was Dr. Dennis Friesen, an IFDC soil chemist. He goes to Indonesia, Thailand, and Bangladesh two or more times a year to check on research projects.

I arrived in Jakarta on Jan. 30, 1990 and then flew to Bandar Lampung, Sumatra. We were met by Dr. M. Sudjadi of the Indonesian Crop Soils Research (CSR) division of the Ministry of Agriculture. Dr. Sudjadi had been the Director of the CSR until recently, when he stepped down because of an age requirement. He is now mainly involved in research. He is a long-term participant with IFDC researchers. After meeting him, we traveled to the Taman Bogo experiment station to meet with Mr. Ardjasa, Head of the station. We discussed the research there and then we went to see some phosphorus fertilizer research sites on farmers fields. In the evening, we talked with Mr. Sabe and Dr. Sudjadi about the IFDC's work and the CSR's needs for additional help from them. Both men thought it would be advantageous to have a more continuous contact with IFDC than is now seen in Indonesia.

The next morning we looked at more fertilizer research sites at the station and then drove to Terbanggi to look at phosphate rock research sponsored by Texas Gulf. This U.S. company is interested in testing the applicability of North Carolina rock phosphate in Indonesia. The plots we looked at were large and on land that had been deforested for farming. The farming had depleted the minerals of the soil and the land then reverted to

Alang-Alang grass cover. There is over 15 million hectares of this kind of land in Indonesia and reclaiming it is of great importance to the country. There is strong social pressure to keep cutting the forests and use the land for farming. The land, however, is only productive for about two years before it is abandoned. The experiments at Terbanggi and other sites are indicating the need for high concentrations of phosphorus to revitalize the soil.

The Indonesian government supports a TSP industry, but it has to import all the rock for making the product. The TSP is highly subsidized and there is a built in resistance by vested interests against using other than the TSP for Indonesian crops. The IFDC experiments are showing that rock phosphate (North Carolina, Moroccan, and Jordanian) are about as effective as TSP in producing a good response in upland rice and corn. These findings have strong implications for policy and practice change in Indonesia, and the benefit of a cheaper way to aid the reclamation of the Alang-Alang lands is a strong incentive for action.

We returned to Jakarta and then to Bogor, Java on the afternoon of January 31, 1990.

On February 1, 1990 we visited again with Dr. Sudjadi at the CSR office in Bogor. He spoke with us about the IFDC's role in sponsoring an annual meeting on fertilizer research in Indonesia. The meeting had not been held for about 18 months, and Dr. Friesin said the IFDC would be willing to help sponsor it again. Dr. Sudjadi said they would schedule one soon. He showed me the proceedings from previous meetings, and said the meetings were useful and necessary to keep interested parties informed about fertilizer research and technology advances in the country. The results of the meetings had influenced policy, especially through the "Recommendations" Section of the reports.

Then we went to visit Dr. S. Effendi, Director of the CSR and we talked about work on which the IFDC could be helpful. He said he would like more research on reclaiming the wasted lands. He also was interested in studying how the subsidies on fertilizer could be reduced. Another need he cited was for

research on dry lands, especially in Eastern Indonesian. Evidence is needed on problems of fertility of soils, and the research should be done in conjunction with social surveys. He said problems exist in areas where farmers were not now using much fertilizer. He spoke about the need to do commodity development and on how to increase forest grasses and legumes. He talked about questions involving organic matter and soil and water quality.

As did the other Indonesians with whom I spoke, Dr. Effendi thought it would be good if IFDC could post a person in Indonesia. A problem, of course, is that one person would have difficulty representing expertise on the range of problems in which he was interested.

In evaluating the IFDC, he said it had been helpful in supporting the Working Group on Fertilizer, a policy recommending group of officials from different ministries and industry. He praised the report they did six years ago, but said there was a need to update it. He encouraged the IFDC to take a lead in doing this work.

He mentioned the CSR's interest in a soil growth hormone. I had heard it discussed several times from other sources. He was more favorable toward it than the other reports I had heard, but he said IFDC could help evaluate it. He said there was a need to do experiments in new lands, other than Western Java, and to use some of the modeling expertise of IFDC to develop response curves of various practices on different soils.

We talked about the differences between the Ministries of Agriculture and Forestry in dealing with some of these problems. The Ministry of Forestry wants to retain a large amount of the forests for water and environmental reasons, and the Ministry of Agriculture is concerned about the level of food production. He said about two million farmers want to slash and burn more of the forest to raise crops. In the past these farmers had gotten loans to do this, and the method was still seen as effective by them. About 350,000 hectares of forest per year are lost to the practice.

As Dr. Effendi spoke, he named many topics on which IFDC could be helpful, but he assumed the Indonesian government would not be able to fund any of them. He said only a small part of the Ministry of Agriculture's budget was available for fertility and soils research. The Ministry's main emphasis was on food production instead. These latter programs were aimed at Indonesia quickly gaining self-sufficiency in food production, and fertilizer research on land reclamation only promised much slower results.

He said that IFDC's work on deep placement and briquetting was very influential in Indonesia, but he pointed out that IFDC's presence has decreased after the IFDC managed Australian fertilizer development project was dropped a few years ago. He said the IFDC staff has been a good source of advanced ideas, and he commented that the CSR did not have many senior scientists. IFDC researchers have been helpful in guiding research and being mentors for Indonesian researchers. He said his division could use help in agronomy and policy research.

I asked how he worked with the fertilizer industry, and if CSR's research was sponsored by the industry or was influential in determining the kinds of products they made and distribution schemes they used. He said industry is not capable of doing agronomic research and that they were one of the clients of the CSR. He said the industry does not fund fertilizer efficiency research.

In general, the CSR had been influenced by the IFDC in building its own competencies. The Division was still in need of research support and advice, but it looked much stronger than six years ago on my previous visit.

In the afternoon of February 1, 1990 we traveled to Jakarta to visit with Mr. G. Sarudji, Secretary General of APPI, the association of government owned fertilizer industries, and two of his staff. He said the IFDC had been influential in training on fertilizer production, marketing, and handling, and in technical consultation to various plants. This activity is not currently as pronounced as it had been in the past. They also acknowledged IFDC's role in introducing the briquetter to Indonesia, and they

talked about the intended use of the machine in farmers' cooperatives. They had examples of the super granules to show us and they talked about how the Metal Industry Development Center of the Ministry of Industry was now responsible for producing the machines. About 400-500 are already made and in the cooperatives, and the training for their use was to start the next week. Mr. Sarudji and his staff were unaware of the research being done on the machine at the IFDC in Muscle Shoals. Indonesia expects to have more than 2,000 of the machines in use before long. They talked about some trouble with getting super granules as large as 1 gram and they mentioned difficulties with durability of the machines.

I asked about the difficulty of getting farmers to accept the practice of deep placement by hand. The deep placement idea had been introduced by the IFDC. They said the method was required by the Ministry of Agriculture and that there would be no difficulty in getting the farmers to use it. This was a little surprising to me, because there was not a great incentive for the farmers to use the method. I was told that Indonesian farmers already plant very orderly rows of rice - a characteristic useful in deep placement - so the method might not be as much a change for them as for other farmers who do not put in such straight rows.

On the morning of February 2, 1990 we visited with Dr. Adiningsih of the CSR, who has worked with IFDC researchers. She showed us recent pictures of her telling President Suharto about a briquetting machine. She spoke favorably of her work with IFDC's Australian funded project, and she said the CSR could use more help from IFDC. She said that the research on lowland crops had moved along well, including the work with the urea super granules and the briquetter, but there was much work to be done with phosphorus and micronutrients, especially in upland crops. She worried about the too quick introduction of the briquetter, but she said the farmers in east and central Java liked the method of deep placement by hand. Again, she repeated an interest in continuing the Fertilizer Working Group, which had been spearheaded by Dr. Sudjadi with IFDC's help. She spoke of the need for more fertilizer research in a number of areas, but said the money was not available in the Indonesian government. The

fertilizer industries, which had money, were mostly interested in funding research about increasing food production. She expressed an interest in having an IFDC person in Indonesia to work on socioeconomic and agronomic research. She would like to see some IFDC work on fertilizer subsidies, which she thought should be changed. She also said she could use help in convincing policy makers about the importance of phosphorus in reclaiming the transmigration (Alang-Alang) lands.

Our final visit in Indonesia was to Mr. W. Scarborough of AID/Indonesia. He pointed out that the mission's goals were not currently concentrated in agriculture or fertilizer research. He was not aware of the IFDC's work in Indonesia, although he had worked with the IFDC in Africa. We discussed the decreasing role of the IFDC in Indonesia, and he said he did not think that would change from AID mission funding. We described the research on the transmigration lands, the implementation of the deep placement methodology, and use the briquetting. He was interested in hearing what we had to say, but again sounded a discouraging note about the potential for future AID support of work on fertilizer. He said the Indonesian fertilizer industry should probably fund more of this work.

IFDC Work in Bangladesh

In Bangladesh I visited the IFDC Fertilizer Policy Reform Project funded by AID/Bangladesh. This project has existed since 1978, and is an exemplary effort in international development. The project started with an emphasis on improving fertilizer distribution, and has expanded into a major policy reform and marketing privatization program. The project staff, in concert with the Government of Bangladesh (GOB) and AID/Bangladesh, has been able to change the marketing of fertilizer from control by a parastatal organization, the Bangladesh Agricultural Development Corporation (BADC), to an almost free market distribution of fertilizer. The project has proceeded in two major directions - policy reform and the training and development of a nationwide set of private fertilizer dealers.

The policy reform followed a number of steps leading to

greater free-market distribution. First, a rather complete set of primary distribution points were established to allow private dealers to buy fertilizer at a larger number of locations. Then special discount locations were set up to encourage dealers to lift larger quantities of fertilizer and receive a discount in their price. Then the dealers were allowed to lift fertilizer directly from the factories, by-passing altogether control by the BADC. A recent policy change was aimed at getting credit for the dealers, so they can lift larger quantities of fertilizer from the factories. Another recent change will allow dealers to import some fertilizers on their own. Each of these policy changes were well planned to develop a private sector in fertilizer marketing. The project led the way in training dealers, establishing the distribution infrastructure, coordinating with the GOB and AID/Bangladesh, and working to ensure understanding and acceptance by everyone involved.

I arrived in Bangladesh late in the day on February 3, 1990.

On February 4, 1990 I went to the IFDC project office and visited with Mr. Ken Moots, Chief of Party (COP). Then I went to see the BADC Chairman, Dr. Shawkat Ali. He was the most negative of any person I spoke with about the project, which was reasonable, because his organization was the most negatively affected by the IFDC's work. He wondered what the role of BADC was to be after the reforms. He raised concerns favoring public control of fertilizer distribution, including the control of prices and supplies in outlying areas where he feared the free market dealers would not get good business. He worried about the volatility of prices, low fertilizer use during high price times, delaying ships and incurring high costs if private dealers do not lift fast enough, and monopolistic dangers. He talked about the destabilization of peoples' careers because of IFDC's reforms. He wondered what check there would be on the dealers to not cheat the farmers. He said he did not necessarily believe IFDC's price figures.

We talked about the potential role of BADC after the policy reforms. He thought the BADC should be able to intervene when there was a localized fertilizer scarcity situation. He wanted a quality control and price monitoring role, and the opportunity to

work on new products, micronutrients, dealer development and training, on-farm demonstrations, market development in outlying areas, and farmer education for a balanced use of fertilizer. Most of these functions are conceded by the IFDC as appropriate for the BADC. However, most of the perceived needs for protection or control of the fertilizer marketing were argued by the IFDC staff as being unnecessary. They believe competition will ensure quality and service better than will government control, and the IFDC staff pointed out that government control had led to abuse of the BADC responsibilities and a lack of trust in it by the dealers. This is exemplified by the fact that after the dealers were given the chance to buy directly from the factories, rather than from the BADC in March, 1989, purchases went from 100% from BADC distribution points to only 7% in December 1989.

Dr. Shawkat Ali went on to say he thought that the IFDC was overstepping its limits. It had left its consulting role to become a decision-maker in Bangladesh. It had done this with the full support of USAID and the GOB. He argued that because AID provides so many funds to Bangladesh, and because the GOB does not have experts who could argue with the IFDC, that the GOB was being pressured into accepting the IFDC's suggestions. This argument is persuasive, but it was not supported in my discussions with GOB officials. They were extremely enthusiastic about the privatization policy reforms and were especially impressed with the hard data results of the project. They spontaneously cited these data as a main reason why they supported the project.

I concluded my meeting with Dr. Ali with a discussion of how such changes should occur. He would have preferred a slower pace and longer trend lines of data before proceeding to direct lifting from the factories and importing fertilizer by private dealers. We talked about approaches to making changes, and discussed how sometimes rapid changes are more effective.

An essential point about this meeting was that Dr. Ali represented one philosophical position opposing IFDC's work. He operates from an assumption about the necessity of strong government control of key economic sectors. The IFDC project is

based on a very different philosophy, not necessarily accepted by everyone involved in international development. The main thesis of the IFDC position is that strength in economies comes from developing a strong free market in the movement of goods and services. This position assumes that prices and supplies will be determined by demand and competition, and maximum service and the most favorable price will occur if private enterprises are allowed to compete for shares of the market. The IFDC project approach aims at building a vitality and energy in marketing not seen with publicly controlled goods and services.

These philosophical approaches influence how international development will be done, and in IFDC's case in Bangladesh how their mission should be defined. The current approach of many international centers has been to do research on various crops or commodities and to try to influence national systems to use the research. An equally important task is trying to improve distribution and marketing systems and government policies so new research ideas and products are used. The Bangladesh IFDC project has dealt with issues of effective use of fertilizer by attacking a number of the marketing constraints influencing effective fertilizer usage and the project has shown impressive results.

On February 4, 1990 I met with Mr. M. Toha, Mr. M. Eunus, and Mr. L. Hashem of the Bangladesh Chemical Industries Corporation, (BCIC), the new cooperating partner of the of the IFDC project. The BCIC is responsible for the fertilizer factories from which the dealers are lifting. The shift in alliances for the IFDC project came about because of the BADC's extreme resistance to the project's policy reforms during the last several years. There were strikes, court injunctions, and threats to the IFDC project that made a continuing relationship with the BADC difficult. The new alliance is friendly, but still a bit awkward, because the IFDC project must still work through the Ministry of Agriculture and BCIC is in another ministry. This arrangement does not seem to have been a problem so far.

The BCIC officials said they liked the IFDC policy reforms and that they had been able to sell 10 mil more tons of urea this year than last, to maintain low and even zero inventories, and to

be paid for their fertilizer. The BADC had not paid for all the fertilizer they took from the BCIC and it was in arrears to the BCIC for about $30 mil for fertilizer. Under the new policy, the BCIC receives payments or bank letters of credit from the dealers when the fertilizer is lifted. The BCIC leaders said they had not believed the positive changes would take place so quickly, but they were pleased with the rapid progress.

During the meeting, Mr. Moots gave advice on pricing, discounts, and a potential use for a wood products' byproduct that could be made into a sulfur fertilizer. This helpfulness was representative of his manner in many of my observations of him. He is highly regarded by the Bangladeshis as a useful source of information.

The BCIC leaders went on to describe how the IFDC project has helped improve the infrastructure of fertilizer movement in Bangladesh.

A next target of the project and the BCIC is the subsidy on TSP. Eventually the goal is to eliminate all subsidies.

The BCIC would like the IFDC to help them work on mixed compound fertilizers.

The men mentioned that unless there is a natural disaster, such as a bad flood, that Bangladesh should attain self-sufficiency in rice this year. They attributed a good portion of that success to the increased sale of fertilizers promoted by the IFDC.

In the afternoon of February 4, 1990 I visited with Priscilla Boughton, USAID Director, and an assistant Mr. Brown. They had nothing but praise for IFDC's work in Bangladesh, and especially cited Mr. Moots's leadership. Ms. Boughton said she had been skeptic about the project at first, but had been won over by its results.

She thought the IFDC should be involved in policy work, and that there were not strong alternatives for the kind of policy work the project has been doing. She was especially pleased that

the IFDC project could document its results. She anticipated attempting an approach similar to that of the project for seeds and irrigation equipment.

They went on to say Mr. Moots has been a strong leader of the project. They said he understands the political forces affecting his project and credited him with having a strong vision of where it should be going. They thought IFDC project's strong suit was understanding the practical implications of the suggestions they made.

Next, I met Ms. Helen Gunther, Deputy Director, Office of Food and Agriculture, AID/Bangladesh and Dr. Ray Renfro and Mr. Nizam. from the office that manages the IFDC project. They, again, said the project had been extremely successful and that the policy changes would not have occurred without the IFDC. They especially valued the data supporting the effects of the changes, and they praised the IFDC's work in setting up the Bangladesh staff to collect the supporting data. They talked about the good relationship of the project to the GOB and they described how the Secretary of Agriculture relies on Mr. Moots for almost daily advice. They said many people go to Mr. Moots, because he is knowledgeable on the fertilizer input side. They see the IFDC project as a prototype for use in other sectors of economic development.

I raised the issue of whether IFDC should do policy work or if it should be left to other groups instead. They said there would be a vacuum if IFDC did not do the policy work on this project. They said other policy groups are not as knowledgeable about marketing and are less able to be involved in the stepwise approach of implementation the IFDC project has followed. We talked about IFPRI's possible role, and they said that it deals mainly with food, and that it would not be as good at getting into fertilizer as was the IFDC.

This AID office was extremely happy with the IFDC project in Bangladesh, but they did offer some criticism of other IFDC work. They cited a report on the TSP factory in Bangladesh. They thought there were errors in the report, and they did not like that there were not concrete recommendations in it. I gathered

that they had some strong opinions about the disposition of the factory before the report was written, and that the IFDC report just gave them options to consider and it did not solely support their position of interest.

On February 5, 1990, I went to Rajshahi, Bangladesh to be present at a Fertilizer Credit Training Workshop for fertilizer dealers and bankers, which was sponsored by the IFDC. On the flight to Rajshahi, I was purposely seated next to the Secretary of Agriculture, Mr. M. Syed, so I could talk to him about the IFDC project. He is a thoughtful and caring man and he praised the work of the project. He said the project was needed and was a great support in correcting many of the former courses of fertilizer marketing in Bangladesh. He had high trust in Mr. Moots and valued him as a source of advice. Mr. Syed has been a key supporter of the policy reforms and said he was won over by the evidence produced by the project. Mr. Syed supports the reform efforts by being present at activities, such as the credit workshop, and he is an active participant and seeker of feedback from dealers and the farmers. At the workshop he assertively directed the bankers to participate in the reforms by easing the restrictions on credit to the dealers. He appealed to the need to introduce such reforms nationwide and in other sectors to help Bangladesh move ahead.

During the workshop, the dealers had a chance to state their needs and criticize the present credit systems and then the bankers were allowed to describe their position and constraints. The meeting became heated at times, but there was never an angry tone. The end results was an increased awareness by both sides and some important concessions by the bankers. This meeting was the last of several on the same topic around the country that had been sponsored by the IFDC project.

That evening a number of the participants gathered in Mr. Moots's room to share some refreshments and debrief the meeting. It was again obvious that Mr. Moots was a respected and valued friend to many of those present.

On February 6, 1990, Mr. Moots, Mr. Nizam and I drove back to Dhaka and we talked about the project. I questioned Mr. Moots

about the design of the project, his action steps, the issues of his philosophy, and the building of an Bangladeshi infrastructure after the project finishes. He had taken most of my questions into account, and had good action steps in place for almost all of them.

That evening we went to a dinner at one of Mr. Moots's friends house, and I continued a conversation with Dr. Sidhu, a finance and credit economist from IFDC headquarters, who is assigned to the project. We discussed his work and how the project is unlike any of the others being done by the IFDC. He, of course, thought the project was very successful and was the kind of project IFDC should be doing. He said that there is not strong technical and possibly philosophical backup for the project at IFDC headquarters, a point mentioned several times to me by other persons. He said the project was an eye opener for the GOB, because it brought discipline to an area they previously had seen as disorderly.

On February 7, 1990 I went into the IFDC office and spoke with Dr. Ray Diamond, an IFDC headquarters soil chemist, who was assigned to the project. He had been involved in urea deep placement and other research in the Philippines and Indonesia, and he is doing some of that work on the Bangladesh project. He is mainly responsible for fertilizer dealer training, and he showed me many of the promotional materials designed by the project as attraction devices or learning aids.

The project has done several kinds of training, usually in cooperation with the BADC, and the training has been an important element in establishing the dealers' competencies. Much of the training was done in Bangladesh, but some of it was at Muscle Shoals or other foreign sites. He said the project is attempting to build ties to the Bangladesh extension service to train farmers about fertilizer use. The relationship with the BADC has been strained because of the policy reforms advocated by the project. Trust will have to be re-established to have the project and BADC cooperate on training as much as they have done in the past.

Several of the Bangladesh IFDC national staff went out of

their way to comment on Dr. Diamond's capabilities and diligence. They said he is an outstanding model as a field researcher, and that he was respected for his high standards. He has been trying to get the urea deep placement method used in Bangladesh, but the farmers plant in more haphazard row patterns than in Indonesia, and the government is not able to mandate the deep placement practice as it had in Indonesia. Fertilizer use practices in Bangladesh will follow different implementation techniques from those in Indonesia. Demonstrations of crop yield improvements and fertilizer cost savings to individual farmers will probably have to be done, so Dr. Diamond sees a slow use of improved methods in Bangladesh. The project has been active in assessing farmers' attitudes and Dr. Tom Thompson, a sociologist from headquarters, has helped in designing and analyzing surveys for this purpose.

Dr. Diamond said he would like to see more of IFDC's core budget used for work in the LDCs, especially for pilot projects that would develop into bigger efforts such as that in Bangladesh. He too commented that the active support from headquarters on this project could have been stronger. He was surprised that in some of the IFDC annual reports the Bangladesh project had not received more prominent attention, because of its documented successes. He along with others, mentioned some moderate issues of difference between Mr. Moots and IFDC managing support staff at headquarters.

On February 8, 1990 I went to Bangkok, Thailand and met with Mr. Alain Vaes, Team Leader, Fertilizer Advisory, Development and Information Network for Asia and the Pacific (FADINAP), a UN agency. We spoke of FADINAP's and IFDC work in the region. The two organizations have some common interests, but in the past have been more competitive than necessary. They have cooperated on training, but the cooperation is a problem because IFDC usually charges fees for its training, while FADINAP does not. I described the projects I had visited and Mr. Vaes was interested in hearing about them. We discussed how FADINAP did not have many resources for doing its work, and how during one difficult funding period IFDC had gotten UN funds and FADINAP was not funded as well. We talked about the relatively small role of IFDC in the region and agreed that a more cooperative approach

might help both organizations better fulfil their purposes. Mr. Vaes was very interested in a stronger relationship with the IFDC and supported the need for a full-time IFDC person in the region. We talked about why there were no regional fertilizer centers for Asia, such as were coming about in Africa, and he said establishing some of these might be a good area of collaboration for FADINAP and IFDC. Overall, he said IFDC had a good reputation and did good work. He was especially interested in the Bangladesh project, and said the approach should be tried in other countries. He said FADINAP had been instrumental in setting up national coordinating bodies in several countries, and he saw the need to continue that work.

Summary and Recommendations

The IFDC, in general, has a very good reputation in Asia, where it is known. Its staff members are seen as competent, professional, hardworking, and objective. The IFDC is not as strong a presence in Indonesia as it has been in the past. Some of the IFDC's work there in the last several years built on Dr. Paul Stangel's work and reputation in Indonesia. The IFDC should be credited for its research on urea deep placement and in getting the urea briquetters brought to that country. The Australian supported IFDC project staff in Indonesia were well regarded. A number of opportunities exist for additional fertilizer work, if funding is available. One important task is reclaiming the Alang-Alang lands where phosphorus is a key needed element.

The IFDC project in Bangladesh has truly been effective. It is not in an area that is always what key supporters may see as appropriate for the IFDC. The usual conception is of the IFDC as an agronomic or engineering research and technical assistance center. The Bangladesh project expands some views of the mission of the IFDC, but the policy and marketing areas are fruitful avenues for the IFDC to exploit in working on issues of fertilizer utilization in developing countries.

Concerning FADINAP, it would be useful to the aims of it and the IFDC to collaborate on training, enhancing regional fertilizer capabilities, and building sectors and networks.