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**IFDC—
Providing Technical Services
to the
Developing World**



International Fertilizer Development Center

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Mission—Fertilizer Technology Development and Transfer

The International Fertilizer Development Center (IFDC), a public, international, nonprofit organization, concentrates on increasing food production in the tropics and subtropics through the development and use of improved fertilizers and fertilization practices.

IFDC can provide developing countries the expertise needed to advance their fertilizer sectors toward the self-sufficiency level. This expertise may involve technical assistance, special studies, or training. IFDC's staff members not only design development plans for fertilizer sectors but also assist in the successful implementation of them.

The Center's activities can be divided into three broad categories:

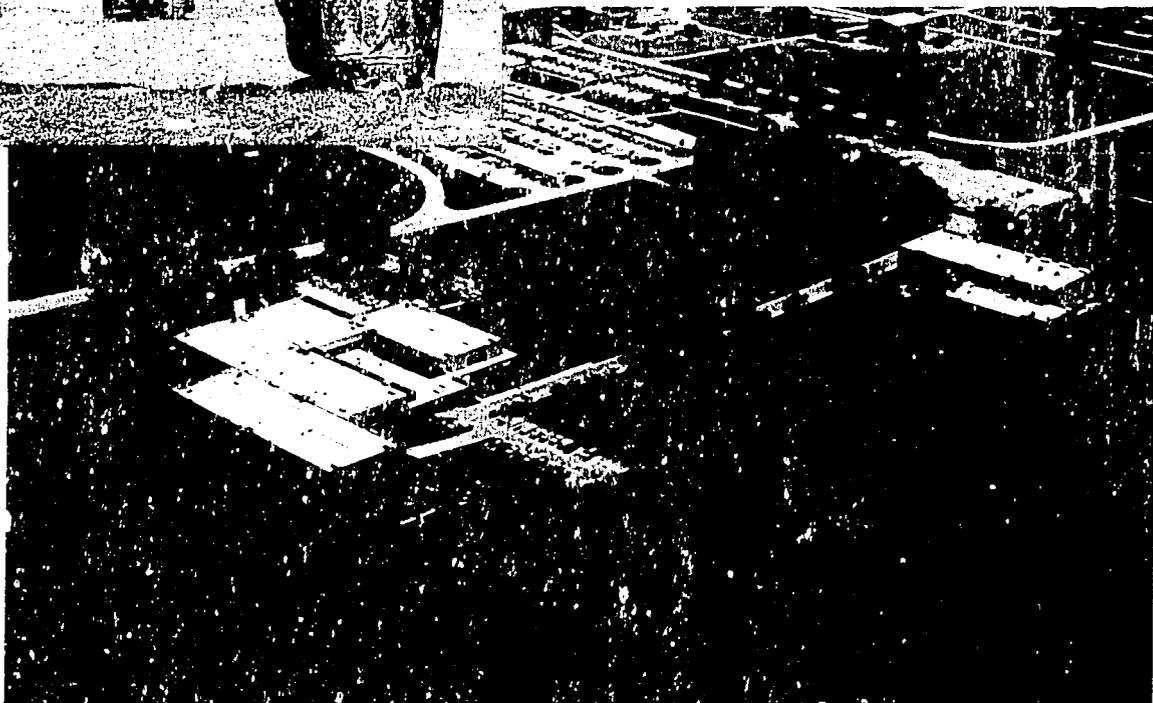
- Collecting and disseminating information on agrominerals;
- Conducting research and development on all phases of fertilizer production, marketing, and use;
- Providing training; advisory services; and technical assistance in the planning, organization, and implementation of fertilizer production, marketing, and use practices.



Experience

IFDC's staff specialize in technical assistance to programs, projects, and institutions in the developing countries. Since 1975 our staff members have logged more than 1,000 staff years of experience in fertilizer-related work in more than 60 countries of Africa, Asia, and Latin America.

Our work has ranged from sector studies and long-term planning to the design, implementation, and management of field projects in fertilizer production, development and use of indigenous agrominerals, agronomic efficiency, policy development, marketing, and related areas.



Unique Multinational, Multidisciplinary Staff

IFDC is unique in that it can draw upon a multidisciplinary, multilingual staff of professionals from more than 20 countries to provide an unbiased opinion regarding most facets of fertilizer sector development. Our staff includes agronomists, chemists, chemical engineers, economists, geologists, social scientists, soil scientists, and specialists in market research and development, communications, and training. These professionals have participated in projects in collaboration with national/international food and agricultural organizations; financial institutions; agricultural research stations; manufacturers and associations; and research and development agencies.

Expertise

IFDC emphasizes practical solutions to the problems encountered in the various facets of the fertilizer sector. Our services can be separated into three broad categories: marketing, production, and use of fertilizers. Specific types of services include:

- Market Development Studies
- Feasibility Studies
- Investment Analyses
- Production Cost Analyses
- Distribution, Transportation, and Handling Studies
- Policy Development and Evaluation
- Mineral Resource Evaluations
- Bench-Scale Laboratory Processing
- Pilot-Plant Processing
- Project Management and Supervision
- Basic Process Design Packages
- Process Plant Problem Solving/Optimization
- Environmental and Industrial Hygiene Studies
- Agroeconomic Studies
- Research & Development of Products & Processes
- Training

The development of projects requires a broad range of knowledge and analytical capability. Most clients know what results they want to achieve, but they often need assistance in developing the information for decision making or for implementing the idea. At IFDC we have the capability to help our clients with project formulation, analysis, implementation, and management. We have developed approaches and methodologies that are highly successful while tailoring our specific services to the needs of the developing countries. IFDC represents the developing-country clients to the best of its ability.

Research & Development Capabilities

IFDC's modern laboratories, pilot plants, and greenhouses are used to perform and evaluate numerous operations and processes. By using these facilities, we obtain data to add credibility to feasibility studies and economic analyses. For more information regarding IFDC's facilities, please consult the *IFDC Story*, General Publication IFDC-G-5.



Market Development Studies

Successful fertilizer marketing means that the right product is available on a timely basis at the right place and at the right price. Thus, fertilizer marketing involves a series of interrelated steps from the point of production to the farmer. To be efficient a marketing system must be designed to operate within the constraints of a given country's policies including its unique political, social, agricultural, economic, and environmental issues. We are finding that as production increases, the problem changes from lack of supply to lack of an effective system for marketing this increased production. As



consumption increases, the opportunities to reduce the cost of fertilizer marketing and to increase the efficiency in serving farmers gain importance in a country's national economy.

Our organization is unique in that we can draw upon an inhouse multidisciplinary staff to assist a country, company, or organization with a particular marketing problem. In addition, we also have personnel with many years of practical experience; many of our staff members were involved in fertilizer marketing with commercial companies prior to joining IFDC.

We assist developing countries in improving the efficiency of fertilizer use, and we welcome the opportunity to assist national planners and/or marketing organizations in developing cost-effective fertilizer marketing systems.

Feasibility Studies

IFDC staff can assist developing-country clients in determining the technical and economic feasibility of building a new production facility or expanding an existing one. In conducting this type of study, our staff will usually evaluate projected local, regional, and world market demands and prices; product mix; plant capabilities and sites; process technologies; feedstock alternatives; investment and production costs; profitability analyses; project funding and management alternatives; and a host of site-specific factors that may be unique to a particular study.

Investment Analyses

The capital investment requirement for most fertilizer sector supply and distribution projects is often quite large. The long-term economic feasibility of such projects depends largely on the level of capital investment and financing options. At IFDC we can help decisionmakers by performing an investment analysis as part of an overall feasibility study or as a separate study.



Production Cost Analyses

Our staff can conduct a comparative analysis of the production costs incurred by a client with respect to other competitors in the marketplace. This analysis can be done either as a separate study or as part of an overall market and supply study. Included in this analysis are the shipping and handling costs to the markets under consideration. We can also provide data on raw material supply and other production cost components.



Distribution, Transportation, and Handling Systems

IFDC's staff study all aspects of systems for physical distribution of fertilizers from the point of production or import down to the dealer and retailer level. This involves management and operation of systems for packaging, transportation, handling, and warehousing. Alternatives are considered, including movement in bulk and/or bags; movement by road, rail, and water; manual or mechanical handling; and use of unitized handling systems such as pallets, slings, and intermediate bulk containers.

Policy Development and Evaluation

Our specialists can help government agencies that are responsible for fertilizer policy development in determining the issues to be addressed and the most effective ways for reaching national, regional, and local objectives. Our work seeks to strengthen organizations in their implementation of fertilizer policy, taking into consideration their capabilities, needs, and the environment in which they operate.

Agromineral Resource Evaluations

Our staff can perform agromineral resource evaluations on a regional, country, or individual deposit basis. Such studies may involve; (1) the quantification of resources,

(2) determinations of ore characteristics, (3) beneficiation studies, (4) the assessment of the ore's potential for uses such as direct-application materials or as raw materials for chemically processed fertilizers, and (5) the economic feasibility of mining and producing deposits. These studies may serve as planning guides for investors, international research organizations, donors, and national programs.

Bench-Scale Laboratory Processing

IFDC Headquarters' facilities house several well-equipped laboratories that allow systematic and thorough evaluations of indigenous raw materials for fertilizer production. After the initial physical-chemical characterization and analyses are performed, the raw materials are taken through sequential processing steps to produce the final product with desired physical properties. Both conventional and nonconventional processes can be simulated in batch and continuously operating equipment to define operating parameters. IFDC capabilities include: (1) coating of fertilizer granules to control nutrient release; (2) upgrading of fertilizer raw materials (beneficiation); (3) acidulation of phosphate ores in wet-process phosphoric acid and nitric phosphates; (4) conversion of phosphate ore and intermediates to granular single or multinutrient products; (5) physical-chemical analyses of raw materials and products; and (6) preparation of other specialized fertilizers and agrominerals.

Pilot-Plant Processing

Although much about the chemistry of a production process can be determined from laboratory- and bench-scale studies, some engineering aspects can only be determined in larger-scale (pilot plant-scale) production where industrial equipment is used. IFDC's pilot plant facility includes units for beneficiation of phosphate ores using several techniques; production of wet-process phosphoric acid by the dihydrate or hemihydrate routes; production of nitrophosphates; bulk blending; and three different plants for chemical or steam granulation at different production rates. These pilot plants have proven indispensable to IFDC in researching and developing new products and processes; optimizing processes; evaluating new phosphate rock deposits; carrying out process and equipment problem solving; and transferring technology (training of plant operators, supervisors and engineers).

Project Management and Supervision

In full-scale projects, our involvement begins with assisting a client in the preparation of bid invitations, evaluations of proposals, drafting of contracts, and contract negotiations. During the detailed engineering and construction phases, we may continue to assist the client in many activities including inspection of equipment during fabrication, supervision of the contractor's work, developing plant operations and management skills, performance testing, and post startup process and product optimization.

Basic Process Design Packages

IFDC's basic process design packages provide the foundation for the detailed engineering, equipment procurement, and construction phases of most fertilizer plant projects. IFDC's laboratories and pilot plants are used to provide the essential process information needed for the preparation of the basic process design package. This package, containing the required material balances, piping, and instrumentation diagrams and equipment data sheets, is then normally used by the client to secure proposals from local or international engineering and construction firms for the full implementation of the project.

Process Plant Problem Solving/Optimization

This activity involves the evaluation of production facilities with the objective of manufacturing different product grades and/or improving plant capacity and therefore profitability. Such evaluations usually result in relatively minor changes in the plant facilities to bring about substantial increases in production and cost savings. Most work is related to phosphate processing and compound fertilizer granulation.

Environmental and Industrial Hygiene Studies

These studies are designed to examine the ambient and workplace environment in a broad range of fertilizer production facilities. In addition to identifying and measuring process losses and estimating the associated impact on production cost, these studies may also include plant safety audits, evaluation of emergency procedures, assessment of hazards, and recommendations for implementing corrective measures. Capabilities are also being developed to measure

and control the impact of the use of fertilizers and agrominerals on the environment.

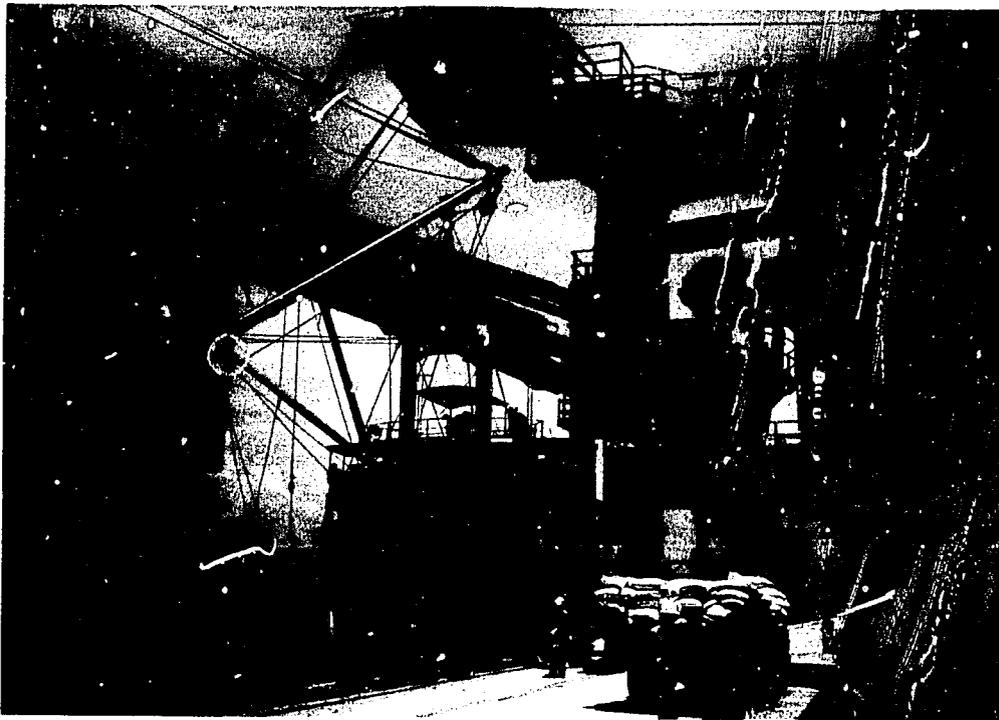
Agro-Economic Studies

Our staff conduct research related to development, selection, and management of fertilizer for efficient crop production in tropical and subtropical soils. Soil chemists, fertility experts, agronomists, and crop physiologists focus on the mechanisms of fertilizer/soil/crop interactions influencing crop response to applied nutrients in laboratory, greenhouse, and field environments. Working jointly with economists, sociologists, biometricians, and engineers, our agronomists provide technical assistance with problems in developing countries ranging from identification of nutrient loss mechanisms and modification of fertilizers or management strategies to overcome these losses to the evaluation of cost/benefit relationships, farm-level constraints, and data decision support systems.



Research and Development of Products/Processes

IFDC is uniquely qualified to offer a wide range of research and development services and can conduct numerous operations and evaluate many processes using a wide range of specialized and sophisticated equipment. Our staff can develop technology appropriate to the constraints of the situation for the small and large entrepreneur. They can use a variety of modern instruments, such as X-ray diffraction, X-ray fluorescence, scanning electron microscope, liquid and gas chromatographs, infrared spectrometers, ultraviolet visible spectrophotometer, differential scanning calorimeter, ion chromatograph, image analysis, and differential thermal analyzer and thermogravimetric analyzer.



Training

An increasing number of specialists must be added to the work force of the fertilizer sector each year if developing countries are to meet their food production goals. IFDC's group training programs are tailored to meet the needs of organizations, governments, or sponsoring agencies interested in fertilizer sector development. These programs cover all facets of fertilizer production, marketing, and use. Specialized training is also provided for individuals at the request of their government, institute, or company. All programs draw on the expertise of IFDC's multidisciplinary team of training specialists to provide stimulating and innovative sessions. This training may occur informally on the job, or it may occur in a larger, more formal group setting.

Product Coverage

Raw Materials

Phosphate rock
Sulfur and pyrites

Intermediate Materials

Ammonia
Phosphoric acid
Sulfuric acid
Nitric acid

Phosphate Fertilizers

Single superphosphate
Triple superphosphate
Monoammonium phosphate
& diammonium phosphate
Ground phosphate rock
Partially acidulated phosphate rock
Sulfur-fortified superphosphates

Nitrogen Fertilizers

Ammonia
Ammonium sulfate
Ammonium nitrate
Calcium ammonium nitrate
Urea
Ammonium chloride
Ammonium bicarbonate

Potash Fertilizers

Muriate of potash
Sulfate of potash
Potassium nitrate

Multinutrient Fertilizers

Ammonium phosphate-based NP and NPKs
Urea-based NP and NPKs
Nitrophosphates

Miscellaneous

Sulfur-coated fertilizers
Rubber-coated fertilizers
Urease inhibitors
Supergranular urea
Slow-release fertilizers

A Partial Client List

Companies and Organizations

Abonos Colombianos, S.A.—Colombia
Agricultural Inputs Corporation—Nepal
Agricultural Services, S.A.—Haiti
Akdeniz Gübre Sanayii—Turkey
Bangladesh Agricultural Development Corporation
Bangladesh Chemical Industries Corporation
Caribbean Development Bank—Barbados
C.F. Braun—United States
Chemical Company of Malaysia
Chilean Nitrate Corp.—Chile
China National Chemical Construction Corp.—
People's Republic of China
Deepak Fertilizers and Petrochemicals
Corp., Ltd.—India
FEECO International—United States
Fertilizantes Mexicanos, S.A.—Mexico
Fertilizantes Ecuatorianos S.A.—Ecuador
Foster Wheeler International—United States
FPM Sendirian Berhad—Malaysia
GEASA—Argentina
Hatch Associates—Canada
Industrial Development Corporation—Zimbabwe
Instituto Venezolano Tecnológico del Petróleo
—Venezuela
IRI Research Institute—United States
Israel Chemicals, Ltd.
Jordan Phosphate Mines Co., Ltd.
M. W. Kellogg—United States
Krebs—France
Monmeros Colombo Venezolanos—
Colombia
Occidental Petroleum Co.—United States
Office Togolais des Phosphates—Togo
Overseas Private Investment Corp.—United
States
PALMAVEN, S.A.—Venezuela
Peladang Kimia Sendirian Berhad—Malaysia
Petroleos de Venezuela, S.A.
Petroquímica de Venezuela
Petrolam Nasional Berhad—Malaysia
Philippine Phosphate Fertilizer Corporation
PhilRice—Philippines
P.T. Kujang—Indonesia
P.T. Pupuk Sriwidjaja—Indonesia
Pyrites, Phosphates, and Chemicals, Ltd.—
India
Queensland Phosphate, Ltd.—Australia

Quimbrasil—Brazil
Saudi Basic Industries Corporation
Singmaster & Breyer—United States

Governmental Agencies/Foundations

Asian Development Bank
Australian Development Assistance Bureau
Centro de Estudos de Fertilizantes—Brazil
Canadian International Development
Agency—Canada
Deutsche Gesellschaft für Technische
Zusammenarbeit—Germany
Egyptian Fertilizer Development Center
Egyptian National Research Centre
Empresa Brasileira de Agropecuaria—Brazil
Empresa Colombiana de Minas—Colombia
Ford Foundation
International Development Research Centre
—Canada
International Fund for Agricultural
Development
Kellogg Foundation
Kuwait Institute for Scientific Research
National Academy of Sciences—United
States
Rockefeller Foundation
Scientific Technical and Research
Committee of the Organization of
African Unity
United Nations Development Programme
United Nations Industrial Development
Organization
U.S. Agency for International Development
The World Bank

Representative Projects Completed by IFDC Staff

- Study to determine the possibility of producing NPK fertilizers in Togo
- Pilot-plant testing and preparation of basic design for revamping a nitrophosphate plant in Colombia
- Evaluation of urea-based NPK production for Mexico
- Feasibility study of producing and using fluid fertilizers in Hungary
- Assistance in the organization, creation, and functioning of a fertilizer research center in Brazil
- Process design and engineering assistance for installation of a pipe reactor in an existing fertilizer granulation plant in Colombia
- Measurement of all effluent streams from a fertilizer granulation plant in Brazil and recommendation of modifications to decrease pollution and recover materials
- Evaluation of proposals for the development of the fertilizer distribution system in Indonesia
- Market analysis for a proposed Indonesian ammonium nitrate complex
- Development of a plan to increase the use of fertilizer on coconut palms in Sri Lanka
- An analysis and feasibility study of a proposal to establish a regional fertilizer production and supply center in the Caribbean
- Process development, coordination with engineering firms, operator training, and long-term startup assistance to a fertilizer plant in Malaysia
- Study to determine the feasibility of using Colombian indigenous phosphate deposits to manufacture fertilizer products for domestic use and possible exports
- Process design for the conversion of a granular triple superphosphate plant to produce urea-based NPKs in Colombia

Approach

We approach each project by discussing and defining the scope of work and objectives with you. A written proposal is then prepared that includes: our understanding of the project's objectives; the scope of work; a detailed work plan and schedule; an estimated completion date; resumé of staff and outside consultants assigned to the project; project cost; and method for presentation of findings, conclusions, and recommendations.

Each project team is headed by a principal investigator or project coordinator. Staff with the required expertise are chosen for specific tasks; senior staff members participate in all projects. The report containing the conclusions and recommendations presented to you is developed through the total effort of the team and represents IFDC's best analysis and judgment.

Services are provided on a cost reimbursable basis.

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W. E. Clayton, p. 7 (center); John T. Colagross, p. 11; M. Terry Frederick, p. 5; Azizul Islam/BADC, p. 2 (top); J. J. Schultz, p. 7 (top); and Tommy L. Wright, pp. 2 (bottom), 3, 4 (bottom), 6, 7 (bottom).

Market Development Studies

Studies in market evaluation conducted by IFDC staff involve a wide spectrum of surveying and technical analyses that can be applied in an international context. Projects have included marketing analyses for both existing and potential products, commodities, and facilities.

Typical projects have covered:

- A fertilizer marketing study for Nigeria. The objectives of the study were to assess the marketing system and any constraints on it; develop supply and demand projections; develop plans and detailed investment proposals for a fertilizer marketing system; and make recommendations concerning policies and government action needed to achieve these objectives.
- A marketing study for Venezuela. The study team examined the fertilizer supply, marketing, and distribution system to determine ways to improve its operational and cost efficiency while providing farmers with fertilizers and fertilizer-use knowledge necessary to derive maximum economic benefits.
- A fertilizer sector study for Cameroon. The study team evaluated the present system and proposed improvements. The team members covered three inter-linked areas: fertilizer supply, marketing, and use.
- A fertilizer sector study for Kenya. The purposes of the study were to (1) determine economic returns to fertilizer use on principal crops and forecast an effective demand for fertilizers and (2) develop a strategy for promoting a market-based efficient fertilizer marketing system.
- Regional supply/demand studies of Africa, Asia, Latin America, and the developed countries.
- World supply/demand studies to analyze the changing patterns of world fertilizer production and consumption and to identify major trends.
- Reports on international fertilizer market information sources.
- Reports on current fertilizer market statistics from about 60 developing countries. These statistics include farm-level prices on major fertilizer products and crops.
- A market survey of phosphate fertilizers in Colombia. The demand for phosphate fertilizers and future supply and demand were analyzed.
- A study of Ghana's fertilizer procurement and marketing system. Proposals for privatizing the fertilizer-related processes and improving the already privatized nonfertilizer farm input system were also developed.

Fertilizer Distribution, Transportation, and Handling Studies

In the developing countries, an effective physical distribution system for fertilizers is a critical component of a successful crop production program. The farmer must be able to rely on the fertilizer being available when and where he wants it.

IFDC's technical assistance in the distribution area involves all aspects of physical distribution, from the point of production or import down to the dealer and retailer level. This covers import handling, packaging, transportation, and warehousing, as well as planning and operation of the overall system and integration with other segments of the overall supply and marketing plan. Alternative methods are considered, such as movement in bulk or bags; use of manual or mechanical packaging and handling systems; use of unitized loads, including pallets, slings, and intermediate bulk containers. These are all considered in the context of integrated supply, transportation, and storage systems using all forms of transport—by road, rail, and water. Storage systems, inventory control, and planning are also of critical importance. The overall objective is to achieve the most practical and appropriate system at the most reasonable cost.

The main routes for technical assistance and technology transfer are (1) in-country studies and (2) training programs, both in-country and at IFDC Headquarters. Technical inquiries are also dealt with on a regular basis.

Examples of distribution studies:

- A review of the distribution system in Bangladesh.
- Assessment of bulk import handling methods in India.
- Review of the Indonesian distribution system.
- A major 10-year distribution strategy study for Indonesia.
- A transportation and warehousing study in Nigeria.
- Studies of distribution aspects as part of overall production and marketing strategies have been undertaken in Nigeria, Venezuela, Turkey, Burkina Faso, and Côte d'Ivoire.

Policy Development and Evaluation

IFDC staff can assist government agencies that are responsible for fertilizer policy development in determining the issues to be addressed and the most effective ways for reaching national, regional, and local objectives. Our work seeks to strengthen organizations in their implementation of fertilizer policy, taking into consideration their capabilities, needs, and the environment in which they operate. Projects concerning fertilizer policy can involve the following:

- Evaluating the economic consequences of alternative fertilizer policy options.
- Analyzing the policy implications of fertilizer research, technology development and transfer, and global economic trends.
- Providing guidelines for evaluating, formulating, implementing, and monitoring fertilizer policies.
- Establishing technology, resource, and research priorities.

Sample projects conducted by IFDC personnel include:

- + A rice policy project in Southeast Asia involving Indonesia, Malaysia, the Philippines, and Thailand.
- + A global energy and fertilizer policy.
- + A global fertilizer sulfur and food production policy.
- + A fertilizer price and subsidy policy for Bangladesh.
- + A review of the Bangladesh fertilizer sector to evaluate developments and identify major issues and policies.
- + A study to identify policy issues influencing the effective restructuring of Pakistan's fertilizer sector.
- + A study to determine technical and economic changes required to improve the effectiveness of Burma's fertilizer sector.

Feasibility Studies and Investment Analyses

An unbiased, understandable, and technically competent analysis of a new venture is a valuable tool for any decisionmaker considering a major capital investment. IFDC's staff use a variety of techniques and financial analyses to meet the specific needs of a particular client. The experience of the IFDC staff in this area includes:

- The technical and economic feasibility of building a fertilizer plant in Burkina Faso.
- The technical and economic feasibility of Niger's producing its own phosphate fertilizer.
- A preliminary economic analysis of selected alternative fertilizer supply schemes to enable a fertilizer company in Ecuador to meet projected sales requirements.
- A feasibility study concerning a urea fertilizer plant in Indonesia. This study estimated the market for urea on Java, determined whether an expansion of the complex could economically supply the urea market of Java, and identified alternatives including export for marketing the tonnage received from outside markets.
- A technical and economic assessment of an NPK plant in Togo.
- The agronomic and marketing components of a feasibility study for a fertilizer complex in Thailand. The purpose of the study was to determine the feasibility of constructing a large nitrogen and phosphate fertilizer complex to supply most of Thailand's domestic fertilizer requirements.
- Determination of the appropriate products and the size and location of their markets for an ammonium nitrate fertilizer plant in Indonesia.
- Economic evaluation of a urea and diammonium phosphate complex in Cameroon, as part of an overall fertilizer sector study.

Data Handling Services

IFDC's Fertilizer Evaluation Program and Information System (FEPIS) unit provides services in data processing and statistical and economic analysis of fertilizer data and crop simulation modelling.

IFDC has computer facilities and appropriate software for the statistical analysis of experimental data and for the management of a data base of fertilizer-related information. Data from field and greenhouse experiments conducted by national programs or IFDC scientists are analyzed at IFDC Headquarters to determine the nature of responses to experimental treatments. The computer equipment and software also include devices to produce high-quality graphical displays of data.

IFDC staff are compiling a fertilizer evaluation database from experiments conducted over a wide range of agro-ecological zones and on a diversity of soils and against a wide background of socioeconomic environments. The database will facilitate identifying which factors are important determinants of fertilizer performance.

In collaboration with various institutes, we have developed computer simulation models of crop growth and response to fertilizer. These models operate with daily climatic data, basic soil description information, and some information used to describe the crop variety and its management. The models can be used to simulate the response to fertilizer in any location where the crop is grown. These models are useful for providing insights into the fate of fertilizer and for examining the consequences of various fertilizer management practices. The models are designed to operate on IBM-compatible microcomputers.

Scientists from many nations are using the models developed at IFDC in their research programs. Scientists, economists, and extension personnel from over 30 countries have requested copies of the models.

Agromineral Resource Evaluations

IFDC's involvement in agromineral resource evaluations ranges from regional surveys to the development of large-scale commercial ventures to the evaluation of small-scale local deposits. A particular emphasis is placed on the use of indigenous resources and the development of alternative technologies to use low-grade and low-quality ores.

One of the first steps in many agromineral resource evaluations is a characterization study. Samples may be submitted to IFDC for analysis, or IFDC geologists may collect the samples. These samples may be the product of extensive exploration and development programs.

Ore characterization involves chemical, mineralogical, and textural studies. The IFDC chemical laboratories are well equipped to analyze for most elements by a variety of methods.

Characterization studies may point out the difficulties in using certain ores, possible beneficiation routes, suitability for direct application, and the suitability for various forms of chemical processing. Characterization studies may provide a firm basis for further testing.

Using the Center's laboratory and pilot-plant facilities, IFDC's mineralogists and geologists can investigate the beneficiation of phosphate and other agromineral ores. They perform laboratory-scale studies to define optimal conditions before possible scaleup to pilot-plant operations. The equipment available includes primary crushing equipment, various grinding mills, attrition scrubbing and screening equipment, magnetic separa-

tors, various types of density separators, and flotation cells.

IFDC's staff have developed and maintain a worldwide agromineral database. This database has been developed for IBM-compatible microcomputers. The database is divided into two general categories. Literature, both published and unpublished, forms the basis of the first category. Chemical and mineralogic information is the basis for the second database category. IFDC has data on approximately 1,200 samples from over 175 deposits of agrominerals in more than 70 countries.

IFDC geologists and engineers are available for onsite evaluations. Among the services offered are geologic evaluations, resource-reserve estimates, development of mining and processing plans, and economic analyses.

Some examples of current and past projects are:

1. Agromineral resources of East and Southeast Africa, Funded by the World Bank and UNDP. (A regional resource review.)
2. Burundi-Matongo Phosphate Project, Funded by the Government of Burundi. (Geologic beneficiation and processing study, also included a mining plan.)
3. Characterization and Beneficiation Studies of Phosphate Rock from Bahia Inglesa, Chile, for CORFO.

Production-Oriented Technical Assistance

Local fertilizer plants are an essential link between the suppliers of basic raw materials and the farmer who has unique agronomic needs. The continued growth and improvement of the local fertilizer production sector will help to ensure increased supplies of fertilizer of the appropriate type required by the farmers.

IFDC staff can provide onsite assistance to plants of this type. A more important role of ours is that of a coordinator for bringing together the appropriate expertise to identify and solve problems. We may recruit experts from industry or other appropriate organizations on short-term consulting contracts. This practice greatly expands the technical expertise available through IFDC.

IFDC staff have broad and comprehensive experience in helping solve the most frequently occurring production problems encountered by the small- and medium-sized producers. Examples of the most common problems that are often handled by our staff are:

1. Process and equipment debottlenecking.
2. Process optimization with emphasis on decreasing production costs.
3. Pollution auditing (field measuring) and cleanup.
4. Maintenance troubleshooting and problem solving.
5. Process design, additions, and improvements.
6. Improvements in packaging, materials handling, and distribution systems.

7. Quality assurance methods and programs.
8. Miscellaneous site- and problem-specific assistance and training.

Examples of specific projects that have been handled by IFDC staff include:

- Development of a bulk-blending strategy using salvaged equipment to complement an existing fertilizer granulation plant in Colombia.
- Measurement of all effluent streams from a fertilizer granulation complex in Brazil and recommendation of modifications and additions to decrease pollution and raw material losses.
- Evaluation of an existing fertilizer granulation plant in Turkey and advice on the feasibility of installing a pipe reactor.
- Production and engineering assistance and training in the operation of an existing triple superphosphate fertilizer plant in Mexico that was converted to produce diammonium phosphate.
- Process development, process design, coordination with engineering and construction firms, operator training, and long-term startup assistance to a fertilizer company in Malaysia.
- Plant layout and equipment specifications for a plant in India to produce partially acidulated phosphate rock.

Research and Development of Products/Processes

IFDC is qualified to offer a wide range of research and development services and can conduct numerous unit operations and evaluate many unit processes. Our staff stand ready to develop technology appropriate to the constraints of the situation for the small and large entrepreneur.

Some examples of unit operations and processes that IFDC can offer depending on the scale are:

1. Acidulation
2. Briquetting
3. Bulk blending
4. Centrifugation (small scale)
5. Compaction
6. Concentration
7. Cooling
8. Crushing/grinding
9. Drying
10. Evaporation
11. Filtration
12. Flotation
13. Fluidization (drying, cooling, granulation, coating)
14. Freeze drying (small scale)
15. Gas scrubbing
16. Granulation (pan, pugmill, drum, pinmixer)
17. High temperature fusion/calcination
18. Materials handling
19. Mixing/dissolution
20. Neutralization
21. Settling/clarification
22. Solvent extraction
23. Screening/hydrocloning
24. Vacuum evaporation/concentration

A variety of modern instruments can be used to support the work of IFDC such as X-ray diffraction, X-ray fluorescence, scanning electron microscope, liquid and gas chromatographs, infrared spectrometers, ultra-violet visible spectrophotometer, differential scanning calorimeter, ion chromatograph, image analysis, and differential thermal analysis and thermogravimetric analysis.

This equipment can be used for such diverse projects as:

1. Evaluation of clays/minerals.
2. Preparation of water treatment chemicals.
3. Routine and special chemical analyses.
4. Specialty products for testing/market development.
5. Use of byproducts to reduce pollution and/or generate income.

Research and development can be conducted for a client on an exclusive, proprietary basis.

Fertilizer Evaluation Studies

IFDC has assisted government and international agencies in the evaluation of fertilizer products and application practices and in the development of fertilizer recommendations to farmers. Work in this area has been focused on the agronomic and economic evaluation of products and practices through experiments conducted in experimental stations and on farmers' fields. Recommendations are derived so as to ensure economic benefits to individual farmers, in particular, and to the nation, in general. Among the different fertilizer evaluation studies conducted by IFDC in general, the following projects are representative of work in this area:

- Response of groundnut and millet to NPK in the groundnut basin of Senegal
- Agronomic and economic evaluation of urea placement and sulfur-coated urea for irrigated paddy in farmers' fields in India
- Agronomic and economic evaluation of Tilemsi phosphate rock — Mali
- Evaluation of phosphate fertilizer alternatives in Colombia
- Evaluation of farm-level urea and SCU trials in the Philippines

Training in Improved Fertilizer Development Technologies

IFDC's staff have a broad range of experience in training the personnel of developing-country agricultural sectors.

We have conducted training programs in such countries as Bangladesh, Brazil, Cameroon, Colombia, India, Indonesia, Kenya, Malaysia, Mali, Mexico, Nigeria, Pakistan, the Philippines, Singapore, Sri Lanka, Syria, and Thailand.

Training programs can be adapted to the specific needs of individuals, organizations, governments, or sponsoring agencies interested in fertilizer sector development. Specialized training can be provided for individuals at the request of their government, institute, or company. Developing-country personnel from varying backgrounds, including fertilizer plant managers, engineers, supervisors, marketing and distribution specialists, agricultural planning officials, research scientists and managers, extension directors, and use efficiency technicians, have participated in the training programs.

These programs draw on the expertise of our multidisciplinary team of training specialists to provide stimulating and innovative sessions. This training may occur informally on the job or it may occur in a larger, more formal group setting.

Some examples of the types of group and individualized training programs conducted by our staff include:

- Fertilizer production.
- Maintenance and production management in fertilizer plants.
- Development of indigenous phosphate deposits.
- Fertilizer quality control.
- Fertilizer marketing management.
- Fertilizer distribution and handling.
- Data collection, analysis, and projections for fertilizer sector studies.
- Statistical and economic analysis of fertilizer experimental data.
- Use of microcomputers for fertilizer sector operations.
- Research on effective use of fertilizer.
- Advances in fertilizer and irrigation technology.
- Investment analysis and decisionmaking for fertilizer sector projects.
- Fertilizer sector development

The IFDC staff is qualified to offer training programs in:

- Fertilizer policy development
 - Communications
 - Commercialization of input marketing
 - Economic forecasting for fertilizer policy
 - Extension methodologies
 - Management of agricultural organizations
 - Management of agricultural research
 - Management of rural development programs
 - Small-farm budgeting
 - Small-farm technologies
 - Soil-fertility and fertilizer use
 - Bulk blending
 - Liquid fertilizers: production and use
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IFDC'S Corps of Fertilizer Specialists

IFDC is unique in that it can draw upon a multidisciplinary, multilingual corps of specialists to provide technical assistance, advisory services, and training to developing-country clients. Our multinational staff represent several disciplines and include soil scientists, agronomists, economists, chemists, chemical engineers, geologists, and marketing and training specialists. These professionals possess the technical skills, area knowledge, and language proficiency for overseas field assignments. Outside experts from industry, government, or other entities supplement the IFDC staff. This diverse expertise and experience is available to assist a government, company, or organization.

Fertilizer Research and Development

E. Richard Austin. Instrumentation analysis, experimental systems design. Ph.D., physical chemistry, Pennsylvania State University.

André M. Bationo. Agronomy, soil fertility. French. Ph.D., soil fertility, Laval University.

Walter E. Baethgen. Soil science and biometrics. Spanish, Portuguese, and French. Ph.D., soil science, Virginia Polytechnic Institute and State University.

Bernard H. Byrnes. Soil science, remote sensing. Spanish. M.S., soil science, University of Wisconsin.

Michael F. Carter. Agronomy, soil fertility. M.S., agronomy, Auburn University.

S. H. Chien. Soil chemistry. Chinese. Ph.D., soil chemistry, Iowa State University.

C. Bruce Christianson. Soil science, microbiology. French. Ph.D., soil science, University of Manitoba.

Ray B. Diamond. Soil fertility, fertilizer use research. Ph.D., soil science, University of Florida.

Dennis K. Friesen. Soil science, chemistry. Ph.D., soil science, University of Guelph.

Lawrence L. Hammond. Soil fertility, fertilizer use research. Spanish. Ph.D., soil science, Michigan State University.

Deborah T. Hellums. Soil chemistry. M.S., biology, University of North Alabama.

Leella S. Holt. Analytical chemistry, industrial chemistry. M.S., chemistry, University of Alabama.

Johannes P.A. Lamers. Agronomy (crops). Dutch, German, and French. M.S., field crops, Agricultural University of Wageningen.

A. U. Mokwunye. Soil science, extension. Ibo. Ph.D., soil science, University of Illinois.

G. Erick Peters. Analytical chemistry. Ph.D., analytical chemistry, organic chemistry, biochemistry, University of Alabama.

Ahli K. Pinto-Toyo. Agronomy, soil fertility. French. M.A., agriculture, North Carolina State University.

Edward R. Rhodes. Soil fertility. French. Ph.D., soil fertility, Aberdeen University.

Narayan K. Savant. Soil science. Hindi, Marathi. Ph.D., soil science, Poona University, India.

Henry Ssali. Soil chemistry. Swahili. Ph.D., soil chemistry/soil fertility/general agronomy, Ohio State University.

John M. Stumpe. Soil science, analytical chemistry, industrial chemistry. M.S., agronomy, Colorado State University.

Thomas P. Thompson. Farm-level constraints to fertilizer use, socioeconomic constraints to agricultural development. Dutch. Ph.D., sociology, Virginia Polytechnic Institute and State University.

P.L.G. Vlek. Agricultural research and development, soil science. Dutch, French, German. Ph.D., soil chemistry and plant nutrition, Colorado State University.

Leif J. Youngdahl. Crop physiology. Ph.D. plant science, University of Delaware.

Data Processing Services

Carlos A. Baanante. Agricultural economics, statistics. Spanish. Ph.D., economics, North Carolina State University.

Douglas C. Godwin. Agronomy, systems modeling. Ph.D., agronomy and modeling, University of New England, Australia.

Julio Henao. Biometrics, agronomy, soil fertility, statistics. French, Spanish, Portuguese. Ph.D., soil fertility, Iowa State University.

Upendra Singh. Soil science, systems modeling. Fijian, Hindustani. Ph.D., soil science, University of Hawaii.

Economics and Policy

Balu H. Bumb. Economics, policy analysis, investment planning, demand forecasting, global analysis of fertilizer situation. Hindi. Ph.D., economics, University of Maryland.

Adolfo Martinez. Economics of fertilizer use, demand forecasting for fertilizer products. Spanish. Ph.D., agricultural economics, Louisiana State University.

Surjit S. Sidhu. Agricultural economics. Urdu, Persian, and Arabic. Ph.D. Agricultural economics, University of Minnesota.

Paul J. Stangel. Agricultural development and management, soil science, plant physiology, extension education. Ph.D., soils, University of Wisconsin.

(Also Listed Elsewhere)

Carlos A. Baanante

Marketing Development Services

Loren E. Ahlrichs. Product and market research and development. Spanish. Ph.D., soil science, University of Minnesota.

John H. Allgood. Market analysis and development. M.B.A., accounting, University of North Alabama.

Yao H. Chuang. Market development economics; manufacturing, marketing, distribution planning; agricultural economics. Chinese, Japanese. Ph.D., agricultural and industrial economics, University of Illinois.

W. Edward Clayton. Transportation and distribution systems development. Ph.D., chemistry, University of Leicester, England.

Rein Coster. Market development, economics. Dutch, French, German, and Spanish. M.S., economics, University of Amsterdam.

D. Ian Gregory. Market development, financial analysis, and demand forecasting. B.S. (Honors), agricultural science, University of Wales, U.K.

Edwin C. Kapusta. Market research and development, chemical engineering. Ph.D., chemical engineering, Iowa State University.

Nam D. Le. Technical/economic feasibility studies, process and cost engineering. Vietnamese, French. M.S., chemical engineering, McMaster University, Canada. Registered professional engineer (PE), Alabama.

Dennis H. Parish. Agronomy, agricultural development and management. French. Ph.D., agronomy, Queens University, Belfast, Northern Ireland.

K. Z. Rahman. Project management. Hindi, Urdu, Bengali. B.S., commerce, University of Calcutta.

Lewis B. Williams. Market development, agronomy, economics. M.S., agricultural economics, University of Tennessee.

(Also Listed Elsewhere)

Balu L. Bumb

Adolfo Martinez

Production-Oriented Technical Assistance

Talaat A.B. Lawendy. Minerals engineering. Arabic, German. Ph.D., physical chemistry, Cairo University.

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Jose Ramon Lazo de la Vega. Design, layout, and supervision of fertilizer plant facilities. Spanish, French, Portuguese, Italian. B.S., chemical engineering, Universidad Iberoamericana.

Vincent E. León. Process design/production consultant. Spanish. B.S., chemical engineering, University of Florida.

Owen W. Livingston. Fertilizer technology, agricultural research and development. B.S., chemical engineering, Auburn University.

Guerry H. McClellan. Geology, agricultural research and development, metallurgical engineering, chemistry. French. Ph.D., geology/chemistry, University of Illinois.

Jorge R. Polo. Chemical engineering, process design and production engineering of fertilizer plants. Spanish. B.S., chemical engineering, University of Michigan.

Amitava H. Roy. Chemical engineering, process design and production engineering of fertilizer plants. Bengali, Hindi, Gujarati. Ph.D., chemical engineering, Georgia Institute of Technology.

David W. Rutland. Quality control, analysis of physical properties of fertilizers, chemical analysis. M.S., botany, Auburn University.

James J. Schultz. Design and development of fertilizer facilities, process design, production engineering. B.S., economics and chemistry, Wisconsin State University.

Steven J. Van Kauwenbergh. Mineralogy, petrography. M.S., geology, University of Akron.

Training

M. Terry Frederick. Chemical engineering, maintenance and production management of fertilizer plants, process design and production engineering. M.B.A., University of North Alabama.

Ram S. Giroti. Management, market development, and communication. Hindi, Urdu. M.B.A., Delhi University.

(Also Listed Elsewhere)

L. E. Ahlrichs

B. L. Bumb

Y. H. Chuang

W. E. Clayton

R. B. Diamond

D. I. Gregory

E. C. Kapusta

N. D. Le

V. E. León

A. Martinez

D. H. Parish

J. J. Schultz