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AGRIBUSINESS AND PUBLIC SECTOR COLLABORATION IN AGRICULTURAL TECHNOLOGY DEVELOPMENT AND USE IN SUB-SAHARAN AFRICA: A SYNTHESIS OF FIELD STUDIES

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GLOSSARY

AFC	Agricultural Finance Corporation (Zimbabwe and Kenya)
AID	Agency for International Development (US)
ANOVA	Analysis of Variance
ARIPO	African Regional Intellectual Property Organization
ART	Agricultural Research Trust (Zimbabwe)
AT	Animal traction
BNDT	Banque Nationale pour le Developpement Agricole (Mali)
CEEMAT	Centre d'Etudes et d'Experimentation du Machinism Agricole Tropical (France)
CFDT	Compagnie Française pour le Developpement des Fibres Textiles (France)
CFU	Commercial Farmers' Union (Zimbabwe)
CG	Abbreviation for CGIAR
CGIAR	Consultive Group for International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CMDT	Compagnie Malienne pour le Developpement des Textiles (Mali)
COLEACP	Comité de Liaison Europe-Afrique-Caribes-Pacifique pour la Promotion des Fruits Tropicaux des Legumes de Centre Saison
DMA	Agricultural Machinery Division (Mali)
DR&SS	Division of Research and Specialist Services (Zimbabwe)
FARA	Division of Food, Agriculture and Resource Analysis of AID's Africa Bureau
GEPC	Ghana Export Promotion Council

ICI	Imperial Chemical Industries (UK)
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IMF	International Monetary Fund
IPR	Intellectual Property Rights
ISRA	Senegalese Agricultural Research Institute
LSCF	Large scale commercial farms
MD	Maryland (US)
NIAE	National Institute of Agricultural Engineering
OAPI	Organisation Africane de la Propriete Intellectuelle
PBR	Plant Breeders' Rights
R&D	Research and Development
SODECAO	Cocoa Development Company (Cameroon)
SODECOTON	Cameroon Cotton Development Company
SRCFJ	Section de Recherche sur le Coton et les Fibres Julieres (Mali)
SSA	Sub-Saharan Africa
TM	Tropical/Mali
UPOV	International Union for the Production of New Varieties of Plants
US	United States
WB	World Bank

EXECUTIVE SUMMARY

This report is a synopsis of five 1992 case studies of public/private sector collaboration on agricultural technology development and adoption in the following country/commodity/technology combinations:

- Mali/cotton/mechanical tillage
- Cameroon/maize/crop protection chemicals
- Zimbabwe/seeds/biological processes
- Kenya/poultry/managerial
- Ghana/fruits/postharvest handling

The field studies were conducted in two stages, Phase I, composed of data collection questionnaire completion, and Phase II, the major information collection stage. Products of this USAID-sponsored Agricultural Marketing Improvement Strategies Project include this synopsis report, the five country reports it draws upon and a data base with the characteristics of the firms interviewed in Phase I.

The objectives of the project are four-fold:

- identify and describe cases of private sector involvement in agricultural technology development;
- examine factors affecting/limiting private sector involvement;
- identify policies and activities to increase private sector participation, and;
- design and apply a framework for private sector research data base development.

A literature review identified the following factors as important to private sector involvement in technology development and adoption:

- technology demand is based on the demand for underlying technology;
- induced innovation applies whereby innovation is endogenous to the development process;
- public and private sector research is complementary;
- user support - stewardship - is critical to adoption and use;
- local adaptation is required for many technologies, and;

- appropriability is critical to private sector participation.

The Phase I interviews indicate that detailed information on private firm involvement, including investment levels, can be collected. These data are useful for a general understanding of the current situation but data bases intended for other purposes, such as assisting new firm entry, must be designed accordingly.

The case studies are divisible, based on adoption level, into the successful (cotton/Mali and hybrid seeds/Zimbabwe) and the less successful (fruit/Ghana, poultry/Kenya and agricultural chemicals/Cameroon). The successful technologies are both older (predating independence) and under significant government control while the others are both newer and less controlled. This comparison indicates the critical role of sector **vertical and horizontal** coordination and the slowness by which private entities arise to fulfill these tasks.

Additional opportunities for the private sector exist in the technology markets all countries studied. Opportunities can be ordered in an ascending fashion as follows: Ghana/fruit, Zimbabwe/seeds, Kenya/poultry, Cameroon/agricultural chemicals and Mali/Cotton. Factors affecting the private market opportunities include degree of public sector involvement, commodity market growth, level of public stewardship, and the form and operation of intellectual property rights.

The ten major findings are as follows:

1. Technology development and adoption are commodity specific and dependent on the overall commodity market.

2. Government policy has major effects on all aspects of technology development and stewardship.

3. Major additional technology markets exist for the studied commodities.

4. For the more recent technologies (poultry and fruit exports) expansion is inhibited by the absence of a coordination system.

5. The public and private sectors are complementary in research and stewardship, not competitors.

6. Stewardship of agricultural production is primarily a public sector activity.

7. Government services are improperly priced.

8. Data base development requires information from prospective users.

9. Enhanced intellectual property rights could stimulate local private investment.

10. A revised case study sample selection process will be required for more in-depth comparisons in the future.

1. Introduction and Objectives

1.1 Background

While many countries prospered during the 1980's, numerous Sub-Saharan African (SSA) nations have lagged in economic development, a condition made worse by the worldwide recession of the early 1990's. SSA comprises a disproportionate number of the world's poorest countries with high population growth rates and, in recent years, declining agricultural productivity gains (data in Craig, Pardey and Roseboom 1991). A severe drought in the southern reaches is presently deepening the problems.

Not coincidentally, many of the SSA nations operate with strongly government-controlled economies which until recently allowed little or no role for the private sector, particularly in agriculture. This centralization of control has a number of antecedents including the penchant for parastatals particularly notable in the Francophone nations and planned socialism among the countries previously allied with the former Soviet Union. France also long retained administrative control of agricultural research in its former colonies (Trigo 1987). No one suggests that the economic difficulties of SSA are solely attributable to, or correctable by, a private sector role. The absence of a private sector, however, has made these economies less vibrant and increasingly detached from many national economies, ranging from the U.S. to Latin America to Southeast Asia, which are making ongoing strides in privatizing their economies.

It is within this general environment that the AID Africa Bureau's Division of Food, Agricultural and Resource Analysis (FARA) is developing a Strategic Framework for Agricultural Research in Sub-Saharan Africa (AID Africa Bureau, 1992). This report is a component of that Strategic Framework, which is intended to build upon past experience in SSA and to extend further knowledge on how and where to foster technological change in agriculture in the region. Special emphasis is given to providing US firms with greater market opportunities in that product area.

Previous work has highlighted the critical importance of developing a partnership between private industry and government in technology research and transfer. A necessary step in that process is the establishment by the government of a business environment conducive to private firm involvement, a process that will be hampered by the widespread ambivalence in Africa toward the private enterprise system (Johnson and Lawson 1987, 14). Necessary components are legal systems that enforce business agreements, and intellectual property laws permitting a recouping of R & D expenditures. This study evaluates and expands the current knowledge on those issues in SSA. Underlying that process is the realization that many agricultural sectors are not supply limited, that demand for input and handling/processing technologies as well as output demand are critical factors. This study examines those issues both analytically and

through the creation of a data base identifying market opportunities and ancillary support agencies and personnel.

The vehicle for providing this information is five technology case studies carried out in a like number of SSA countries during 1992. The selection criterion and technology/country mix chosen are described in Section 1.4 and Appendix A. Section 1.5 and Appendix B include a treatment of the case studies. A synthesis of results and delineation of an action plan highlighting AID's potential role is included in the conclusion section, Section III. Conclusions are drawn through the evolution of a series of hypotheses about technology and private sector involvement which are drawn from the available literature.

1.2 Objectives

This synthesis, drawing on the five case studies, has the overall purpose of providing clarification of what is currently being done in agriculture by the private sector in Africa, how collaboration with the public sector can best be achieved and the appropriate role for AID in supporting and fostering increased involvement by the private sector in agricultural technology development and transfer.

Specific objectives are as follows:

(1) identify and describe cases of private sector involvement in agricultural technology development in selected countries and commodity systems;

(2) collect and analyze information to examine factors affecting/limiting private sector involvement and public-private sector collaboration;

(3) identify policies and activities to increase the participation of the private commercial sector in agricultural technology development and stewardship of technology in SSA, and;

(4) design and apply a framework for private sector agricultural research data base development.

1.3 Conceptual Basis/Literature Review

This review considers in order three levels of abstraction, beginning with an overview of the role of agriculture in development and progressing to technological change and agriculture development. It culminates with a treatment of the literature on patterns of collaboration, leading to a derivation of hypotheses to be examined in Section II.

The majority of SSA nations are in the early stages of economic development, those in which the bulk of the population is directly involved in agriculture, and many have little or no cash income. The transformation to a more balanced, industrialized and prosperous economy will depend on the creation of a marketable surplus from agriculture, as well as surplus labor which can serve in off-farm tasks. This is especially true in SSA where farm labor productivity lags behind that of the broader economy (Craig, Pardey, and Roseboom 1991, Figure 6.3). These requirements, however, do not necessitate that a surplus should be drawn off from agriculture as rapidly as it is generated. Indeed, such policies are counter to rapid and effective economic diversification.

Urbanization requires a larger marketed surplus produced by a smaller agricultural work force. That dual objective can be accomplished only through an increase in agricultural productivity, which is dependent on technological/management advances, the two being critically and directly linked. Without advances in productivity food prices rise, halting growth and creating a nutrition problem for the most disadvantaged groups. Hence the creation of wealth in agriculture first requires investment in agriculture. The interactions, however, go beyond this.

In order to interest farmers in moving to a more cash-based economic system, it is necessary to supply goods those moneys can buy. The fledgling industrial sector is one source of those goods. Thus an efficient agricultural sector can provide not only industrial inputs (labor, capital), but a market as well. Indeed, productive agriculture depends on inputs originating from outside the sector while producers who remain in the sector will look towards industry for consumer goods (Mellor 1973).

If agriculture, then, is intertwined with industrial development and dependent on technology for its advancement, it is important to have a conceptual view of the sources of agricultural technology development. Ruttan (1982, Chap. 2) reviews six models:

- Frontier model,
- Conservation model,
- Urban-industrial import model,
- Diffusion model,
- High-payoff input model, and
- Induced innovation.

The first four approaches are found wanting because they apply to an era of opening new lands to agriculture, something no longer possible in most areas of the world. The high-payoff model seeks to understand the responses to and consequences of yield-enhancing inputs like fertilizers on high yield potential varieties. However the actual development of those inputs is treated as being exogenous, which is only partly true. For the induced innovation model, the

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preferred one by implication, "technical change is treated as endogenous to the development process, rather than as an exogenous factor that operates independently..."(Ruttan 1982, 27).

Innovations are classified as being either "labor-saving" (mechanical) or "land-saving" (biological and chemical) with the scarce factor inducing technical advances in that area, as occurred with agricultural labor and mechanization in U.S. agriculture. In SSA land is likely to be the scarcer factor with ongoing population growth, although labor availability is an issue in determining some cropping patterns.

Ruttan (1982, 35/36) also discusses "induced institutional innovation," a term referring to the means by which public sector researchers are motivated to focus on the desired innovations. This is particularly an issue with non-market, publicly funded projects. As Lele notes (1975, 33/36), securing the desired innovation often involves considerable coordination of activity. Some inputs like "tractorization" can actually serve only to shift the labor bottleneck from planting to weeding. Alleviating the labor scarcity requires improved mechanical/ mechanized weeding or chemical suppressant technologies as well. Some labor constraints are more societally then physically based as Kamarck (1971, Chap. 5) emphasizes in his discussion of the consequences of traditional work specialization practices in SSA. Where, for example, women traditionally retain the proceeds of surplus food crop sales there is little incentive for them to convert to market crops even when they are altogether more profitable, because that falls into the sphere of men's work (and pay).

Alston and Pardey (1992) go further by arguing that government policies, especially price policies, are inhibiting agricultural research investment. Certainly the prevalence of policies of taxing agriculture limits its profitability and the size of the technology market.

Assumed in all of this is a clear distinction between what is public and what is private. The lack of clarity of these terms is made clear by Echeverria and Thirtle's (1991, 17/24) taxonomy of entities as public or private, commercial or non-commercial, a point reiterated by Johnson and Lawson (1987, 7). In Malawi a quip is, "the private sector is alive and well in the public sector."

The preceding, while providing some insights into what determines the level of private firm investment in agricultural R & D, is nonetheless static. It says little about how private firms decide to invest and what form that investment takes - importation, joint ventures, etc. In general little is known about these activities, especially for multinational firms for which it is proprietary information (But see Germidis 1977). Nonetheless some information on these activities is available. Echeverria and Thirtle (1991, 4) emphasize that a major failure of the public sector is a lack of understanding - even interest - in clients' needs. Often there is little direct incentive within governmental systems to have, for example, varieties adopted. By inference, successful private firms devote considerable attention to collecting information on

needs (Pray and Echeverria 1989, 10). Marketing, another relative failure for the public sector (Echeverria 1991, 372), also receives considerable private sector attention.

Marketing of technological products requires more than sales. Customers must understand the products before purchase decisions can be made, and use them properly to be profitable (and to be repeat customers). This requires support-stewardship. Writing about the US, Woleck (1987, 459) emphasizes, "...the success of many technologies in agriculture requires the active support of service firms...". Those firms have several roles: (a) consulting on product decisions, (b) contracting and training users, (c) testing and setting standards, and (d) documenting and disseminating information and field data. Information transfer may be done by the private or public sector. Indeed, an example of informal collaboration between the two is when an extension agent recommends a chemical treatment, or of more formal collaboration when land grant Universities test private varieties.

Local firm investments in SSA are undocumented but believed to be very low (Pray and Echeverria 1991, Table 10.5 and 362). This information underlies several observations regarding private agricultural research in developing countries in general and SSA in particular. First, public and private research is **complimentary** (Pray and Echeverria 1991, 348/49). One reason for this is specialization in research, with the public sector taking responsibility for the more basic research while the private does the applied work (Echeverria and Thirtle 1991, 3). Echeverria (1991, 376) provides the example of maize where private firms produce hybrids using public inbred lines. He adds (1991, 393) that local adaptation is necessary for success.

The point about local adaptation is significant because it is in the final stages of product development - known as commercialization - that the most moneys are spent (Pray and Echeverria 1989, 5). Indeed, studies have shown that the basic creative work is a result of a personal drive. Transforming that initial idea into a product, the commercialization process, is a meticulous and costly process which requires the likelihood of financial rewards (Jewkes, Sawers and Stillerman 1969). This brings us to the second point, the appropriability issue. Many agricultural technologies, whether they be self reproducing varieties or simple mechanical technologies, are easily copied so there is, in the absence of legal control, little opportunity for private firms to recover an R & D investment. The legal controls referred to are intellectual property rights and, in particular, patents. Patent protection varies across SSA but is generally limited. (For an overview of coverage and discussion see Lesser 1991.) Largely lacking is Plant Breeder's Rights (PBR) protection, a specialized patent-like system primarily for open pollinated plant varieties. In the US the adoption of PBR was a major stimulus to private firm entrance into what had been a public (university and government) preserve (Butler and Marion 1983).

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A third issue is market size - demand. The Pray and Echeverria (1991) private investment data cited above are an indication that private investment does indeed flow to wealthier countries where markets are large enough to provide a profit. Developing countries typically have small markets which is a disincentive to investment, and SSA contains a disproportionate number of low population level countries. However governmental policy, and agricultural policy in particular, can influence the level of demand. Pray and Echeverria (1991, 351) note the subsidization of hybrid maize seed in the Philippines as a market-driven inducement to private investment there in maize breeding. One important factor in the Philippines, as well as throughout the developing world, is the provision of credit. This involves both government-sponsored credit, including credit for "technology packages," and informal sources (Floro and Yotopoulas 1991).

Government policies can have other less benign effects on private investment. At one level frequent policy changes, or even threats of them, increase uncertainty which acts to depress investment. More directly, policies which limit private firm activity clearly hold down investment levels. Thus regulations which affect profit repatriation, limit foreign ownership or retain some research as government monopolies act to restrict private activities. Echeverria and Thirtle (1991, 51) list the regulations with the greatest impacts on the private sector as follows:

- permission/approval required for new technologies;
- specific conditions like controlled profit repatriation placed on multinational corporations.
- property rights (patents, PBR).
- trade and price regulations
- tax policies

When considering the role of private R & D in SSA, it is instructive to begin with an overview of justifications for public investment. These are often characterized as market failures which have been subdivided under three headings (Echeverria and Thirtle 1991, 5/9):

- **Inappropriability**: limited opportunity/high cost of claiming benefits of research because of easy (technical and legal) copying.
- **Uncertainty**: risk; overseas firms will limit investments with highly uncertain outcomes.
- **Indivisibilities**: low marginal cost for additional users, a component of the inappropriability issue. (Also called nonrivalness).

If one accepts the authors' position that market failure is rife in SSA, then there is reason to expect that public agricultural research levels would be relatively high there. Available evidence indicates otherwise, that the government role is the inverse of development level (Echeverria and Thirtle 1991, 15). Public agricultural R & D tends to be lower in developing countries. Data in Alston and Pardey (1992, Table 4) indicate that the richer countries outspend poorer ones two to one as a percentage of agricultural GDP. SSA nations are near the mean for developing countries at .5 percent.

Similarly when public investment is high, private expenditures tend to be as well. For example, Pray and Echeverria (1991,Table 10.4) report data for the mid 1980's for private investment in agriculture in India of $US 16.7 million compared to $1.4 billion in the US. Similar composite figures are unavailable for SSA, but some primary data for multinationals there indicate private expenditures of $US 5.3 million. Other formal links between public and private activities are joint ventures and contract research by the public sector (Echeverria and Thirtle 1991, 50/51)). The authors (1991, 54) lay out the possible forms of interactions in research between public and private entities as follows[1]:

Possible Interactions Between the Public and Private Sectors in Funding Execution of Research

Funding Execution		Public Sector		Private Sector	
		Non-Commercial	Commercial	Non-Commercial	Commercial
Public Sector	Non-Commercial	Institute ARC	Parastatal	Foundation Public	Joint Ventures
	Commercial		Parastatal		
Private Sector	Non-Commercial			NGO Foundation	
	Commercial	Joint-ventures			
					Multinational National Inputs Co.'s

[1] See Echeverria and Thirtle (1991, 17/19) for a classification of researchers as public and private, see 20/24 for a listing of involved organizations.

1.4 Methodology[2]

The paucity of published information on technology development and adoption in SSA, and especially on public/private sector collaboration, necessitated the collection of primary information. The approach used in this study was refined at an October 1991 meeting at Abt headquarters in Bethesda, Maryland. There it was decided to focus on products in or approaching Development Stage III, using the taxonomic system of the Strategic Framework. Moreover, the final selection of sites and products was based on commodity demand (e.g., demand driven approach) (AID Africa Bureau 1992, Chapter 4). Commodity based approaches are also known as subsector analyses.

Information collected was maximized by using a case study methodology focused on diverse subsector-based technologies in a range of agroecological and political zones across SSA. A possible limitation of this approach is the small degree of comparability across case studies which reduces the number of insights which can be gained into common factors.

The principal subsector/technology/country pairs selected for the study were as follows:

1. Cotton - Mechanical tillage - Mali
2. Maize - Chemical pesticides - Cameroon
3. Seeds - Biological - Zimbabwe
4. Poultry - Managerial - Kenya
5. Vegetables - Postharvest handling - Ghana

In addition, each technology studied incorporated several ancillary technologies which were also evaluated. Thus in Mali the development and use of animal traction carts were found critical for transportation of inputs and outputs as well as people in conjunction with the principal cotton production activities. Intensive poultry production in Kenya relies on pharmaceuticals (vaccines and antibiotic feed additives) along with the principal management inputs.

The case studies incorporated two phases. Phase I was a preliminary survey for the identification of terms/institutions/individuals to be interviewed in the major Phase II visit. In addition, the Phase I analysis incorporated the collection of secondary and primary (survey)

[2] Only a broad overview of the study design, justification and approach is presented here. Details are contained in Appendix A.

information which is incorporated into a data base. Field study of the two phases in the five target countries was completed in the period March - July 1992. The synopsis is based on the reports of the five case studies as follows:

- Roos, J. and K. Owusu-Sekyere. June 1992 (Draft), "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Ghana: A Study of Postharvest Technology for Fruits and Vegetables".

- Blake, J.B. and P. Njerga Mbugua. July 1992 (Draft), "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Kenya: A Study of Poultry Feed Processing Technology".

- Ouedraogo, I. and F. Loeffel. May 1992 (Draft), "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Zimbabwe: A Study of Cereal Seeds Development Technology".

- Serafini, P. and B. Sada Sy. July 1992 (Draft), "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Mali: A Study of Mechanization of Cotton Production".

- Heureux, C.J., S. Kone and K. Waila. May/June 1992 (Draft), "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Sub-Saharan Africa: The Case of Crop Protection Technology in Cameroon".

All are published by Abt Associates of Bethesda, Maryland under AID contract No. DHR-5447-Z-00-7074.

1.5 Case Study Overviews

The purpose of this subsection is to provide brief overviews of the five case studies. More detailed synopses are contained in Appendix B, although the interested reader is directed to the case study reports for full details. The overviews are structured to provide key information as follows:

- Country
- Commodity Subsector
- Technology - principal/secondary
- Degree and Form of Government Intervention
- Private Sector Role
- Key Issues

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- *Zimbabwe*

Commodity Subsector: Cereal seeds (esp. hybrid maize)

Technology -principal: Breeding and hybridization

Secondary: None

Degree and Form of Government Intervention: High but declining. Most breeding done by public agencies; another provides credit. Publicly produced varieties channeled through industry-owned Seed Coop.

Private Sector Role: Recent entry in maize breeding and propagation with emphasis on service. Zimbabwe is the production base for a regional market.

Key Issue: Recent shift in emphasis for public agencies from large to small scale farmers.

- *Kenya*

Commodity Subsector: Intensive poultry production (eggs and meat)

Technology -principal: Production systems

Secondary: Pharmaceuticals, feed inputs, esp. concentrates.

Degree and Form of Government Intervention: Low; little government activity in livestock sector or with management.

Private Sector Role: Substantial in production systems.

Key Issue: Feed supplies, affected indirectly by limited fertilizer and irrigation supplies.

- *Ghana*

Commodity Subsector: Fruits and Vegetables

Technology -principal: Postharvest

Secondary: Carton manufacture

Degree and Form of Government Intervention: Limited beyond production and input supplies

Private Sector Role: Postharvest systems are private

Key Issues: Must emphasize quality, as there is a transport cost disadvantage for European market. Carton production system outmoded.

▸ *Mali*

Commodity Subsector: Cotton

Technology - principal: Tillage (four levels)

Secondary: Traction carts, plow design, pesticide applicators, spinning and weaving.

Degree and Form of Government Intervention: High - subsector controlled by parastatal with credit and monopoly marketing system, as well as processing.

Private Sector Role: Limited due to dominance of parastatal.

Key Issues: Government dominance of agriculture is declining slowly under structural adjustment program.

▸ *Cameroon*

Commodity Subsector: Cash crops (Coffee, cocoa, bananas)

Technology -principal: Crop protection chemicals

Secondary: Sprayers

Degree and Form of Government Intervention: High but changing - parastatal is sole importer of chemicals and applicators.

Private Sector Role: Traditionally limited to sale and transportation of chemicals under tender offers.

Key Issues: Bankruptcy in 1989 of several state agencies led to virtual cessation of chemical imports despite their necessity for cocoa and coffee quality. Subsidies are being phased out and imports beginning again slowly.

2. Key Relationships

The purpose of this section is the assessment of commonalities among the five case studies and identification of the key factors affecting public/private sector collaboration. Broad conclusions are presented in the following section, Section III. The current section contains more specific comparisons using, in part, hypotheses as a means of focusing the examination of specific issues. Rather than attempting to rephrase the case study findings, excerpts inserted into "text boxes" are used where appropriate to emphasize key points.

2.1 Phase I Findings

The Phase I surveys were designed to serve two purposes. First, they provided a list of key contacts for the Phase II in-depth surveys. These contacts included for each of the five countries:

- A comprehensive list of names and addresses of key ministries; public research organizations, development, and extension agencies; and all private enterprises engaged in activities related to the technology.

Field staff also collected information on two additional areas:

- All available legal documentation (of the rules ad procedures) related to the technology, e.g., intellectual property law, patent law, technology licensing procedures, investment code, etc.

- Updated (last 5-10 years) statistics on both the country and the individual enterprise's use/production of both the commodity and the technology.

Identification of respondents was done through a series of sources including embassies, national departments of agriculture, headquarters of multinationals and word of mouth. Using such an approach there is no assurance that all possible entities of interest were identified but with every due effort made the results are believed to be virtually complete for the producers of the targeted technologies. Users of those technologies were also contacted, but on a sample basis rather than the universe.

The questionnaires were compiled and loaded into a data base. Key characteristics are outlined in Table 2-1. As indicated there, the bulk of the interviewed firms is private (86/103

or 83%). However, the public/mixed sector participants account for over forty percent of the total documented sales of $US 67 million.[1]

A large number of the respondents identify themselves as technology producers, although only 18 (20%) of the non-seed producing firms claim to have a research program. The total research expenditures recorded outside plant breeding is $US 260,000. Obviously research is not a major activity, as was suspected. Plant breeding is a more research intensive area with 10 (71%) of the Zimbabweans firms carrying out breeding activities at the level of $US 1.3 million annually. Clearly, local variety adaptation is a major area for R & D investments. Relatively few (17%) firms provide extension type services, and the bulk of these (55%) are public sector entities like cooperatives.

Table 2-1: Characteristics of Interviewed Firms by Country:

	Ghana			Mali		
	Public	Coop	Private	Public	Coop	Private
No. Entities	4	16	3	4	5	26
Sales ($thousands)	3625	6681	5375	21785	58	341
Research ($thousands)	11	227	12.5	9	0	0
	Kenya			**Zimbabwe**		
	Public	Coop	Private	Public	Coop	Private
No. Entities	5	3	20	4	4	6
Sales ($thousands)	0	0	881	2700	21700	14000
Research ($thousands)	0.1	0	8	502	490	310

Notes: Private includes "farms"
Public includes "mix" (parastatals)

[1] These figures apply to Mali, Ghana, Zimbabwe and Kenya only.

The proceeding were tabulated from extensive in-person interviews with the identified firms/agencies. The collection of basic information on activities and revenues/expenditures involved about three-fourths of the forty odd questions asked. The questions were tailored to the specialties of the technologies studied in each of the countries. Beyond that there is no record of the rationale for the questions selected.

The remaining ten questions were open-ended inquiries about growth, reasons and problems. Pertinent responses, up to the three most common answers, are summarized in Table 2-2. Several commonalities are apparent from these responses. It is evident that, in the view of the interviewees, the growth of the underlying demand for the commodity is the principal factor in technology demand. In the ensuing competitive environment firms either adopted technology as a cost-restraining necessity or as a service to their customers. This suggests that the service-oriented approach taken by private breeding firms in Zimbabwe is potentially a viable one. (Box A) Regarding the required incentives, respondents often mentioned financial

Table 2-2: Selected Factors Affecting Technology Adoption and Private Investment

ISSUES:	Ghana	Zimbabwe	Kenya	Mali
Reasons for Growth	1. increased demand 2. good capacity and services	1. high technology demand	1. high demand 2. pharmaceuticals	1. technology demand 2. demand 3. stewardship
Sector Needs	1. financial incentives 2. increased exports 3. better linkages	1. incentive pricing 2. increased extension 3. stable land tenure	1. chick supply 2. feed quality 3. raw materials	1. technical assistance 2. higher income
Needs of private sector	1. financial and technical assistance 2. access to information 3. investment incentive	1. end exclusivity agreement with government breeding 2. financial assistance	1. credit 2. technical assistance	1. reduce speculation
Needs for foreign investment	1. profit repatriation 2. enabling environment	1. profit repatriation	1. profit repatriation	1. improved education 2. better management

Source: Phase I Surveys

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incentives. These include better access to capital for domestic firms and a freer business environment for foreign firms. Among the recommended reforms of the business environment is easier profit repatriation for foreign firms. Strides in that regard have been made through the economic restructuring underway in several countries, but apparently not sufficient progress in the judgment of the respondees. The other identified need is for more extension activities and other improved sources of information. Clearly in SSA, as in the US, extension can play a critical information role leading, indirectly, to greater sales (Box A).

Zimbabwe - private firm service approach (p. 28):

"Pannar offers large discounts to wholesalers to help establish a reliable distribution network. Cargill is emphasizing quality control, making sure its products are returned for repackaging to relieve wholesalers of unsold stocks and to ensure good germination of its products."

Kenya - technical support (p. 47):

"The production of poultry meat and eggs is an extremely complex operation. It requires professionally trained experts in the fields of poultry economics, genetics, nutrition, environmental control, poultry husbandry, pathology, food technology, disease control, and marketing. This kind of specialized support system does not currently exist.

The development of the poultry industries in Kenya is likely to be constrained by these factors, therefore, specialized training in modern commercial poultry production should be implemented immediately."

Box A

There are multiple uses for data base information such as that collected in Phase I. It can be useful for policy makers, both national and multinational, to understand better the perspectives and needs of sectors or by private firms who wish to invest in those countries and sectors. As presented the Phase I data base consists of a mix of that information with no obvious user group identified. Thus its usefulness in its present form is limited. Constructing a more useful data base would require, as initial steps, the identification of user groups and consultation with them about information needs and optimal formats. This is a critical step but need not be unduly lengthy. A nearly complete list frame is also important for the statistical reliability of the results.

The Phase I results do, however, demonstrate that the collection of detailed and potentially sensitive information from public agencies and private firms in developing countries is possible. Previous compilers of primary information on private firm R&D in particular have raised questions about the possibility of accomplishing this step. Personal interviews are of course

expensive and time consuming so that appropriate arrangements must be made and standard data collection practices followed.

2.2 Phase II Findings

The purpose of this section is the assimilation of the materials presented in the case studies (and abstracted in Appendix B) and drawing of general conclusions. Those conclusions are cast in the form of hypotheses "tested" by information and examples drawn from the case studies. The relationships to be examined are grouped under four headings; (a) technology and commodity systems, (b) public/private collaboration, (c) stewardship, and (d) policy and regulatory environment. These are considered in turn below. More general conclusions are reserved for Section III.

Technology and Commodity Systems

Technology transfer must be embodied in particular technologies which in turn are associated with a specific commodity or commodities. This subsection examines the relationships between the technology specifics and private sector involvement.

Three hypotheses can be examined under this heading:

1. Private sector involvement in technology development is dependent on the nature of the technology.

2. Improving commodity marketing systems is neither a necessary nor sufficient condition for inducing the development and use of technology.

3. Widespread technology adoption is dependent on local adaptation.

1. Private Sector Involvement in Technology Development is Dependent on the Nature of the Technology.

The case studies were selected so as to maximize the differences among the technologies studied (See Appendix A). Thus considerable variability exists which will assist in responding to this hypothesis. The short answer is yes, the form of technology affects the level and type of private sector involvement. The postharvest handling and packaging equipment used in Ghana is supplied exclusively by the private sector while seed breeding remains dominated by the public sector as are the cotton ginning and weaving machines. Simpler products (carts, small tractors) are largely publicly developed. Thus there is an apparent relationship between technology and supplier, with the more sophisticated (and lower volume) machines and crop protection

chemicals provided exclusively by the private sector and the simpler by the public. Some, seeds, permit a more mixed involvement.

Mali - local adaptation (p. 19)

"There is a range of soil tillage equipment that has been developed or modified specifically for cotton farmers in West Africa. The "Tropical/Mali" (TM) plow is one of the most successful of these pieces of equipment. Research organizations in England (National Institute of Agricultural Engineering - NIAE), France (Centre d'Etudes et d'Experimentation du Machinism Agricole Tropical - CEEMAT), Holland (Wageningen - Tillage Laboratory) and West Africa (Senegalese Agricultural Research Institute (ISRA)-Bombey, Agricultural Machinery Division (DMA)-Mali, etc.) as well as private companies, such as Rumptstad in Holland and Muzon in France, and the several parastatal animal traction manufacturing concerns in West Africa have contributed to the development and improvement of the AT equipment so widely used in the cotton producing areas throughout the region. More than 80% of the farmers (90% of the area cultivated) in the cotton growing areas in Mali have this piece of machinery."

Box B

The reasons for these differences, however, is not immediately clear. It involves a mix of market size, need for stewardship (esp. technical assistance) and the necessary degree of local adaptation. (Box B) Spinning and weaving equipment is standardized so there is little need for local adaptation while crop protection chemicals are costly to develop and have worldwide applicability. Private firms can achieve economies of scale in world markets. Technical support would be part of that process. Seeds, however, can be adapted to infinitely finer niches so that there is, at the technical level, opportunity for multiple entrants. Thus, in this context, "technology" should be taken as a composite of factors which to a greater or lesser extent favor private firm involvement.

2. Improving Commodity Marketing Systems is Neither a Necessary Nor Sufficient Condition for Inducing the Development and Use of Technology.

This hypothesis can be answered in the negative by examining the experiences in Kenya and Ghana. The Kenyan poultry sector is inhibited by underdeveloped marketing systems at both ends. The supply system for feeds is poorly developed, contributing to spot shortages and sell-offs of birds. The product market is rudimentary, notably lacking in quality control (Box C). This limits sector prices and profits. The relationship is even more clear in the Ghanan pineapple sector. There a high quality product is essential to compete with the cost advantage of surface transported pineapple from the Ivory Coast. Yet the infrastructure system necessary

to deliver that quality is incomplete. At the same time secondary processing and local markets are required for disposing of all of the crop in a profitable manner. That too is underdeveloped.

A good commodity marketing system is, then, a necessary condition for inducing technology adoption, but is it sufficient? The Mali cotton case can give some insights. There the cotton marketing, be it unprocessed or in the form of cloth, is well developed and in fact serves neighboring countries as well. But in addition the CFDT found it necessary to finance "technology packages" and otherwise stimulate production. Apparently the mere existence of an efficient marketing system was inadequate. Similarly in Zimbabwe, credit is the key to a high adoption rate for hybrids. (Box C)

Kenya - broiler meat (p.11):

"Most frozen, commercially processed, whole broilers are distributed in small uninsulated trucks to restaurants, hotels and other institutional users. A small number of broilers are sold directly to consumers through supermarkets throughout the city. Poultry meat packing is unimaginative (usually plastic bags). Dressed broilers are quite small with poor conformation and weight between 1.0-1.2 kg. Because white maize is sometimes used in the feed ingredients, the birds are pale skinned. There is very little cut-up chicken. It is only cut up at the customer's request by the butcher who uses a cleaver to produce many bone-fragmented pieces."

Zimbabwe - importance of credit (p. 27):

"Financing input purchases is one important element of 'production pacts' promoted by the Government of Zimbabwe. For more than 70 years, the Agricultural Finance Corporation (AFC) has provided loans for agricultural inputs and capital equipment primarily to LSCF's [large commercial farms]. Since independence more and more loans are reaching communal farmers as well ... Extensive credit loans to communal farmers account for the success of hybrid maize in Zimbabwe."

Box C

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3. Widespread Technology Adoption is Dependent on Local Adaptation.

This is a subset of hypothesis one above. What is the need for local adaptation and hence what is the role for private firms which principally conduct adaptive R & D? The general answer is extensive (see Evenson, Evenson and Putnam 1987). The closer to commodity production the more the adaptation seems to be needed. This is true for varieties (Zimbabwe), management systems (Kenya), feeding programs (Kenya) and simple implements (Mali) (Box B). The only technology systems which were found in the case studies to be widely adopted were those which were specifically and continuously adapted to local conditions (Box D). This need provides a broad opportunity for the private sector. The exception is Cameroon where chemicals were merely formulated in-country. However, the costless access to these products by farmers bypasses a market test. Box D

Private/Public Collaboration

In recent years it has become evident to many that agricultural R & D is not competitive (substitutive) between the public and private sectors but rather collaborative (complimentary). Typically, the public sector concentrates on more basic research while private firms apply the results. This is of course not a complete distinction for both groups become involved in both areas of research. In particular, the public sector champions some products which either have small markets or act as a competition-maintaining effort. However, the pattern is broadly applicable. What then can be said about the specific types and forms of collaboration between the two sectors in SSA? Four hypotheses apply:

Mali - adaptations of sprayers (p. 40):

"Pesticide based insect control is by its nature a mechanized process. It is in this area, perhaps more than any other, that technical progress in equipment designed especially for limited-resource farmers has resulted in a more effective and user appropriate situation. The transition from "back-pack" sprayers to the ULV sprayers has made crop protection available, easier, safer, more economical, and more effective for cotton farmers in Mali."

Box D

4. The traditional government monopoly of agricultural research, while easing to a degree in recent years, continues to limit private investment in that sector.

5. Commodity marketing is dominated by public institutions while technology marketing is a mix of public and private concerns.

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6. Collaboration is limited when the public sector has nothing to offer.

7. Collaboration in kind is more common then the direct transfer of funds.

4. The traditional government monopoly of agricultural research, while easing to a degree in recent years, continues to limit private involvement in that sector.

In order to understand better the issues raised here, government involvement can be categorized in three spheres, policy, R & D and attitudes/expectations. Government policy continues to influence heavily private investment. By holding seed prices low, the Government of Zimbabwe limits private firm opportunities. Restrictions on hard currency availability for feed imports keeps the intensive poultry sector operating inefficiently. (Box E) Outright monopolies of agricultural R & D are now rare. However, export parastatals effectively retain this control as they are typically the sole buyer in a country, as with Mali and until recently Cameroon. (Box E).

Kenya-High Quality Feed Imports

"The consensus is that maize and soybean will need to be imported if poultry production is to increase, until such time as grains are produced in-country. Soybean meal, the major vegetable protein source in poultry feed, is not yet produced in Kenya and there is no guarantee by the government that a steady supply can be imported."

Cameroon - parastatal deprivation

"It is generally believed [...] that the subsidy system, because of its implied state-centralized distribution system, has deprived farmers of opportunities for learning and for developing managerial competence."

Box E

As important, perhaps, are public attitudes and expectations. With the long tradition of sole public activity in agricultural R & D there is suspicion within and outside government of private firm involvement. This is fueled by a broad ambivalence toward capitalism in SSA (Johnson and Lawson 1987). All this indicates that the public sector continues to retain the dominant position in agricultural research and will do so for the foreseeable future.

5. Commodity marketing is dominated by public institutions while technology marketing is a mix of public and private concerns.

This issue is not nearly so clear. Certainly it applies to cotton marketing in Mali, but seed sales in Zimbabwe are dominated by Seed Coop, a cooperative of seed propagators, albeit one with monopoly rights to government-produced varieties. Specialized products, especially brewing ingredients, are purchased by the (sole)

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brewery. Thus there is a mix of public and private actors in all these markets. The more fundamental issue is the absence of a clear distinction between the public and private (Echeverria and Thirtle 1991; Johnson and Lawson 1987). For example, the Zimbabwe Seed Coop while owned by private firms has an exclusive no royalty arrangement with the national breeding institute. The markets are mixed because the entities themselves are mixed.

6. Collaboration is limited when the public sector has nothing to offer.

This hypothesis is close to a tautology. Collaboration implies a sharing; when there is nothing to share it does not occur. That applies in the case of the Kenyan poultry sector where the responsible ministry lacks the necessary equipment (feed testing) or Ghanan fruit handling where it is defined as being outside the scope of extension activities (Box F). Even where it existed it can ebb. Whereas the Zimbabwe ESS had collaborated by testing the private sector varieties it fell behind and the work has been shifting toward the privately supported Agricultural Research Trust (ART) (Box F). Similarly the export crop parastatals in Cameroon are atrophying under financial difficulties. (Box F)

Ghana - limits on extension (p. 21):

"The concept of extension in Ghana has been narrowly defined. Extension has been used primarily with reference to crop production and the distribution of inputs rather than as a mechanism to transfer agricultural technologies to the farmers. In the fruit and vegetable industry of Ghana, there is no extension service to postharvest technology."

Zimbabwe - Public Support for Variety Testing Inadequate (p.33):

"Private seed houses are also complaining about DR & SS's inability to keep up with the load of advanced trials for their varieties. More and more, ART has become the independent organization seed houses are turning to for running trials.

Box F

7. Collaboration in kind is more common then the direct transfer of funds.

Joint ventures do exist, but are not common. Fundamentally, the sector has such limited budgets the payment of public funds to private companies would seem to be politically difficult. Similarly it can be difficult for private entities to provide direct support for government activities. All private donations to support Zimbabwe's DR&SS services are pooled in the government treasury rather than being used in the intended ways. This is frustrating to the donors. As a result it is common to exchange products such as germplasm (Box G).

Zimbabwe - Inability to Support Public Sector Programs Directly (p. 37):

"Seed Coop [...] and other private companies express frustration because all monetary contributions they give DR & SS are pooled in the government treasury, rather than being earmarked for research. ... Most contributions to DR & SS from Seed Coop and other private seed houses are in-kind."

Box G

Stewardship

One of the apparent limitations of the public sector in the realm of technology is the lack of follow up services, also known as stewardship. The public sector may lack the necessary expertise of the actual producer or the incentive to see that a technology is implemented correctly and profitably. This applies equally to products generated by the public sector (e.g. seed varieties) or handled by them (e.g. chemicals). The private sector has much clearer incentives and opportunities in this regard.

In examining the question, what has been learned (in SSA) about how stewardship actually applies? Four hypotheses can be examined:

8. Public organizations with a regional mandate have not been major contributors to stewardship.

9. National agricultural extension programs are inadequately funded to provide an important role in technology transfer and marketing.

10. National markets for processing and packaging equipment are too small to justify maintaining local manufacturer representatives.

11. The existing information base is inadequate for the completion of marketing studies required by private firms.

8. Public Organizations with a regional mandate have not been major contributors to stewardship.

Many of the CGIAR centers have operational responsibilities in the areas studied for the commodities/technologies evaluated. For example CIMMYT conducts corn and wheat breeding and ICRISAT sorghum and millet breeding in Zimbabwe. Because of the Centers' mandated focus on foodstuffs they are not heavily involved with the other products evaluated for the case studies. Several international agencies are, however, involved in intermediate technology development - e.g. CEEMAT/France, NIAE/Great Britain, and the Royal Tropical Institute and the University, Wageningen/Netherlands for carts, plows and small tractors in Mali. Of course,

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AID and other donor groups support much of the research and extension in the study countries, but through grants rather than ongoing direct contacts.

Typically, the CG centers are involved in research and breeding, leaving local adaptation and extension to the national systems. There is no mention in the case studies of the technology development programs carrying out the stewardship activities. Thus all of the evidence indicates that stewardship is a national rather than an international responsibility.

9. National agricultural extension programs are inadequately funded to provide an important role in technology transfer and marketing.

Almost without exception the case studies report national extension programs to be virtually moribund. This is primarily due to combinations of inadequate training, limited transportation or a restricted definition of the role of extension in the vertical marketing system (Box F). CMDT (Mali) and until recently the parastatals in Cameroon are the exception as they provide direct assistance to growers. The situation there is distinct because CMDT has separate funding from product sales and, through it, the incentive to increase production (Box H). Otherwise product stewardship falls to the private sector by default (Schwartz 1992).

10. National markets for sophisticated inputs are too small to justify maintaining representatives.

This issue is addressed in the Ghana case study where it is noted that technical support for processing and packaging equipment is unavailable in-country or even regionally (Box I). The same situation could apply to the cotton processing equipment in Mali but it is not brought up as it lies somewhat outside the focus of that case study. One response has been the use of trade associations to organize advice/service supply from outside the country or region. COLEACP was set up by the European Economic Community expressly to provide a technical go-between for exporters and European importers. It is supported by members' fees.

Mali - funding stewardship (p. 48):

"The CMDT, with support from the CFDT, has extended the entire cotton-production technology package to farmers in Mali. --- This extension effort is funded from cotton reserves and by direct and indirect support from the multinational input producers and the donor community, both on a bilateral basis and through the WB."

Box H

The absence of manufacturers' representatives almost certainly is a result of insufficient sales to justify such a position. In Cameroon private firms are reducing in-country staffing in line with declining sales (Box I). Independent service companies are also rather scarce in most SSA countries.

Ghana - small local market (p. 21):

"The private sector, particularly importers, are interested in providing products for postharvest processing but, due to financial constraints, local demand is insufficient to warrant an increase in the provision of these products. The quantity demanded is too small to be very profitable... An example of this concerns the chemicals..."

Cameroon - reducing local private sector staffs with declining sales (p. 24):

"These five [chemical importation] corporations have drastically reduced their staff. --- All four rely for general services on sister companies established in Cameroon, involved in other business..."

Box I

Whatever the source, the lack of technical assistance and, by implication, repair services and scarce spare parts are a major impediment to exporting activities in particular. For example Cameroon farmers will not purchase chemicals if application equipment is lacking or unreliable. There competition is keen and reliable supply is an important factor in securing markets.

When national markets are inadequate to support manufacturers' representatives they are assigned on a regional basis. The sharp decline of the Cameroon pesticide market in 1990 as noted led to the withdrawal of most sale/technical support representatives from Douala to adjacent countries where staff was given multi-country mandates. The general organization of multinational companies' distribution/support structures indicates that they approach markets on a regional basis.

11. The existing information base is inadequate for the completion of marketing studies required by private firms.

Stewardship begins prior to private firm involvement in studies of market potential. One aspect of such studies is a determination of what forms of technical support will be required, and how they can be supplied. Marketing studies require at a minimum the names and addresses of possible suppliers, customers and technical support groups. The Phase I surveys conducted under this study provide for the targeted countries and technologies this and other information (Section 2.1). Otherwise this information is not generally available, creating an impediment for initial private firm entrance, especially smaller firms. This hypothesis is therefore substantiated.

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Policy and Regulatory Environment

Policy and regulatory environment, as the terms are used here, refer to government macroeconomic policy (tariffs, exchange rates, etc.), business policies (ownership restrictions, profit repatriation, licensing), intellectual property laws (patents and related laws), and agricultural policy (price controls, credit). Individually or as groups there factors can have major impacts on profits and incentives, and indirectly on the production or use of a technology. However, the understanding of how policies function, indeed how they are interpreted and applied by bureaucracies, are substantiated studies in their own right. Hence the interpretations presented here should be considered as initial assessments only.

Six hypotheses can be examined under this heading, as follows:

12. The absence of appropriate IPR skews the forms of private investments to appropriable technologies, such as hybrid seeds.

13. The more appropriable technologies receive greater private investment then the less so.

14. The more centralized the economy the less the opportunity for private sector involvement in research or technology sales.

15. The level and direction of agricultural research is determined principally by the funding priorities of international donors.

16. Government agricultural policy, including production loan programs, is the major determinant of the market for inputs.

17. Government policies continue to draw resources from agriculture.

12. The absence of appropriate IPR skews the forms of private investments to appropriable technologies, such as hybrid seeds.

The experiences in the US and Europe support the hypothesis that private firms do not invest in breeding unless direct copying can be controlled. That means either by production of hybrids or legal protection under Plant Breeders' Rights. Presently among the SSA countries, only Zimbabwe has a local law, that is it does not have membership in the international convention, UPOV. However the particulars of that law are not known (Kenya has a PBR law on the books but it was never operationalized). What does the Zimbabwe experience tell us about the role of PBR in SSA?

The private firms presently involved in breeding in Zimbabwe, DeKalb Hybrids, Pioneer Overseas Corporation and Cargill Zimbabwe, are all concentrating on hybrid maize which does not require legal protection with the exception of the inbred lines. Thus PBR is not a significant factor at this time, but may become more important with wheat, barley and millet in the future (Box J). Perhaps a more suitable area would be the temperate highlands. It has been found that PBR is helpful in accessing foreign materials useful in export markets (Gutierrez 1991).

13. The more appropriable technologies receive greater private investment than the less so.

This hypothesis is at the heart of the role of intellectual property rights when IPR is weak or cumbersome private firms are expected to invest only in technologies for which alternative protection mechanisms exist. For the technologies under study here the more inherently protectable technologies are hybrid maize and the more complex technologies, such as postharvest handling and packaging machinery and agricultural chemicals. The more copyable products are simple equipment (carts, pesticide applications) and management systems (intensive poultry production).

Zimbabwe - Availability of PBR (p. 41):

"The existence of Plant Breeders Rights in Zimbabwe was not a major factor influencing Pioneer and Cargill to locate their breeding operations in the country. However, it was another tangible advantage..."

Box J

The evidence on these is mixed. The most specific private investment is in maize breeding. There is no direct investment in handling/packaging equipment development for SSA, although this may be an inappropriate test, for this machinery is presently available from foreign sources and does not require local adaptation. On the other hand there have been some private funds spent on improving pesticide applicators, but that may be seen as a means of making the basic product, agricultural chemicals, more marketable rather than an interest in profiting from the applicators directly. Private funds are responsible for all agricultural chemical development. In contrast, there is no private investment in poultry systems for SSA even though the copying of these systems has proven difficult.

This mixed evidence indicates strongly that the existence of IPR are but one inducement to stimulate private investment. The existence of IPR is not necessary for all technologies and certainly not sufficient for any.

14. The more centralized the economy the less the opportunity for private sector involvement in research or technology sales.

For the sectors/technologies studied, the extremes of control are cotton in Mali, cocoa in Cameroon, and fruits and vegetables in Ghana. The farmer is nearly completely controlled by CMDT or SODECAO, both parastatals, while the fledgling export sector in Ghana has relatively little contact with the public. In the case of Mali the dominant position of CMDT prevents most private firm involvement. The same has been true of Cameroon until recently. When private firms do participate it is as sellers under tender arrangements which do not include stewardship. At the other extreme in Ghana the system is almost entirely open to private investment (although that does not necessarily imply that there is any). Thus the hypothesis that the more centralized the economy the less the opportunity for private sector involvement in research or technology sales can be supported.

That conclusion is supported by the seed sector in Zimbabwe and the feed industry in Kenya, both of which are heavily affected by government policies, especially price policies. The present opportunity there for private involvement is also severely restrained. Private breeders in Zimbabwe, for example, must compete largely through the provision of service, an expensive and problematic enterprise where price controls establish returns below profit making levels (Box K).

Zimbabwe - Seed Price Controls (p. 38):

"Prices of commercial seeds remain controlled in Zimbabwe. With the increased participation of private seed companies in recent years, seed pricing has become a thorny issue in Zimbabwe. --- From 1987 to 1989, prices of seeds and all other commodities and services were frozen by the Ministry of Commerce to fight rampant inflation. In real terms, obviously, seed prices declined these years."

Box K

15. The level and direction of agricultural research is determined principally by the funding priorities of international donors.

Government funds in all of the case study countries and indeed through the SSA region are severely reduced by the sagging economies and, most currently, repeated drought in the southern-most areas. Government funding for research, already low by developed country standards, is declining further under these budget pressures. Actual research conducted is probably impacted more, for reductions are made first in operating budgets rather than in staff. What remains is scientists without the equipment needed to carry out their work. In Kenya, for example, the Ministry of Livestock Development does not have operable equipment for meeting its mandate of feed testing while in Zimbabwe the Department of Research and Specialist Services is falling behind on advanced variety trials.

In this funding void the moneys supplied by foreign governments either directly or through the CGIAR often determine the direction of research. The design of carts, plows and applications in Mali was largely foreign funded. In Zimbabwe ICRISAT leads much of the non-maize breeding programs. This foreign financing is very significant in shaping the research directions.

Two exceptions apply in the area of self funding. In Ghana a trade association supported by member fees, COLEACP, provides technical assistance and some limited R & D while the GEPC uses retained profits to assist and encourage exporting. In Mali the CMDT earns a six percent commission on cotton exports from which it supports its activities. These arrangements not only provide a funding base they also give a direct incentive to support production and exports.

Cameroon - Impacts of Subsidy Cessation for Chemicals (p. 3):

[The] cocoa industry was, until 1989, the major user of pesticides --- with all inputs being given entirely free to growers. During the past two years, the cocoa pesticide demand plummeted to practically nothing with the abrupt elimination of all subsidies and of crop payments to growers, following the bankruptcy of various state cocoa support institutions."

Box L

16. Government agricultural policy, including production loan programs, is the major determinant of the market for inputs.

Strong evidence exists to support this hypothesis. In Mali the "technology packages" proposed by the CMDT and, more importantly, the credit allowing their purchase, are credited with the high level of yields. Agricultural chemical sales in Cameroon collapsed when the 100 percent subsidy was withdrawn (Box L). Maize hybrids have been adopted at such a broad level in Zimbabwe since loans were made available to communal (small scale) farmers. "Extensive credit loans to communal farmers account for the success of hybrid maize in Zimbabwe." (Box C). These successes can be contrasted with the poor adoption in poultry and pineapple where funding is unavailable. These conclusions have ramifications for private sector firms which are unwilling or unable to provide credit, such as in maize seed in Zimbabwe.

17. Government policies continue to draw resources from agriculture.

This is more of a macro policy issue for which a complete answer would require a detailed study in its own right. However the available evidence does indicate the continued heavy taxing of agriculture. In Mali, cotton producers are paid prices below world levels. Zimbabwe seed prices are regulated as "retail goods." While far from conclusive, these examples suggest that resources continue to be taken out of agriculture. This has major long term ramifications for the sector and for private involvement.

3. CONCLUSIONS

The purposes of this section are four-fold. The first is to identify the relatively more "successful" and "unsuccessful" technologies/commodities analyzed and the reasons for the success or difficulties. Secondly, the key factors affecting public/private collaboration are explored, and in the third subsection prospective technology markets are identified. Finally, Section 3.4 is an evolution of the major findings of the current studies and suggestions for future research.

3.1 Successful and Unsuccessful Technologies/Commodities

Successful Technologies

A review of the case studies quickly leads to the conclusion that the two successful technology offerings **in terms of adoption levels** are hybrids seed (Zimbabwe) and cotton production (Mali). Zimbabwe has over 90% maize hybrid adoption, and notably higher yields, than neighboring countries, while Mali cotton production grew by 740% between 1960 and 1985, twelve times the increase of the remainder of SSA. Moreover the distribution benefits of these technologies is relatively widespread.

To a degree these successes are surprising because the two countries involved are (or have been) the most completely and centrally controlled. However there are several other factors which also contribute to the successful implementation of these technologies. First, these are both long-standing programs. Second, both countries are currently undergoing structural change. The increased attention on reducing the role of the public sector in favor of private firms may mean a more conducive environment than exists in the other countries which have not operated at either extreme. Third, both technologies are delivered in "packages" involving input recommendations/requirements as well as credit to purchase those requirements. Clearly credit is an integral aspect of agricultural technology adoption. Finally, price policies were in place to make the production of the commodities in question attractive and the technology adoption profitable. Policies are not at cross purposes.

It should be noted that age of program and national focus are not sufficient, as the recent Cameroon experience indicates. If the policies are not financially stable in the competitive world of agricultural commodity markets, the system will eventually collapse, leading to a dramatic retrenchment in technology use.

As in any case study there are individual (national) factors at play as well. In Zimbabwe, for example, until recent years government policy was directed to the small number of large scale commercial farmers. This is always an easier group to work with than the larger number

of resource poor small farm operators. Nonetheless the program has been successful as well in reaching farmers of all sizes.

Less Successful Technologies

The technologies which have not been as successful in terms of adoption are poultry feed (Kenya) and fruit exports (Ghana). This situation may change in the future, but the identified limitations and impediments in the case studies suggest that change will be slow. This is to be expected with the introduction of newer technologies. The two technologies share two key requirements. Both necessitate coordination across several sectors (and government departments). Feed, for example, requires harmonious production incentives for the components and further local research on proper blending of rations. At the same time the poultry sector must be structured to utilize these products and market its own output. Export fruit and vegetable production requires a knowledge of foreign markets, very good production and handling techniques to maintain quality, and secondary markets for off-quality or off-season product. Clearly this degree of coordination across the sector has been impossible to achieve to date.

Additionally these more complex production systems require better management. In the absence of management training the necessary level of sophistication has been difficult for individual producers to achieve. The more specialized products are inherently more risky to produce and market, making credit less available.

At this gross level of analysis, then, it is evident that a sector requires considerable vertical coordination among the components in order to be productive. The sectors involved can include inputs (fertilizer, seed), machinery (tractors, plows, sprayers), production, intermediate markets (feed ingredients), credit, final markets (maize, eggs) and processing (spinning and weaving, packaging and handling). The "successful" technologies identified here are coordinated by government agencies - largely parastatals. However, it is rare that government agencies are successful in these endeavors as the political pressure to support producers at non-profit levels is great, and with predictable consequences. Witness the collapse of the system in Cameroon.

One of the key, but less visible, coordinating roles is the minimization of risks, especially price and market access risks. In the US and other developed countries there is a large governmental presence in the form of support prices and disaster loans (floods, droughts, hail, etc.). In selected cases other programmatic activity exists in the form of grading, price reporting and marketing orders (see e.g. Armbruster, Henderson and Knutson 1983; Marion et al. 1985, Part II). For highly perishable products, in the absence of major Federal programs, the systems have evolved into a complex of production contracts giving the contractor considerable control over volumes, methods and dates. This allows close coordination of production and processing as well as risk reduction by balancing the production across numerous individual producers and

regions. In the US major examples are poultry (esp. broilers), sugar beets and processing vegetables (e.g. Marion et al. 1985, Chapter 3).

In SSA in the absence of a major government role, a key factor will be the development of such private coordination mechanisms. It is evident that parastatals inhibit the development of these mechanisms by severely limiting the role of the private sector to, in the case of Cameroon, importers and distributors. Similarly, the individual producer is denied any entrepreneurial incentive/opportunity (Box E). Another inhibiting factor is government budgeting procedures which do not permit private research/service support in public agencies, as in Zimbabwe (Box G).

3.2 Key Factors Affecting Public/Private Collaboration

It is easy, as was done in the preceding subsection, to identify inhibitions to public/private collaboration. More significant, and more difficult, is the identification of what contributes to successful collaboration. Major examples of successful collaboration can be identified as follows:

- Sprayer and animal traction (plows and carts) equipment in Mali
- Variety trials in Zimbabwe
- Production of carts by local blacksmiths in Mali
- Registration of chemicals in Cameroon

In addition there are examples of collaboration within the private sector:

- Production of hybrid maize seeds for the private Seed Coop in Zimbabwe
- Contract production of broilers in Kenya
- Use of trade associations for use of postharvest technology in Ghana

What are the commonalities among these? Certainly they are limited in number with most public/private exchange restricted to in-kind exchange (Hypothesis 7 and Box G). In some cases the "collaboration" is mandated, as with the registration testing of chemicals in Cameroon. In that case the complaint is that the cost is too high and limit imports, but more often the services appear severely underpriced, even free, denying public agencies much needed revenues. A second factor is that donor funding can induce collaboration as with the small equipment in Mali (Boxes B and D). Within countries, government encouragement, including some financial

assistance in the case of carts in Mali, can lead to the expansion of an industry, in this instance local blacksmiths.

The existence of contract production in Kenya and Zimbabwe indicates that this critical coordination mechanism is viable despite the heavy reliance on legal systems for definitions and enforcement. Contract production is likely to expand.

3.3 Factors Affecting Private Investment

Private investment decisions are individual ones which are a response to general market conditions as well as factors particular to the company. Nonetheless an evaluation of the responses to the Phase I surveys combined with the observations of the areas in which investments were actually made suggests some clear patterns.

Not surprisingly, private firms are concerned with profitability. In terms of incentives this involves several aspects. National firms are concerned with demand and with credit access and cost. International firms have more varied credit sources but the additional need for easy profit repatriation. Since both profit repatriation and credit terms are affected by economic restructuring programs, these observations attest to their importance for encouraging private sector involvement.

Investments in technology, as noted in Section 2.1, are driven principally by growth in the underlying demand for the commodity. Two other factors also determine investment, the need to keep costs low and the provision of services to customers. These two factors describe the results of competition while the growth in commodity demand describes the need for a dynamic commodity sector. In short, private firms invest when opportunities are expanding through growth and change. A stagnant sector does not attract private funds.

Private investments are also affected by government policies which do not discriminate against private investment and which allow firms control over their inventions. The former suggests minimizing government monopolies within subsectors while the latter is an argument for strong intellectual property protection.

3.4 Prospective Markets

The case studies allow a broad assessment of the potential future market opportunities in each of these technology/market areas. Ranked in ascending order of opportunity they are cotton, feed, seeds and vegetables.

Cotton/Mali: This technology/country is ranked lowest in future opportunity because production and processing currently appear to be at a high technological level and relatively

efficient. The region's production is relatively input intensive, suggesting limited additional opportunities for further expansion. The cessation of the dominant CMDT role, especially its tender system for purchasing inputs solely on a price basis, would open the opportunity for more inter-firm competition over quality and service. The effect on US firms is unclear because the current suppliers are not identified. However a reduction of a CMDT role is unlikely to happen any time soon. The future of farm mechanization is with the Boyer tractor, and the private sector appears to have a limited role. In any event the US is not a major producer of this small scale equipment.

At the processing level, the US already dominates the fiber cleaning equipment market. Weaving equipment comes from China, which may provide a size and technology of machines which is below that currently produced in the US. Thus, overall, there are limited growth opportunities in the Mali cotton sector.

Where the potential exists is in neighboring countries where yields are a quarter to a third of those in Mali. Also, and possibly because of this, fiber processing is more limited. These areas provide major potential markets for further intensification. The success in Mali is a good example and test for the neighboring countries.

Chemicals/Cameroon: Restoration of the chemical market depends largely on a revival of cocoa production involving both the public and private sectors. The public sector must make major macroeconomic changes in business regulation, agricultural policy, and banking activities. None of this will come quickly or easily although hopeful steps are already underway. Essentially, Cameroon must make its export sector more cost competitive to regain a major position in the world agricultural market.

The private sector too must adjust to evolving national policy. The allowance of more services by private entities requires a greater investment, but whether the market prospects warrant it is questionable. The best positioned firms are the EC, especially French, companies which already have a local presence. US firms operate through agents, which complicates the adaptation process.

Feed/Kenya: The intensive poultry production system in Kenya does have substantial potential. The domestic market for eggs should be moderate and, while the internal meat market will be limited because of cost, the export potential is good. And since this sector is relatively input intensive, the long term technology market opportunities are substantial.

What is currently limiting production is the cost and availability of feed. Since feed is the major production cost, this is a serious impediment indeed. For a balanced ration, protein is most lacking. Some sources are locally available - cotton and sunflower cake and fish meal - but are limited in quantity or can be used only in low concentrations. The ideal source,

soymeal, is not produced in quantity internally and imports are sometimes barred for foreign exchange reasons. Energy feed components are also restricted but not to the same degree.

More research is needed on the efficient utilization of currently available components. This work could be privately, publicly or externally funded. Beyond that, the development of a local soybean sector will take time and resources beyond the reasonable scope of private firms.

Seeds/Zimbabwe: Despite the good national breeding and propagation system there, opportunities for private firms exist. Much of the competitive advantage for private firms, which are predominantly US companies as world leaders in hybrid maize production, will be in the provision of services, as is presently recognized. Government policy, especially pricing, will be a key determinant of profitability, but restrictions appear to be lifting. The prospect for hybrid sorghum may be even greater, especially if the current drought is prolonged. The same companies presently operating in Zimbabwe can produce this product as well.

Export market potential is even greater as few countries have the effective national breeding and distribution system available in Zimbabwe. At the same time, many countries have been easing the restrictions on private firm involvement in the seed sector. Thus, the sector is poised for growth, and US firms are already well positioned.

Fruits and Vegetables/Ghana: Ghana is expanding the fresh export market just as that market is growing rapidly. The prospects are good. The European market is relatively close and the land resources good. What is lacking is the structuring of a complete vertically coordinated system. That would involve coordinated planting and cultivation for quality and timing control, the development of secondary (processing and local) markets and appropriate post harvest handling systems. In short a duplication of the US vegetable processing system is needed (see Marion et al. 1985, Chaps. 2 and 3). Preceding all of this, a careful marketing study in Europe is required.

Structuring such a system in Ghana using market incentives (contracts, etc.) will be a lengthy process. Alternatively, a major multinational like Dole can establish the entire system and organize contract production. This is the expedient choice, but Dole has the choice of many parts of the world to operate in, and Ghana may not be among them.

3.5 Major Findings

The major findings can be identified as follows:

1. **The Case Studies support the underlying position of the Strategic Framework that technology development and adoption are commodity specific and dependent on the overall market for the commodity.**

2. **Government policy has major effects on all aspects of technology development and stewardship.**

This is most easily seen in the negative ways in which policy through parastatal control or low prices prevent or limit private sector involvement. However, governments can also specifically encourage private efforts and interaction.

3. **Major additional technology markets exist for the studied commodities.**

While the opportunities vary across the commodities, additional marketing opportunities exist in all cases. To attract private sector investment the commodity sector must be dynamic and growing and firms must be allowed the opportunity to recover investments and, for multinationals, repatriate profits. US firms often have a relatively small market share which could be expanded.

4. **For the newer technologies/commodities (poultry products and export vegetables) the major inhibition to expansion is the absence of an overall coordinating force.**

Subsector vertical coordination is critical to expansion. In the absence of a government-imposed system it will take time to evolve. Contracts are likely to play a major coordinating role, as they are beginning to in a few instances. Trade associations and other groupings of private firms exist and are a likely vehicle for enhanced coordination.

5. **The public and private sectors are complementary in research and stewardship, not competitors.**

The view of the private sector as a competitor is one of the major inhibitors to further collaboration.

6. **Stewardship of agricultural production is principally a public sector activity.**

The case studies contain few examples of private stewardship, especially at the production level and for credit. Yet these remain crucial to subsector growth. It is a major challenge to

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determine how to deliver these services when many government budgets are depleted. The situation for technological inputs is different - they are typically supported by that private sector manufacturer.

7. Government services are improperly priced.

One component of public/private collaboration is and will remain the purchase of public services by the private sector. Presently those services are mispriced, sometimes too high but often too low. Rectifying the matter will facilitate collaboration.

8. The development of a data base requires information from prospective users on needs and wishes.

The Phase I data base was in part developed for use by firms wishing to identify technology market opportunities in the case study countries. While some of the collected information - e.g. on the business climate - is undoubtedly useful, further development of such a data base requires input from prospective users on needs.

9. Intellectual property rights not presently available in SSA nations would be useful in stimulating local private investment and enhancing productive markets.

Current patent protection scope in SSA is comparable to that of most developing nations, and the existence of patent unions simplifies the application process (see Lesser 1991). However, for agriculture, the major exception is the ability to patent plant and animal varieties, but that will not be a binding issue until agrobiotechnology products are employed commercially. Trade secret legislation, often an important complement to patents and R&D, is undocumented and should be explored further. Plant Breeders' Rights legislation is unavailable except in Zimbabwe.

An evident gap in protection is that for petty patents, also called utility models. These are a lesser forms of patents intended for more minor innovations, especially mechanical ones. The "inventive step" requirement is reduced compared to regular (utility) patents as is the duration, five to 10 years. Evenson, Evenson and Putnam (1987, 507) make a strong case for petty patents in basic agricultural technology. "By providing a weaker and narrower standard of patentability and by administering the system efficiently, [the Philippines, Brazil and Japan] have stimulated local adaptive invention." Would these experiences be extendible to SSA?

The closest case is animal traction implements in Mali, especially the cart and Tropical/Mali plow. Major advances were made when the government allowed (through a modification of the acquisition process) and even encouraged local blacksmiths to manufacture these products. They became simultaneously less costly and more widely available while the

increased manufacturing provided employment. Design, however, has been done heavily by foreign nationals with some multinational firm involvement. The new pesticide applicators are following much the same pattern in development and manufacture. At this point there is no direct evidence that local blacksmiths could/would contribute to design. At the same time there is little incentive for them to do so as advances can be readily copied. Thus while no direct support can be found from these case studies, the adoption of petty patent legislation throughout the SSA is a prudent and relatively simple means of supporting local adaptation and employment.

10. The case study methodology as applied here limits the kinds of information which can be collected.

As valuable as it is, the case study methodology as applied here has several major limitations which must be considered for subsequent studies. First, the sample design procedure was constructed to maximize differences among the studies. While this leads to broad insights it forecloses the likelihood of replications so that detailed cause and effects in theory cannot be studied. For future studies a different sample design should be studied, such as a pairing of similar cases (near replication).

A second limitation of the Phase II studies was a focus on what is rather than on what might be. That is, only currently involved private sector firms were contacted. Clearly these firms had made a decision that such factors as the business climate were acceptable. A number of additional firms may have found certain factors inadequate and not participated. They were excluded under the methodology used, yet, as in any study, the opinions of non-participants is often as important as those who do participate.

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APPENDIX A - METHODOLOGY

A.1 Study Design Criteria

The conceptual basis and derivative hypotheses developed in Sections I and II demarcate a wide range of issues to be explored in the field studies. The design of these studies then becomes critical in maximizing the amount of information collected and the generalizability of the results within the available financial and human resources. This appendix details the conceptualization of the study design.

There are several bases for the selection of the design. One is akin to list or area frame sampling - essentially the distinction between surveying previously known examples (the list) or a random search through a specified area (the area frame). In the case of SSA, insufficient prior information exists to limit the analysis to a list frame so that some form of area sampling is required. The Phase I surveys were designed in part to prepare a list for the subsequent study. The use of lists greatly enhances the efficiency of information collection.

The second and related issue is the "area" to be sampled across - is it to be geographical or product space? Ouedraogo and Martin (1991) describe three distinct designs - the ecoregional approach, market demand approach and technology approach. The ecoregional method gives primacy to the ecological conditions. These conditions determine the range of commodities to be grown in each region. As examples, the semi-arid lands would specialize in course grains and ground nuts while the temperate highland are suited to producing fruits and vegetables along with the traditional coffee and tea export crops. Technologies, both mechanical and plant-based, are clearly linked to the commodities produced.

The market demand approach focuses on exports and the identification of exportable commodities with the potential for greater market penetration. Sampling would then focus on regions where those commodities are grown; the focus technologies would then be those which were capable of expanding an exportable surplus while reducing costs to internationally competitive levels. The third or technology approach is based on the identification of technologies which serve in important production or marketing problems. They include seeds and fertilizers as well as processing and storage methods or equipment. Sampling on this basis requires a prior knowledge of where certain technologies are in use or, even more critically, where they ought to be applied.

Considering private sector involvement, the level of market development becomes an additional important consideration. The Strategic Framework (AID Africa Bureau 1992, Annex B) identifies five stages of which only the first three are applicable to SSA. Stage I describes a sector economy which operates largely on a subsistence basis, which is to say has poor market access, limited use of purchased inputs and poor information flows. Clearly, such circumstances

provide few opportunities for private sector involvement. Stage III refers to economies evolving rapidly into specialization with a concomitant increase in purchased inputs and marketed outputs, greatly expanding the private sector opportunities. Of course, it is possible within a country for some commodities to operate in a Stage I environment while others are at the third level, or even for the same split to occur within a commodity within a country as, for example, production for home consumption/local sales and an export oriented sector possible composed of estates.

The preceding can be collapsed into a matrix as follows:

		Sample Basis		
		Ecology/Commodity	**Demand**	**Technology**
	I			
Stage				
Of	II			
Development				
	III			

Recall, then, the area/list frame decision was resolved by designating a preliminary (Phase I) survey for generating the list frame for the detailed studies (Phase II).

A.2. Selection of Study Sites

Further refinement of the sampling procedure was the topic for a meeting held at Abt Associates Inc. headquarters in Bethesda, MD on October 9, 1991. As a basis for the discussion several background/concept papers were presented followed by a discussion of the case study method and site selection.

During the discussion it became apparent that the major target would be products in or approaching Development Stage III. Other stages would not be excluded, but some level of market interaction is essential for significant private sector involvement. Using terminology of the Strategic Framework, the selection was based on an assessment of commodity demand (demand driven) (AID Africa Bureau 1992, Chap. 4). The rows of the sampling matrix then collapse to one. At the same time the interrelationships between two study designs, demand and technology, were recognized. Most exported commodities utilize purchased technologies as inputs and/or marketing services. While not all technology-based production is for export, all commodities use some technology. Thus, by setting technology and ecology/commodity as the axes of a 2x2 matrix it is possible to maximize variability in commodities while concentrating on the target of technology, as follows:

	Technology
Ecology/ Commodity	

This is an application of commodity-based analysis, also known as subsectors (AID Africa Bureau 1992, Chap. 4). Remaining is the identification of the individual cells. Echeverria and Thirtle (1991) identify five areas of technology (1) mechanical, (2) chemical, (3) biological, (4) managerial/agronomy and (5) processing/ transformation. These then become the columns of the study matrix. Within these broad descriptions further refinements were made as follows:

Mechanical: Tillage

Chemical: Plant Protection

Biological: Varieties

Managerial: Intensive poultry production

Processing: Postharvest handling

Of course individual case studies are not strictly limited to these particular technologies, but they are the focus and basis for selection of study sites.

When selecting commodities it was desired to maximize the distinctions among them as a means of enhancing the inter-cell variability. Thus all major zones - semi-arid and temperate upland, subtropical and lowland valley-were included. The nation became the unit of observation as the basis of variation of such government policies as extension service, business, policies and private sector climate. These factors are then, in ANOVA terminology, nested within the selection of case study nations. One obvious basis for differentiation is between the former colonial power, whether Anglophile or Francophile.

Prior knowledge helped in the identification of the study commodities. The selection of five study technologies mandated a **minimum** of five case studies sites while time and budgeting considerations mandated a **maximum** of five. The case study matrix is therefore a diagonal. However the off diagonal cells (technologies) were also examined for each commodity, but as a secondary objective.

The final case study selection is as follows:

Commodity	Technical: Mechanical (tillage)	Technical: Chemical (pesticide)	Technical: Biological (varieties)	Technical: Managerial (processed foods)	Technical: Processing (postharvest)
Cotton	Mali				
Maize		Cameroon			
Seeds			Zimbabwe		
Poultry				Kenya	
Vegetables					Ghana

A.3 Case Study Design

The five case studies were carried out over the period February-June 1992. Each study involved two sequenced phases, a Phase I included principally to collect background information and data for the data base, as well as to prepare for the subsequent in-depth Phase II investigation. The bulk of the analysis was completed in the Phase II studies. Phase I studies were carried out by a knowledgeable national who also participated in the Phase II study in conjunction with one or more international experts. Following is a more detailed discussion of the two study phases.

Phase I: The purpose of the field study is to develop an inventory of the major public and private sector firms involved in technology development and use in the commodity sub-sector of interest in the country selected. The survey also attempts to identify factors that facilitate or impede the private sector's role in the distribution and sale of technology products. The first phase has four (4) specific objectives:

- develop a data bank of key actors involved in activities related to the technology and commodity of interest.
- Provide indications of the growth and potential market of the technology in the selected country.
- Collect available information related to the rules and regulations affecting the participation of private enterprises in technology development and use.
- Collect available statistics regarding the use of technology products in the commodity of interest.

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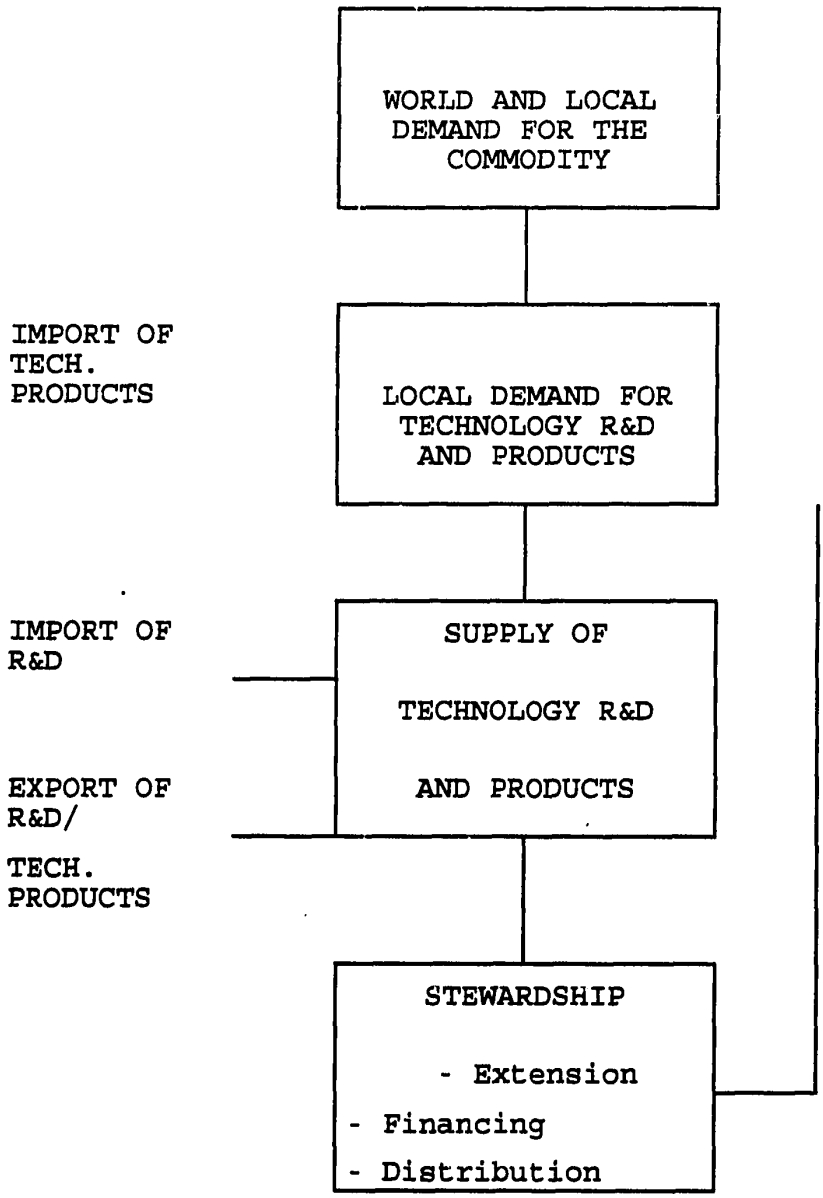
The data were collected from both public and private sector participants through structured interviews. A comprehensive list of local contacts was also collected. Key documents in such areas as those describing investment policy (foreign ownership and profit repatriation) and licensing requirements as well as intellectual property laws were to be collected and made available to the Phase II teams. Relevant secondary data on technology use and imports were also collected.

Phase II: The purpose of the fieldwork is to examine in-depth the interaction between the technology development and sales system and the production and marketing of the commodity. In this phase, each team was to trace the involvement of private sector technology firms in the production and marketing system of the commodity. It was also to document the degree to which the public sector assists in technology development for specific crops by utilizing the results of Phase I fieldwork to develop hypotheses regarding the technology development and utilization system and the flow of technology through that system. The second phase has four (4) specific objectives:

- identify and analyze the existing patterns of collaboration between public and private sector in technology development and use.
- understand how these patterns are determined by the existing business and regulatory environment.
- suggest appropriate mechanisms of collaboration between public and private sectors in technology development.
- determine the appropriate policy instruments (including intellectual property rights) required to make these mechanisms effective).

The conceptualization of the Phase II studies is demand driven/based on the concept of "induced innovation" (see Section 1.3). Under this development model, presented schematically in Figure A-2, demand, external or internal, creates the opportunity to produce more of a commodity. That in turn creates the demand for production-enhancing inputs which becomes a derived demand-inducing technology requiring development and support services (stewardship). Applying this model requires an understanding of the driving forces behind the demand for a commodity, the determinants of, and prospects for, increasing the demand for technology, its generation, development testing and production, as well as the stewardship needed to facilitate the most effective use of the technology. All this is part of the second phase tasks.

Figure A-2: TECHNOLOGY R&D TRANSFER SYSTEM



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The above-mentioned tasks can be partitioned into several main areas of investigation, as follows:

- **Commodity system.** This area is an overview of world and local demand for the commodity. It aims to briefly describe and analyze the characteristics of the commodity, its market size, input distribution networks, market channels, and supporting infrastructure and services.

- **Demand for the technology.** This area of investigation focuses on the type of technology, its use as complement or substitute to other inputs in the production or processing of the commodity, its importance in the economy, and eventually, environmental impact. For seed, for example, one may estimate the importance of the technology by the rate of adoption of improved hybrid seeds, and the efficiency of the technology by the yield increase from these improved seeds relative to local varieties.

- **Supply of Technology.** This area of investigation focuses on research efforts and the commercial production of the technology products by public and private organizations. How are national research systems organized to generate, test, and produce technology? What participation of the private sector is there in technology research and production?

- **Stewardship of technology products.** Stewardship concerns supporting services that promote and distribute technology products to users. Stewardship includes extension, information, training, financing, and distribution efforts. How do public and private institutions handle stewardship or technology products? Are there efficiency gains or privatized distribution networks in terms of technology development and use?

- **Public/private collaboration.** This area of investigation summarizes and expands the information gathered in analyzing the supply and stewardship of technology by private and public organizations. Public and private sectors may collaborate in the conducting/financing of technology development and the stewardship of technology products thought different mechanisms. How is vertical coordination achieved by public and private sectors or through the collaboration between public and private sectors? What does the public sector do to support the private sector in its technology development efforts?

- **Economic, business and regulatory environment.** This environment affects the demand for and supply of the commodity and the technology. Researchers will identify key elements of this environment, for example, macroeconomic reforms,

market and price liberalization, business environment, and regulatory measures. What are the relationships between technology development and regulatory measures?

- **Intellectual Property Rights.** IPRs are a subset of the regulatory environment that affects technology development and use. The second phase emphasizes IPRs because these rights may strongly affect the participation of private organizations, particularly foreign enterprises, in technology research and development.

The AID Africa Bureau Scope of Work calls for a coding and computation of data from the Phase I studies and a descriptive and analytical report for each of the Phase II case studies. Those reports provided the basis for this summary evaluation.

APPENDIX B

CASE STUDY SYNOPSES

Zimbabwe - Cereal Seeds

Key Features: Zimbabwe, recently independent (1980), inherited both a diverse and heavily regulated economy, the legacy of the preceding rebel government. Economic performances during the 1980's has been mediocre as structural weaknesses, including an inequitable land distribution, were being addressed.

Maize is the staple crop with white maize preferred for human consumption and yellow for feed and processing (beer). Malting barley is also grown for local use and export. Wheat is making inroads into the maize market but production must be subsidized.

Marketing: The entire marketing system is heavily regulated in prices, movement and storage for the key commodities, maize, wheat and white sorghum. Inputs are coordinated through farmers' organizations such as Seed-Coop, owned by the Commercial Farmers' Union (CFU), the association of commercial scale (and white) farmers or by supplier groups like Agricultural Chemical Industry Association.

Seed: Zimbabwe is unique in SSA in having nearly 100% hybrid maize adoption, which has greatly expanded output. The success of hybrids is attributable to breeding as well as good government support services - input delivery, credit access, favorable prices and extension. Other crops have not received this level of services.

The Seed Coop, which has exclusive rights to hybrids developed by the government's Department of Research and Specialist Services (DR&SS), also has for the past score of years its own breeding program. Other entrants are more recent: CIMMYT (1985), Pioneer Overseas Corp. (1988), Cargill Zimbabwe (1991) and DeKalb Hybrids (1991-92-joint with Seed Coop). Sorghum breeding is carried out by DRSS and ICRISAT. The National Brewers funds barley breeding at DRSS. Competition in actual seed production remains limited with Seed Coop (owned by some 150 seed propagators) having virtual monopoly control. Pioneer (Panar) and Cargill have begun to operate recently, competing heavily over service.

Stewardship and Collaboration: Government extension efforts have in recent years been shifted from commercial to communal farmers. Financing "production pacts" by the Agricultural Finance Corporation (AFC) are credited with the high level of adoption by communal farmers. Private firms cannot compete in financing but are concentrating on more streamlined distribution and improved services. The main contact between the public and private sectors is in the exchange of breeding materials. Government budgetary problems are limiting public R & D.

Business Environment: Commerce is heavily regulated, down to commercial seed for which prices are fixed. Zimbabwe has (since 1973) a national PBR law. A pending land redistribution plan is likely to lead to more maize production despite a public program for diversification. The opportunity for hybrid maize development and production exists for both domestic and export markets. Price increases however are needed.

Kenya - Poultry Feed

Key Features: Kenya has a rapidly growing population (4% annually) and limited land resources - 70% semiarid. Poultry production (meat and eggs) is currently underdeveloped for internal and export markets.

Production Technology: Improved varieties are imported - only one domestic hatchery produces commercial chicks and supplies are a key limiting factor. Feeds are not imported (due to foreign exchange limitations) and a ready supply of high quality local feeds is a second limiting factor.

Marketing: Marketing channels are largely informal. Supplies and quality control at the few supermarkets are erratic. Current prices are too high for most families to afford.

Stewardship and Collaboration: Sector support is the responsibility of the Ministry of Livestock Development. Extension services are practically nonexistent. The need for management guidance in these complex technologies is especially acute. A key service function, feed quality testing, is also not provided (due to inoperable equipment). The national agricultural credit program, Agricultural Financial Corporation (AFC), does not fund poultry production because of the risks involved.

Feed Supplies: Uncertain supplies of balanced rations are an ongoing problem. At its root is inconsistent production of both energy and protein components. Feed input supply in turn is limited by the absence of a commercial fertilizer operation and inadequate irrigation. Further research is needed to evaluate alternative feed sources, including sorghum, dried poultry waste, and cotton and sunflower seed cake. Much extant research is funded by foreign governments - Netherlands, Norway, Canada, and the US.

Business Environment: Public-private collaboration does not have a historical precedent, research traditionally being the responsibility of the government. Several domestic and foreign companies (Kenya Breweries, Hoffman-LaRoche, Unga Feeds) are beginning separate or joint efforts. National/foreign joint ventures exist in other sectors, although permission of the Central Bank is required. A number of pre-initiation approvals are required,

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but they can be secured from a single office within a month. Foreign exchange is critically short, making imports of products or equipment difficult and slow.

Ghana - Postharvest Technology

Key Features: Ghana is well situated in terms of land and climate resources for expended vegetable production. However, prior to a 1989 Norwegian-funded program, exports were practically nil (1% of production). By 1991 10.6 tons of pineapples and 4.6 tons of other products were exported, all by air freight, to Europe. The short term goal is for Ghana to capture 5% of the European market.

Marketing: Europe is a competitive market for exports. Ghana must compete on quality, as Cote d'Ivoire can ship by sea at far lower cost. A demand study in Europe is recommended. For production to be sustainable, domestic fresh and processing markets must be developed concurrently.

Technology: Competitive exports require a range of input, postharvest handling and transport technologies. Demand for postharvest technologies in particular is not being met. Especially lacking are packing facilities and carton manufactures to European specifications.

Stewardship and Collaboration: Two public institutions, the Ministry of Agriculture Postharvest Unit and the Food Research Institute, have R & D responsibilities for postharvest technologies but both lack the facilities and transport to carry out these tasks effectively. Extension in Ghana does not go beyond production and input supplies. Neither of these situations will change for the foreseeable future.

One trade association, COLEACP, exists as an interface between exporters and European importers and provides a range of production and marketing services, including technical assistance. However for the major part technical questions are referred to European suppliers, as local technical representatives are few. Postharvest technology is an imported commodity. Collaboration between public and private interests is limited because the public sector has little to offer.

Business Environment: Performance of the economy has improved following the 1983 Economic Recovery Program which, among other steps, devalued the currency, dismantled price and distribution controls and improved tax collection. Also enacted were a number of investor incentives which have rekindled private investors' interest, subject to eligibility requirements. The investment codes control foreign ownership levels and technology transfer agreements.

Ghana is a member of ARIPO (the English-based African patent union). It has no plant breeders' rights legislation.

Mali - Cotton Production

Key Features: Cotton production, a target of government policy since the 1950's, is characterized by high inputs and outputs. Yields are three to four times the levels of neighboring countries. Cotton accounts for the major share of export earnings. Fiber is largely exported either raw or as cloth while the oil and seed cake by-products are utilized locally.

Marketing: The entire production system is highly vertically integrated and controlled. CMDT, a parastatal, regulates research, input supplies, production, processing and exports. It also maintains the necessary infrastructure including trucks and roadways.

Technology: Production systems are classified into eight levels based on the degree of animal traction power. Relatively fewer farms exist at the extremes with mechanical power or only hand labor. Important technical advances have been made at the local level with animal traction carts and pesticide applications. Local blacksmiths have received government assistance for improving their capacities and equipment. Another simpler product in widespread use is the "Tropical/Mali" plow. A group of European and West African research groups have contributed to the production and improvement of this devise. Mechanization is less common in seeding and weeding. All ginning and spinning/weaving and related equipment is imported. Inputs are purchased by the CMDT on a tender basis limiting opportunities except for the recent increase in local blacksmith production and repair activities.

Stewardship and Collaboration: CMDT, which dominates all aspects of cotton production and processing, is also heavily involved in R & D, testing and extension. Research is done through two Malian entities (DMA and SRCFJ). The French, Dutch and UK governments have contributed to the development of some technologies while multinational firms including ICI, Ciba-Geigy and Rone-Paulenc have contributed to sprayer development.

CMDT representatives handle input supplies, credit application and product sales for cotton farmers, placing CMDT in a key position to communicate management strategies and effect technology adoption often in the form of "technology packs." In recent years credit has been increasingly handled by BNDA, the National Agricultural Development Bank.

Business Environment: Mali has been involved in a WB and IMF collaborative structural adjustment program for a decade. During this far reaching program many areas of contact between the government and private business have been affected. Especially important among these is a clarification of relationships, improved incentives to invest and relaxation of commodity trading restrictions (except petroleum). The right to transfer funds and profits is guaranteed.

Mali is a member of OAPI, the African Francophile patent union. No PBR exists.

Cameroon - Plant Protection Chemicals

Key Features: The major cash and export crops in Cameroon have traditionally been cocoa, coffee, bananas and the industrial crops including sugar cane, maize and oil palm. Then in 1989 the cocoa production support system collapsed with the bankruptcy of several state support agencies. With coffee, too, Cameroon became a high cost producer as world prices remained at depressed levels. As a result the crop protection chemical market (insecticides, fungicides and herbicides in that order) sank by two thirds to about $US 12.5 million estimated for 1992. The leading market is now for bananas (31%) and cotton (28.5%). Increases in the market depend on a recovery of the cocoa and coffee markets, which will require a macroeconomic restructuring.

Marketing: Crop protection chemicals are purchased largely through tender offers formulated by several state agencies including DirAgri, SODECAO and SODECOTON. Until recent years the responsible state agencies applied the chemicals directly to small holder crops at no cost to them. With the collapse of those agencies that service has been halted although a limited tender was authorized for 1992 - too late for that crop season. Subsidies are being phased out over a three year period. Estates are permitted to purchase directly from the state agencies.

Private firm involvement is largely limited to importation and transport although the major importers have established a few interior distribution centers. Plans are underway for sales through retail outlets. Presently 13 firms import into Cameroon, including subsidiaries/agents of multinational manufacturers and locally-owned importers. The latter group accounts for a small part of sales. US firms have a 19 percent market share, the largest behind France.

Chemical: Crop protection chemicals are essential for many crops in Cameroon. Without treatment cocoa plants can be killed in three to seven years while the quality of coffee is reduced.

Stewardship and Collaboration: Due to the tender system manufacturers/ importers are limited to delivery. Presently no chemical-related research is conducted in Cameroon, the role of the Agronomic Research Institute being limited to efficacy tests and importation approvals. With the sharp decline in the market, foreign firms have reduced in-country staffs to a few individuals with primarily sales promotion responsibilities.

The parastatal-based extension services are considered good but are being drastically reduced because of budgetary problems. Farmers are being trained to apply chemicals directly,

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although equipment maintenance will be a problem. There is an effort underway to establish producer cooperatives and other farmer groups.

Business Environment: The business environment can only be described as difficult but improving. Currently the costs of doing business are high, with corporate financed efficiency tests and import licensing and inspection slow as well. The parastatals are also heavily indebted to the major multinational importers. Banking is also slow and expensive with little credit, or credit terms provided. "Rent seeking" (bribes) further complicates the business environment.

Recent legislation encouraging investment and simplifying procedures is helpful, as is the proposed liberalization of the marketing system. However, it is questionable if the sector is sufficiently profitable to attract the needed new investment.