Best Practices for Moving Seed Technology

New Approaches to Doing Business

Jitendra P. Srivastava and Steven Jaffee
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ABSTRACT

This study emphasizes the increasing importance of improved seeds in agricultural development and advocates a re-direction in the strategies of governments and donor agencies in their support of seed system development in developing and formerly centrally-planned countries. The paper reviews the nature and limitations of past assistance and interventions in this area, highlights several global technological and economic trends which are and will continue to strongly influence the development and dissemination of seed-based technology, and develops a strategy for future assistance.

The proposed strategy centers around policy and institutional reforms and an array of mechanisms to support the seed producing and marketing activities of farmers, specialized seedsmen, private enterprises (including multinational companies) and other non-governmental organizations. The strategy sees the private sector taking increasing responsibility for the production and delivery of seed products and calls for greater attention to support for informal, farmer- or community-based, seed supply arrangements. It also recognizes the critical and complementary roles of the public sector in the areas of research, training, quality assurance, and promotion. The paper provides guidelines for pragmatically phasing in greater private sector activity. Examples of effective recent policy reforms and collaborative public and private sector activities in several countries are highlighted.
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This paper on strategies for moving seed technology advocates changes in the current orientation and approach to seed systems development. To benefit from emerging seed technologies and the changing economic order, new ways of "doing business" are necessary and these are considered here.

In the past, World Bank's assistance in this sector was directed at establishing or strengthening public sector seed production and processing facilities. The results fell short of expectations. This and other experience indicate that the primary responsibility for seed production and dissemination can and should lie with the private sector, including farmers themselves.

In contrast to the earlier parastatal-directed, bricks-and-mortar approach, this paper advocates a strategy centering on:

- An agenda for policy reform,
- A set of principles to achieve a more efficient, yet socially responsible mix of public and private sector roles, and
- Measures to strengthen the linkages between farmer-based and more formal seed activities.

Future support for seed system development should be based on a holistic perspective which recognizes the important roles of both the public and private sectors. Strategies should be devised to encourage and assist the different players in a seed system -- farmers who save their won seed, small seed producers, domestic enterprises, and multinational companies. In designing investments in seed-related activities, farmers should not be viewed simply as 'consumers' of seed. Farmers can and do produce, store, and distribute seeds of certain crops. Indeed farmers were the main conduit of high-yielding varieties that generated the 'Green Revolution.'

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Agriculture & Natural Resources Department
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EXECUTIVE SUMMARY

Goals

The basic motive for developing a seed supply strategy is to move productive research on crops -- embodied in seed -- into farmers' fields for specified gains, each tailored to agricultural and economic circumstance. At the primal level, the unambiguous objective is to produce more and better food. While global aggregation of food supplies may be considered sufficient for the moment, the real issue is whether supplies of food are available in all locations. Local production is paramount in developing countries, more so in the least-endowed economies. Moving better seed to local producers is essential in breaking the stranglehold of poverty and subsistence. Seed is the initial lever for bolstering production, potentially creating a surplus and commercial markets for its products and seed itself.

To be that lever, seed must be a reliable product with credible gains to offer, accessible to farmers who want to use it, affordable, and effective in addressing farmers' constraints, such as poor yield, pests or diseases. This paper seeks to tackle a range of technological, policy and institutional issues in order to ensure that:

- **Seeds are improved**, i.e., deliver on their promise of technical reliability and effectiveness in dealing with farmers' productive concerns;

- **Seeds are accessible**. Technology development is a global enterprise. Wherever available, its potential utility for local application cannot be overlooked. Seeds must reach farmers in every pocket of agriculture. The remotest, most disadvantaged farmers need the benefit of improved seeds most. The newly commercialized farmer must effectively disseminate better seeds to other farmers, setting off a chain reaction of improved production. And large commercial farmers are the most efficient users of new seed products -- to keep their competitive edge.

- **Seeds are affordable**, without subsidy, within the economic context of each farmer.

Setting

Despite varying degrees of donor involvement for 30-40 years, the results of involvement in seed programs/projects have been less than anticipated. Some form of supply system for improved seed is in place in most countries, yet the capacity to absorb and generate seed
technology varies widely within and across countries. Reasonably effective and diversified seed industries have slowly emerged and are operational in a few countries (Group 1), e.g., Argentina, Brazil, Chile, Colombia, Costa Rica, India, Kenya, Thailand, and Turkey. In a growing number of other countries (Group 2, e.g., Guatemala, Indonesia, Malawi, Zimbabwe, Pakistan, and the Philippines) the seed production and supply system has developed reasonably well in some areas for some crops, but inadequate supplies of seeds still impede progress in other areas and/or for other crops. In much of sub-saharan Africa (Group 3), e.g., Cameroon, Ethiopia, Ghana, Tanzania and Uganda, progress has been very limited despite substantial and, in most instances, sustained assistance.

The paper points that in all settings, seed program/industry development is far from complete. At the same time, the importance of seeds in agriculture is increasing, not diminishing, as new roles for seeds are rapidly coming on stream: as the delivery systems for many innovative products and techniques from plant biotechnology and as efficient, ecologically preferred carriers of plant protection chemicals, biologics, growth regulators and modifiers. The implications for agriculture are enormous and multiple. Seeds are also moving to center stage in several broad arenas of growing social concern and activism: how to restore and sustain the environment, maintain the soil resource base, manage and maintain unique ecosystems, and preserve genetic diversity. Seeds are and will be a key ingredient in the implementation of programs of conservation, reforestation, restoration of ecosystems, and maintenance of biodiversity.

Investment Needs

Assistance and investment will continue to be needed in most developing countries. Even in counties with reasonably effective seed industries (Group 1), government involvement in production and marketing is inefficient and subsidized, and on a much larger scale than can be rationalized. The industry will be required to shift toward the private sector to the extent that it is economically feasible so that public sector resources can be assigned to better-suited tasks. Countries with uneven gains (Group 2) will require assistance to expand their seed industry to encompass neglected areas of the country and "secondary" crops. Countries that have not made much progress (Group 3) need to be revisited to determine the adequacy of underpinnings for establishment of a seed program/industry and/or to identify other impediments that need to be attended so that strides can be made and the benefits of improved seeds garnered.

In all developing countries there is need for a framework of policies and related institutions and infrastructure that establish a favorable but socially responsible climate for the entry and utilization of advances in plant genetics, biotechnology and agri-chemistry to increase the yield and efficiency of crop production and improve the economic status of cultivators. Some revolutionary products of plant biotechnology are in the advanced field trial stage and could have enormous impact on the agriculture of countries that permit their entry. Policies and attitude are key.
Focal Points for Action

In this strategy paper, important changes in perspective and economic order affecting seed production and supply are discussed, the importance of a policy framework that is favorable for seed subsector development is given attention, and some new currents and themes that do, will, or should involve the seed sector are considered. Best practices for emerging needs that require urgent national and donor attention are provided. Focal points for action are:

- How to develop a holistic seed system and devise strategies to assist the needs of each player, i.e., farmers who save their own seed, small seed producers, domestic enterprises and multinational companies.

- How to integrate the roles of both the public and private sectors in a more efficient, yet socially responsible mix.

- How to design seed systems that take into account the important, but grossly neglected role of farmers as seed producers, not only as consumers.

- How to analyze constraints, formulate policy shifts, and phase reforms that address them in a problem-solving mode.

- How and where the World Bank’s role is likely to be more effective, given fast changing global trends in seed technology, organization and investment.

It will be increasingly important for governments to conduct in-depth analysis of their present seed system, taking into account its stage of development, infrastructural support and absorptive capacity and tailoring a realistic and pragmatic strategy to guide future development of the industry.

Parallel to governments’ willingness to address constraints on seed supply will be their requests for advice from international development agencies. Are we truly prepared, equipped and ready to offer "down to earth" advice on the issues that should be of concern to the ministries and institutions involved? Are we giving an old prescription for a new strain of problems? Have we changed gears to address the challenges of a global industry in the 21st century?

Keeping in mind the increasingly important role that seeds will play in meeting next century’s needs for agricultural produce and environmental considerations, it is imperative for development agencies to give high priority to the seed sector. The World Bank should build its capacity in institutional analysis to evaluate and deal with the oncoming responsibilities, challenges and opportunities.
I. BACKGROUND

Singularity of Seed

Seeds are agriculture -- its starting point, source of continuity, change, and restoration, as well as its most important product. Although vital and multifaceted, seeds are too often taken for granted, or worse, neglected. Yet a sound understanding of the primary and catalytic roles of seed is important for the formulation of effective strategy and policies for agricultural development. It is time to take stock and reassess how improving and moving seed changes agriculture for the better.

Most important input. Seeds are, first of all, the basic unit for distributing and maintaining plant populations over space and time -- crop-based agriculture's most important input. They carry the genetic potential of the crop plant, determining the upper limit on yield and, therefore, the ultimate productivity of fertilizers, agro-chemicals and other inputs. Similarly, improved farming techniques and machinery can only be as effective as the germplasm they support.

As a production input, improved seeds have several advantages over other inputs. Seeds are required in relatively small quantities, multiplied rather than consumed in the production process, familiar to all cultivators, and their use does not require substantial change in farming practices. On the other hand, seeds have two major disadvantages: they must be maintained in living condition to fulfill their propagative function and their production must be planned well in advance of the time they will be needed.

Agent of change. Plant crops change as seeds change. For millennia, farmers have improved crops by saving seeds of plants that exhibited traits perceived as most useful. The result: slow but reliable improvement. This process has been exponentially accelerated by the application of genetics, and the range of improvements has been vastly expanded by biotechnology and chemistry. Such improvements are most efficiently maintained, transmitted, and multiplied by seeds. Seeds are, therefore, the primary means of delivering improvements in crops to farmers' fields.

The two sources of seed improvement are:

- Genetic -- altering genetic make-up in order to provide potential for higher yield, greater pest resistance or shorter growing season. This process, based on an effective agricultural research system, is a prerequisite for a dynamic seed sector; and

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1Broadly defined as all living materials used to plant a crop: As dry seeds for some crops, including wheat, rice, maize, and most vegetables; for many others, including cassava, sugarcane, bananas, and some cut flowers, the "seeds" are cuttings or vegetative part of the plant that is detached and replanted to grow another plant.
**Physical** -- improving the physical and physiological properties of seed -- color, size, purity, germinability, storability. Derived from processing, handling, storage, and quality control methods, such improvements provide value through enhanced performance and compatibility with other production technologies (e.g., mechanical planting).

Both sources yield *improved seeds*. Even so, improvement based on genetics is more effective and explains its primary role in agricultural productivity. Yet, seeds’ catalytic role -- as carrier of chemicals and biologicals -- is becoming increasingly important. Coated or dressed in relatively small quantities, the seed and ensuing plants may be protected against insects, diseases and weeds, while plant growth is regulated and the nutrient status of the soil may be amended.² Offering effectiveness, efficiency and ecological soundness, this role promises substantial gains in the future.

**Last resort.** Seed can also rapidly rehabilitate agriculture in the wake of natural disasters such as floods, drought, and wipe-outs due to insects or plant disease. Seed’s value as a sort of disaster insurance cannot be overlooked.

**What Improved Seed Can Do**

**Direct benefits.** The potential benefits from the spread and use of improved seed are enormous. Some potential benefits are direct: at the farm level, enhanced productivity, reduced risk and increased net incomes by generating higher yields, more efficient use of available nutrients, faster maturation, more resistance to pests, and/or providing higher nutrient content in harvested food or fodder. At the national and regional levels, benefits are: more flexible and diversified agricultural production systems by allowing multiple cropping and spreading crops to a wider set of agro-ecological or geographical zones. This greater flexibility, together with enhanced yield and/or nutritional value, may contribute to increased food security. Varieties requiring lesser amounts of agro-chemicals to combat disease and predators also promote more sustainable agricultural production patterns.

**Multiplier effects.** Other potential benefits relate to the multiplier effects of enhanced productivity. Where the diffusion of improved seeds contributes to increased yields and multiple cropping, greater opportunities for farm and post-harvest employment may be generated. Where improved seeds contribute to higher yields and higher-quality crops, both processors and consumers may benefit through more plentiful, lower-cost, and higher-quality supplies of raw materials and food. The spread of improved seeds may also speed up the adoption of agricultural production technologies and economic returns on existing or planned investments in rural and agricultural infrastructure.

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²Examples: systemic and non-systemic insecticides and fungicides; safeners for herbicides; phytohormones such as gibberellic for improving emergence in rice, lettuce and peanuts; molybedum, boron, zinc, other essential micro-elements.
Hence, in the development and spread of improved seeds a multiple set of agricultural and rural development objectives can be pursued: economic growth, rendering the existing agricultural system more sustainable, and/or promoting socioeconomic welfare. In both varietal development work and seed production and distribution, narrower objectives pertain, depending upon targeted crops, locations, and types of producers. The direction of such work will likely have substantial impact on patterns of agricultural and agro-industrial production, patterns of food consumption, and distribution of income. While there is a tendency to focus (at least initial) work on major crops and more favored areas, there are normally opportunities also to enhance productivity in secondary crops and in disadvantaged areas.

**Supplying Seed: Three Arrangements**

**Simultaneity.** Since the first cultivator, every serious farmer has taken steps to ensure adequate supplies of seeds, i.e., developed a seed program. Without seed-saving, there is no agriculture next season. Seed arrangements can be broadly grouped in three categories:

- Informal
- Commercial
- Transitional

Farmer seed-saving, bartering with neighbors or farmers in different villages, and purchase of seeds from local grain stalls are usually termed the informal or traditional system, although arrangements are seldom informal. The formal, organized or commercial system involves production and supply of seeds by large specialized agencies (parastatals) and private companies. Recently, a third category has been recognized and given attention, viz., the farmer-based seed enterprise, a transitional mode that straddles the informal and commercial systems and involves the specialization of farmers in production of seeds for the local market. All of these seed supply arrangements are simultaneously operable in most countries, including industrialized ones because many farmers make mixed arrangements for seed supplies. For example, a West African farmer may save seed for the sorghum or millet crop, but buy, or be supplied with, seeds for the groundnut or cotton crop. An American farmer might purchase seed each season for the maize or cotton crop, every two to three years for the soybean crop, and only when a new variety is available for the wheat crop.

**Determinants of arrangements.** While various factors interact to determine farmers' choice of seed supply arrangements, in all cases, farmers' perceptions of best choice for a specific crop dominate. Also, nature has imposed technical limits on farmers' ability to reproduce certain seeds. For most staple foodgrains -- self-pollinated crops, such as wheat and rice -- and some open-pollinated crops and clonal varieties, farmer seed-saving is usual. Such seed is replaced only periodically, and in small part, as its vigor declines or it becomes susceptible to insects and disease. Or, occasionally, a much better variety is made available and replaces the previous one. Only a small portion of total seed supply (roughly 2%) is needed to introduce that new variety. Thereafter the farmer reproduces it on site. Once introduced, the
overwhelming bulk of high-yielding wheat and rice seeds of the green revolution was multiplied and moved by farmers themselves.

**Hybrids necessitate commercialization.** However, farmers cannot efficiently reproduce and store hybrid seed equal to seed purchased commercially. Forage, horticultural and ornamental crops also pose difficulties for farmers seeking to reproduce them. In addition, market standards of size and uniformity and convenience become important factors as agriculture becomes larger-scale and more commercialized. So, for such crops, purchased seed is the norm. Moreover, total resupply is required each season. Thus, due to technical difficulty for farmers, and frequency and volume of seed needed, hybrids, forage and specialty crops are the center of commercial attention in agriculture.

**National Seed Supply Systems**

**Diversity on a continuum.** Seed supply arrangements are mostly crop-specific. As agriculture diversifies, so does the local and national seed supply system. With global variety in crops, national seed supply systems vary in crop choices, complexity, level of technology, institutional capacity, and degree of commercialization. Even so, seed supply can be conceptualized as moving toward more diversity and commercialization through four stages:

*Subsistence* -- farmers produce and save all their own seed or procure supplies from nearby farmers and no seed industry *per se* exists;

*Early commercial* -- improved varieties are first developed or adapted from plant breeding and testing work and initial investments undertaken in commercial seed multiplication and distribution focus on major crops in favorable areas;

*Rapidly commercializing and diversifying* -- a wider range of varieties and hybrids is being developed, traditional cultivars being rapidly replaced with commercial seed, and a wide range of institutional arrangements (public and private) being developed to undertake and regulate seed-related activities (see Figure 1); and

*Mature* -- the technical and commercial development for seed is advanced and all or most commercial functions have been assumed by the private sector.
Figure 1
MOST COMMON PATHWAYS FOR SEED SUPPLY IN DEVELOPING COUNTRIES

Legend:
Hybrids → Varieties
Major Functions: Resupply Seeds and Replace Varieties

The main functions of a seed program/industry are to:

- Resupply seeds seasonally or periodically as needed; and
- Replace varieties with better ones or introduce new crops.

**Resupply.** Resupply is the dominant function in industrialized countries, and is the attribute of a fully commercialized system. Seasonal resupply is required for well-established hybrid crops such as corn and sorghum and the more recently developed ones such as hybrid sunflower. The seeds of sugarbeet, forage, turf, fiber, recreational, and vegetable crops are mostly purchased from seed companies in order to ensure a quality commercial product and on-farm seed production is too difficult. Even in the case of the self-pollinated grain, grain legume, and oilseed crops, such as wheat, rice, barley, soybeans, and peanuts, farmers in developed countries frequently purchase rather than save seeds because of convenience and less risk.

Also, in some developing countries, the seed industry’s prime function is seasonal resupply for specific crops and cultivars, whereas it previously focused on varietal replacement. With wide adoption of hybrid corn, sorghum, millet, cotton (India), and rice (China), relevant segments of the seed industry have flourished.\(^3\) Similarly, emphasis on vegetable, conservation and specialty crops, for which seed-saving is difficult, has required substantial expansion in the seed resupply function.

**Replacing varieties.** In most developing countries, however, varietal replacement was and remains the primary mission of seed programs that were hastily started in the late 1960s and thereafter. Intentions were well-placed. Demand for seed of dramatically higher-yielding foodgrain varieties was enormous, and such seed was simply not available. Cranking it out as fast as possible became the public sector’s goal. Yet, at the end of the day, seldom more than 2-10% of the total quantity of seeds used was needed from this function.

Similarly today, commercial supplies to replace varieties of self-pollinated crops, such as rice, wheat, non-hybrid sorghum, and grain legumes, are frequently less than 10% of total seed requirements in well-developed systems: in Haryana and the Punjab, India, seed replacement is roughly 10%, rice production in Thailand requires less than roughly 10% seed replacement, and even wheat production in the United States requires less than 30% seed replacement.

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\(^3\) IRRI is committing substantial resources to developing hybrid rice systems for areas other than China. If its efforts are successful only for rice grown under controlled irrigation, demands on the rice seed system will be enormous.
Uneven Spread of Improved Varieties

Overall, for developing countries, improved varieties of maize, wheat, and rice occupied approximately 50% of the area planted to these crops during the early-to-mid-1980s, but the spread of improved seeds has been uneven among and within countries. There has been tremendous spread of wheat and rice in irrigated areas of Asia and Latin America, although more limited spread in upland and rainfed areas. The spread of improved maize has been particularly uneven, with high rates of adoption in a few countries within each region and very low rates elsewhere. A major spread of hybrid maize has occurred in only a few countries, including Argentina, Brazil, Chile, China, El Salvador, Guatemala, Kenya, Mexico, Thailand and Zimbabwe.

Focus on staple crops. And among developing countries, varietal development and seed production and distribution are more advanced for staple food crops. According to a 1985 FAO survey, nearly half of all developing countries had well developed varietal development programs for food crops and 33% had working seed production systems for such crops. In sharp contrast, the proportions of countries with relatively advanced formal seed production systems for industrial crops, pasture crops, and vegetables were only 25%, 7% and 6%, respectively.

Such uneven patterns derive from the overall structure of agricultural production in developing countries, emphasis on food security by many governments, research emphasis on staples by international agricultural research centers, emphasis on foodgrains in national seed programs by donor agencies, and income-constraints on demand for higher-value products (including vegetables and meat) in many developing countries.

Majority channel ignored. At the same time, although much thought, planning effort and investment have been focused on the organized, commercial segment of national seed systems in developing countries, essentially no attention has been given to the informal system that supplies most seeds. Expert views on informal seed systems are mostly ambiguous. At the outset, newly established commercial systems in developing countries are seldom expected to supply more than 15% of total seeds requirement for target crops. The implicit understanding is that the informal system will supply the rest. Yet, there has been a reluctance within the agriculture sector and the donor community to recognize this implication. Only recently and in a small way has the informal seed system been recognized as the majority channel of diffusing improved varieties. Unfortunately, much effort and substantial resources have been wasted, trying to replace the informal with a commercial system, rather than recognizing the strengths and defining the roles of each.

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4 Mostly non-hybrid grain, grain legume and oilseed crops.
Three-way split. Put in perspective, only about 30% ($15 billion) of the value of seeds used worldwide ($50 billion in mid-1980s) is sold commercially by private firms. Farmer-saved seed is 35% ($18 billion) of total value and public sector enterprises produce the remaining 35%.

Industrialized countries account for 88-90% of seeds sold commercially, with more than half of volume in hybrids for industrial, horticultural and major and minor grains. Yet, even in the United States, as much as 30-50% of seeds needed to plant self-pollinated crops such as wheat and soybeans comes from stocks saved by farmers. (See Box 1).

By contrast, more than 80% of the crops cultivated in developing countries are planted with seeds from the informal farmer-to-farmer seed system. For self-pollinated crops (e.g., rice and wheat) and for crops grown primarily for subsistence (e.g., dry beans, millet, cassava), the proportion of farmer-saved seeds is generally even higher. These patterns are even found in several developing countries with relatively advanced seed industries, including India, Mexico and Thailand.

Overview

Several observations stand out from developing country experience with seed supply in the 1960s and 1970s.

- Food crisis spurred action on seed supply.
- Clearly superior seed will always be in demand and adopted by farmers.
- Varietal replacement alone will not economically support a seed supply system. Seed supply and resupply generally will.
- Farmer-based seed supply perpetuated the green revolution in self-pollinated crops. Due to technical limitations, farmers cannot efficiently replicate most hybrids and seeds of specialty (e.g. vegetable, plantation) crops.
- Private commercial engagement in seed research, production and distribution leans almost entirely toward hybrids whose R&D costs can be commercially recouped.
- Without incentives for profit, the private sector will not engage in seed production.
Box 1: United States - Multi-layered Structure of Seed Sector

The structure of the formal seed sector in the United States is unique: while there is a mix of public and private sector activities in varietal development, virtually all seed production, quality control, and distribution activities are undertaken by private companies, large and small.

The United States is the world’s largest producer and consumer of commercial seeds, valued at $4.4 billion. Agriculture is advanced, large-scale, commercially oriented and diverse. The most advanced segments of its seed industry are hybrid field crops, vegetables forage, ornamental and forest crops -- 100% supplied by the formal supply system. Yet wheat and soybean, also major crops, have seed replacement rates of less than 30% and 50%, respectively. Seed replacement for cotton, another major crop, varies from nearly 100% in the irrigated regions of the west and the upland cotton areas in the mid-South to less than 50% in the high plains of Texas where yields are low and farmers cut costs whenever possible; they save seeds but get them cleaned and treated for planting.

Within the public sector, the US Department of Agriculture, the State Agricultural Experiment Stations, and the land-grant universities play a major role in collecting germplasm, basic research and varietal development. Public varieties are still dominant for several self-pollinated crops. Even with plant breeders' rights, the private sector has directed little investment toward such crops. The fact remains that in the United States, the large quantity of seeds for several major self-pollinated crops is farmer-saved.

All commercial seed production and trade rests in the private sector. A few firms are large in size and engage in R&D, seed production and marketing. Many firms have multinational and multi-sectoral interests. Another group of firms is engaged in seed multiplication, processing, and distribution, but not R&D. Many firms are crops-specific and cater to a specific agro-ecoregion. Some of them acquire licenses to produce specific varieties, as well as offer public varieties. Individual certified seed growers multiply and distribute public varieties and a large number of farmers (brown-baggers) multiply and sell truthfully labelled seeds of self-pollinated crops. There are also seed companies that develop new varieties and supply parent materials to other seed companies.
Box 2: Kazakhstan - Assessing a Seed System in Disarray

Kazakhstan, a former Soviet republic, is tackling the difficult issues of how to make a state-controlled seed supply system with outmoded infrastructure more efficient and viable. In the past, collectives and state farms planned and controlled seed production and supply. Poorly managed and operating well below capacity, the system has been highly subsidized, yet often produced substandard seeds. It is one of the factors for very high seeding rates, e.g., wheat at 250 kg per ha, maize at 45 kg per ha -- at least two times higher the seeding rates in other countries with similar climates.

Farms generally plant seeds of varieties provided to them; there is little choice. The majority of seeds planted by state and collective farms are produced in their own seed multiplication plots from seeds initially obtained from seed farms.

In 1992, collectives and state farms were mandated by the Ministry of Agriculture to provide 1,692,000 tons of wheat seeds, 1,053,000 tons of barley seeds, 109,000 tons of oat seeds, 80.5 thousand tons of maize seeds and 36.8 thousand tons of rice seeds. Relatively small quantities of seeds are officially imported, particularly of hybrid maize, sunflower, sugarbeet and vegetables. Seeds of self-pollinated crops (e.g., wheat, barley, oats) are sold at a 30-50% higher price compared to grain. However, imported maize seeds from Eastern Europe are sold at 8-10 times the price of grain. There is considerable unfulfilled demand for early maturing high-yielding varieties of crops.

Currently, R&D is exclusively done by public research institutes, which also import germplasm and test it in adaptation trials. Plant breeding institutions are responsible for production of elite (breeder) seeds, then multiplication is contracted to specialized collectives and farms. In general, seed drying, processing and storage facilities are inadequate, inefficient and outdated. There is an urgent need to modernize or replace many such facilities, as well as improve their management. It is also important to encourage participation of private sector seed enterprises.
Box 3: Bangladesh - Commercial Opportunity for Non-hybrid Crops

In developing countries, as Bangladesh illustrates, opportunities for commercialization of the seed sector can be strong, even with non-hybrid crops. Opportunities are particularly good for fiber and forage crops and can be good for some grain crops, such as wheat, if they cannot be grown with certainty each year, due to variable rainfall.

The country's formal seed supply system is operated by the Seed Wing of the Bangladesh Agricultural Development Corporation, a large parastatal. Development of the seed sector has been assisted by many donors, including the World Bank, for more than 20 years. The average utilization by farmers of "supplied" or purchased seeds (even with substantial subsidies) during 1984-89 for some major crops was:

<table>
<thead>
<tr>
<th>Crop</th>
<th>% Formal Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulses</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Rice</td>
<td>2 - 3</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>5</td>
</tr>
<tr>
<td>Jute</td>
<td>13 - 15</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 - 20</td>
</tr>
</tbody>
</table>

Seed of pulses, rice, and oilseeds is generally saved by farmers. But wheat is a relatively new crop in Bangladesh, not grown each season unless there is sufficient rain, and its seed must be saved over a monsoon period, which puts its viability at more risk. This combination of factors opens the possibility for more commercial production of wheat seed. Also, for jute, the plant is cut for its fiber, prior to seeding, so seed must be resupplied. This commercial use leads to more seed supply opportunities, which the private sector can gradually fill.
II. OLD APPROACHES, NEW TRENDS

Evolving Approaches to Assistance

Development assistance for seed supply systems has a 30-40 year history, with most activity spawned since the mid-1960s. While no formal, consistent strategy has emerged, certain hallmarks are evident. The point of reviewing that experience is to ascertain how strategy evolved, what worked, what is the status quo, what needs to be done.

**Start-up.** Early approaches were largely opportunistic and piecemeal. Using seeds generated by international research, assistance was geared toward multiplying improved seed through national networks of experiment stations. The focus was on major staple crops, i.e., rice, wheat, and open-pollinated maize. Funds were largely used for technical assistance, training, and limited processing, storage, and laboratory equipment.

**Bricks and Mortar.** Responding to rapid increase in demand for high-yielding varieties (mainly rice and wheat and, to a limited extent, maize), funds and technical assistance were provided to establish icons of formal seed supply systems, such as parastatal seed farms, testing laboratories, processing plants, and certification departments. However, there was little, if any, consideration of whether there were or would be seeds to test, process and certify; and more importantly, whether seeds were sufficiently improved and worthy of testing, processing and certifying. Results were mixed. During this period, training was given a high priority and linkages were established between research institutions and national seed corporations responsible for multiplication and supply of seeds. Also, technical assistance was provided to help governments develop national seed policies, regulations, quality standards and plant quarantine systems. Two well-known examples of success from the early period are the Terai Seeds Corporation in Uttar Pradesh, India, and Seeds I in Indonesia, focusing on wheat and rice, respectively. Follow-on projects focused on the establishment of seed systems for individual states in India and seed supply for secondary crops in selected provinces in Indonesia.

Substantial investments have been made in seed supply, programmed as components of area or sector development projects to deliver an adequate supply of improved seeds to a specific locale, due to unreliable sources at the national level. Although many seed components were often effective during implementation, many degenerated within a few years for a variety of reasons, ranging from lack of support to incompetence of management and workers.
Transition to Private Sector. Ineffectiveness, inefficiency and over-capacity of parastatals eventually became constraints to rapid diffusion of improved seeds, and donor support declined. Therefore, seed projects started to define the role of government and to promote private sector participation, as well as to look at alternative ways to encourage informal farmer-to-farmer seed production and supply systems. In Brazil, for example, a seed project was long-term, national in scope, and focused on training and policy reform. Many Brazilian seed specialists were trained and a rapid and sizable resurgence of private investment in seed supply occurred. See Box 3 for developments in Peru. In many countries, however, avenues to assist the private sector and small farmers remain unclear.

Systems orientation. Recent donor-assisted seed projects have followed a more holistic and systems-oriented approach, with major attention to policy reform. The aim is to divest the public sector of seed production and supply functions and to establish a favorable environment for private sector entry and participation to the extent economically feasible and to broaden and liberate sourcing of improved seeds. In some cases, seed programs established earlier have been and are being revisited by donors with emphasis almost entirely on policy reform and privatization.

Limitations of Previous Approaches

Despite important differences, past approaches share similarities in rationale and "design" principles. Perhaps the most consistent and persistent features, until recently, were a formal approach and close adherence to a rigid scheme of seed certification.

A formal, top-down seed supply system emerged rather naturally from programs for crop-specific research and was rationalized and critically related to a three-sided paradigm -- research, seed as product, and information/education activities -- to reach farmers. While this programmatic approach may have served well in the past, certain features are presently inducing inadequacy, inflexibility, inefficiency, and, in some cases, irrelevancy, namely:

Supply-side distortions. Emphasis on building seed "factories" to achieve supply targets, based on various versions of "central planning," rather than responding to and/or promoting demand for seed from farmers has resulted in over-production, excess plant capacity, limited distribution and much inefficiency.

Closed and restricted product base. The technological/product base of many developing seed industries is limited to products developed or supplied by NARSs and the IARCs. Barriers to entry or active acquisition of foreign products (i.e., improved crop varieties) stymie productivity.
Box 4: Peru - Quantum Leap from Public Sector to Private Seed Enterprise

In the late 1980 in Peru, USAID initiated a development project with a seed component to increase private sector participation in production and distribution and to establish an external quality control system.

The first two years were dedicated to bringing public and private sectors together and delineating the basis for a national seed system, training personnel in seed-related activities, implementing regional seed associations, later to be responsible for seed certification, and creating "seed-awareness" among farmers to promote seed use and increase demand.

A new government in 1991 further emphasized the advantages of private sector participation, with the following outcomes:

- Growth of private seed industry from seven to 28 enterprises.
- An almost 50 percent increase in seed production in 1991/92 (17,500 tons), compared to 1990/91 (12,000 tons); all seed was produced by the private sector.
- Although non-mandatory certification is in effect, all 17,500 tons were field inspected and laboratory-tested by the regional seed associations upon request by the seed companies.
- Of eight regional seed associations, four are self-sustaining.
- The private sector has grouped itself in a Peruvian Association of Private Seed Enterprises, with 15 members.
- Regional training courses on seed production and quality control.
- Installation of seed drying and processing facilities in two key areas, managed by regional seed associations and open to any farmer wishing to establish a seed enterprise.
- Provision of on-site technical assistance to newly formed seed entrepreneurs.
- Annual seed meetings with participation of government, private seed companies and regional seed associations to identify constraints and propose solutions.
Too few crops. Seeds of a few selected crops were produced, with benefits frequently concentrated in specific project areas. Crop exclusivity has been a special affliction of ad hoc seed components, although stand-alone seed projects did not escape it, e.g., Indonesia Seeds I. As seed supplies for targeted crops and areas became adequate, those for other potentially important crops remained inadequate or non-existent.

Public-sector bias. The formal seed supply system was generally developed within the public sector as a department, agency, or parastatal budgeted as a line item similar to other public sector programs such as agricultural research and extension. The results are operational inefficiencies and ineffectiveness that plague the seed sector in many countries and hamper privatization.

Inadequate farmer involvement. The development of national seed supply systems has been heavily planned and directed, often lacking in participation by farmer and local distributors. The consequences are loss of credibility, relevancy, and clientele.

Passivity. Many developing seed systems operate passively -- without any semblance of promotion and marketing. Their operational mode is static, directed only by supply goals, without thought or attention to creating demand or marketing.

The deficiencies and limitations of seed supply systems across countries range from essentially nothing in place (the result of neglect and inattention) to gross inefficiencies, incompleteness, and lack of balance. The latter deficiencies are, in part at least, the legacy of previous approaches enumerated above, viz: heavy to total public sector involvement; over-emphasis on supply-side programming; narrow focus on most favored areas or crops; and excessive attention and reliance on the "formal" seed supply system. Another is inadequate product development, or put another way, ineffective R & D on crop development. This derives mostly from defects and problems in the R & D base, but also from the closed-end and protective stance associated with public sector control.

It is easy, of course, to criticize previous approaches to sectoral development in light of subsequent or probable circumstances and needs. To be objective, the approaches taken were fitted to the most pressing needs and resources available. If there were no changes in setting, the seeds system would be satisfactory in many cases. But changes have occurred and are occurring in global agriculture and in socio-economic contexts. They point up weaknesses, even obsolescence, in many past premises and policies for seed sector development.
Problems Delineated

In brief, important issues affecting technology, policy (pricing, access, regulation), and institutions stem from maintaining the status quo, rooted in public sector entrenchment in seeds supply, as outlined below.

- **Inadequate technology** -- *not enough value-added in so-called improved seeds.* This is a pervasive and debilitating constraint to developing commercial seed supply systems. When value-added is insubstantial or nil, no seeds will be purchased. Public sector seed suppliers have often criticized the backwardness of farmers, when in reality, the seed product was poor. Access to demonstrably better technology for farmers is the only way out of this muddle.

- **Skewed subsidies and pricing policies** for agriculture in general, and seeds in particular. Without market pricing of seed, no private agent can compete with public sector sources. Without such competition, public sources will remain inefficient and costly. However, the public sector may serve as a seed supplier of last resort, i.e., when the private sector fails to assume seed supply functions on reasonable terms. In any event, private operators cannot succeed in an environment of heavy subsidies for public suppliers, controlled prices, restrictive practices, or lack of access to superior products.

- **Limited or tardy access to superior seed technology,** regardless of source -- whether other farmers, NARSs, IARCs or multinationals. Seed technology needs to move and move freely within and across borders to be useful and effectively adapted.

- **Restrictive practices.** Public sector seed institutions have developed numerous protective stances to maintain their position and ward off competition, including lengthy and cumbersome quarantine, plant testing, and certification procedures.

- **Deficient institutional services** -- mainly credit and extension. Assuming a worthwhile technology, farmers require credit to purchase inputs, including seeds. Inadequate availability of credit can be a crushing constraint on advancing commercial seed supply systems, which require financing for construction of facilities and purchase of equipment and supplies and working capital to maintain seed inventory for relatively long periods. Further, farmers and seed supply enterprises require information on the availability of new seeds, how to best use them, help in the design and specification of facilities, sourcing of equipment and supplies, and assistance in locating contract growers. A seed industry rarely advances in the absence of a reasonably effective extension service.
Global Trends

At the same time, significant trends toward globalization and privatization of seed research and supply are impinging on the seeds sector, and are cause enough to revise country approaches to sectoral strategy.

Globalization of agricultural research, input supply, and output marketing. With trade liberalization, more markets are opening for agricultural products from developing countries. Vegetables and fruits for export to Australia, Europe, Japan and North America are already taking the lead. Seed sourcing is internationalizing just as rapidly.

Substantial and continuing investments in biotechnology R&D. Many unique products from biotechnological R&D are in the final testing stages and some will be marketed in selected countries in the next year or so. Seeds will be the main "delivery" system for such products. While most of these products -- genetically engineered plants (seeds) -- are targeted to industrialized countries, their potential in developing countries is enormous: much biotechnology is aimed at increasing crop tolerance to environmental stresses, e.g., salinity, aluminum toxicity, drought, high and low temperature, and insect pests and diseases, which are more severe, widespread, and a greater constraint on crop productivity in developing countries.

Entry of multinational plant genetic and seed corporations. Selected segments of seed supply in numerous developing countries, especially those with large crop agriculture and good economic growth, are engaging multinationals. The most attractive segments are vegetable and forage/conservation crops and hybrid field crops, such as maize, sorghum, sunflower, millet, cotton and rice. The multinationals frequently enter into partnership or joint venture arrangements and need to use lines and varieties developed by the NARS until suitable products from their own R&D come on stream. Expertise in seed production and marketing, management, and most importantly, improved seed with superior performance are the noteworthy gains.

Shift in crop improvement R&D from public to private sectors. With downsizing of public sector support to agricultural research generally in the industrialized countries (even "quasi-privatization" in some cases), and cutbacks in support of NARSs and IARCs, due to financial stress in donor economies, this trend is moving rapidly. In industrialized countries, the private sector has increased investments in agricultural R&D, especially for biotechnologies. Increasing, but still limited private R&D is the case in developing countries, excluding finance by multinationals seeking to introduce and market proprietary seed products.

Privatization of seed supply, with a transition to an open market, to the extent economically and socially feasible, occurring in several countries. This involves disengagement of public sector entities from huge and near monopolistic involvement and dominance of the seed supply system.
Emergence of strong and successful private seed companies. In economically lucrative segments of seed markets in some larger and "advanced" developing countries, private seed companies, some with substantial crop R&D programs, are emerging. Some private companies are national in organization and scope, some are regional (in larger countries such as India), and some are in joint ventures with government or multinational seed corporations.

Country reluctance. Resistance to both globalization and privatization, however, is particularly manifest in the attitude and approaches at the country level to multinationals, which sometimes encounter difficulty, often to the point of discouragement, in gaining access and entering a national market. Impediments include compulsory variety registration with long trial periods (one to four seasons) and much red tape, unreasonable phytosanitary restrictions and procedures, no access to foundation seed stocks of varieties developed by the NARS, and inequitable implementation of seed certification and control procedures. Restrictions on conversion of local to hard currency and repatriation of capital are additional constraints.

Also, while plant breeders’ rights, utility patents, and intellectual property rights arouse controversy in most, if not all, countries, their treatment will affect the flow of seed technology into developing countries. Ways and means of using and reproducing technology while protecting rights of inventors or proprietors, including multinationals, is on the agenda of the global R&D establishment, including policymakers in developing countries.
Box 5: Turkey - Progress in Privatizing Seed Supply

Turkey's private industry is taking a growing slice of the seed market after only a few years of engagement. In the early 1980s, government liberalized the agriculture sectors, moving away from price supports and allowing more imports. It also encouraged the introduction of new seeds as an integral move toward efficient agriculture.

In 1985, only 1.5% of total seed production was private. Then international companies started to enter, seeking local partners. With them they brought hybrid seeds, with corn and sunflower leading the way. These seeds enabled farmers to improve production and quality. Until then, hybrid seeds were virtually unknown in Turkey, except for a few varieties which had been smuggled in through the "suitcase" trade. By 1990, agriculture represented 18% of Turkey's exports. Now about 30 foreign companies operate in the country in collaboration with local enterprises. These include among others, Ciba-Geigy, Pioneer, Sandoz, Interstate, Cargill and Dahlgren - mainly Dutch, French, German and US concerns.

In 1986, a Seed Industry Association was set up to represent the interests of private companies. Since inception, it has grown rapidly in size and influence. It deals with issues such as registration, certification of seeds and production, and holds regular meetings with the Ministry of Agriculture. By 1990, its members accounted for just over 10% of total seed production. There was an almost corresponding decline in state production. In 1990 they were responsible for 80% of soybean seed production, over 96% of hybrid maize, 99% of hybrid sunflower and nearly half the seed potatoes. The private sector also grew the entire lentil seed production and more than 71% of vegetable seed. Irrigation projects could further expand the private sector's market for all crop seeds. Farmers can now afford to be more selective, since there are so many varieties on the market; for example, about 20 varieties of sunflower. This has led to an increase a competition.

Since liberalization, however, most private sector activities have been confined to hybrids. Parastatals are still dominant in wheat, rice, barley, chickpeas and cotton. Farmers' uptake of improved seeds for these crops is low by international standards. Numerous public sector organizations are operating in production, distribution and regulation and there is a need to rationalize their activities and provide clear guidelines to the industry. There is also need to strengthen and improve the role of informal seed production and dissemination activities.
In parallel with the rapid expansion in world trade in fresh and processed horticultural products which has taken place over the past two decades has been a similarly rapid growth in trade in horticultural seeds. While the United States and the Netherlands have been by far the leading exporters of such seeds, several developing countries, including Chile, Thailand, India, Turkey, Taiwan, and Kenya have developed successful trades in this area. This export trade has been undertaken almost exclusively by the private sector, using different production systems and involving different combinations of multinational corporations, indigenous private firms, and/or farmer cooperatives.

One especially interesting case is the development of horticultural seed production and exports in Northeast Thailand during the 1980s (Dolinsky, 1992). The basis for this development was a government and aid-financed irrigation project at Lam Nam Oon. Following a failed government effort to promote expanded groundnut production in the area, a program of public research, extension, and market assessment was developed to support the production and marketing of non-traditional horticultural crops. Under a USAID-funded Agro-Production and Marketing Program (APMP), pre-feasibility studies were conducted and private firms were invited into the area. APMP staff were seconded to these firms.

The operating environment proved to be especially attractive to seed enterprises, both multinational and local, who contracted smallholder farmers to produce vegetable and flower seeds. Farmers have been provided with parent seed and with technical support by the companies, with production credit coming from the Bank for Agriculture and Agricultural Cooperatives. While initially each company was given exclusive zones in which to recruit and support contracted farmers, this gave way to a more competitive system involving half a dozen companies and up to 3000 farmers. Farmer incomes have been considerably higher than for traditional crops. In 1991, judging that the contract-based seed industry in the region was now self-sustainable, the Thai Government disbanded the APMP support units.
III. TOWARD A NEW STRATEGY

For the rest of the century and well into the next, agriculture will be strongly influenced by these trends in technological development and economic organization. Globalization of agricultural distribution and marketing, the broadening of agricultural R&D, and the movement toward market economies all offer opportunities for many developing countries to move into and along with the trends, or at least to benefit from many spin-offs. The alternative to not joining in/or positioning to benefit from spin-offs is to be left out. Considering the continuum of agricultural and seed industry development in individual developing countries, no single approach toward establishing a seed supply system or improving the effectiveness of existing ones is proposed. Rather, objectives and direction of policy are articulated.

Characteristics of the New Strategy

The new strategy for seed industry development in developing countries would focus primarily on policy reform (broader access, deregulation, public sector disengagement); diversifying the sources and strengthening the R&D base for seed technology; and broadening the role of private sector institutions, while streamlining and effectuating improvement in the public sector’s support for farmers, small seed farms, and commercial seed enterprises.

Approaches under the new strategy should seek to establish a seed industry that is:

- **Open** in terms of sourcing improved seeds, rather than closed or restricted.

- **Dynamic** in terms of responding to opportunities, rather than passive, static and programmed; proactive rather than reactive whenever possible.

- **Inclusive** and comprehensive regarding different segments of the seed industry, rather than exclusive and selective.

- **Competitive**, rather than monopolistic; influenced by market forces, rather than determined by central programming.

- **Collaborative** between the public and private sectors, with each sector performing roles for which it is best suited, rather than public sector dominance in all roles.

- **Effectively supported** by public sector institutions for research, extension, credit, and quality control, rather than impeded or stifled.
Delivering on Technology

Adding value through research. Seeds supply deals with a technical product -- crop improvement through R&D -- to which value is added genetically and to a lesser extent physically and physiologically. Adequacy of the R&D base for crops is an important precursor to expanding the role of improved seed and commercial agriculture. Crop improvement is the most important aspect of R&D being internationalized. Players are private national and multinational companies and public-sector national and international institutions. Advances in plant breeding and technology (tissue culture, recombinant genetics, and variations) will have to be delivered to developing countries in the form of improved seeds by a supply system. Preventing further environmental degradation and ameliorating conditions, where possible, will also require the introduction, reintroduction, multiplication and distribution of selected or improved seeds through a seeds supply system. The importance of a continuing supply of new seed products for farmers cannot be over-emphasized. The formal seeds supply system must have something worthwhile to deliver if it is to be successful. When new products are not forthcoming with adequate frequency or the value-added is perceived as insufficient by the farmer, demand for seeds diminishes to low levels -- unless artificially stimulated by heavy subsidies, or seeds are linked to other inputs in a credit package, and so on. The perception of value-added is very important in maintaining demand for seeds at high enough levels to sustain an industry. Indeed, unproductive R&D is cited as a major factor in retrogression in seed industry projects during the past 30-40 years of project experience.

Policy Shifts and Reforms

Entrenchment of public-sector agencies and parastatals in research, seed production and distribution reflects longstanding policies that favored central planning, bureaucracy, monopoly and subsidy over the alternatives: demand-driven production, private initiative, competition and market pricing. The new strategy necessitates important shifts in policy toward the alternatives.

Key actions will involve liberalization and a deregulated legal framework for the flow of seed research ingredients and seed itself; economic policy and incentives to engage the private sector; and divestiture of public sector institutions from several activities -- production and distribution and marketing -- for most seed over time. Public roles, resources and personnel would be refocused on research, quality assurance and control, training/promotion and credit. While the public sector will dominate in these latter roles, the private sector may develop mechanisms for filling them in particular niches of a given economy.
Box 7: Public Research as an Engine for Private Seed Development

In many countries, private plant breeding and seed production has been dependent upon prior or parallel public sector plant breeding R&D. For example, in India, public plant breeding breakthroughs in the 1960s created the demand as well as the products for the private commercial seed industry. The activities of international and national public research institutes in introducing high-yielding varieties of wheat and rice and in developing hybrids for maize, sorghum, pearl millet, and cotton suitable for Indian conditions provided the basis for the subsequent development of local private seed companies. Private Indian companies continue to rely on public institutions for much of the genetic material, self- and open-pollinated varieties, and inbred lines for several major food crop seeds.

In Zimbabwe, for most crops the government has entered into long-term agreements with farmer cooperatives and associations, providing the latter with exclusive control over publicly-released varieties and licenses to multiply and distribute seeds of such varieties. While the government Crop Breeding Institute (CBI) retains the ownership rights to the varieties, the associations are not required to pay royalties. Seed Coop, Zimbabwe’s largest seed producer, has held an exclusive license to produce and distribute publicly-bred maize hybrids. Seed Coop conducts extensive trials of government-bred hybrids and varieties on its own farms.

In the United States, small seed companies have long relied upon publicly-bred varieties for their production and distribution of wheat, rice, and other seeds of self-pollinated crops. Historically, universities and other public research institutes also played a major role in the development of hybrid maize, the largest commercial product of the private sector seed industry. As late as 1979, some 72% of maize hybrids in use had at least one inbred line of public sector origin.

In Guatemala, the government research institute has provided inbred lines and breeder seeds to private companies which have developed their own research and seed multiplication programs despite the relatively small size of the local seed market. Once dependent largely on imports of maize seeds, Guatemala is now virtually self-sufficient, with the private sector accounting for more than 90% of marketed seed.
Specific reforms are foreseen:

- Public-sector withdrawal from the "business" of seed production and distribution for most crops over time. The likelihood of withdrawal varies by crop. For vegetable, forage, specialty crops, and hybrid seeds, all of which have good profit potential and are well-suited to privatization, divestiture could be immediate.

- Self-pollinated cereal grain, grain legume and oilseed crops should be privatized to the extent feasible, based on conducive policies and incentives. Public-sector seed production and marketing should be limited to residual crops and areas for which there is insufficient private sector interest. In cases where the public and private sectors might compete as seed suppliers, a "level playing field" should pertain.

- Phase-out of all public subsidy on seed prices. The most efficient and appropriate public subsidy relates to crop research.

- Liberalized acquisition, entry and utilization of breeding lines and improved seed products of foreign origin.

- A more favorable legal and regulatory environment regarding phytosanitary requirements and plant quarantine, variety, registration, and certification.

- Reasonable arrangements for the security and protection of intellectual property rights as related to crop agriculture.

- Entry of international seed companies under reasonable arrangements concerning equity ownership, joint ventures, access to hard currency, repatriation of capital, and security of genetic lines and proprietary products.

- Assorted investment, credit and information/educational incentives to enlist small, local-based seed producers into more commercial activity, as well as general investment credit and extension services to the sector as a whole.
Box 8: Private Sector Response to Policy Reforms in India

The recent experience in India illustrates the potential impact which policy reforms can have on private sector participation in seed production and distribution (Pray and Ribeiro 1990). In India, prior to the 1980s, private sector seed activities were limited by restrictions on landholdings, germplasm and technology imports, foreign ownership, and the size of domestic companies permitted to participate in the seed industry. Most of the private companies which operated lacked the financial resources to undertake their own research and concentrated on multiplying and distributing either public varieties and hybrids for staple food crops or vegetable crop seeds.

In the early 1980s, a policy change allowed private firms to obtain breeder seed directly from ICRISAT and from Indian public research institutes. This and subsequent changes in industrial licensing policies, foreign investment regulations, and policies on seed imports have contributed to a boom in private sector seed activities. By 1990, the estimated share of the private sector in the value of commercial seed sales reached 70%, with private sector growth occurring most rapidly for sorghum, pearl millet, cotton and vegetables. While there has been a substantial increase in foreign investment in the sector, the larger Indian companies have proven that they can compete with the multinationals, both in their breeding programs and in the market. Many new companies have emerged as spin-offs from other companies. One firm alone, Maharashtra Hybrids, has given birth to at least eight additional private companies since the mid-1970s.

Institutional Turnabout

In redressing historical imbalance in favor of the public sector and formal seed supply, the new strategy shifts both gears -- toward the private sector and the informal sector (already privatized at a low-level of production), which can be transformed into a more effective and commercialized component. The transitional component should be the arena for most initiative and activity. As public sector institutions are divested of certain functions (seed production and distribution), new roles will assume more importance, each shift demanding an institutional response or reform:

- Public sector institutions in crop research require broadened scope, higher-level training, and improved productivity in order to take maximum advantage of and be a participant in the global market for genetic technology of crops.

- The bundle of functions that center on quality control, phytosanitary requirements, and seed entry and certification all require upgrading in the public sector, which appropriately will concentrate more on these functions.
The caliber of extension services is determined by training. As technology transfer speeds up and intensifies in terms of knowledge base, public sector personnel will have to keep pace and/or this function will increasingly be assumed by the private sector.

Public credit facilities for seed as input and commercialization of seed production and distribution will be important facilitators. Administrative capabilities need attention.

World Bank's Role in Improving and Moving Seed

The need for revising strategy and approaches to seed sector development is urgent in the context of trends and critical issues that define agriculture. (See Table 1). The establishment of an effective, efficient and responsible seed supply system -- that is appropriate to absorptive capacity, resources, and opportunities, and at the same time, dynamic, open, and heavily private -- may well be one of the most important things that a developing country can do to ensure that it will be a participant, not an on-looker, in the biochemical revolution underway. The Bank's role in revitalizing seed industry development and in promoting, negotiating, and supporting the needed reforms and updating have been discussed and set forth in rather broad terms. In many cases, the Bank's advice will be fulfilled in the works and activities of specific projects. Despite tremendous variation across countries, development assistance should adhere to and inculcate the common and unifying themes that follow:

Holistic system. As a critical input and agent for change in agriculture as a whole, not just certain crops, nor crops in certain areas, the seed supply system needs to be viewed as a network of interactive production-utilization cycles, a continuum of use and regeneration. Crop and area priorities are necessary given resource limitations. There is also natural segmentation of commerce and to a lesser extent the informal system, according to mode of pollination, purpose of production, nature of product, kind of propagule i.e., true seed or vegetative cutting. Nonetheless, the policies, legal framework, and services established, as well as assistance allocated, ought to be conceived and structured broadly and thoughtfully. In time, as other kinds of seed or other segments of the industry engage, their presence can be accommodated with minor adjustments.
Absence of a coherent national seed policy.

- Farmers as seed producers, domestic seed enterprises and multinational.
- Predominance of public sector in production and distribution of seeds.
- Ineffective and inefficient seed production and supply system.
- Excessive rate of seed application to compensate for poor quality seed.
- Excessive lag between release of new varieties/hybrids and farmers' use.
- Low market demand for improved varieties/hybrids.
- Insufficient pipeline for locally adapted varieties.
- Dependence on imported seeds for crops with a commercially viable market.
- Lack of improved varieties/hybrids.
- Predominance of unadapted, disease- and insect-infested, low-yielding cultivars.
- Large gaps between yields of experiment stations and farmers' fields.
- Low crop yields, compared to other regions/counties with similar agroclimatic conditions.

Table 1: Indicators of Need for Potential Investment in a Country's Seed Sector.
Box 9: Ethiopia - Expanding the Scope and Impact of Seed Supply in Early Phase

Ethiopia represents case of a seed industry in a relatively early stage of development with most seeds being farmer-saved and the formal sector dominated by the public sector. As a result of recent policy changes, encouraged under a proposed new-stage World Bank seed project, there are significant opportunities for sectoral development and greater participation by the private sector. Commercial seed is 5% and farmer-saved seed 95%. Only 2% of seed used by smallholder sector is commercially supplied.

The Ethiopian Seed Corporation (ESC) accounts for nearly all production and marketing of locally improved seed of major food crops. State farms multiply the seed, subsidized by capital grants, deferred taxation and other financial measures. Yet the price paid to them remained constant in nominal terms over 1979-90 and no price difference existed for grain versus seed. This pricing structure led to persistent financial losses and little incentive to produce quality seed. Due to lack of improved varieties and quality, demand for ESC seeds has declined over time.

As part of the proposed seed project, many initiatives are highlighted to improve the overall effectiveness and efficiency of Ethiopia's seed supply system. In broad terms, the proposed project will help accelerate productivity of the agriculture sector and economic growth by: promoting the participation of private and public investors in the seed industry; creating healthy demand and supply conditions; stimulating rapid transfer of technology from the national agricultural research system to producers; and creating an enabling environment to produce and supply sufficient quantities of high quality seeds. Specific objectives are to:

- Improve seed supply for small farmers through development of an effective secondary seed multiplication and distribution mechanism.
- Produce and supply seeds of secondary crops, horticultural and forage crops.
- Strengthen and decentralize ESC to make it commercially viable.
- Upgrade seed technology and quality control.
- Promote private sector participation through foreign exchange and credit facilities.
- Develop human resources to operate the seed industry efficiently.
- Stimulate government and farmer/industry seed associations.
• **Open, wide and opportunistic souring of improved varieties and seeds.**
Prevalent policies and attitudes that keep the sourcing of genetic improvements in a nationalistic and protective mode are retrogressive and will be obsolete in a few years. The most revolutionary advances in plant genetics will continue to come from a relatively few sources, as they have in the past, mostly industrialized countries and IARCs. Increasingly, products of multinationals and biotech R&D companies, i.e., the private sector, will add a new dimension. Developing countries must establish policies and develop capabilities to take rapid and maximum advantage, with reasonable precautions, of relevant advances in production technology.

• **Market orientation.** While specific segments of a seed system may need to be nurtured and protected in a formative period or as new kinds of seed and marketing areas are tackled, overall strategy, scope, pricing structure, and services must sooner than later be sorted out in the marketplace. Even in the short term, goals should include market testing of seed products, demand-determined supply, elimination of subsidies (open or hidden), and free market pricing.

• **Private sector participation.** The hallmarks of efficient, effective and responsive seed supply systems are rooted in competition, usually based on private sector involvement to the extent feasible. The informal seed supply system is private and competitive, except where seed exchange is part of a mandatory social obligation or tradition. Indications are unmistakable: a favorable climate for private entry into seed supply must be established, and private sector involvement must be promoted and encouraged with appropriate incentives, and an array of innovative arrangements including, as necessary, some start-up enticements.

• **Linkage and networking of informal and formal components.** The informal system is private and unsubsidized, and very effective in maintaining and diffusing improved seeds of self-pollinated crops. But, it is not without defects. It is time to update its capacities to cope with technological change, acknowledge its critical role, and forge links to the formal system (See Box 10). As the main reservoir of genetic diversity, the informal system must also be scrutinized to identify crop varieties with highly valued characteristics that fit well into sustainable farming systems for diffusion to other farmers in other areas. And, with some assistance, farmer-based seed enterprises might emerge from the informal system.

• **Promotion and service attitude.** The agricultural establishment in most developing countries appears to emphasize seed regulation and control, with a distorted concept of the role and purpose of seed certification in many donor-assisted projects. Of course, appropriate seed control, certification and other regulatory measures can help establish a responsible, credible, and equitable seed industry, as well as protect the rights of consumers and the interests of crop agriculture. However, premature, misplaced and overly zealous control features can stifle development and become abuses in their own right.
Box 10: Informal Seed Distribution in Remote Regions and Narrow Agro-Ecological Zones

Informal seed distribution systems are typically based on localized farmer-to-farmer or community-to-community exchanges. These systems are typically quite flexible, involving a variety of different exchange mechanisms. Informal seed systems are most appropriate and often dominant in circumstances where: 1) the farming community is located in a remote location (inhibiting farmer access to markets and seed distributor access to the area), 2) production is undertaken within a narrow agro-ecological zone (limiting seed market size and the suitability of widely marketed varieties), and 3) the major crop(s) have very high seeding rates (implying high transport costs for seeds moved over considerable distances).

All of these conditions prevail in the Peruvian highlands where potatoes are the primary food crop as well as the most important cash crop for some 60% of the smallholder farm households. Because of the narrow agro-ecological niches within the highlands, the considerable risk of production due to drought and frost, and the varied culinary tastes of farmers and consumers, several hundred indigenous potato varieties are grown. Within the highland areas, the road network is poor and some production areas are completely cut off from vehicular access.

Until the early 1980s, seed potato programs in Peru had focused on supplying improved seeds to large-scale commercial seed growers (located in the coastal area or in the Central Highlands), with the expectation that this improved seed would spread into the production systems of small-scale hill farmers (Scheidegger et al. 1989). This, however, generally did not occur and smallholders tended to save their own seeds or exchange seeds amongst themselves. In order to strengthen the links between formal research and the informal highlands seed distribution system, a special program was launched in 1983, with the participation of the National Institute for Agricultural Research, the International Potato Center, and the Swiss Development Corporation.

As part of the program, laboratories and research stations were set up in five locations in the highlands to produce pathogen-free foundation seed of the twenty most popular modern varieties and sixteen most popular native varieties. This foundation seed was sold by the extension service or by non-governmental organizations to farmers or farmer communities for them to multiply and distribute. Individual communities made their own arrangements for such multiplication and distribution. The program has been successful. A follow-up study undertaken after two years of the program found that the volume of seed production had expanded rapidly, that seed quality had been maintained, and that improved seed had been widely diffused among many farmers and nearby communities.
Shifting away from control toward promotion and service on the part of the public sector will be important as the public divests of seed production and distribution facilities. Service will become the major function of the public sector in seed system development. Services will range from quality assurance to extension, and in each case, attitude, as well as technological capacity, will determine effectiveness.

**Dynamism.** This elusive, but invaluable attribute is largely a product of interactions that acknowledge performance and reward them accordingly.

The above themes combine to encourage attainment of the long-term goal: establishment of a comprehensive seed supply system, with segments strongly linked and interactive, soundly based on a productive crop R&D, commercialized to the extent possible, sustained by market pricing, unsubsidized, effectively supported by the public sector, as needed, and responsive and responsible to customers.

**Phasing of Reforms**

Bringing about the needed policy reforms will not be easy, but for the most part, they will be accomplished wholly or partly through dialogue with decision-makers. Reforms need to be targeted in terms of both crop (type, propagule) and time. Reforms that can be accomplished over the short term, with minimal disturbance to crop agriculture, should be tackled almost immediately, while those that require considerable reorganization, transfer and reassignment of many personnel, disposal of assets, start-up time for new players, and especially, substantial changes in the "business" of seeds supply need to be approached cautiously, with a more distant horizon.

**Early Phase.** The first phase could include: Withdrawal of the public sector (government) from the "business" of seed importation, the production and marketing of seeds of hybrid varieties, most vegetables, most forage and specialty crops;

Elimination of controlled, subsidized and/or guided prices for these crops;

Liberalization of variety registration procedures and requirements, e.g., minimization of the trial period for vegetables, forages and specialty crops; its reduction to one to two years for hybrid grain, grain legume and oilseed crops and to two to three years for other varieties and crops (taking into account, of course, reputation of the originator and performance data from other sources within and outside the country).

Opening of foundation seed allocations to *bona fide* seed producers and companies;

Liberalization of policies and regulations relating to importation of seeds and genetic lines, the terms of entry for multinationals, and organization of joint ventures.
Later phase. Withdrawal of deeply entrenched public agencies and parastatals from production and supply of seeds of the self-pollinated grain, grain legume and oilseed crops -- usually the most important to developing agriculture -- needs to be carefully phased. Creative solutions, additional and special efforts, some concessions in terms of principle, some special arrangements and some incentives will be required. The private sector is hesitant to make substantial investment in seeds for self-pollinated crops, due to highly variable and unpredictable demand because each farmer has the option of saving seeds and, thus, is a competitor. Nonetheless, the following options may be helpful in enlisting the private sector in seed production of self-pollinated crops.

- Off-season use of private seed facilities (mainly for hybrid varieties, such as maize) for opposite-season, self-pollinated crops (wheat is in opposite-season to maize, for example), thus spreading the fixed costs over a larger revenue stream, even though the profitability for self-pollinated crops is near nil.

- Exclusive release of varieties developed by the public sector to private companies for seed production and marketing on the basis of proposals, bids, or a lottery.

- Granting of exclusive seed marketing concessions or franchises to private companies on the basis of proposal, bid, or management.

- Guaranteed offtake of a specified amount of seeds by government for use in rehabilitation and development projects.

- Investment incentives and/or special access to foreign exchange to purchase supplies and equipment.

- Special technical assistance and credit to identified, progressive farmers in the informal sector, including early access to foundation seeds of new varieties, and/or collaborative arrangements for on-farm testing of new varieties and good local distribution of good performers.

- Education of farmers regarding new varieties.

It is acknowledged that such concessions and incentives may fall short of the ideal of a free and competitive market for seeds. In a sense, they are halfway measures designed to move a lumbering public sector out of the seeds business, to the extent possible, and bring private sector management and motivation in.
Residual seed supplies. Regardless of incentives, concessions and other enticements, the private sector will not assume production and supply of all seeds needed for ecological zones, farming systems, area development, maintenance of genetic diversity, environmental amelioration and other public welfare purposes. Such "residual" seeds will have to be foregone or produced by the public sector or under its sponsorship (contracted to the private sector). And, production will have to be subsidized. This situation should be viewed pragmatically, not ideologically.

Client Orientation

Any seed program should start with farmers’ crops and be responsive to their agroecological areas. Its core objective should be to provide a wide range of improved planting materials at an affordable price and within easy reach. To meet this objective, assistance strategy for the seed sector has to be holistic and multipronged. It will require a multiplicity of actors, operational models for assistance, and public support measures. Seed projects should provide specific assistance to four main categories of seed producers: subsistence farmers; small farmers/seed producers; domestic seed enterprises (ranging from single commodity in a local area to a multi-crop national company); and multinationals.

Table 2 matches major players in seed production and marketing with their assistance needs. Each category caters to a portion of a market and together they should serve the overall seed requirements of a country. To reach all farmers in the shortest time, the donor community should recognize the necessity of assisting governments in addressing the needs of each category, based on their complementarity and respective comparative advantage.
Table 2. Matching Assistance to Needs of Seed Producers

<table>
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<th>Category of Seed Producer</th>
<th>Assistance Needs</th>
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| Subsistence farmers who save own seeds | - Information on:  
  * most suitable variety  
  * improved techniques for on-farm seed selection  
  * improved harvest, cleaning and drying methods using local materials  
  * improved storage and seed treatments using local materials  
  * access to small farmer/seed producer's seed and trained extension staff |
| Small farmer/seed producer | - Access to most suitable varieties for locality  
  - Training in seed production of specific crops  
  - Access to credit for input supplies, basic infrastructure (drying and storage) and carrying costs of storing seed till next cropping season  
  - Close linkage to domestic seed enterprise and/or public research institutions for access to information, training, and certified seed  
  - Access to seed testing laboratory  
  - Assistance in conducting "on-farm" variety performance trials and organizing field days for adjoining farming communities |
| Domestic seed enterprise | - Easy access to improved varieties/hybrids (breeder/foundation seed) from national research institutions  
  - Easy flow of improved germplasm from outside sources  
  - Hard currency to purchase improved germplasm, specialized seed equipment, external technical assistance and training  
  - Credit in local currency to pay contract growers and cover operating costs  
  - Market pricing and demand for improved seeds  
  - Access to information on external markets  
  - Government policies to promote seed export  
  - Plant variety protection  
  - Encouraging government policies to undertake R&D activities |
| Multinational seed companies | - Minimal restriction on international movement of germplasm/seeds  
  - Government policies and legal framework for joint ventures with domestic companies  
  - Ability to relocate profits  
  - Plant variety protection  
  - Policies encouraging participation of national seed companies |
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