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Seed industry development in a North-South perspective

Ton Groosman, Anita Linnemann
and Holke Wierema

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Foreword

The world's population has increased from one billion inhabitants at the beginning of this century to 5 billion at present. Periods of food shortage and starvation were common to large numbers of people, especially in the developing world. Today hunger and malnutrition are still major problems in many countries largely as a result of poverty and failing political systems. The agricultural potential of most areas is considerably higher than actual production.

The technological revolution which has provided the means to increase annual yields from 20 to 80 kg grain per hectare, known as the Green Revolution, occurred just after World War Two in the industrialized countries of Europe, USA and Japan, and some twenty years later in most developing countries. Further increase in yields is still possible, and from an agricultural point of view, there is no need for starvation, even with the ever increasing world population. However, the technological progress responsible for the Green Revolution has also had negative side effects. Measures are now being taken to compensate for the environmental consequences, as well as to meet the need for more equitable distribution of the benefits of technological progress.

Another consequence of the Green Revolution is the increased technological interdependence of nations, especially with regard to the seed supply system. Transnational companies have become increasingly involved in seed production and supply in the last few decades. Dependency on these companies as well as monopolization of seed material, fertilizers and pesticides may have negative effects in many developing countries still relying on local seed production strategies.

To study the changes in the seed sector, the Development Research Institute (IVO) at the University of Tilburg undertook a cooperative project with national research institutes in three countries with different policies on seed production aimed at safeguarding national seed supply systems. Thailand as a country with few protective measures, India with a very closed system, and Kenya with a seed policy somewhere between, were studied and the findings presented at an international seminar held at IVO in 1988. At the seminar recommendations were formulated for government policy makers and seed sector institutions.

The results of the research project and the conclusions of the seminar demonstrate the diversity in seed supply systems in developing countries. More than eighty per cent of seed used is produced by the farmers themselves in all countries .

The study and seminar were sponsored by the Netherlands Ministry of Foreign

Affairs, Minister for Development Cooperation. Demonstrating the need for reliable data for the development of a sound strategy for seed improvement, production and supply systems, this book makes very informative reading for policy makers.

Rudy Rabbinge
Professor of Theoretical Production Ecology
Wageningen Agricultural University

Jaap Hardon
Netherlands Centre for Genetic Resources

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Part A
Dynamics of the international seed sector

1 Technology, agriculture and seed supply systems

1.1 Technological development in agriculture

In the past few decades technological progress has led to a rapid transformation of agricultural systems in industrialized as well as developing countries. In industrialized countries, large scale mechanization and biological/chemical innovations have drastically reduced the agricultural labour force. Development of modern varieties of some basic food crops in the early 1960s was a technological breakthrough which had major impact on the agricultural sector in developing countries. This led to the Green Revolution in which improved varieties, highly responsive to fertilizer, were distributed over large areas especially in Asia.

Controversy over this technology persists, focusing on those who usually gain, farmers in irrigated areas, fertilizer industries, and consumers versus those who inevitably lose, agricultural labourers, small and marginal-scale farmers in non-irrigated areas (Lipton, 1984). Criticism comes mostly from social science researchers and environmentalists. Sachs (1987), for instance, believes that even limited extension of Green Revolution technology requires enormous outlays of capital. Alternatively, redirection of agricultural research towards labour absorption and higher productivity would build the necessary knowledge intensive rather than capital and energy intensive food production systems.

Proponents see great potential in the new technology. According to Borlaug (1987), it is impossible to provide enough food for today's global population using the less intensive production methods of the last centuries. His view may be valid for high-input production systems in developed countries, but it overlooks the diversity of farming systems in the developing world. Farming in tropical rainfed areas, for instance, is characterized by environmental diversity and low external input. A wide range of technological options is, therefore, required to improve and sustain adequate levels of food production.

1.2 Changing seed supply systems

Advancements in agricultural research and increasing technological interdependence between nations have received much attention in recent years. Change has come through innovations within conventional plant breeding and breakthroughs in genetic manipulation of higher plant species are expected to have an even more

important impact. Transnational companies entered agricultural research only in the early 1970s. Further internationalization and global restructuring will surely follow (Doyle, 1985; Ahmed, 1988). National agricultural research organizations, bilateral and multilateral agencies, as well as traditional seed companies should adapt their policies accordingly. Unfortunately, policy options are not clear, because of the complicated nature and structure of the seed sector and supply systems in developing countries.

These systems, in both industrialized and developing countries, will also change considerably in coming years. The speed and direction of change will depend largely on technological decisions in seed sector development (Figure 1.1). The feasibility of objectives in plant breeding and seed delivery systems depends on prevailing agricultural production systems and socio-economic environments. Changes will differ from region to region and country to country, depending on the evolution, in particular commercialization of the farming systems.

Organized seed supply systems are by nature highly market oriented. Technologies for plant breeding, seed production, processing, treatment, and packaging have been almost exclusively developed and used in high external input agricultural systems in industrialized countries. Transfer of these technologies to developing countries began only recently through bilateral and multilateral programmes.

Current restructuring of private transnational seed companies will alter the options available to developing countries for expanding and improving organized seed supply systems. New systems often interfere with traditional seed methods. Developing countries are now confronted with how to restructure the seed sector to meet national objectives and the needs of the farming community. Against this background a research project was formulated.

1.3 Scope of the study

The main objective of this study was to document past and potential changes in seed supply systems in developing and industrialized countries, through a study of technological development and organizational structure in the global seed sector. The seed sector is defined as all public and private activities in plant breeding, variety development, seed production and distribution. Constraints and initiatives in seed industry development and policy options for improvement of seed supply systems were identified. The researchers sought answers to the following questions:

- What is the current status of plant breeding, seed production and seed distribution, and what development plans exist for the short and long term?
- What hampers or accelerates development of improved varieties, and what are the consequences for traditional seed supply systems?
- What has been the impact and effectiveness of bilateral and multilateral development agencies on seed supply systems in developing countries, and how have national agricultural research organizations responded?

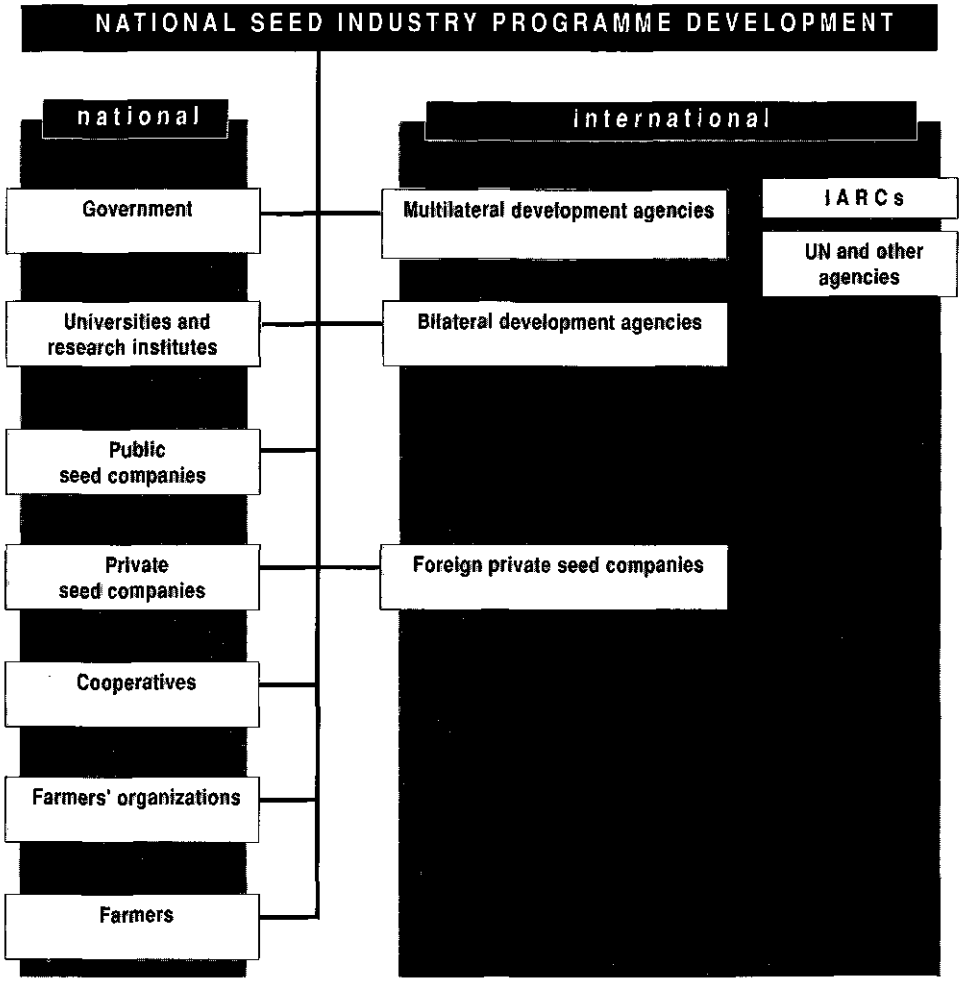

Figure 1.1. Main actors in the seed sector in developing countries.

– What are the technological and organizational options for structuring and improving seed supply systems, and what policies could be developed to promote them?
– What is the present and future role of the internationally operating seed industry in seed sector development in developing countries?

1.4 Implementation

The sector-specific approach used in this study distinguished between the commercial seed sector consisting of hybrid and non-hybrid seed markets in agricultural and horticultural crops and the public sector, both national and international, that covers another large share of seed supply. In addition, attention was given to the

traditional seed sector, that is seed produced by farmers.

Research teams were formed of social and agricultural scientists experienced in seed technology and familiar with plant breeding and seed production. In addition to the Netherlands, teams were formed in three developing countries selected as case studies on the basis of activities in seed industry development: Kenya, India and Thailand. In these countries, seed supply systems have changed considerably and policies to develop them could be evaluated for performance and impact.

The Europe-based team analysed literature on structural changes in seed industry development in industrialized countries that were relevant for developing countries. The research included transfer of seed-related technologies, impact of transnational corporations on global seed supply systems, international seed trade, investment patterns, transfer of plant genetic resources, and official development cooperation related to the seed sector (Groosman, 1987). In Kenya, India and Thailand, the research teams analysed literature on seed sector development and collected data on the structure of the seed industry.

This study focuses on basic food crops, in particular cereals (wheat, rice, maize, sorghum and millet). In India, these crops cover approximately 75% of the gross area sown; in Thailand, rice alone accounts for 60% of the planted area; and in Kenya, maize is the dominant crop. Non-cereals, for example pulses, oilseeds and vegetables, were also studied but national seed programmes for these crops are scattered and dependence on imports of especially vegetable seed is considerable. Vegetatively propagated crops, such as oil palm and potatoes, were not considered in the case studies. Interim reports were presented and discussed at a seminar in Thailand (TDRI/IVO, 1987). Subsequently researchers undertook interviews to assess constraints and opportunities in seed supply and to gather opinions on the desired direction of seed sector development.

Interviews with private seed companies in the Netherlands focused on strategies of involvement in developing countries. A questionnaire was sent to some 200 companies in Western Europe, USA and Japan (Wierema, 1989). Approximately 300 organizations were interviewed in Kenya, India and Thailand. Information obtained from these interviews has been incorporated in the case studies and published separately in a series of research reports (Setboonsarng et al. 1988; Agrawal, 1988; Ruigu, 1988).

In June 1988, a seminar was held at the Development Research Institute in Tilburg, the Netherlands, to discuss the project's conclusions and recommendations (Groosman et al., 1988).

2 Seed industry development: an international perspective

2.1 Origin and structure of the seed industry

For centuries farmers have produced seed by saving and selecting part of their harvest for the following growing season. This practice of saving seed of traditional and improved varieties still dominates many farming systems today. At the beginning of this decade an estimated 80% of total seed requirements in all developing countries were met by saved seed. Low-income developing countries are still only minimally supplied by organized seed industries.

The organized seed industry has an important role in agricultural modernization. Study of the nature and structure of the seed industry reveals that it is fragmented into several branches, each with its own characteristics. The agricultural branch concentrates on a few types of bulk seed for use over large areas, whereas the horticultural industry produces a great number of varieties of many crops, usually of low seed weight. In industrialised countries there is little interaction between the two branches, and seed companies usually specialize in either horticultural or agricultural seed.

Distinctions exist in both hybrid and non-hybrid seed industries. Plant breeding and seed production techniques for hybrid varieties are complex, and therefore more costly than for non-hybrid varieties (Sneep & Hendriksen, 1979). The advantages of hybrid crops are considered to be greater uniformity and usually higher yield, although this can be difficult to ascertain. In general, hybrid varieties are produced for cross-pollinated crops, but private seed companies have also tried to develop hybrid varieties of, for instance wheat, a self-pollinated crop, to create commercial seed outlets for this crop. A selection of international companies involved in hybrid wheat development are listed in Figure 2.1.

Development of hybrid varieties, in particular maize, started in the USA at the beginning of this century. Since the introduction and widespread distribution of hybrid maize in the USA, large and profitable markets for several hybrid crops have developed worldwide. Profit in the hybrid seed industry is high compared with the low margin of 'easy to save' seed (Butler, 1983). Technology in the seed industry ranges from rudimentary research and development to highly complex breeding methods. The newest scientific developments, such as tissue culture techniques and genetic engineering, require more research and capital investments, and therefore, the seed industry is increasingly difficult to enter.

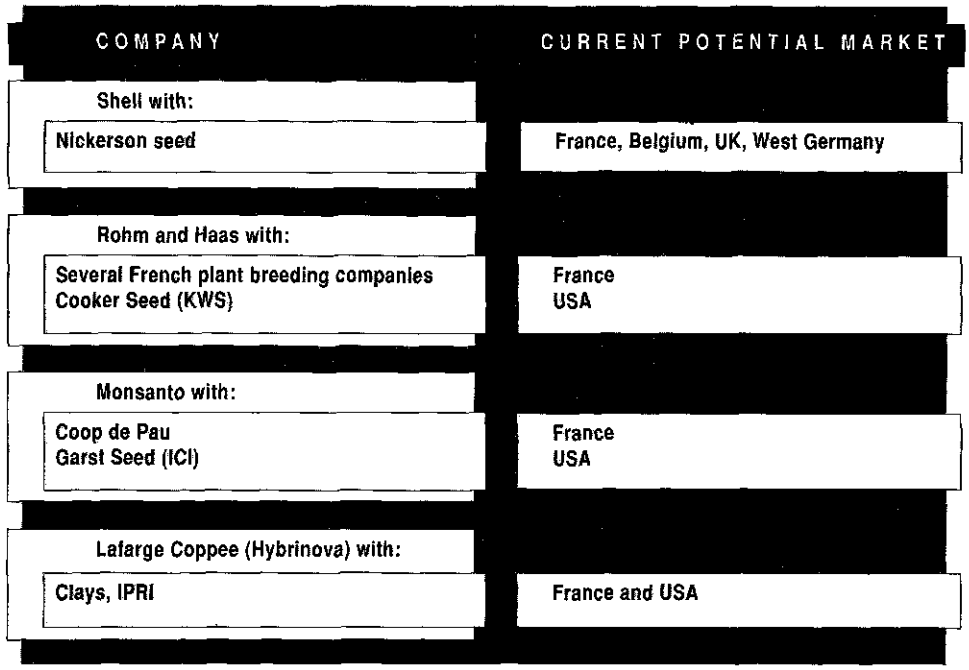

Figure 2.1. Selected seed companies active in hybrid wheat development (Source: Cultivar, 1985).

The major characteristics of the seed industry are presented in Figure 2.2.

As the seed industry develops, companies generally shift from non-hybrid to hybrid production, depending on the technical potential. This is exemplified in the USA, where hybrid maize accounts for almost half the total seed supply. The major characteristics of the USA seed industry are shown in Figure 2.3. Hybrid seed is more expensive than non-hybrid seed, and the industry can set the prices, because hybrids cannot be easily reproduced. The difference in development in prices of hybrid and non-hybrid seed is shown in Figure 2.4 by means of a price comparison of hybrid maize, non-hybrid wheat, and soya bean in the USA in the period 1970-1980.

2.2 Restructuring of the seed industry in industrialized countries

The commercial seed industry is still highly concentrated in industrialized countries. The American seed consultancy firm, Teweles, calculated the global seed market in the mid-1980s to be US$ 50 billion (Figure 2.5), of which US$ 18 billion was farmer-saved seed (Teweles, 1985). In developing countries, farmer-saved seed is important in terms of turnover despite its relatively low value added.

Most production and export of improved seed occurs in Europe and North America. The value of the commercial market in developing countries is estimated

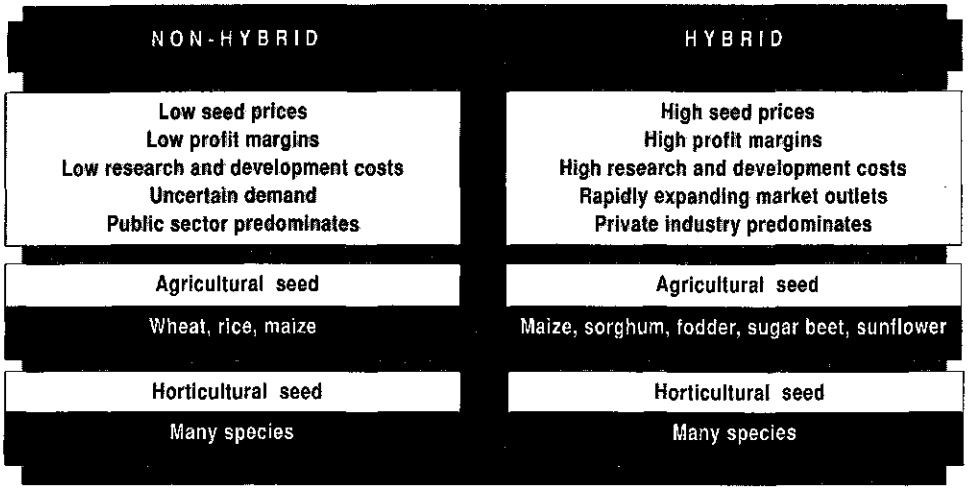

Figure 2.2. Major characteristics of the seed industry.

at US$ 3.8 billion, that is 12% of world seed sales (Figure 2.6). Western European and North American countries were responsible for 90% of the estimated US$ 1.2 billion international seed trade at the beginning of 1980s. Development of seed exports from the USA and European Economic Community (EEC) is presented in Table 2.1. Because of wide fluctuations in the United States dollar, exports are also shown in the European Currency Unit (ECU). In ECUs, seed exports from the USA and EEC combined increased by almost 10% annually in the period 1980-1985.

Until the early 1960s, the seed industry in industrialized countries consisted of mainly small and medium-scale private enterprises and agricultural cooperatives producing for limited national and international needs. Public plant breeding organizations played an important role in the development of new varieties, and still do so. Depending on the local structure of the seed industry, varieties developed by the public sector were commercialized by the public or the private seed industries.

Seed commercialization, however, occurred for the most part in the private sector. Many small and medium-scale seed companies were independent, and produced improved seed for specific national and international markets. Companies in the horticultural seed industry also developed new seed outlets. Traditionally, agricultural cooperatives supplied seed to local, regional and national outlets. Their role as local grain traders in the non-hybrid seed market is threatened by entry and expansion of transnational corporations in the seed industry of industrialized countries (Groosman, 1987). Their market share will diminish unless they can also invest in new breeding technologies.

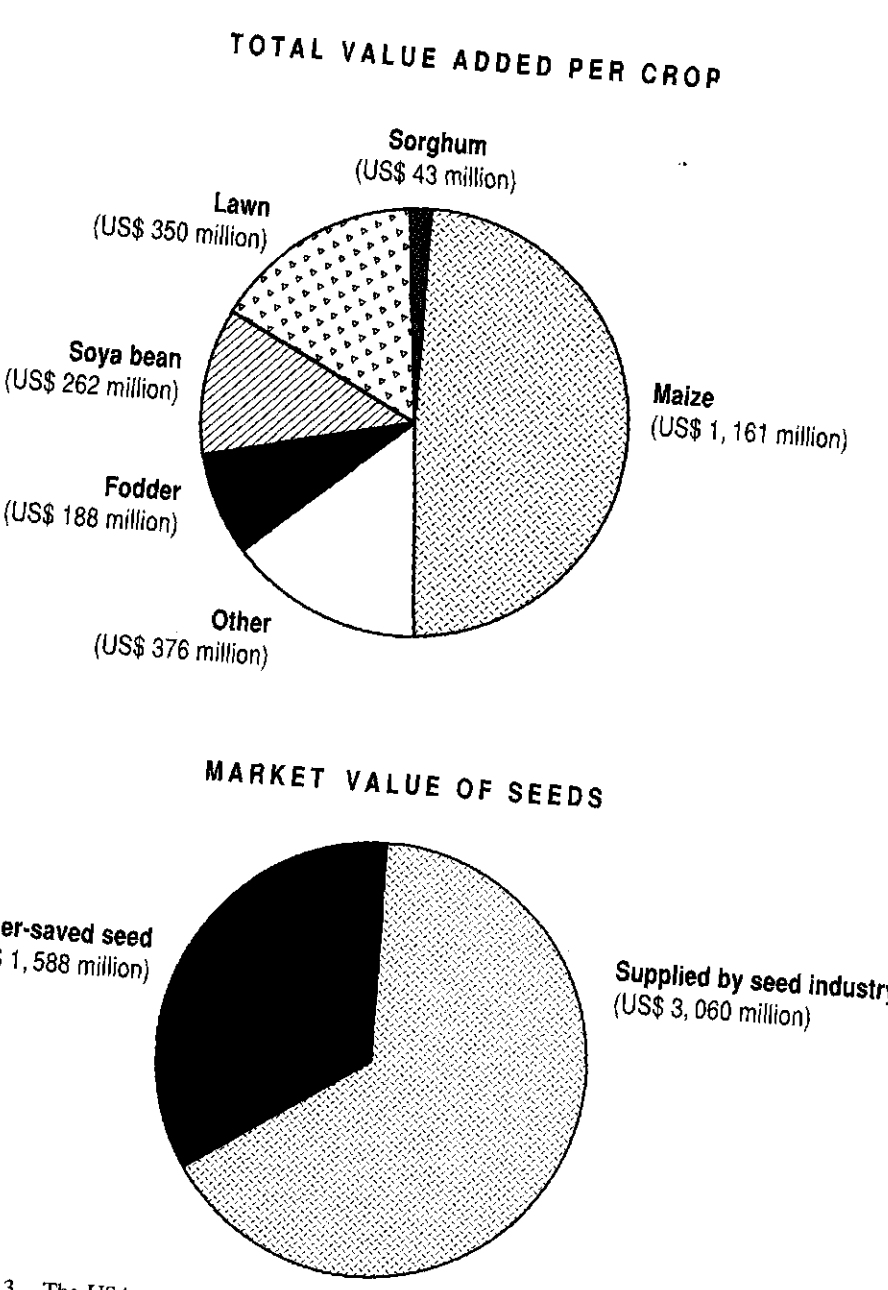

Figure 2.3. The USA seed market, 1982 (Source: Kania, Harvard, 1982).

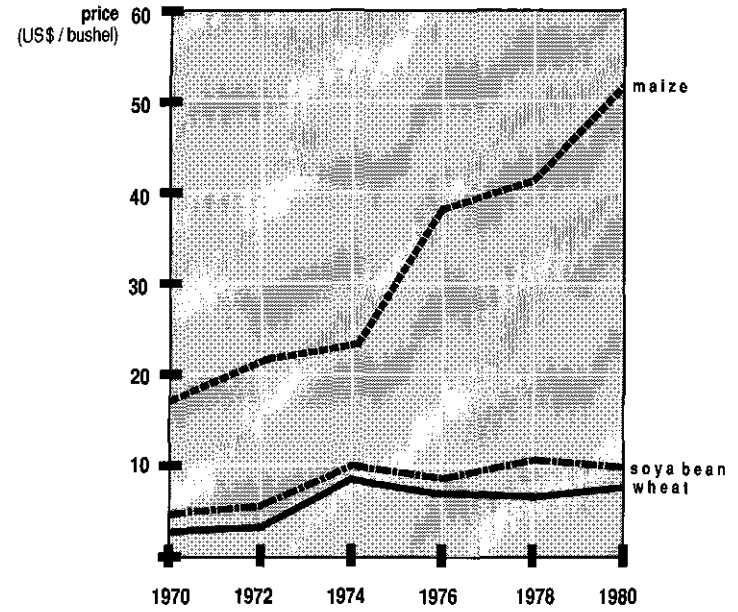

Figure 2.4. Seed prices of selected crops, USA, 1970-1980 (Source: Butler, 1983).

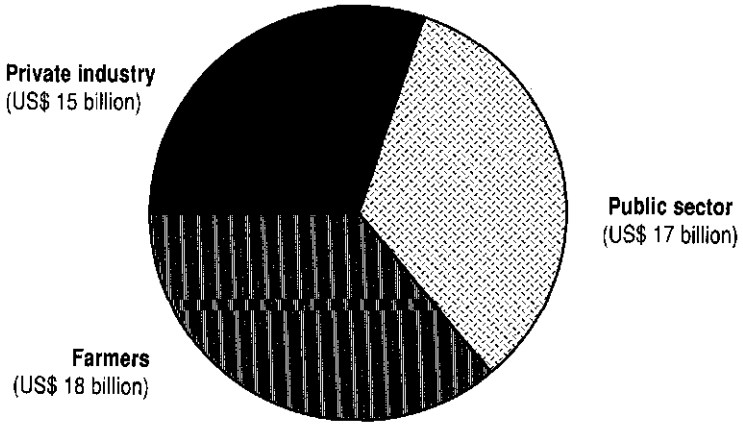

Figure 2.5. Estimated global seed supply in the mid-1980s.

2.2.1 New technology

Although commercial varieties of basic food crops have not yet been developed, expected results from the use of recombinant DNA techniques and other new, biotechnological tools have already led to restructuring of some branches in the seed industry. New techniques in plant biotechnology offer a promising future for agricultural productivity.

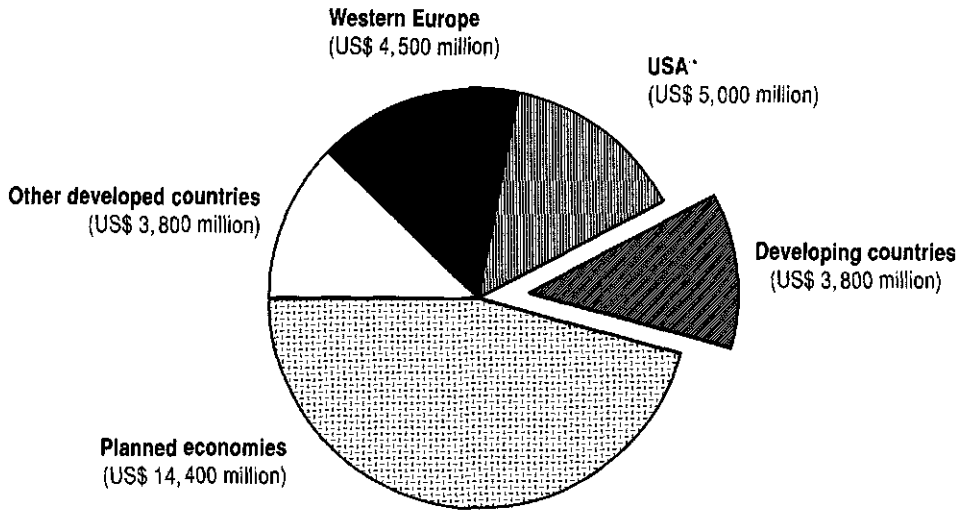

Figure 2.6. Estimated global supply of improved seed in the mid-1980s.

Table 2.1. Development of seed exports from the USA and EEC.

	Year	US$	Index	ECUs	Index
USA	1980	297	100	212	100
	1981	290	98	284	134
	1982	305	103	311	147
	1983	328	110	368	174
	1984	353	119	452	213
	1985	362	122	476	225
EEC	1974	371	100	445	100
	1980	784	211	563	127
	1982	753	203	769	173
	1983	727	196	808	182
	1984	750	202	950	213
	1985	746	201	981	220

Source: Foreign Agricultural Circular, several issues; Eurostat,several issues; conversion of US$ to ECUs: Eurostat, several issues.

Tissue, organ and cell cultures. Fragments of plant tissue, organs, or separate cells are kept alive in an artificial culture medium, brought to cell division, and ultimately regenerated into complete plants. Quick in vitro vegetative propagation, and selection for stress tolerance in cell cultures may speed up the selection process.

This technique has been widely applied in vegetatively propagated plants, such as oil palm, coffee, tea, cacoa and many forest, vegetable and ornamental crops, which are all important exports in developing countries (UNCSTD, 1984).

Genetic engineering. Genetic material is transferred in vitro from one cell to another to create via asexual means a reproducible combination of hereditary material in the latter. The transformed cells must then be regenerated into complete plants. Genetic engineering uses cell culture techniques in two distinct ways:
- Protoplastic fusion, also called somatic hybridization, combines the contents of two cells. With this technique, incompatibility in crossing or self-fertilization can be circumvented via sexual in vitro recombination, and greater genetic variability can be attained in the parental population.
- DNA, in the form of nuclei, cell organelles, chromosomes or genes, is transferred in vitro from one cell to another to create a specific hereditary change. This technique is in an early developmental stage and its usefulness for plant breeding is not yet certain.

Most plant breeders do not expect conventional breeding methods to lose importance as genetic engineering and tissue culture techniques evolve. New technology is expected to aid plant breeders and to create greater opportunities for efficiently combining genes. However, some practising plant breeders doubt that laboratory developed varieties will prove satisfactory in the field (Sneep & Hendriksen, 1979; Pudoc, 1983).

2.2.2 Changing seed legislation

Changes in the western seed industry's structure have resulted from technological advances, and also from national and international variety protection and quality control legislation. Some highly industrialized countries have Plant Breeders' Rights, a system of legal protection for new varieties. In 1961 a number of Western European countries adopted the Convention International pour la Protection des Obtentions Végétales, also known as UPOV Convention or Paris Convention, to allow breeders to acquire sole rights to the multiplication and commercialization of newly developed varieties. However, these varieties can be used for plant breeding. Current Convention members include EEC member countries (except Greece and Portugal), Japan, South Africa, Switzerland, Israel, New Zealand, Sweden, USA and recently, Hungary. Some industrialized (OECD) countries, such as Canada, Austria, Finland, Australia, Norway, and Turkey, do not belong to UPOV. So far, no developing country has joined the Convention, despite potential economic advantages of Plant Breeders' Rights for private breeding firms. Newly developed varieties would be protected, making investment and operation on a commercial scale as well as non-hybrid plant breeding more attractive.

Whether or not to patent biotechnological inventions in plant breeding is an increasingly important consideration in the formulation of seed legislation. Until

recently, plant varieties could be protected by Plant Breeders' Rights but not patented. To increase control some parts of the seed industry especially the transnational corporations strongly advocate a patent system that would provide private ownership of plant products and processes. Currently, no living organism is exempt from patenting in the USA.

Steady expansion of patent coverage for living organisms there, and proposed introduction of patenting in Europe and Japan, indicates that most countries of the Organization for Economic Cooperation and Development (OECD) are moving towards rights of ownership, far exceeding protection offered by Plant Breeders' Rights.

Patents of plant products and processes will seriously reduce availability of cultivars for further plant breeding, thereby undermining the basis of current plant breeding practices.

International technological competition has caused some developed countries to demand increased protection of intellectual property. Loans from the World Bank and the International Monetary Fund may soon be conditional upon acceptance of the intellectual property law (Kenney, 1988). Patenting of biotechnological inventions and further privatization of research can easily lead to a decline in research for the public good. A probable increase in trade secrets would also make new technology less accessible.

2.2.3 Transnational corporations

Transnational corporations and private biotech companies entered the USA seed industry in the early 1960s. In the 1970s and 1980s consolidation of independent seed firms into transnational corporations accelerated. A complete list of mergers and takeovers is not available, but there have been several hundred transactions. These corporations entered the seed industry to diversify their activities and often because they already had vested interests in the supply of agricultural inputs, such as pesticides, and in agricultural trade.

Consolidation is a continuing process. ICI (Imperial Chemical Industries), for example, recently acquired three seed companies with a combined turnover of US$ 200 million, and is still expanding its seed activities. Other transnational corporations (such as Sandoz, Ciba Geigy, Shell, Hoechst, Monsanto, Pfizer, Dow Chemical, Elf Aquitaine, Rhône Poulenc) had penetrated the seed industry earlier, and have acquired large shares in several segments, especially the hybrid seed market.

All these companies are also large pesticide producers. Interviews with them revealed that expected results of biotechnology and the accompanied increase in seed sales were major reasons for their investment in seed enterprises. Most likely, these conglomerates will integrate recently acquired seed companies into their agrochemical (pesticide) subsidiaries, which have similar research and development programmes and marketing outlets (Fowler et al., 1988). Transnational seed companies have invested heavily in plant biotechnology, as shown in Table 2.2.

Table 2.2. Research and development expenditure of transnational seed companies (US$ mln).

Company	Conventional breeding	Plant biotech	Pesticide sales 1987[a]
Pioneer Hi-Bred	30	5	0
ICI	11	15	1 800
Dekalb/Pfizer	19	6	0
Sandoz	16	7	650
Ciba Geigy	9	13	2 050
Monsanto	1	15	1 200
Shell	9	3	1 050
Orsan/Lafarge	4	3	0
Rhone Poulenc	2	3	1 050

Source: Fleming Securities, July 1987.
a. Cultivar, 1987.

Food processing and trading companies, such as Continental Grain and Cargill have also entered the seed business. Unilever, for example, recently began buying seed companies, including a major public breeding organization and its seed sales department in the UK. For Unilever, and other vertically integrated transnational corporations in the food sector, entry into the seed business allows adaptation of varieties to processing plants, and consequently reduced costs of raw material.

Other companies that have integrated plant genetic research into food processing activities are Campbell (tomato), Delmonte of the Reynolds Group (peas, beans and tomato), Heinz (tomato), Firestone (rubber), United Brands (banana), Carlsberg of Denmark (barley) and Cargill (sunflower). They all now have in-house research facilities or research contracts with private biotechnology companies and agricultural universities (Kenney, 1988).

Plant genetic research has come increasingly from the private sector. In 1987, private enterprises in the USA were responsible for 80% of total investment in agricultural biotechnology and for only less than 60% in conventional agricultural research (Jensen & Pope, 1987). The trend is similar in Europe and Japan. Public sector research expenditure levels off or is declining, while the private sector proportion is increasing, especially in biotechnology and plant breeding. Private agricultural research expenditure in the USA, for instance, increased from only 4.2% in 1965 to 28.7% in 1984 of total agricultural research expenditure.

Whatever the reasons for entering the seed industry, private sector efforts are producing impressive results. According to our estimates, transnational corporations accounted for approximately 25% of total seed sales in industrialized countries in 1982-1983. Leading seed producers from industrialized countries and their estimated 1986 sales are listed in Table 2.3.

The ten largest seed companies represented 17% of global seed sales in the mid-

Table 2.3. Estimated seed sales of leading private international companies, 1986/87.

Company	Country of origin	Seed sales (US$ mln)	Proportion of global sales[a] (%)
Pioneer Hi-bred	USA	800	4.4
Sandoz	Switzerland	450	2.5
Shell/Nickerson	UK/Netherlands	350	1.9
Limagrain	France	300	1.7
Dekalb/Pfizer	USA	220	1.2
Cargill	USA	200	1.1
Upjohn/Asgrow	USA	200	1.1
ICI	UK	190	1.1
Takii[b]	Japan	180	1.0
Orsan/Lafarge	France	170	0.9
Van der Have/Suikerunie	Netherlands	150	0.8
Ciba-Geigy	Switzerland	150	0.8
Sakata[b]	Japan	140	0.8
Maisadour	France	120	0.7
Dow Chemical/United Agriseeds	USA	120	0.7
Lubrizol/Agrigenetics	USA	120	0.7
Clause[b]	France	100	0.6
Volvo/Provendor (Hilleshog/Weibull)	Sweden	100	0.6
Sanofi/Elf Aquitaine	France	80	0.4
KWS	West Germany	70	0.4
Unilever/PBI	UK	60	0.3
Hoechst	West Germany	60	0.3
Royal Sluis[b]	Netherlands	60	0.3
Barenbrug[c]	Netherlands	60	0.3
Coop de Pau/CACBA	France	50	0.3
UNCAC/Expansem	France	50	0.3
CEBECO	Netherlands	40	0.2

a. Global sales of improved seed estimated at US$ 18 billion (excluding socialist countries).
b. Horticultural seed only.
c. Acquired by Unilever in 1988.
Note: No data available for US flower seed companies, for example, Ball, Goldsmith, Panamerican.

1980s. In comparison, the ten major pesticide producers controlled 85% of the pesticide market.

In summary, emerging plant breeding technology, changing patent legislation, and decline in public breeding programmes superseded by transnational corporations and private biotech companies all have a great impact on structure of the seed industry in industrialized countries. These developments also cause concern for policy makers and the traditional seed industry. New patent legislation may limit future research and development programmes, and private plant breeding programmes may become biased towards promoting corporate sales by developing herbicide-resistant plants and concentrating on hybrid varieties. In many countries,

the seed industry is regarded as a promising high-tech private industry. Government spending on conventional plant breeding is under pressure as public breeding stations and agricultural experimental stations must compete with private biotech companies and the plant genetic research laboratories of transnational corporations.

Figures and analysis presented in this section indicate that change in the seed industry is fairly recent. This process will accelerate, leading to new mergers, takeovers and concentration in most branches of the seed industry. Speed and direction of change will largely depend on breakthroughs in plant biotechnology and changes in patent legislation.

2.3 North-South relationship: increasing interdependence in the seed industry

The developments mentioned have also had a significant impact on agriculture and the seed industry in developing countries. Concentration of the seed industry into transnational corporations with subsidiaries in developing countries will increase North and South relationships in the coming years. Interdependence between industrialized and developing countries is not new, and has been expressed in a variety of avenues, as follows.

International trade. The value of seed exports from the USA and EEC to developing countries in 1985 was US$ 269 million, or approximately 25% of total seed exports (Table 2.4). Vegetable seed export was almost US$ 100 million; agricultural seed, over US$ 120 million; and potato seed, US$ 50 million.

American seed exports to developing countries are mostly hybrid maize and sorghum, fodder crops, soya bean, and vegetables. About 50% of European exports in the mid-1980s were potato seed and 30% vegetable seed. Basic food crops, such as rice, wheat and pulses, accounted for less than 2% of total seed exports from industrialized countries. However, seed exports to developing countries are important to industrialized countries, particularly the USA, as indicated by the data presented in Table 2.4.

Direct investments in developing countries. The exact total of direct foreign investment in the seed industry in developing countries is not known, but seems low compared to local public investment. Low foreign investment is partly due to the northern seed companies' concentration on temperate crops. Transnational cor-

Table 2.4. Seed exports from the USA and EEC to developing countries, 1985.

	EEC	USA	Total
Seed exports (US$ mln)	135	134	269
Proportion of total seed exports (%)	18.1	37.0	24.2

Sources: Foreign Agricultural Circular, 1985; Eurostat, 1985.

porations have just recently ventured into overseas seed markets, as described in the case studies Kenya, India and Thailand.

Many developing countries no longer prohibit establishment of foreign private seed companies or discourage their activities. However, most developing countries remain unattractive to private companies (Plucknett et al., 1987). This was confirmed by our survey of seed companies in industrialized countries, even though most expect investment in selected developing countries to increase considerably in the next decade (Wierema, 1989). There is almost no private foreign investment in the least developed countries due to the low use of commercial seed. Increasing potential for commercial seed sales in several newly industrializing countries has attracted more foreign investments, generally joint ventures with local partners in North Africa, the Middle East, South and South-East Asia, and Latin America. Seed companies in the USA have been the most active in developing countries. Transnational corporations have not yet been able to acquire a dominant position in the seed market, however, in some Latin American countries they have strong positions in the hybrid seed sector.

Investment in custom seed production, that is seed production for re-export of multiplied seed to industrialized countries, is important for many developing countries, especially in the horticultural seed sector. These investments have generally no direct effect on national seed industry development.

Transfer of technology. Private transfer of technology has occurred mainly in the hybrid seed sector, particularly in maize (Pray & Echevarria, 1988), sorghum and selected vegetable crops. Transfer of technology to public institutions has been largely stimulated by the International Agricultural Research Centers (IARCs), World Bank, FAO, USAID and other bilateral aid agencies. These agencies have been major agents in establishing organized seed supply systems in many developing countries.

The Consultative Group on International Agricultural Research (CGIAR), which organizes the IARCs, had a core budget of US$ 180 million in the mid-1980s largely funded by bilateral and multilateral donor agencies. USAID and World Bank contribute approximately 25 and 15% respectively. Outside the framework of the CGIAR, donors have also supported establishment of seed programmes and several public seed enterprises in developing countries (World Bank, 1981).

Exchange of plant genetic resources. Transfer of plant genetic resources from developing to industrialized countries has been the subject of much discussion in recent years (Kloppenburg, 1988). The western seed industry has been criticized for 'monopolizing' plant varieties and land races from developing countries for development of their own plant breeding programmes.

Discussions have led to an FAO Undertaking on Plant Genetic Resources, in which free exchange of genetic resources should be guaranteed, but which is not legally binding (FAO, 1983; Seedling, 1988). Some industrialized countries have

not signed because the Undertaking is considered to be detrimental to expansion of national seed industries. To support implementation of the Undertaking and to reverse the outflow of plant genetic resources from developing countries, FAO established the International Fund for Plant Genetic Resources in October 1987. Donor governments, intergovernmental organizations, non-governmental agencies, private industry, and other bodies were invited to participate. In 1989, the FAO Commission on Plant Genetic Resources discussed financing of this newly established gene fund. Third World countries would prefer the fund to be established with mandatory contribution related, for example, to the sales volume of seed. This view is supported by a few European countries, including the Netherlands, but is firmly opposed by the USA (South, 1989).

2.4 Seed sector development in the South: the role of bilateral and multilateral development agencies

Development agencies, such as FAO, have stressed the importance of national seed programmes since new varieties became available to developing countries from IARCs in the early 1960s (FAO, 1975; 1978). Supply systems to maintain and replace high-yielding varieties should also be developed. Many agencies helped developing countries formulate national seed programmes, thereby creating the infrastructure and institutional framework necessary to stimulate diffusion of new varieties.

Almost every developing country now has national projects and programmes to improve seed supplies (FAO, 1986; 1987). Most are the responsibility of the Ministry of Agriculture and have been designed and established in cooperation with donor agencies. Several manuals have been drafted to establish and implement seed programmes (for example, Douglas, 1980).

According to prevailing theory, seed supply systems should coincide with agricultural development in a particular country. It assumes that countries have initially no scientific plant breeding or seed programmes and farmers retain all seed from the previous harvest. As research and development begin, specialized seed production emerges and traditional varieties are replaced by newly developed ones. Inputs, such as fertilizer, are introduced as availability of new varieties increases and supply networks are created. Finally, when agriculture is well-developed, commercial seed companies supply most seed required, legislation and supporting activities are fully developed, and annual replacement of varieties is high.

This development model, apparently inspired by Schultz' book on Transforming Traditional Agriculture (1964) and Rostow's Stages of Economic Growth (1962) is based on progress observed in industrialized countries. In practice, agricultural development in Third World countries cannot copy the historical development in industrialized countries. The dualistic nature and structure of agriculture, and the diversity of agricultural production systems in developing countries have been largely overlooked in seed industry development.

3 Seed supply systems and seed industries in developing countries

3.1 Agricultural modernization and development of the seed industry

Despite the Green Revolution, which started in the mid-1960s, the impact of new varieties in many regions in developing countries has been limited. In these areas, low input farming and traditional seed supply systems remain practically unchanged.

Use of agricultural seed in developing countries is proportionally higher than in industrialized countries. This is reflected in the large areas devoted to cereals, pulses and oil crops (Table 3.1). Wheat and rice alone represent over 60% of the estimated value of seed used by farmers.

The area under modern, basic food crop varieties has increased substantially in the past two decades. According to the CGIAR Impact Study (1985), new wheat and rice varieties, often referred to as high yielding varieties (HYVs), cover 24 and 45 million hectares respectively in developing countries, or 50 and almost 60% of total planted area. Modernization focuses on wheat, rice and maize. The spread of new varieties in other basic foods, such as sorghum, millet and root crops, has not been impressive. Thus, in most developing countries where wheat and rice are not the major staples, as is the case in many African countries (Table 3.2), use of improved varieties is low, hence seed supply is almost exclusively farmer-saved or locally exchanged seed.

International development agencies, in cooperation with local governments, have initiated several national seed programmes in the past ten years to develop new

Table 3.1. Area, yield and seed requirements of major food crops in developing countries (excluding China), 1980.

	Area (mln ha)	Yield (t/ha)	Seed requirements (1000 t)
Wheat	67.4	1.43	7 900
Rice	106.0	2.17	9 216
Maize	58.3	1.44	1 887
Sorghum and millet	77.5	0.77	2 005
Pulses	48.7	0.49	2 012
Oil seed	58.2	0.40	712
Vegetables	8.0	14.92	10

Source: FAO, 1983; Supply Utilization Accounts.

Table 3.2. Proportion (%) of total cultivated area planted to major food crops in developing countries, 1984.

	China	India	Africa	Others	All developing countries
Wheat	31	19	8	25	22
Rice	36	33	7	39	32
Maize	21	4	23	27	18
Sorghum/millet	7	26	42	8	18
Pulses	5	18	20	1	10

Source: FAO Production Yearbook, 1985.

seed supply systems (Van Amstel & Van Gastel, 1985). In some developing countries, supply systems have emerged and traditional varieties have been replaced by new varieties. Proportion of the total area of wheat and rice cultivation under improved varieties is given in Table 3.3. As the figures indicate, modern varieties (HYVs) of wheat and rice are widely used, but annual seed replacement in many cases does not exceed 10% of total seed requirements.

Low seed replacement of wheat and rice, and consequently, low demand for seed has hampered development of commercial seed supply systems in many developing countries. Profit margins are also low because the price of improved seed is closely related to the price of grain, as farmers can easily grow these self-pollinated varieties. With no variety protection and low effective demand, commercial seed companies cannot earn sufficient profits to warrant new investment.

Unlike the area planted to new varieties of wheat and rice, 40% of the maize area in developing countries is planted with hybrid varieties (Table 3.4). Their total market value is over US$ 500 million. There are large disparities between countries, but in general the importance of hybrid maize has increased substantially

Table 3.3. Proportion (%) of area under improved varieties of wheat and rice and annual seed replacement in selected developing countries, 1984.

	Area under HYVs		Annual seed replacement	
	wheat	rice	wheat	rice
India	83	57	6.6	10.8
Pakistan	70	50	6.1	2.7
Turkey	90	n.a.	17.8	n.a.
Argentina	100	n.a.	28.0	n.a.
Sri Lanka	n.a.	85	n.a.	19.5
Thailand	n.a.	n.a.	n.a.	1.8
Indonesia	n.a.	96	n.a.	10.8
Philippines	n.a.	85	n.a.	10.0

Source: FAO, 1987; national surveys.
n.a. = not applicable.

Table 3.4. Area of hybrid maize cultivation in selected developing countries.

	Total area (mln ha)	Area planted with hybrids (%)
Argentina	3.10	100
China	18.40	72
Brazil	11.58	63
Kenya	1.55	61
Zimbabwe	1.45	60
Zambia	0.51	53
Guatemala	0.77	36
Mexico	8.23	25
India	5.89	13
Egypt	0.80	10
Thailand	1.71	8
All developing countries	79.07	38

Source: CIMMYT, 1987.

over the past few decades. Use of other hybrid varieties, for example sorghum, millet, sunflower and many vegetable species, is also increasing in developing countries.

3.1.1 Induced innovation and availability of new crops and varieties

IARCs have been the largest contributors to change and innovation in plant breeding in developing countries. Several countries have benefited from the new technology developed by these institutes (Evenson, 1987), but most have not yet established plant breeding stations to secure new varieties of crops suited to specific ecological circumstances and, for instance, with resistance to pests and diseases. New varieties are usually introduced from abroad, even though the crops often originate in the importing country (Wood, 1988). In Africa, 70% of cultivated crops are introduced from other areas, in the Americas 68%, and in Asia 30% but where rice is dominant, most crops are of Asian origin. Developing countries often depend on imported varieties because setting up large-scale plant breeding programmes to accommodate different agro-ecological regions is beyond their financial and managerial scope.

Thus, the IARCs are still springboards for development of new varieties. In the absence of strong national plant breeding programmes, these centres will be crucial to development of the seed industry in developing countries. With stagnant research budgets and emergence of transnational corporations as suppliers of new varieties, the centres may have difficulty maintaining their commitments to supply germplasm and new varieties to developing countries. Even in countries with fully developed plant breeding programmes, development of many varieties adapted to specific

environments and suited to farmers' needs is slow. Absence of well-developed national plant breeding programmes is a major barrier to the extension of new seed supply systems.

Many national seed programmes have been set up by FAO, World Bank and bilateral agencies, without prior investigation and assessment of available and suitable varieties. Douglas (1980) described this shortcoming in detail, yet most programmes still concentrate on seed supply. They assume that if 'good' varieties are available from seed suppliers, farmers will buy them. This approach has led to numerous mis-allocations of scarce funds and to high overhead costs. Seed programmes set up in this way have not been effective in stimulating appropriate seed supply systems in developing countries.

In conclusion, externally induced technology to develop new seed supply systems in developing countries is generally not well integrated in and adapted to the local situation. The most effective programmes have been developed by the IARCs, but in many cases availability of new varieties has not resulted in integrated development of appropriate seed supply systems. Thus, modernization often resulted in increasing disparities in the agricultural sector.

3.2 Traditional seed supply systems in developing countries

According to Delouche (1982), at least 80% of all seed planted is produced by farmers. Banerjee (1984) stated that this is the case for more than 85% of seed in India, and this figure is also confirmed in our case study. In Thailand, modern varieties of major crops constituted only 6-7% of total seed requirements in the mid-1980s. For rice this was less than 3%. With some exceptions, such as Kenya and Zimbabwe, African farmers south of the Sahara also use mainly seed saved from the previous harvest. For the most important food crops, sorghum and millet, the area under improved varieties was only 6% and seed replacement negligible (CTA, 1985). In Latin America farmer-saved is also widely used. In Colombia, for instance, 55% of seed planted is estimated to be farmer-saved seed of traditional varieties and land races (CIAT, 1982).

Although farmers using traditional seed supply systems form a large group, and in many developing countries the majority of the farming community, little information is available on the varieties used. Plant breeders and policy makers have not paid attention to low-input farming systems and seed supplies. Fresco (1985) states that development of genotypes for low-input farming has only recently concerned plant breeders, as a result of the unequal distribution between rich and poor farmers of the benefits of the Green Revolution.

Seed supply in traditional farming systems, which use few external inputs, generally adjusts with time to local circumstances. In East Java, for instance, the short storability of soya bean seed is compensated by year-round cultivation. Seed rotates between the 'sawah' field in the dry season and the upland field in the rainy season (Linnemann & Siemonsma, 1988). Good varieties meet several criteria, most impor-

tantly yield stability under different climatic conditions. To produce a constantly high yield, a variety must be adapted to ecological conditions, such as length of the rainy season, periodic water shortage and excess, soil fertility, pest and disease incidence. Adaptation to intercropping, product taste, and quality of byproducts for fodder, building material, for example, are also important. Plant breeding programmes have not recognized the necessity of these criteria for small-scale farmers, with the exception of pest and disease resistance. Most national and international plant breeding stations emphasize favourable input conditions, in particular fertilizer, and neglect the needs of farmers using less external inputs.

Station and farm trials with soya bean in East Java that compare farmer varieties with varieties from national and international research organizations demonstrate variation in local planting material and good performance by some carefully chosen local selections. The results show that large-scale introduction of varieties into low external input farming systems can easily become counterproductive by causing rapid loss of valuable sources of genetic diversity and threatening the stability of the traditional systems.

Varieties developed in national and international plant breeding programmes are generally appreciated by larger, market-oriented farmers who grow crops in pure stands under good conditions. These improved varieties are primarily selected by breeders on the basis of their yield potential with sufficient water and nutrients. Other evaluation criteria are resistance to pests and diseases, length of the growth cycle and dietary value of the product. In conclusion, the value of improved varieties from national and international breeders for use in low-input agriculture has often been overestimated.

3.3 Constraints to seed industry development

The present evaluation of seed projects and programmes in developing countries found that specific country-related problems in seed supply systems are usually not addressed. In particular, realistic demand forecasting and effective pricing policies are serious problems. Policy makers and local institutions have generally accepted new, often imported varieties as being 'superior' without either assessing their viability and desirability in prevailing agricultural systems, or evaluating locally available material.

Despite problems involved in technology-transfer, seed projects and programmes operate in most developing countries. Many public seed production organizations have also been created, and activities of local and foreign private seed companies are increasing. Although these organizations currently supply only a small proportion of annual seed requirements, it is not clear what their role should be in future development of seed supply systems. Apart from emphasizing development and further strengthening of large-scale seed supply systems by private and public seed companies, alternative strategies should be developed that respond to the needs of farmers not benefiting from improved seed produced by these companies.

In the following chapter experience in seed industry development in Kenya, India and Thailand is compared in order to assess similarities and differences in policies and performance. Seed sector development in three countries – Kenya, India and Thailand – is discussed in part II.

4 Comparative analysis of seed industry development in Kenya, India and Thailand

4.1 Macro-economic indicators and role of agriculture

Selected macro-economic indicators for Kenya, India and Thailand are presented in Table 4.1. In the period 1965-1986, only in Thailand was economic growth higher than annual population growth, and per capita income much higher than in the two other countries. Thailand and Kenya can be characterized as open economies, with international trade being a substantial proportion of the gross domestic product. The Indian economy is more domestic oriented. Exports represent only 5% of gross national product. All three countries receive considerable amounts of foreign assistance from donor agencies.

Table 4.1. Macro-economic indicators, 1987, and annual growth, 1965-1987.

	India	Kenya	Thailand
General indicators			
area (mln km^2)	3 288	583	514
population (mln)	797.5	22.1	56.3
Economic indicators GDP (US$ mln)	220 830	6 930	48 200
trade deficit (US$ mln)	4 068	497	723
total external debt (US$ mln)	46 370	5 950	20 710
ODA[a] (US$ mln)	1 852	565	506
proportion of exports in GNP (%)	5	30	20
proportion agriculture in GDP (%)	30	31	16
Annual growth rates			
population (%)	2.3	4.0	2.2
GNP, 1965-1987 (%)	1.6	1.9	3.9
GDP, 1980-1987 (%)	4.6	3.8	5.6
agriculture, 1980-87 (%)	0.8	3.4	3.7
Per capita indicators			
GNP per capita (US$)	300	330	850
total external debt per capita (US$)	58	269	368
ODA per capita (US$)	2.3	25.6	9.0

Source: World Bank, 1989.

a. Official development assistance.

Table 4.2. Basic agricultural indicators.

	India	Thailand	Kenya
Agriculture in GNP (%)			
1965	47	35	35
1984	35	20	31
Agriculture contribution to labour force (%)			
1965	73	82	86
1984	70	70	81
Total arable land (mln ha)	173	14.6	7.2
Proportion (%)			
holdings below 1 ha	55	16	66
arable land	11	3	6
holdings over 4 ha	13	20	7[a]
arable land	57	60	51[b]

Source: World Bank, 1985; case studies.

a. Integrated Rural Survey, 1976-1979.

b. Large farms and 'gap' farms over 20 ha in area.

In the past two decades, agricultural labour as a proportion of total work force activities in Thailand and especially in India has declined less than agriculture in GDP (Table 4.2.) The difference in Kenya has been negligible. For the majority of the Kenyan population, agriculture remains the most important economic activity. Due to population growth, the agricultural labour force has increased enormously.

Even in Thailand, where economic growth rates have been high for the past two decades, the industrial sector absorbs only 10% of the total labour force. In India this was 13% in 1984 (12% in 1965), and in Kenya 7% (5% in 1965). In all three countries agriculture still generates most employment, and consequently, contributes to overall economic development. Moreover, agriculture has to support the growing populations in these countries. In this respect, improved seed supplies are needed to increase agricultural output. Diversification of the economy is also necessary to create new employment opportunities.

Farm land distribution differs greatly in the countries studied. Kenya's colonial heritage of large farms has not been reversed. World Bank figures for India indicate that 55% of holdings are below 1 hectare and together cover only 11% of the arable land. Despite land ceilings in many Indian states, 13% of the farms are over 10 hectares in area and cover more than half of the arable land. Thailand has relatively few farms of less than 1 hectare while larger farms, about 20% of the total, cover 60% of the farm land. This disparity in farm size is responsible for a dualistic structure of agriculture. Smallholders having less than one hectare are the most numerous, but their purchasing power and access to markets are generally low. Fragmentation of land among smallholders is common and increasing. Recog-

Table 4.3. Area of major crops in India, Thailand and Kenya (1000 ha).

	India	Thailand	Kenya
Wheat	23 100	n.a.	125
Rice	40 300	9 400	11
Sorghum	15 780	240	250
Millet	10 680	n.a.	60
Maize	5 870	1 600	1 200
Pulses (beans)	22 800	450	800

Source: case studies.
n.a. = not applicable.

nition of this dualistic structure is critical to the functioning of modern seed industries. Supply of new varieties is often directed towards the commercial farming community, leaving the large number of smallholders unable to take advantage of the new technology.

Cereals are the largest crops in the three countries. Thus, total seed demand depends largely on the area of cereal cultivation. Seed requirements for basic food crops in India are about ten times greater than in Thailand, and about 20 times higher than in Kenya. Land use in the three countries is summarized in Table 4.3.

4.2 Agricultural research and availability of new varieties

Each case study country has a national agricultural research structure, which covers the seed sector, although may be not optimally. For example, the ISNAR mission to Kenya concluded that agricultural research has played a significant role in the economy, and agricultural and industry development. Recommended rationalization of the national research structure was taken with the reorganization of the Kenyan Agricultural Research Institute (KARI) in July 1987 (ISNAR, 1985). Nevertheless, problems in implementing research results and innovative research in non-traditional crops are encountered. Manpower limitation is another problem to varying extents in the three countries. Innovative research has largely been induced from foreign research institutions. For wheat and rice in India, hybrid maize in Kenya, and most commercial crops in Thailand, new varieties have all been introduced from abroad. Adaptation and diffusion of new varieties have been successful, and large groups of farmers have benefited considerably. In India, for instance, 83% of the wheat area and 57% of the rice area is cultivated with modern varieties, and the impact of hybrid varieties of sorghum and millet in India has also been large. In Kenya, over half the maize area is planted with hybrid seed, while only improved varieties are used in wheat and barley cultivation on large-scale farms.

Large-scale diffusion of new varieties has also had a negative impact, namely rapid erosion of locally adapted genetic resources. Public and private organizations

have not paid enough attention to this process. In the case studies, several policy measures to reverse genetic erosion have been suggested, in particular development and release of more varieties of diverse genetic background, and improvement of the infrastructure for conserving and evaluating plant genetic resources.

4.2.1 National breeding programmes and new plant breeding technology

Large-scale plant breeding programmes have been set up in all three countries to improve the supply of new varieties of agricultural crops. Breeding programmes for horticultural and other non-cereal crops have received less attention and funding. The All India Coordinated Crop Improvement Projects, established in the 1950s, regularly develop new varieties for various agro-ecological environments. National and regional research stations in Kenya have specific mandates for crop improvement aimed at the large agro-ecological diversity in the country. Public breeding programmes in Thailand develop new rice and other field crop varieties, for example, the open-pollinated maize varieties, Suwan 1 and 2. All these plant breeding programmes use conventional technology.

Hybrid varieties have a large impact on seed supply systems in Kenya, and on specific seed markets in India and Thailand. Their use is expected tø increase considerably in the coming years. National innovative agricultural research has received more attention in recent decades as the number of newly released varieties has increased. New varieties from International Agricultural Research Institutes have been important in India and to a lesser extent in Thailand and Kenya. National plant breeding programmes still largely depend on foreign introduced germplasm and advanced breeding lines. Free access to outside genetic resources is, therefore, vital to their further development.

Until recently, new biotechnological techniques in plant breeding have had little impact in the case study countries. The potential has now been acknowledged by the respective governments and national programmes have been established to use tissue culture and cell fusion techniques. It seems, however, that these methods will only yield short-term results in vegetatively propagated crops. Development and application of new techniques should have high priority in the three countries because improved crops are vital to increase agricultural productivity.

Use of new technology for cereals, pulses and oil seeds is not expected to increase in the next few decades. Conventional breeding programmes including hybridization should be strengthened firstly to cope with current demand for diverse varieties.

4.2.2 Direction of national research programmes

Agricultural research in the three countries has been biased towards high input farming systems. Development of hybrid maize has been emphasized in Kenya, and Indian research has concentrated on nitrogen responsive varieties of wheat and rice. As a result, both India and Kenya are largely self-sufficient in food crops.

Yet, because of the dualistic agricultural structure, food security in these countries has not improved much. Food security should, therefore, receive higher priority in national agricultural research. In Thailand, which has always been a net exporter of rice, research for higher yielding varieties has been modest. Thai rice varieties are generally acknowledged as having a more preferred taste to IRRI varieties, and therefore, adaptation of IRRI varieties to Thai agriculture has not been emphasized.

The research bias towards maize and high input farming for wheat and rice has had a negative impact on varietal development for many other important food crops. Beans and sorghum have been largely neglected in Kenya, as well as pulses, smaller grains, oil seeds and vegetables in India, and vegetables in Thailand.

4.3 Government activities in seed industry development

Government policy has greatly influenced seed sector development in the three countries. The Governments of India and Thailand have initiated organized seed production, while in Kenya, the State through the Agricultural Development Corporation, soon became an important shareholder in the Kenya Seed Company, which was set up in 1956 as a private company.

Kenya and India both began seed industry development in the 1950s with a concentration on hybrid maize. For the Kenya Seed Company, hybrid maize has remained the most important crop. India's major breakthrough occurred in the mid-1960s, when the National Seed Corporation was established. Thailand's National Seed Programme was initiated in 1976, together with the Seed Division of the Ministry of Agriculture and Extension.

The public seed sector has not performed well financially. Even though profit is not the first objective of public organizations, great financial losses have been incurred in seed production and marketing. With the exception of hybrid maize in Kenya, the public sector produces and markets seed of non-hybrid varieties of basic food crops, which is essential for increased food production. This segment of the market, characterized by low profit margins and low seed replacement is, therefore, not commercially attractive. Because the public seed sector functions in general as a subsidized programme for farmers, operation on a commercial basis will continue to be difficult. It is also quite clear that private sector initiatives in this segment of the seed market will remain negligible.

There are many additional problems in public seed programmes in the three case study countries, such as neglect or absence of realistic seed demand forecasting, and high prices of improved seed compared to farmer-saved seed, being almost the same price as grain. Often the quality of improved seed is low. Overestimation of economies of scale results in high overhead costs and bureaucratic structures. Improved seed often implies high production and marketing costs. Distribution of many newly developed varieties causes problems, because of the lack of an adequate distribution network, while often these varieties are unsuited to region-specific

agricultural systems. Further, insufficient budgets for public seed enterprises to improve effectiveness, and often inadequate manpower, hinder development and distribution of new varieties. Finally, there is frequently a high dependency on foreign donors and their development concepts.

Donor agencies helped create new seed supply systems by directing the objectives and implementation of national seed programmes. Agencies cooperated almost exclusively with the public sector in developing the seed industry. They drew on experience in industrialized countries where high input and management intensive seed propagation systems dominate. This development model has proven to be inappropriate for the dualistic agricultural structure in developing countries. The case studies show that the public sector produces seed of only a few varieties of specific crops. Although initial spread of new improved varieties in these countries was large (except rice in Thailand), replacement by new seed from production organizations was overestimated. This has been less of a problem with hybrids, especially in Kenya.

The public sector's responsibility for creating new seed supply, however, cannot be overstated: a seed programme for most basic food crops must be created and implemented. Public involvement should be strengthened to meet this need. In all three countries, the public sector has not explored the potential for a more decentralized approach to seed industry development. Active participation by agricultural cooperatives, farmers' organizations and other non-governmental organizations in establishing new seed supply systems has not been sufficiently encouraged. Only recently has the potential role of the private sector been acknowledged and cooperation with it improved. In Thailand, the task of improving seed supply systems has been divided among several actors, and similar options are being considered in India and Kenya.

Government policies to develop new seed supply systems vary in the selected countries. However, constraints in implementation of seed programmes and stimulation of seed enterprises have made policy adjustments necessary in all of them. Blueprints for seed industry development should be avoided. This does not imply that past experience and policies cannot help other developing countries implement seed programmes and projects.

4.4 Role of private seed companies in seed industry development

As already stated, the private sector has only recently begun to participate in the seed industry. Thailand has an 'open door' policy to foreign investors in the seed industry. The public sector's role is to support private sector activities. This model has permitted rapid development of the seed industry. Foreign private companies have responded favourably and are currently developing specific seed markets. With little public interference, private seed companies concentrate research and development programmes almost exclusively on the hybrid seed market and high value crops. Rice seed supply, for instance, is largely ignored because of its low

profitability. The public sector is left to develop and expand seed supply in crops which are unattractive to private industry. Government should encourage extension services and, in particular, standards for seed quality.

India's public sector controls a large share of the domestic seed market. Private industry does not invest in wheat and rice research, because of low profitability in production and trade. Several domestic private companies have become large producers of hybrid varieties in specific crops (for example, pearl millet, sorghum, cotton and maize), but their activities have not been supported by the public sector. As a result, competition rather than cooperation between the public and private sectors has prevailed, although recently, cooperation between the seed suppliers has improved. Also, foreign seed companies can now operate in the Indian seed market. The country's new 'open door' policy is rapidly changing the formerly 'closed' seed market. The 'New Policy on Seed Development' of September 1988 confirmed the new role of foreign private companies in seed supply development. Kenya has also opened its seed industry to foreign investment, although the Kenya Seed Company retains its monopoly position in hybrid maize. Domestic and foreign private seed companies can operate in some high value seed markets, such as vegetables, but foreign involvement is not expected in the maize seed market. The private seed industry in all three countries is limited to high value crops and hybrid varieties of specific crops, as shown in Table 4.4.

Private seed companies are increasing activities but the future impact depends on the degree of government support. Effective support, such as strong plant breeding programmes, seed quality control and seed legislation, can attract private interests. Several options are open to invite foreign companies to participate in seed industry development. Transnational corporations will be eager to expand activities in specific high value seed markets which are comparable with those in industrialized countries.

Management contracts between public seed companies and foreign companies may be an alternative to direct investment by transnational corporations. Joint ventures with relatively small foreign private seed companies are also possible. (For these concrete options in private foreign participation in seed industry development, see Turner, 1988; Groot et al., 1988.) Agricultural cooperatives from industrialized countries could also contribute to seed industry development. However, these cooperatives have not been active in overseas seed markets, and already face stiff competition from transnational corporations in their home markets.

Little private plant breeding of non-hybrid varieties is done in Kenya, India, and Thailand. Except for maize, development of new techniques to produce hybrid varieties of wheat, rice, and other basic staples, will take considerable time, and when results are achieved, commercialization will occur firstly in industrialized countries. A system of plant variety protection, such as Plant Breeders' Rights, could change the seed supply of non-hybrid varieties considerably. Without it, private seed companies will surely continue to focus on hybrid variety development.

Interviews in the three countries revealed little support for introduction of plant

Table 4.4. Participation of private enterprise in seed industry development.

	India	Thailand	Kenya
Wheat	-	n.a.	+[a]
Rice	-	o[b]	o
Maize			
hybrid	+	++	++
non-hybrid	o	+	+
Sorghum			
hybrid	++	++	-
non-hybrid	o	o	o
Millet			
hybrid	++	n.a.	-
non-hybrid	o	n.a.	o
Pulses	-	-	o[c]
Oil seed	+	++	+
Vegetables			
hybrid	++	++	++
non-hybrid	+	o	o

- = no participation
o = some participation
+ = active participation
++ = major participation
n.a. = not applicable
a. Wheat is produced only on large-scale farms, seed replacement is high.
b. Only in Basmati rice.
c. In beans, not in cowpeas or other pulses.

variety protection. Most industry participants do not believe that variety protection will increase private plant breeding; and furthermore, many do not favour privatization of plant breeding for basic food crops. The system of Plant Breeders' Rights developed in Kenya has never been invoked. In theory, such rights should give Kenya access to foreign bred varieties and stimulate domestic, private research. As long as Kenya is prepared to pay the price charged for such seed, Plant Breeders' Rights need not be used to facilitate innovation. Domestic private companies and subsidiaries of transnational corporations undertake their own research and have developed varieties adapted to local conditions for production of agriculture-based products. Thus, even if losses are incurred in the seed business, these corporations make adequate profits from the production and processing of the final product. Moreover, foreign seed companies that multiply seed for re-export are active in Kenya and have not been hampered by the absence of variety protection. They can still enjoy Plant Breeders' Rights in export markets or in their domicile, even though varieties developed for a country without such rights may be used without payment.

Adoption of Plant Breeders' Rights in Kenya could permit an increase in seed

prices, thereby creating incentives for commodity research stations. However, other incentives are also possible, including improved schemes of service, direct research grants, and cesses or levies on commodities. Plant breeding by private seed companies in India is new and limited to a few hybrids. A detailed study of variety protection is needed to determine desirability for India. Introduction of Plant Breeders' Rights in Thailand is hampered by manpower constraints as well as anticipated difficulties in enforcement. A well functioning, flexible and independent research institute is needed for objective distinctness, uniformity and stability (DUS) testing and determination of the value of varieties. The importance of Plant Breeders' Rights should not be exaggerated. Even the private seed industry does not give this high priority, as introduction of hybrid varieties has appeared to be more suited to their needs. Major constraints to private investment mentioned by representatives of the international seed industry are not the non-existence of Plant Breeders' Rights but lack of purchasing power and preference for locally adapted varieties by farmers (Wierema, 1989). Systems of varietal protection may be beneficial to highly commercial agricultural systems, but are generally considered inappropriate for the case study countries at present (Setboonsarng, Ruigu, Agrawal, 1988).

4.5 Status and prospects: improved seed supply

Establishment of public and private seed supply has gained momentum in the case study countries. Use of improved seed in relation to total seed requirements is summarized in Table 4.5. Although there are large disparities between countries, some general conclusions can be drawn. Only in specific crops is there considerable demand for regular supplies from the organized seed sector. This is the case for hybrid maize and wheat in Kenya, sorghum and millet hybrids in India, and non-hybrid and hybrid maize in Thailand. Seed replacement is very low for pulses (beans) in Kenya and wheat and rice in India. Furthermore, commercial seed markets are not well developed. Even use of hybrid maize seed in Kenya has stagnated since the beginning of the 1980s.

Table 4.5. Estimated annual seed replacement as a proportion of total requirement, mid-1980s.

	India	Thailand	Kenya
Wheat	6.6	n.a.	48.0
Rice	10.8	1.6	n.a.
Sorghum	31.3	1.5	2.1
Millet	57.2	n.a.	2.0
Maize	13.1	40.0	50.0
Soya bean	n.a.	11.5	n.a.
Pulses	3.4	6.9	2.2

Source: case studies.
n.a. = not available.

Diffusion of new varieties does not substantially increase seed replacement. Most farmers in India use high yielding varieties of wheat, but annual seed replacement is less than 7%, which is the average replacement rate for all varieties introduced in the last 14 years. A replacement rate for new varieties of 3-4 years has generally been used to assess demand in developing countries. However, demand assessment should be based on actual replacement rates, not general rules.

Newly introduced non-hybrid varieties maintain their yield without annual seed replacement. The number of new introductions is small, and superior varieties are, therefore, not regularly available. Low margins and 'competition' with farmer-saved seed make a viable non-hybrid seed industry almost impossible. In India and Thailand seed supply of non-hybrid varieties by the public sector is often highly subsidized. Potential for large-scale public or private seed enterprises is clearly limited for most crops produced in developing countries. There are, however, specific seed markets which have not yet been exploited by seed enterprises. Local seed companies are urgently needed in high value crops to prevent dependency on generally non-adapted import varieties.

Development of seed enterprises depends on technical aspects of seed production in addition to pricing policies for agricultural produce, increasing awareness of the benefits from improved seed, and access to reasonably priced farm inputs. Government policies must recognize the value and effectiveness of traditional local supply systems. Donor agencies should continue to support public seed programmes in developing countries which increase the availability of new varieties. It is also important that they stimulate decentralization of seed operations to cope with diverse local demand and to secure sustainable land use.

5 Policy options for the coming decade

The seed industry is in a period of transition and rapid change. Although still largely concentrated in highly industrialized countries, it has expanded considerably in the past two decades. Entrance of transnational corporations has altered the nature and structure of the seed industry in industrialized countries. New technology in plant breeding, privatization of national agricultural research systems, high profitability in specific market segments, and changing legislation to protect new inventions have all contributed to major restructuring.

In contrast to industrialized countries, the seed industry in many parts of the developing world is still in its infancy, and seed supply tends to be organized on an informal basis. Most seed is retained from the previous harvest. Organized seed supply is generally introduced by donor agencies and foreign seed companies, which operate almost exclusively in the high value/low volume hybrid seed market. This market segment is growing fast in developing countries, although it covers a relatively small proportion of total seed requirements. Foreign private investments are expected to increase greatly with the entrance of transnational corporations into the seed industry and economic liberalization in many developing countries. A relatively high proportion of total seed exports from industrialized countries in specific high value/low volume seed markets, such as vegetable seed, hybrid sorghum and soya bean, goes to developing countries. These exports will continue to grow, especially from transnational corporations. They will, thus, play an increasing role in selected seed markets and will continue to influence the organization of national seed industries in developing countries. Governments can best provide for their country's interests by defining criteria for technology transfer to support sustained agricultural development.

Foreign private involvement is negligible in the seed supply of major staple foods in particular wheat, rice, sorghum, millet, pulses, and locally important crops, which are all easy to reproduce and do not enjoy breeders' rights. Export to developing countries is marginal and to many developing countries, non-existent. As observed in the case studies, improved varieties of these crops are supplied by the public sector. The role of domestic and foreign private sectors in these crops will remain marginal because of the characteristics of this segment, that is high volume/low value seed and low annual replacement. The private sector would not be inclined to invest in this seed market even in a country with an open market and liberal price policies. McMuellen (1987) favours this system in policy formula-

tion for seed industry development. However, price cannot resolve other problems inherent in the seed industry of developing countries, such as weak infrastructure and dualistic nature of agriculture.

Public sector programmes have been crucial in plant breeding improved varieties and creating new supply systems, but they are in great need of consolidation and improvement. Seed demand assessment is a neglected area, which should be strengthened to improve seed supply for major food crops. Problems of genetic erosion deserve higher priority in seed industry development. The public sector should also stimulate, rather than compete with, non-governmental organizations. Local systems of seed production and marketing need encouragement to cope with the diverse seed requirements in developing countries.

Donor agencies should continue to improve seed supply systems and varietal development in cooperation with public seed organizations. Adaptation to the specific structure of the seed market in developing countries is a first step to new initiatives. Large-scale seed industry development is not optimal for many developing countries, therefore, generation of new ways to organize efficient seed supply systems is a primary task for development cooperation (Groosman et al., 1988).

Donor support is needed to reach several stages: development of well-formulated national plans for agriculture, in particular the seed sector; working collections and conservation of germplasm; and training programmes on organization, maintenance and use of germplasm collections. These efforts could redress the former imbalance in germplasm conservation, in which most collections were held by industrialized countries and IARCs. Long-term cooperation in technology transfer is also important. Non-governmental organizations should be more involved and financially supported in all aspects of local seed supply because they usually have relevant contact with the farming community. Donor governments could stimulate small and medium-scale seed companies in their own countries to help seed companies in developing countries expand their activities. Agricultural cooperatives in particular have valuable expertise in basic food crops. Training is required in plant breeding, seed science, seed quality control, and in the socio-economic aspects of seed production. Programmes should be adapted to different types of farming systems and more attention paid to low external input farming.

Developing countries need to formulate policies and legislation to secure good quality seed, and policies for varietal protection and patenting of new inventions in agricultural research. Governments can support farmers' capacity to improve their own varieties by providing low-cost inputs. Experiences from the case study countries could help formulate new initiatives (South-South cooperation).

IARCs need strengthening to cope with new and emerging biotechnological and technological developments in plant breeding, production and training. They should disseminate information and technology to developing countries, while taking into account environmental, social and economic consequences. Research on local seed supply systems should be encouraged to increase awareness and insight of

researchers, extension officers and policy makers about high performing local varieties and farmers' seed distribution networks.

Part B
Seed sector development in Kenya, India and Thailand

6 Seed industry in Kenya[1]

6.1 Role of agriculture in the Kenyan economy

Kenya has an open economy. In 1982 imports of goods and services amounted to almost 41% of the Gross Domestic Product (GDP) at factor cost, while exports accounted for 30% of GDP. With so much of the GDP linked to international trade, the country's economic fortunes depend on developments in the world economy. Being a small country, Kenya has little influence on international developments but has to adjust domestic policies accordingly. Since 1973, the terms of trade have deteriorated substantially because of the continuous fall of export prices in relation to import prices. Price fluctuations of export commodities, such as coffee, prevent balanced economic growth pattern.

Because of these adverse factors, together with droughts in 1979 and 1984 which resulted in large food imports, Kenya's trade deficit rose to unprecedented levels in 1980 and 1984. Escalation of the deficit forced the country to resort to increased international borrowing and implementation of measures such as quantitative import restrictions, devaluation of the Kenya shilling (Ksh), higher interest rates and various export incentives. Since 1976, the physical volume of imports has been reduced by 9%, while real GDP has grown considerably, reflecting the structural adjustment in Kenya's external trade.

From 1964 to 1982 the average annual growth rate of the GDP and the population of Kenya were 5.1 and 3.4% repectively, resulting in a growth of 1.7% per year of the per capita income. Employment in the modern sector grew at 4.3% per annum in this period, while non-wage employment, mainly in agriculture, absorbed more than 80% of the increased labour force. The public sector accounted for about two-thirds of the growth in wage employment between 1972 and 1982. Creation of employment opportunities remains a critical issue in Kenya.

With the majority of the population living in rural areas, agriculture has remained the most important economic activity in Kenya and has to address several problems. The first is that of providing the country's food requirement. Given the present

1. This chapter is based on research undertaken by Dr G.M. Ruigu, Institute for Development Studies, Nairobi, Kenya. For a detailed account of this research project, see: Seed industry in Kenya: evolution, current status and prospects. IVO, Tilburg, the Netherlands, 1988.

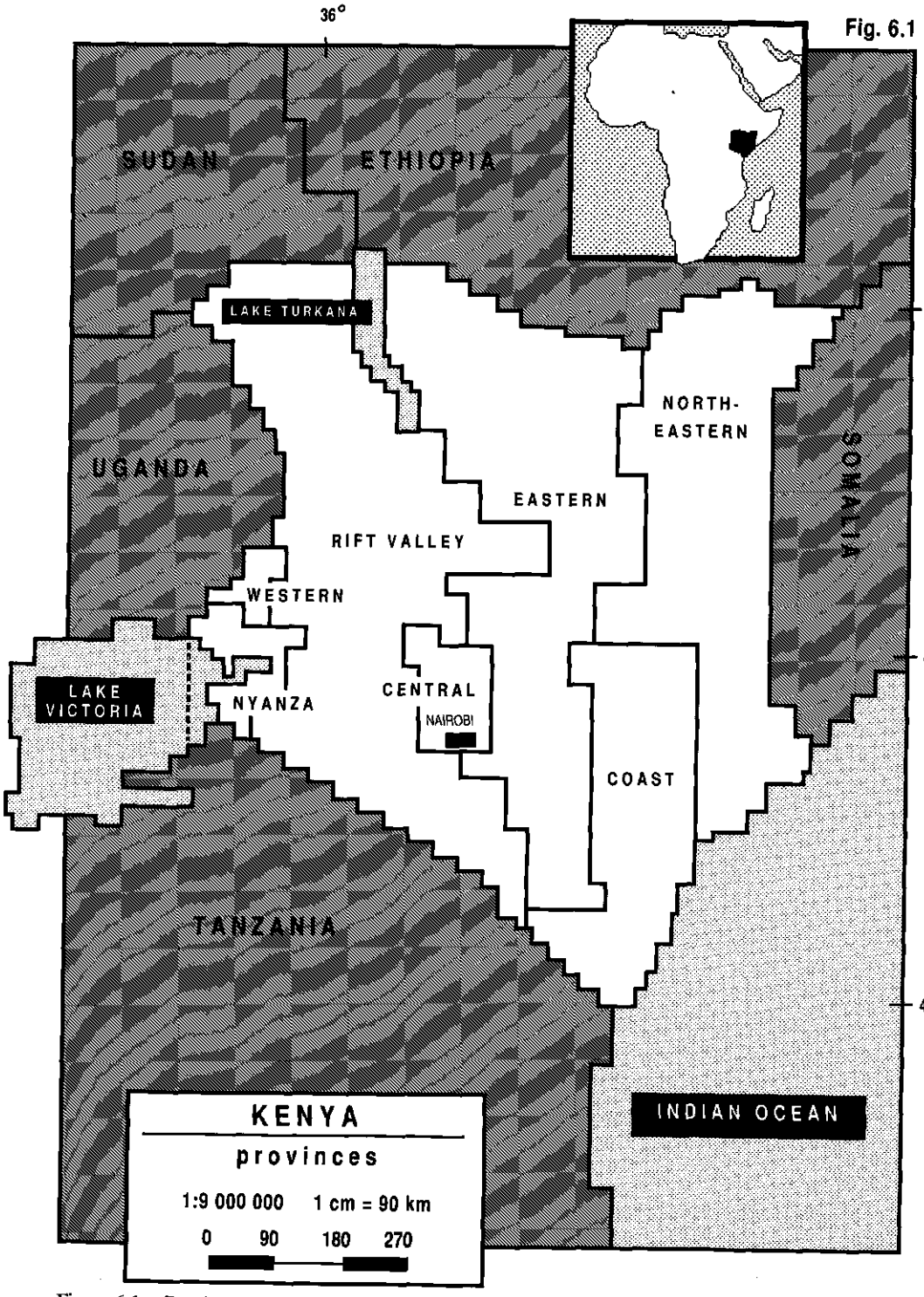

Figure 6.1. Provinces of Kenya.

population growth rate of 4% per annum, a minimum annual food production growth rate of 4% is required to maintain food per capita at current levels. The World Bank (1984) estimates that annual food production must increase at an average rate of 4.3% based on a per capita income growth of 1.5% per annum and an elasticity demand of 0.2. Between 1964 and 1973 agricultural output grew rapidly, stimulated by redistribution of large-scale mixed farms, diffusion of hybrid maize and expansion of cash crops and dairy cattle. After 1973 agricultural growth lost momentum as the main sources of growth were almost exhausted (World Bank, 1984). Growth between 1972 and 1982 was 3.1% per annum which was much less than the annual growth of population. Secondly, agricultural development has to provide employment for the burgeoning labour force which is expected to double by the year 2000 when it is estimated to be 14 million. Agriculture must absorb farm workers at a rate of 3% per annum (Government of Kenya, 1986b), and provide reasonable incomes. Thirdly, agriculture should generate adequate foreign exchange and, fourthly also stimulate the growth of off-farm activities to create employment for the growing rural population.

6.1.1 Land use, holdings and fragmentation

Kenya is short of good agricultural land. Based on rainfall patterns, 9.3% of the 56.9 million hectares is classified as high potential zone II and a further 9.3% as medium potential zone III. However, only about 7% can be described as good agricultural land based on a variety of physical and biological criteria such as vegetation ecology, annual and seasonal rainfall reliability, potential evapotranspiration, soil type and annual water balance. Another 4-5% is used for crops, although rainfall varies from year to year and crop failure is common. The remaining land is suitable for stock raising of varying degrees of intensity. The increased population has pushed agriculture into the low potential areas, where the chances of obtaining a crop in any given season are low and the risks are high.

Kenya's agriculture is characterized by a wide variety of production systems reflecting different ecological zones, population densities and landholding patterns, as well as dualism. There are two farming sectors, large-scale farms and smallholdings, which differ markedly in technology and input use. The large-scale farms, defined as farms of 20 hectares or more, date from the early 20th century when European settlers established mixed farms, plantations and ranches. These were in areas known as the White Highlands or the scheduled areas, mostly in the Rift Valley, Central and Eastern Provinces. About 3 600 large farms were operative in the 1960s, covering roughly 3 million hectares. Approximately 1.4 million hectares were devoted to large-scale mixed agriculture and 1.6 million hectares to plantations and ranches. They produced the bulk of agricultural output marketed which enjoyed privileges and protection from domestic and foreign competition.

Since Independence in 1963, some large-scale farms have been subdivided for settlement to correct imbalances in land ownership. By 1971, about 0.5 million

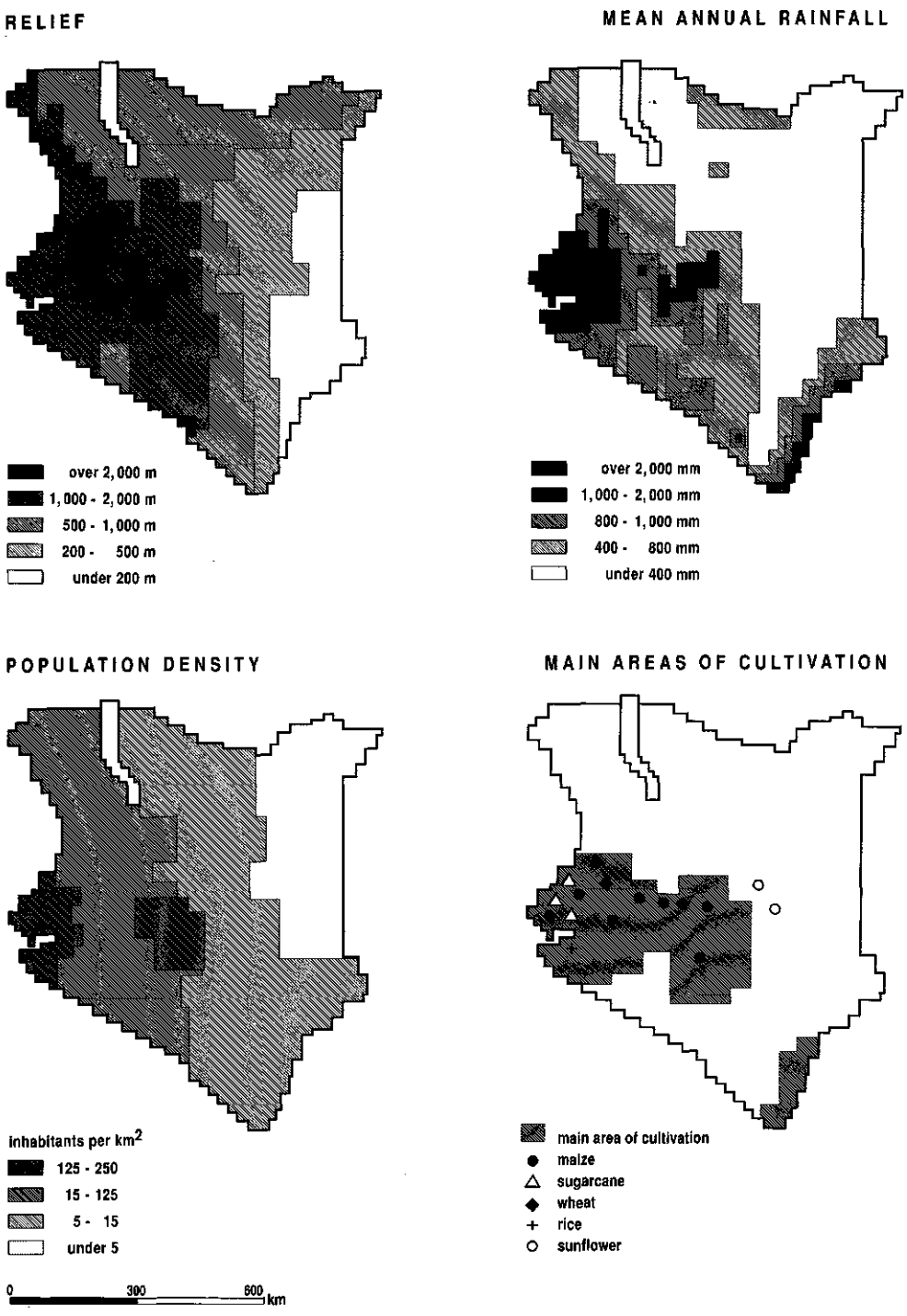

Figure 6.2. Kenya: relief, mean annual rainfall, population density and main areas of cultivation.

hectares had been settled by some 50 000 families. Agricultural output was stimulated by this redistribution which permitted more intensive land use, but the debate on the relative merits of small-scale versus large-scale farms, as well as on land distribution policies continues (Tidrick, 1979). Land tax has been advocated as a way to reduce concentration of land ownership and speculation (Heyer, 1976; World Bank, 1984).

The large-scale plantations and ranches have changed little since Independence. Coffee, tea, sugarcane and sisal are grown on plantations. Commercial ranches constitute an important source of beef. Some of the remaining large-scale, mixed farms produce mainly maize, wheat and barley, as well as livestock products (meat and milk). These farms are the major users of agricultural inputs, including fertilizers and improved seed, and of agricultural machinery. Some of the remaining mixed farms owned by cooperatives and companies are being subdivided into smallholdings.

Small farms are officially defined as less than 20 ha, although only 3% of all smallholdings in the Integrated Rural Survey 1974-1975 exceed 8 hectares (CBS, 1977). In 1979 it was estimated that there were about 1.7 million smallholdings in Kenya employing about 3 million people. Over 70% of maize, the country's staple food, is grown on smallholdings. Smallholders also grow tea, coffee, pyrethrum, beans, potatoes, cotton and fruit, and over 50% of the livestock in the high potential areas. Smallholder output by size of holding is given in Table 6.1.

Serious attempts to develop the smallholdings date from the mid-1950s, when the Swynnerton Plan (1954) was published. The plan proposed consolidation and registration of land holdings, introduction of high value products such as coffee, tea, pyrethrum and dairy products, as well as improvement of training, credit and cooperative development. All colonial inhibitions and restrictions on African agriculture were removed in 1955. Many of the ideas developed in the Swynnerton Plan form the basis of present policies, including the individualization of land tenure and the role of individual farm management and planning.

Table 6.1. Smallholder output and employment, Kenya, 1975.

Size of holding (ha)	Labour use (Ksh/ha)	Output (Ksh/ha)	Labour output ratio
Under 0.5	969	4 335	0.22
0.5 - 0.9	419	2 213	0.19
1.0 - 1.9	221	1 104	0.20
2.0 - 2.9	151	904	0.17
3.0 - 3.9	122	713	0.17
4.0 - 4.9	133	800	0.17
5.0 - 7.9	70	519	0.13
Over 8.0	32	224	0.14

Source: Based on Livingstone, 1981.

Table 6.2. Land use in Kenya, mid-1970s.

	Area (mln ha)	Proportion (%)
Recorded small-scale farms	3.5	6.1
Recorded large-scale farms	2.7	4.7
'Gap farms'	1.0	1.8
Forest	1.9	3.3
Range and land unsuitable for agriculture	46.0	80.7
Other use	1.9	3.3
Total	57.0	99.9

Source: Hazelwood, 1979.

At present, large-scale farms cover 3.7 million hectares or just over 50% of Kenya's arable land. This includes 2.7 million hectares of large-scale farms in former scheduled areas and 1.0 million hectares of 'gap' farms, which are large farms outside the scheduled areas. Small-scale farms cover 3.5 million hectares (Table 6.2). The area under irrigation (39 500 hectares) is small, and is only 0.6% of total arable land. The country is experiencing a declining per capita area of good agricultural land which is estimated to be 0.4 hectares per person by 1990. In the more densely populated areas of Nyanza, and the Central and Western Provinces the land per capita will be a mere 0.25 hectares.

Table 6.3. Major crops, gross farm value, and value per ha, Kenya, 1984.

	Estimated area (1000 ha)	Gross farm value (1980) (K£ mln)	Value per ha (K£)	Rank of value per (ha)
Maize/beans[a]	1 200	12.5	153	8
Wheat	125	17.7	191	7
Barley	15	4.3	249	6
Sorghum/millet	360	n.a.	48	13
Cotton	110	6.3	32	14
Sunflower	10	0.1	141	9
Rice	11	2.8	519	4
Vegetables	36	1.3	917	3
Coffee	151	118.8	1 498	1
Tea	61	71.5	1 325	2
Sugar	88	29.5	-432	15
Pyrethrum	10	9.7	419	5
Sisal	60	9.7	137	10
Groundnuts	28	n.a.	84	11
Dairy (milk)	2 403	15.0	70	12

Source: Government of Kenya, 1986.

a. Part of the maize crop is interplanted with beans.

n.a. = not available.

Table 6.4. Kenyan exports of agricultural products (mln K£).

	1970	1980
Coffee	445	2 163
Tea	254	1 160
Fruit and vegetables	78	475
Other agricultural commodities	290	1 204
Total agricultural products	1 067	5 002
Petroleum products	163	3 254
Other non-agricultural products	201	1 609
Total exports	1 431	9 865
Agricultural products in total exports (%)[a]	84	75

Source: Annual Trade Reports, Republic of Kenya.
a. Excluding petroleum products.

6.1.2 *Growth of production*

Annual growth of the total GNP between 1965 and 1984 was 4.0%. Agriculture's contribution has declined only slightly, from 35% in 1965 to 31% in 1984. In contrast, there have been wide fluctuations in the annual growth rate in the agricultural GDP. In 1977, for instance, the real growth rate exceeded 10%, following the boom in coffee and tea prices, but growth rate was negative in 1979 and 1980. The sector recovered with a growth of 6.2% in 1981 and 4.3% in 1982. Weather is an important variable affecting agricultural growth. Delayed and uneven rain in 1983 and 1984, together with rising input prices, slowed down the growth rate to 3.7% compared with the previous year.

The area and value of major crops and livestock are given in Table 6.3. Agricultural products made up 70% of total Kenyan exports at the beginning of the 1970s and declined substantially to only 50% in 1980, predominantly because of increased exports of petroleum products (based on imported crude oil). Coffee and tea are now the major export crops, but in 1980 their share of total agricultural exports was approximately 70% (Table 6.4).

6.1.3 *Modernization, institutional change and agricultural policy*

According to the fourth and fifth Development Plans, the objectives of agricultural development include overall sectoral growth, improvement of rural incomes, increase of employment opportunities, improvement of the balance of payments by expanding exports, self-sufficiency in domestic food production, and conservation of natural resources. The more recent sessional paper 'Economic Management for Renewed Growth' (Government of Kenya, 1986) stresses that economic growth will be the primary concern of economic policy, as it was in the first, second and

third plan periods. Agriculture will continue to be the leading sector for stimulating economic growth. The paper's targets are ambitious: an overall economic growth rate of 5.6% per annum and 5.3% for agriculture.

To accomplish this, various policies and programmes were formulated. Within the existing cropping patterns, farmers will be encouraged by pricing and marketing policies to adopt more productive practices, especially the use of improved varieties, fertilizers and disease and pest control. Research will be reorganized and accelerated to generate the new high yielding varieties necessary to keep pace with consumption. Finally, the production pattern will be diversified to a limited extent in favour of crops such as tea, coffee and vegetables, which generate much higher income and more employment per hectare than other crops or livestock activities.

6.2 Agricultural research and the development of new varieties

6.2.1 Structure of agricultural research

Agricultural research is dominated by the public sector. A policy review took place in 1979, and, for better management, the mandate of agricultural research was given to the Kenyan Agricultural Research Institute (KARI). The Ministries of Agriculture, Livestock Development, and Research, Science and Technology are responsible for general agricultural policy. The Ministry of Research, Science and Technology (MRST) has been created to co-ordinate all research and development in the country.

The national research stations have a nationwide mandate for major commodities such as maize, wheat, sugarcane and livestock, and for scientific disciplines such as entomology, pathology, soil physics and agricultural chemistry, dryland farming and soil and water management. There are 12 national research stations for crops and five for livestock. In addition, regional research stations undertake research specific geographical regions of the country (Ruigu, 1988).

The fourth National Development Plan (1979-1983) recognized the importance of technology constraints, and the fact, that agricultural growth would require a substantial increase of research investment. Kenya, however, has many different ecological zones and it is difficult to conduct research on all of them effectively (Ruthenberg, 1978; 1986). Kenyan researchers must, therefore, keep in close contact with counterparts elsewhere in the tropics, so that innovations can be imported as soon as they become available.

Research activities of the private sector and universities. The agricultural research and plant breeding activities of the private sector in Kenya are limited, are largely adaptive in nature, and support plantation production. The results are rarely made public. Such private enterprises include Kenya Canners Ltd. of the Delmonte Group at Thika (pineapples), the East African Tanning Extract Company at Eldoret (interested in wattle trees, maize and wheat) and East African Industries (EAI)

which has research interests in sunflower and rape seed. EAI's oil seed development department is based at Nakuru and its research department works in collaboration with the oil crops programme of the National Plant Breeding Station at Njoro and the Mwea Tebere Agricultural Research Station at Wanguru in Kirinyaga District. Kenya Breweries Ltd (KBL) has interests in barley and has exploited materials received from both International Maize and Wheat Improvement Centre (CIMMYT) in Mexico and the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria. The British American Tobacco Company (BAT) undertakes adaptive variety trials and has introduced tobacco varieties from Zimbabwe, Malawi and the USA. They also have an interest in afforestation, since they require wood for tobacco curing. Smaller domestic private companies have some research programmes in horticultural crops.

The Faculties of Agriculture, Veterinary Medicine and Science at the University of Nairobi (established in 1970) undertake basic and applied agricultural research. There are collaborative research programmes between the faculties and research stations. The Department of Crop Science is carrying out studies on beans, in collaboration with the Grain Legume Project of the National Horticultural Research Station (NHRS) in Thika. Studies carried out on pigeon pea have resulted in the release of a high yielding variety. The Faculty of Science at Kenyatta University College and Egerton College Njoro also undertake research related to agriculture.

6.2.2 Technological development in plant breeding

Conventional plant breeding. The national agricultural research institutes conduct conventional breeding and crop improvement programmes aimed at development of high yielding varieties and resistance to pests and diseases. Such programmes often begin by collecting farmers' varieties rather than by introducing material from outside Kenya (Muturi, 1986). Imported collections are particularly important for cereals and pulses, as well as for the traditional cash crops. Large-scale national breeding programmes have been carried out in the Rift Valley, in particular for the development of hybrid maize. There is also a breeding programme to develop open-pollinated (non-hybrid) maize varieties. Several composite maize varieties have been bred at Katumani. For certain crops, such as rice, local production does not justify a fully-fledged plant breeding programme. Screening and adaptive research into local and exotic varieties are undertaken in these cases.

The problem of genetic erosion is apparent in Kenya, mainly because of the replacement of traditional varieties by modern varieties, and by degradation of the environment as a result of high population pressure. This is true for crops as well as for stock breeds (Muturi, 1986; Rural Enterprise Programme, 1986).

Tissue culture and other sophisticated biotechnology. Significant results have been achieved with tissue culture at the Muguga Plant Quarantine Station, where over 70 accessions of Irish potatoes were propagated in 1986. The Department of Crop

Science of the University of Nairobi is also doing research in this field, mainly on horticultural crops, as well as Rhizobium inoculation of seeds. Coffee-related tissue culture work is expected to be initiated shortly. No genetic engineering involving protoplastic fusion (somatic hybridization) or in-vitro transfer of DNA has yet been introduced. The National Council for Science and Technology is currently evaluating the country's options. A consultancy report on new plant technologies is being assessed by the Specialist Committee to establish priorities. Support of biotechnology research is a likely recommendation.

Constraints to use of new technologies. Improved varieties generally require the purchase of complementary inputs, including fertilizers and pesticides, and are often more labour intensive in cultivation. Many of these inputs, including the seed, require substantial financial outlay, but lack of cash is an important constraint for smallholders. Agricultural credit is supported in an attempt to overcome this constraint.

Extension work is vital to inform farmers about the new technologies and requirements of the new varieties. Ecological diversity in Kenya is large, and the available varieties have to be specific to agro-ecological zones. Without an adequate extension service there is a danger that farmers will plant inappropriate varieties.

The risks associated with new varieties is sometimes an important constraint, especially in areas of unpredictable and unreliable rainfall. In the arid and semi-arid areas of Kenya, farmers may need to plant twice or more, as happened during the 1984 drought.

Farmers may, therefore, opt not to use improved varieties, which are regarded as being expensive and risky. The resulting unpredictability of seed demand is an important concern for commercial seed distributors, who may not find it profitable

Table 6.5. Area planted to hybrid maize, Kenya, 1981/82

Province	Total area (1000 ha)	Hybrid maize		
		area (1000 ha)	proportion of total area (%)	proportion of domestic consumption (%)
Western	199	74.2	37	13
Rift Valley	345	303.7	88	53
Nyanza	189	103.1	55	18
Central	103	71.9	70	13
Eastern	320	15.6	5	3
Coast	63	4.3	7	1
Total	1 219	572.8	47	100

Source: World Bank, 1985a.

to supply all areas. Irregular supply may discourage farmers from purchasing improved seed. The problem could be complicated further where there are no incentives or where prices are not remunerative.

6.2.3 Impact of new varieties

The impact of new varieties has been particularly important for maize, barley and wheat. Approximately 50% of the maize area is cultivated with hybrid varieties (Table 6.5), and about 53% of the total hybrid maize in the Rift Valley Region.

The diffusion of hybrid maize seed in Kenya is considered to be a unique success in Africa and the Kenya Seed Company (KSC) an 'effective producer and marketer of seed' (World Bank, 1985a).

6.3 The seed industry

6.3.1 Historical development

Before Independence in 1963, improved seed production in Kenya was established in the Central Highlands and aimed at the large-scale holdings of the white settlers. After Independence the industry expanded quite rapidly, particularly because of the introduction and diffusion of hybrid maize varieties. Several supporting activities for seed industry development have since been created.

6.3.2 Institutional framework and government policies

The Kenyan Government supports research done by the National Seed Quality Control Service (NSQCS) and partly owns the Kenya Seed Company (KSC) and the Agricultural Development Corporation (ADC). It has also supported the Kenya Grain Growers' Cooperative Union (KGGCU) which distributes seed. The Government is committed to providing suitable incentives to sustain the KSC. The World Bank and other donors have stressed the importance of flexibility and reasonable prices. Price controls on agricultural inputs result in critical margins.

The main aims of the Government seed policy are to ensure a steady increase in improved varieties and to keep prices to the farmer low. The KSC is responsible for ensuring adequate supplies of seed at the beginning of each season, particularly for maize and wheat. The major drought of 1984 caused shortages of some seed, including medium-altitude hybrids and synthetics for the lower rainfall areas. To avoid such a situation in the future, the Government has adopted a policy of increased strategic seed reserve. Such a reserve is commercially viable and has to be maintained at government expense. National food policy (Government of Kenya, 1981; 1986a) calls for the review of seed prices to be an integral part of the Annual Review of Agricultural Prices mandated under the Agricultural Act (CAP 318, Laws of Kenya). The Government has also set an annual growth rate target of

10% for maize and wheat seed sales, which are expected to increase by 150% during 1980-1990. The Government is committed to ensuring adequate land for seed multiplication.

Variety release procedures. Before a variety can be released in Kenya, various procedures set down by the Seeds and Plants Varieties Act (CAP 326, Laws of Kenya; Government of Kenya, 1977) have to be followed. These include distinctiveness, uniformity and stability trials (DUS) and the national performance trials (NPT). Before 1976, NPTs were carried out by the commodity stations, but later became the responsibility of NSQCS. To qualify for NPT, the breeder must have accumulated preliminary performance data over a two-year period. In addition, a full description of the crop and its characteristics must be provided (see schedule IV, Plant and Varieties Act). The results are submitted to the Specialist Release Committee which, on the basis of consistency of good performance, recommends inclusion of the crop in the NPT.

The objective of the NPTs, which are normally conducted for three years, is to compare the performance of new materials with varieties already on the market. The trials are conducted at various sites representing major ecological zones where the crop is grown. The results are evaluated by the commodity station, and the methodology counterchecked by the biometrics section of the National Agricultural Laboratories (NAL). Information about suitable varieties is then presented to the Specialist Release Committee, which in turn makes recommendations to the National Variety Release Committee chaired by the Director of Agriculture. A variety is released to farmers if the Committee approves, that is if the variety gives consistently high yields during the three-year testing period, passes the DUS test, and has good characteristics and disease resistance.

This procedure is also followed for new introductions from IARCs and elsewhere. In certain cases the National Variety Release Committee may deviate from the three-year rule and release a variety after two years. This occurred in 1980 with the release of H 625, a hybrid maize variety of exceptional performance. Experimental materials may sometimes be pre-released to farmers while testing is still going on.

Seed legislation. The current comprehensive seed law, the Seeds and Plant Varieties Act (CAP 326, Laws of Kenya), was established in 1975. Essentially, this act is based on the 1964 Plant Varieties and Seeds Act of the United Kingdom. Revised in 1977, it provides a broad basis for Kenya's Seed Quality Control Programme (Government of Kenya, 1977). The objective is:

> 'to confer power to regulate transactions in seeds, including the provision for the testing and certification, for the establishment of an index of names of plant varieties, to empower the imposition of restriction on the introduction of new varieties; to control the importation of seed; to authorize measures to prevent injurious cross-pollination; to provide for the grant of proprietary

rights to persons plant breeding or discovering new varieties and to establish a tribunal to hear appeals and other proceedings; and for purposes connected with and incidental to the foregoing' (p. 4).

Plant Breeders' Rights. The Seeds and Plant Varieties Act of 1977 provides specifically for granting of plant breeders' rights for plant varieties of species or groups specified by the Minister (Section 17[1]). The act also states that the applicant must be the person who bred or discovered the plant variety concerned, or his successor in title (Section 18[2] of CAP 326, Laws of Kenya). If a plant variety is bred independently by two or more persons, the first to apply in the prescribed form is entitled to the grant. The plant variety must meet DUS standards and be sufficiently varietal pure. Moreover, the agro-ecological value must surpass existing varieties in one or more characteristics, on the basis of results obtained in official tests.

The merits of granting plant breeders' rights in Kenya is still a matter of debate. The Government has made little use of the provision in the Act, mainly because breeding and seed programmes are largely carried out by the public sector and because of concern about higher seed prices for the farmers. In 1985, the Dutch Mission to the NSQCS (Government of the Netherlands, 1985) recommended that further consideration be given to adopting international plant breeding rights.

Seed certification and quality control. Seed certification was established in the 1970s. The Kenyan Inspection Service for Seeds, called the National Seed Quality Service (NSQCS) from 1977, was developed in cooperation with the Netherlands. The NSQCS is classified as a commodity research station under KARI. According to current proposals, NSQCS will constitute one of the national stations with the following mandate:

- production and testing of breeder seed of recommended crop varieties and clones;
- standardization of techniques for seed testing and production;

evolution of procedures for production of hybrid seed of crops, such as maize, sorghum and millet;

- improvement of seed storage methods and physiological studies on seed dormancy;
- establishment of standards for seed viability, genetic and physical purity, crop varieties in respect to breeder, foundation, and certified seed;
- development of fungicides and other chemical treatments for the production and supply of pathogen-free and pest-free seeds.

The NSQCS needs to carry out periodic annual inspections of 16 200-20 200 hectares of crop throughout the country. The Government of Kenya finances the NSQCS, which also generates some revenue through fees charged to seed growers for field inspection services, and sampling and sealing of approved seed lots. These fees are not adequate to cover NSQCS operations and have been the subject of discussion by the Governments of Kenya and the Netherlands, and the World Bank.

Following the Agricultural Inputs Review (1985a), the World Bank recommended that NSQCS be established as a self-financing organization, by increasing seed certification fees and improving management. The review of NSQCS assistance suggested creation of a revolving fund to finance the service (Government of the Netherlands, 1985).

Seed pricing policies. The seed pricing structure in Kenya is dominated by maize seed which constitutes over 50% of KSC turnover. The KSC Board approves prices paid to farmers producing seed (contract growers), as well as the wholesale seed price to the KGGCU. This sometimes results in delays in price increases. Retail prices of maize are determined by the KSC Board in consultation with the Minister of Agriculture. For some time KSC has considered that prices to the consumer do not reflect the real cost of seed and that wholesale margins are inadequate. The World Bank has argued that the seed price is minor in relation to other inputs, and that farmers would be willing to pay the actual cost of hybrid maize seed after relaxation of government price control.

In 1985, following the World Bank Agricultural Input Review, the Government and the World Bank agreed on immediate action towards the medium-term objective of ensuring availability and quality of improved seed by:
- maintaining adequate producer prices;
- establishing adequate certification fees to ensure adequate funding for NSQCS;
- developing a contingency plan to ensure adequate supply;
- addressing financial and management problems of KSC.

Most of the details were agreed and implemented in 1987. The pricing of wheat follows lines similar to maize. Seed prices of several varieties, as well as the price

Table 6.6. Average seed and grain prices, Kenya, 1984.

	Retail price (Ksh/kg)	Producer price (Ksh/kg)	Ratio of seed to grain
Hybrid maize H 613	7.2	1.75	4.1
Hybrid maize H 625	7.2	1.75	4.1
Hybrid maize H 512	9.1	1.75	5.2
Coast composite maize	7.2	1.75	4.1
Katumani composite maize	6.7	1.75	3.8
Local maize variety	2.3	1.75	1.3
Wheat	5.3	2.69	2.0
Hybrid sunflower	24.0	2.65	9.1
Non hybrid sunflower	11.0	2.65	4.2
Beans ('Wonders')	12.5	3.66	3.4
Beans ('Monel')	17.5	3.66	4.8
Local bean variety	5.0	3.66	1.4

Sources: Grain prices; Ministry of Agriculture, 1986. Seed prices; World Bank, 1985a.

ratio of seed to grain, are presented in Table 6.6. Seed prices are given in the Ministry of Agriculture's annual publication, 'Agricultural Costs and Prices'.

Seed marketing and distribution. The KGGCU is the main outlet for improved varieties in Kenya. The Union has 50 branches throughout the country which are supported by 4 500 stockists. The KGGCU is well suited to provide complementary inputs including fertilizers, pesticides, agricultural tools and machinery. The distribution of vegetable seed is even more widespread as local dukas (shops) stock appropriate packs for the smallholder.

The KSC's Elgon Downs farm provides demonstrations and field days for seed growers and the general public. The staff also participate in radio programmes and numerous agricultural shows to popularize improved varieties. The major seed distributors, however, have complained about inadequate extension service and lack of credit for smallholders. Margins for retailers are a significant problem and some seed producers experience insufficient supply of breeder seed. The slow introduction of new varieties is also an important obstacle to improving seed distribution (Ruigu, 1988).

Seed storage is another source of concern. The KSC's rejection of returned KGGCU seed is partly due to poor storage. The KSC has reported low germination of seed, as their storage facilities are not adequate. Poor germination rates of 1985/86 wheat and barley seed stocks, for instance, meant that they had to be written off.

6.3.3 Private seed industry

Seed production in Kenya has been dominated by KSC since the start of operation. Until 1963 the company was relatively small catering for a limited market. It began in 1958 with the production of good quality sunflower seed for the international birdseed market. In the following seven years, production of maize seed increased steadily as a result of the release of hybrids by the national maize programme. Production capacity increased, staff were trained and a distribution network was built up. In the early 1970s KSC began production, processing, and distribution of wheat seed (Douglas, 1980). Now a parastatal, the KSC is involved in seed production, processing, sales and research. The dominance of KSC has been enhanced by the takeover of Simpson and Whitelaw (Simlaws), which specialized in importing and distributing horticultural seed. In 1981, the KSC subsidiary Hortiseed merged with Simpson and Whitelaw. The Njoro Seed Company, a wheat dealer, was also sold to the KSC.

There are several other private seed companies including East African Seed Company (EASC), Jardinage Seed Company, and Mount Kenya Agro Industries. The USA seed company, Cargill, has set up a local company, Cargill East Africa Ltd, to establish seed business in Kenya and Africa. Pioneer Hi-Bred is involved in hybrid maize seed distribution, and another transnational corporation, Ciba-Geigy, has shown interest in entering the market. The Unilever subsidiary, East

African Industries (EAI), has played an important role in sunflower and rape seed development in Kenya.

Government policy is to encourage competition in the economy, including the seed sector. The aim is import substitution and further expansion. Many think it inevitable that transnational corporations will enter the Kenyan seed market, and that there will be increased opportunity for private foreign seed firms to establish joint ventures for increasing seed exports. Many private including foreign seed firms already operate in the Kenyan horticultural seed market.

Kenya Seed Company. KSC is the chief supplier of certified seeds in Kenya. It was a private company prior to 1976, when the Government assumed a major share (52%) through the ADC. The KGGCU holds 28% of the equity, and farmers and KSC staff own 20%. Between 1970 and 1987 the staff increased from 300 to 450 and the number of full-time researchers rose from two to five. Seed production is the main business activity. The turnover from the seed and farm management services was Ksh 175 million in 1986, rising to Ksh 270 million in 1987. The company deals in maize, wheat, sorghum, barley, sunflower, various vegetables and fodder grasses. Maize seed sales represented 53% of the total turnover in 1983 (Table 6.7).

In addition to seed production, KSC carries out plant breeding and testing programmes. The company is also heavily involved in export and import of seed of most crops, including horticultural seed. Kenya supplies maize and bean seed to East Africa. Export of sunflower, fodder grasses and horticultural seed is an important source of income for the company. Hybrid maize seed exports (3 000 tonnes in 1981) have declined sharply because of export restrictions. Imports include hybrid sunflower and a wide range of high value horticultural seed.

About 10% of all seed from KSC is produced by the company itself, the rest is supplied by ADC and contract farmers. ADC, a parastatal responsible for national farms, produces about 35% of seed and 200 contract farmers produce the remaining 65% (Ndegwa et al., 1985). KSC processes the seed after harvest. Processing capacity needs to be expanded for maize and wheat, and set up for sorghum seed. KSC dominates the seed supply of various commodities.

Table 6.7. Turnover and profit margin, Kenya, 1982-1983

	Proportion of turnover (%)	Profit margin (%)
Seed sales		
maize	53	6
sunflower	9	10
fodder grasses	7	33
cereals (wheat/barley)	23	-2
Farm management services	9	8

Source: KSC.

6.3.4 International cooperation in the seed industry

Some of the International Agricultural Centres of the Consultative Group for International Agricultural Research have contact with national research institutes (Ruigu, 1985). The International Maize and Wheat Improvement Centre (CIMMYT), for example, has three regional programmes for Eastern Africa based in Nairobi, namely maize improvement, wheat and triticale, and the economics programmes. Other centres are either represented locally by staff or do collaborative work with Kenyan stations. These include the International Institute of Tropical Agriculture (IITA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and International Board for Plant Genetic Resources (IBPGR), which has established a field gene bank at Muguga. The International Potato Centre (CIP) cooperates with the Faculty of Agriculture at Nairobi University. In addition, some centres without regional programmes contribute to local programmes. Kenya's National Agricultural Research System has benefited from and interacted with the IARCs.

Apart from these multilateral cooperation agreements, many bilateral projects are directed to improving seed supply in Kenya. The Netherlands has been heavily involved in seed certification, as well as supporting breeding programmes, on beans, vegetables and fodder crops, for example. Canada and the USA have been involved with wheat and maize. The Federal Republic of Germany has supported the National Gene Bank at Muguga, which was completed in July 1988. More recently, donor coordination in seed industry development has improved, and commercial cooperation among private companies has also increased in the same way.

6.4 Seed supply and demand

6.4.1 Assessment of demand

The dualistic structure of agriculture influences seed demand in the country. The large-scale farms have maintained a high demand for seed given commercial operation principles, and smallholders have increased their demand, depending on the crop.

Estimates of improved seed requirements and use in Kenya, presented in Table 6.8, are based on planted areas and recommended seed rates, while actual seed use is based on past averages. Seed replacement of maize, wheat and barley is high in comparison to other countries in the region, but for beans, sorghum and millet replacement is less than 3%.

Maize. Maize breeding and production has been implemented successfully in Kenya. KSC produces hybrid and non-hybrid, open-pollinated varieties which are well adapted to the four main agro-ecological zones. Kitale is the main centre for maize seed production. In 1985/86, a total of 16 685 tonnes of maize seed were

Table 6.8. Seed requirements and estimated improved seed use, Kenya, 1982-1983.

	Area (1000 ha)	Seed rate (kg/ha)	Seed requirements (t)	Seed use (t)
Maize	1 200	25-30	36 000	18 000
Beans	700-1 200	25-40	30 000	650
Wheat	125	100	12 500	6 000
Barley	12	100	1 200	1 200
Rice	8	40-45	360	n.a.
Sunflower	7	4	28	n.a.
Sorghum	200- 300	25	7 500	160
Millet	50- 60	10	600	12
Vegetables	36	n.a.	n.a.	22
Fodder grasses	2 500	4	500[a]	50-100

a. Based on replacement every 20 years.
n.a. = not available.

sold on the domestic market (Table 6.9), reflecting an increase as a result of the 1984 drought. The demand for maize for domestic consumption will reach 2.8 million tonnes. Assuming about 1 million hectares of maize will be planted using improved seed, the KSC will need to double seed output by the year 2000 (Mwangi & Migot-Adholla, 1985).

Maize hybrids. The first hybrid varieties were sold in Kenya in the early 1960s, initially to large-scale farmers under the assumption that small-scale farmers could

Table 6.9. Maize seed production and sales in Kenya, 1967-1986.

	Production (t)	Domestic sales (t)
1967/68	–	1 973
1969/70	–	3 207
1972/73	–	7 145
1976/77	15 169	10 600
1977/78	22 371	12 224
1978/79	13 431	10 922
1979/80	9 385	8 192
1980/81	15 661	13 073
1981/82	22 451	12 197
1982/83	16 436	13 815
1983/84	14 074	12 377
1984/85	14 243	15 181
1985/86	22 702	16 685

Sources: Production figures; KSC, 1987. Sales figures; World Bank, 1985a.

not cope with the agronomic requirements of hybrid maize seed. The KSC, however, later mounted an aggressive campaign to involve small-scale farmers. The company involved government extension workers and local businessmen in the dissemination of seed and information about the use of hybrids. The new hybrids released in 1964 gave 30% higher yields than the original variety (Kitale flat white). Since then, demand for the hybrids has increased, because the breeding programme has produced hybrids 30-80% superior to local varieties, depending on altitude, and because agronomic research has shown where and how to grow these hybrids to maximize their potential. Field extension staff have organized hybrid-growing demonstrations within walking distance of most farmers. KSC organized production and distribution of high quality hybrid seed at reasonable cost.

Hybrids are now available for planting at high (late maturity) and medium altitudes (medium maturity), and recently, hybrids of the USA company, Pioneer Hi-Bred, have been introduced in coastal areas.

Maize composites. Breeding work at Katumani has concentrated on synthetic (composite) maize. The programme started in 1959, two years later than at Kitale, and was geared to production of early maturity maize to escape drought. The first release in 1966 was Katumani composite A, a variety cross-bred from local and exotic sources. A Coast composite B was released in 1974, and since then there have been regular variety releases with important improvements in both earliness and yield.

The introduction of drought-resistant and fast-maturing varieties has significantly increased the use of improved maize seed in medium and low-potential areas. Demand for the composite is difficult to ascertain, because farmers prefer to replant with their own seed. This causes the KSC difficulties, although the new strategic reserve may help solve uncertainty over sales. The KSC estimates that all composite seed is sold to small-scale farmers.

Sorghum and millet. These are smallholder crops. Commercial seed companies have not found it profitable to supply seed to smallholders, most of whom are in the semi-arid areas. Most farmers retain their own seed, because of high production risks (Lynam, 1978). A fairly sophisticated farm seed system has evolved, probably because of the fluctuations in seed availability because of drought cycles (Muhammed & Njuguna, 1987). The demand for sorghum and millet is undermined by the ascendancy of maize. The damage to sorghum caused by birds is also a serious problem.

The range of local varieties is large, and KSC supplies hybrid sorghum. In 1986 KSC produced about 150 tonnes of seed and EASC, a smaller supplier, produced 5 tonnes of certified sorghum seed.

Government policy is now geared to promoting production of drought-resistant crops, so that demand for seed can be expected to rise. Potential demand for sorghum and millet seed requires urgent study.

Wheat. Wheat is grown on large-scale farms, but suitable land is becoming scarce. Physical conditions are conducive to diseases in the crop, particularly rusts, and new varieties succumb frequently to new rust outbreaks. KSC started to produce certified wheat seed in 1972. Nakuru became the centre for wheat seed production. The demand for wheat seed is high, but uncertain. In 1986, KSC had about 4 000 hectares under wheat, giving about 12 000 tonnes of seed.

Long-term seed production is difficult to plan because not only do farmers tend to use their own seed, but there is also farmer-to-farmer trade in seed (World Bank, 1985a). Improved seed yields about 2.52 tonnes per hectare compared to a national average of 1.74 tonnes per hectare. KSC estimates that slightly more than 50% of the wheat area (110 000–125 000 hectares) is planted with improved varieties. A large number of varieties have to be maintained to cope with the problem of rust outbreaks.

Barley. Like wheat, the demand for improved barley seeds is dominated by large-scale farmers. Virtually all barley is grown under contract to KBL and seed is replaced every year. Between 1977 and 1984 the area devoted to barley fell by almost 50%, and the demand for seed from KBL has declined as a result. Unlike wheat, only a few varieties of barley are grown.

Rice. The area under rice in Kenya is small, less than 0.5% of the total area. Area expansion is difficult and depends largely on capital investments in irrigation facilities. There is no commercial market for rice seed, and demand is dominated by the National Irrigation Board (NIB) schemes. KSC does not produce or sell rice seed. NIB produces seed for its tenants and occasionally for the Lake Basin Development Authority and Tana and Athi Rivers Development Authority. Seed production is organized by NIB's own farmers.

Beans and other pulses. Demand for bean seed and seed of other pulses, such as cowpea and pigeon pea, is dominated by small-scale farmers, most of whom grow beans. Demand is cyclical due to serious fluctuations in consumer prices and uncertainty of production (World Bank, 1985a). Seed demand is high after crop failure or when crops have been sold at high prices, and similarly low when market prices for produce are down. Consequently, farmers plant their own seed one year and purchase from the commercial seed suppliers in another. Commercial demand for bean seed does not generally exceed 3% of total requirements.

In 1986, KSC produced about 400 tonnes of bean seed and EASC produced 27.6 tonnes. There are a few other small bean seed producers, such as Mount Kenya Agro-Industries. Unlike the other producers, KSC has no bean breeding programme, and supplies seed at wholesale and retail levels. Its subsidiaries, Hortiseed and Simpson and Whitelaw, also deal in these seeds. Yield increase from the use of certified seeds is not substantial, about 20%.

Research has emphasized bean varieties for cultivation in pure stands, although small-scale farmers practise mixed cropping with maize. Moreover, bean seed is expensive compared to the price of beans for consumption, and thus farmers tend to replant their own seed. Massive introduction of improved varieties may lead to genetic erosion. As with sorghum and millet, the potential demand for bean seed and seed of other pulses needs to be studied.

Oil crops. In 1958, KSC started to produce sunflower seed for the American and European bird seed market to reduce the overheads of the new company. In recent years this market has declined greatly and KSC now aims production at the domestic oilseed market. KSC has its own sunflower breeding programme, and in 1986, 600 tonnes of sunflower seed was produced.

Oil crops, in particular sunflower and rape seed, are now being promoted as part of the EAI programme. Demand has increased in recent years following establishment of the EAI Oil Crops Division. The company purchases and distributes seed to farmers who grow the crop under contract. EASC also provides sunflower seed, while Cargill has an interest in this crop, but is not yet in business. Expansion of production is urgent in order to substitute imports (about US$ 80 million annually) with local production.

Vegetables. Demand for vegetable seed is quite high. Small-scale farmers use improved vegetable seed because of the high product value. After coffee and tea production, the value added in vegetable production is highest. Vegetable exports have increased considerably over the past 15 years.

Advances in horticultural seed production have been considerable, especially with the expansion of local multiplication of improved varieties. Local seed production has reduced imports by about 40% in the last few years (World Bank, 1985a). There are several producers of vegetable seed, including EASC, Jardinage Seed and KSC. In 1986, EASC planted 56 hectares of vegetable seed, while KSC planted 810 hectares. Seed production is dominated by the private sector, but a large proportion of improved seed has to be imported. Vegetable seed is also multiplied in Kenya under contract to foreign seed companies; this is known as custom seed production (Ruigu, 1988).

Fodder grasses. Livestock production has been one of the dominant activities in Kenya. Intensification of milk and beef production requires greater attention to fodder crops. There is an urgent need to improve breeder seed production to sustain production of commercial seed. Between 1969 and 1979 the grass-breeding project at the NARS, Kitale, was supported by the Netherlands Government. Its mandate was to develop new grass varieties, maintain the varieties, and provide adequate breeder seed to enable KSC to produce commercial seed. Four new varieties were developed during the project period.

KSC is the main producer of fodder crop seed. The company organizes contract

production with farmers around Kitale, amounting to approximately 2 000 hectares annually. The use of new grasses is encouraged and KSC attempts to meet the demand of both large-scale and small-scale farmers. About 15-20% of the pasture seed sold is purchased by small-scale farmers, who for many years have been able to buy one-kilogram seed packets. About 50-100 tonnes of grass seed is used annually, sufficient to plant about 12 500–25 000 hectares of pasture land.

International seed trade. Kenya, in particular the KSC, has been involved in the international seed trade for many years. Sales of maize and bean seed to regional markets and sunflower, horticultural and fodder grass seed to overseas markets have had a positive impact on the development of the domestic seed industry. Although export of maize and bean seed is difficult at present because of certain government restrictions, Kenya is still involved in custom seed production of several horticultural crops, particularly vegetables and flowers.

6.4.2 Traditional seed supply systems

Traditional seed supply systems are important for most crops. Even in the case of maize and wheat, only half of the national crop is grown from commercial seed, the rest is from the farmers' own seed. Information about the use of non-commercial seed is not available, despite the fact that it is the dominant source for many crops, such as sorghum, millet, beans and other pulses. Little distinction is made between seed and grain for food. This becomes clear in times of stress. For example, crop failure ensuing from the 1984 drought led to a severe shortage of commercial seed and necessitated several plantings, instead of the usual one. Food shortages also compelled farmers to consume seed.

Cash constraints on small-scale farmers tend to reduce the demand for improved varieties. Moreover, risks associated with new crop packages, especially in areas of low rainfall force small-scale farmers to cling to the same old crops and varieties. While yields may not be as high as those of new varieties, the characteristics have been proved over many years of practice. These crops also provide a wide and varied genetic base crucial to resistance to environmental stress, including diseases, pests and moisture stress. In addition, costly inputs are not required each year.

6.5 Major results and constraints in seed industry development

The declining land base is a central factor in agricultural policy. Kenya is short of good agricultural land because less than 20% of the country's land resources is arable.

Research, breeding and diffusion of high yielding varieties have advanced considerably for maize, wheat, barley, rice and sunflower. Maize is the national staple grain, produced by smallholders and large-scale commercial farmers alike. Approximately 23% of the total arable land is planted with maize, often interplanted with

beans. Smallholders use over 90% of hybrid seed sold in Kenya. Wheat and barley are large-scale crops while rice is predominantly an irrigated crop. These three crops cover less than 3% of total arable land. Research and breeding related to other crops have advanced less. This is especially true for sorghum and millet, which cover 7% of the total arable area. A few improved bean varieties have been developed but their diffusion is limited because smallholders prefer mixed varieties, while research has emphasized pure lines of beans.

In general, there is an urgent need to develop drought-resistant varieties suited to arid and semi-arid environments. There is a shortage of qualified and experienced staff, including plant breeders, geneticists, agronomists, entomologists, and plant pathologists, and this is accentuated by a rapid staff turnover. Human resource development will remain one of the first priorities in expanding seed-related activities and research programmes.

The Kenyan seed sector is inward looking; imports and exports are not significant except in the case of horticultural crops. Some foreign companies carry out vegetable seed multiplication for exports, because margins are comparatively high. The dominance of KSC in seed production and marketing is accepted in the pursuit of seed self-sufficiency. Although the Government has been receptive to increased competition, the Kenyan seed sector remains relatively closed to outside competition. KSC prefers some protection while major donors, such as USAID and the World Bank, opt for privatization. The maize seed trade will probably be fully protected because of self-sufficiency requirements, but some competition in other crops may be allowed in the long-term.

Bilateral and multilateral donors have played a considerable part in expanding the seed sector. Moreover, Kenya participates in useful collaborative projects with several IARCs. Wheat and rice varieties, for instance, consist largely of germ plasm from these institutes.

Policy makers recognize that, given new developments in biotechnology, the structure, management and control of the seed industry are beginning to change. The transnational corporations are emerging as an influential force, from plant breeding and seed production to marketing. Economic and political power will be placed in the hands of foreign corporations, which may not augur well for policies related to food production and security. The issue of Plant Breeders' Rights is likely to gain attention, particularly when foreign companies establish themselves in the local market. More studies on the transnational corporations dealing in seed are crucial to evaluate the implications for national policies on food security, strengthening of small-scale producers, and conserving the totality of national resources. Disappearance of traditional varieties with their invaluable characteristics has been a matter of concern for some time. Kenya's wide genetic base of land races, particularly in the case of sorghum, millet, maize and beans, must be conserved.

7 Seed industry in India[2]

7.1 Role of agriculture in the Indian economy

Agriculture plays a dominant role in the Indian economy, although its share of the Gross Domestic Product (GDP) dropped from 47% in 1965 to 35% in 1984 (World Bank, 1985). For the past few decades about 70% of the total labour force has been employed in the agricultural sector. Productivity per worker has lagged behind other sectors, and fertilizer-use and land productivity are low. In some regions, the Punjab, Haryana and the western part of Uttar Pradesh, however, yields have increased significantly. In these regions, the introduction of high yielding varieties (HYVs) in the 1960s and 1970s has had a tremendous impact, but in most states crop yields have remained low.

During the second half of the 1970s, India substituted cereal imports for local production of wheat and rice. Even so, the average annual food grain (cereals and pulses) per capita consumption did not improve in this time. The increase per capita in cereal availability was accompanied by a sharp fall in availability of pulses which are used for preparing 'dal', a food rich in protein compared to cereals. India is not self-sufficient in oilseeds or pulses (Government of India, 1987).

7.1.1 Land use, holdings and fragmentation

The net sown area has not increased considerably over the past decade, but the gross sown area has gone up as a result of the widespread practice of double-cropping. Since the early 1950s about three-quarters of the total area cultivated is sown to cereals and pulses (Table 7.1). Small and marginal holdings in particular concentrate on food crop production (Table 7.2).

In 1976, most holdings were less than 2 ha, and about 55% less than 1 hectare (Table 7.2). There were some 60 million marginal and small holdings supporting a population of at least 300 million, mostly tenants and share-croppers. Yet most of these holdings cannot provide enough food for the family, and agricultural labour and off-farm employment are crucial to supplement the income.

2. This chapter is based on research undertaken by Dr P.K. Agrawal, Indian Agricultural Research Institute, New Delhi, India. For a detailed account of this research project, see: Seed industry in India: history, policies and perspectives. IVO, Tilburg, the Netherlands, 1988.

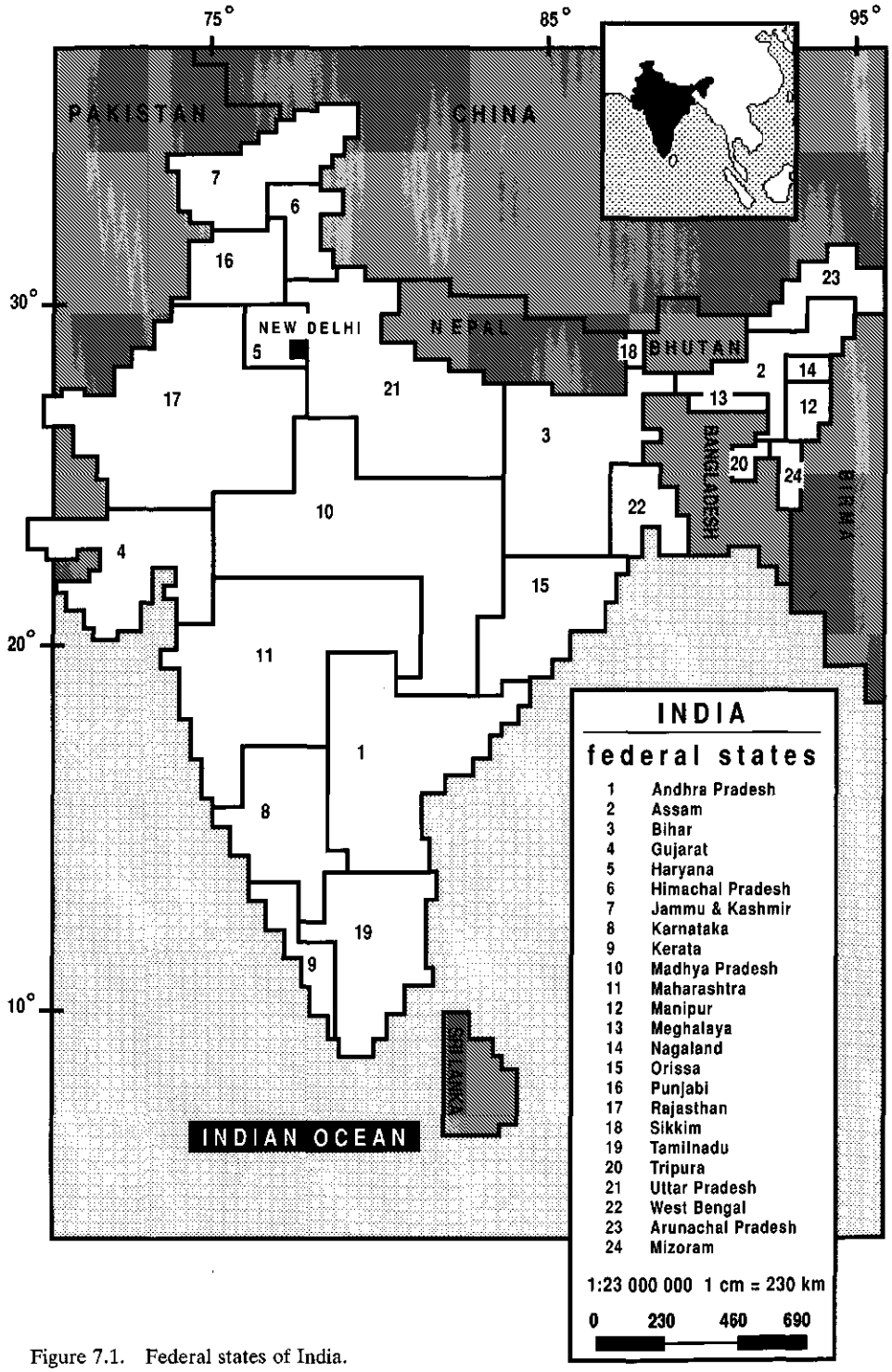

Figure 7.1. Federal states of India.

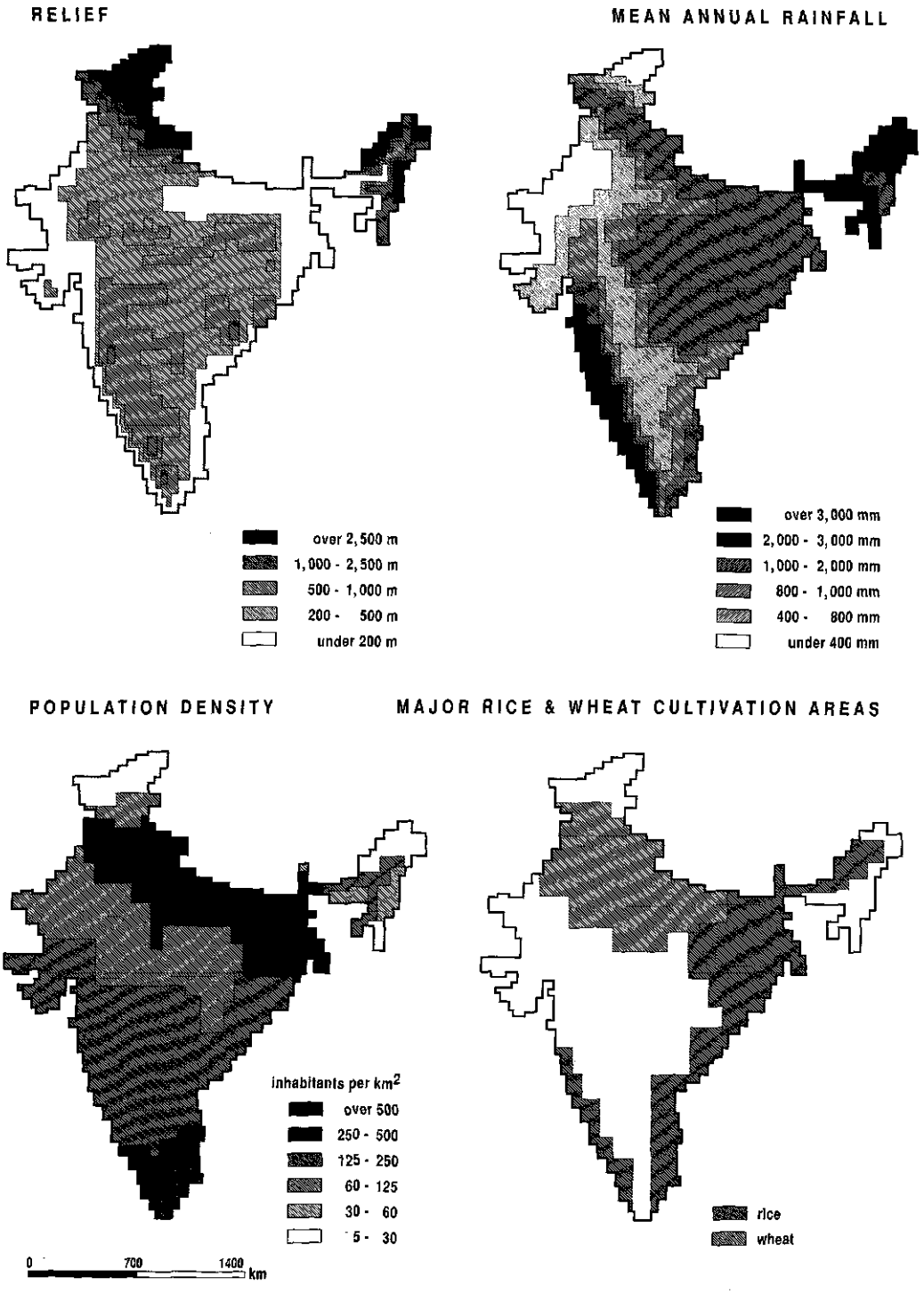

Figure 7.2. India: relief, mean annual rainfall, population density, and major rice and wheat cultivation areas.

Table 7.1. Gross sown area to agricultural crops (mln ha).

	1950	1960	1970	1980
Rice	31	34	37	40
Wheat	10	14	20	22
Sorghum	16	18	17	16
Millet	10	12	13	12
Maize	3	4	5	6
Other cereals	8	7	7	7
Pulses	20	23	23	23
Total food grains	98	112	122	126
Oilseeds	11	13	15	16
Fruit and vegetables	2	3	4	5
Fibre crops	7	9	9	9
Total other crops	20	25	28	30
Total cropped area[a]	118	137	150	156
Food grains as proportion of total cropped area (%)	83	82	81	81

Source: Indian Agriculture in Brief, 1985.

a. Gross area sown, that is net area sown plus area sown more than once per year.

Table 7.2. Size and distribution of agricultural holdings.

Size class (ha)	Number of holdings (mln)	Gross area cropped (mln ha)	Proportion under food crops 1976 (%)
Marginal (below 1)	44.5	17.5	90.1
Small (1-2)	14.7	20.9	87.2
Semi-medium (2-4)	11.6	32.3	84.1
Medium (4-10)	8.2	49.6	78.8
Large (over 10)	2.4	42.8	74.0

Source: Indian Agriculture in Brief, 1985.

During the 1970s the number of marginal and small holdings throughout India increased approximately 20%, resulting in considerable land fragmentation. However, in the State of Punjab, the heart of the Green Revolution, the proportion of marginal and small holdings decreased by 70 and 23% in 1970 and 1980 respectively.

The number of the landless in rural areas has also increased rapidly in past decades. According to Spitz (1987), the number of landless agricultural labourer households increased from 5.7 million in 1965 to 10.2 million in 1975, representing

60 million people. Seasonal employment is the only source of income for these labourers.

Pressure on land in India is high. Since Independence in 1947, the average size of a holding has decreased from 2.5 to 1.7 hectares. On the basis of farm management data from the 1950s (Sarma, 1982), the minimum economic farm size, that is the area required to meet the needs of an average family, is between 3 and 4 hectares. Using new technology, 1 hectare under double-cropping of high-yielding rice or maize followed by wheat would give an income sufficient to provide the nationally desired minimum level of consumption. In rainfed areas, the same income level could be obtained from a 2 hectares holding, with land development, application of improved technology and the necessary physical inputs (National Commission on Agriculture, 1976).

7.1.2 Growth of production

Compound growth rates of the area, yields and production of food grain crops for the period 1967-1978 are given in Table 7.3. This marks the Green Revolution period, when HYVs of wheat and rice were introduced on a large scale. Wheat showed the highest productivity increase during that period, but area expansion has also contributed to production increases. The increase in rice production, as a result of yield increase and some area expansion has just kept pace with population growth in India. Pulse and maize production fell below population growth. The situation in pulses, a basic staple, has given particular rise to concern.

Fluctuations in weather conditions, and other factors have hampered increased production of crops other than wheat and rice. The present agricultural strategy for national self-sufficiency has been achieved at the cost of other objectives, such as stability of output growth, eradication of rural poverty, and reduction in regional disparities (Hanumantha Rao, 1988).

Table 7.3. Compound annual growth rate (%) per area, yield and production of food grains in India, 1967-1978.

	Area	Yield	Production
Rice	0.8	1.8	2.6
Wheat	3.2	2.8	6.0
Sorghum	-1.5	3.6	2.1
Millet	-1.2	1.5	0.3
Maize	0.1	-0.1	0.0
All cereals	0.4	2.1	2.5
Pulses	0.7	-0.1	0.6
All food grains	0.4	1.8	2.2

Source: Sarma, 1982.

Table 7.4. Production of cereals, pulses and oilseeds in India, 1975-1986 (mln tonnes).

	Wheat	Rice	Sorghum	Millet	Maize	Pulses	Oilseeds
1975/76	29	49	10	6	7	–	–
1977/78	32	53	12	5	6	12	10
1980/81	36	54	10	5	7	11	9
1983/84	45	60	12	8	8	13	13
1985/86	46	64	10	4	7	13	11

Source: Government of India, 1987.

Since 1983/84 crop production has levelled off somewhat (Table 7.4), and drought in many areas in the past two years has severely affected agricultural output. Total cereal crop of 1987/88 was only 134 million tonnes. The buffer stock, estimated at about 23 million tonnes at the end of 1987 was, however, large enough to compensate for the production decrease. The 1990 planning for cereals and pulses is 175 million tonnes.

Production data from various states reveal great disparities in growth rates. Cereal production has increased in Punjab, Harayana and Uttar Pradesh in the past decade, whereas in most other states food production has barely kept pace with population growth. Food grain yields per hectare vary from state to state and are 2.5 times higher in the irrigated areas of Punjab than the all India average yields, while in Eastern India (Orissa, Bihar) and in rainfed areas throughout India, yields are low (Economic Survey 1986/87).

The modern methods of wheat and, to a lesser extent, rice cultivation have been quite costly in terms of energy requirements because of large-scale use of fertilizers and irrigation pumps (Singha, 1986). Without a doubt, the potential of traditional, mixed cropping has been largely neglected in agricultural research. This has resulted in increasing disparities in the Indian rural scene with many areas not benefiting from the newly available technologies. The increasing gap between 'progressive' and 'backward' agricultural areas can be attributed to the fact that the majority of marginal and smallholders lack purchasing power and access to production factors as well as to limited infrastructure in their areas.

7.1.3 Modernization, institutional change and agricultural policy

Agricultural policy is primarily aimed at self-sufficiency in major staple foods of cereals, pulses and oilseeds. India still depends heavily on imports of oilseeds, and domestic production of pulses is not yet sufficient to meet national requirements (Agrawal, 1988). In general, agricultural development focuses on food crops and is not export-oriented, except for tea, coffee, spices and tobacco.

Since the late 1950s, agricultural policy has concentrated on stimulating modern agriculture with emphasis on the agricultural model of industrialized countries. This model, while quite successful for a small minority of farmers in India, could

not be extended to all regions and to all socio-economic groups (Spitz, 1987). Therefore, stimulation of low-input agriculture, directed to the needs and capacities of the majority of small and medium-scale farmers, should receive more attention from the national agricultural research system.

7.2 Agricultural research and the development of new varieties

7.2.1 Structure of agricultural research

In the last 25 years there has been a major reorganization of agricultural research in India. The research institutes have been transferred from the administrative control of the Ministry of Agriculture to the Indian Council for Agricultural Research (ICAR), which administers national agricultural research programmes. Individual states have also transferred responsibility for agricultural research to the new agricultural universities. ICAR has organized Coordinated Crop Improvement Projects to speed up agricultural progress in the country.

In 1957 ICAR started the All India Coordinated Maize Improvement Project in close collaboration with the Rockefeller Foundation. This marked the beginning of an intensive, integrated and multidisciplinary approach to crop improvement. In 1961 the first four maize hybrids were released. At the same time the Planning Commission's report, entitled 'Improved Agricultural Seeds with Emphasis on Hybrid Maize' (1962) recommended establishment of an organization to produce foundation seed of maize, and stimulation of the private seed industry. ICAR also started the All India Coordinated Sorghum and Pearl Millet Improvement Projects in 1960. The first sorghum hybrid was released in 1964 and the first pearl millet in 1965. Encouraged by the success of these three projects, ICAR organized several research projects on other crops, or groups of crops.

Today there are 33 All India Coordinated Crop Improvement Projects[3]. One of the most successful coordinated projects, started in 1965 and has released some 114 varieties of wheat. Development of dwarf varieties by the Coordinated Wheat Project marked the beginning of large-scale production of certified seed in India (Katyal & Lal, 1986). These projects helped to generate interinstitutional and interdisciplinary cooperation, to ensure efficiency in the research programmes of experimental stations, to provide a mechanism for joint evaluation of new technologies developed by their scientists, and to arrive at a collective recommendation for the release of these technologies to farmers (Jain, 1984).

3. For more information on their mandates and locations, see Agrawal, 1988.

7.2.2 *Technological development in plant breeding*

Conventional plant breeding. Public sector plant breeding has played an important role in the seed sector in India. Agricultural universities and ICAR institutes are closely involved in cultivar development. In recent years private seed companies have also participated in variety development, including hybrids. ICAR established project directorates to improve oilseeds, pulses, millet, wheat, rice and soya bean. Agricultural universities and research institutes have plant breeding programmes on cereals, pulses, oilseeds, fibre crops, fodder crops and vegetables. Private companies are engaged in varietal development of hybrid vegetables, hybrid millet, hybrid cotton, pulses, oilseeds (hybrid sunflower) and fodder crops.

At present about 200 small and medium private seed enterprises are active in India, many of them having a turnover of more than Rs 10 million. During this research project, 40 private seed companies were interviewed in 1987/88. Of these, 15 companies supplied information on seed sales; two companies have annual seed sales of more than Rs 50 million; nine companies, between Rs 10 and 50 million annually; and the remaining four companies, less than Rs 10 milllion.

Only a quarter of these companies were established before 1970, 60% (24) between 1970 and 1980 and the remainder after 1980. About a quarter of these companies started plant breeding between 1948 and 1970, and about half between 1971 and 1985.

New and emerging technologies to support plant breeding. The potential of biotechnology in agriculture has been recognized in India. In 1982, the Government formed an interagency apex body, the National Biotechnology Board (NBTB). In February 1986 a separate Department of Biotechnology (DBT) was formed within the Ministry of Science and Technology. DBTs outlay for 1986-87 was Rs 235.2 million (approximately US$ 20 million). Actual expenditure was Rs 179.4 million, and the budget estimate for 1987-1988 was Rs 409.9 million. Great expectations of yet another revolution in agriculture through biotechnology have been expressed at various forums, but no new crop varieties have been produced by the application of recombinant DNA technology. Tissue culture has become a standard technique, and some private seed companies in India have established laboratories for this purpose. The technique is being used in various vegetatively propagated crops for rapid multiplication of sugarcane, turmeric, ginger, rubber, cardamom, bananas and a few medicinal and aromatic plants. Efforts are also under way to propagate coconut, oil palm, bamboo and papaya. India could tap the potential of biotechnology for development, but in plant breeding considerable time is required to deploy this technology to develop varieties of higher productivity and greater disease and pest resistance. In nitrogen fixation through gene transfer, and in the development of biopesticides, little progress is to be expected in the short and medium term, although opinions on this differ.

Most of the seed companies and research institutes surveyed were sceptical about

biotechnology replacing conventional plant breeding. However, conventional methods supplemented by biotechnology can have a great impact on plant breeding and improved seed production in the long term. The development of synthetics in vegetables, such as cabbage, cauliflower and capsicum, and of varieties resistant to diseases and stress conditions are two areas where major breakthroughs could come in India, according to the organizations interviewed.

Policy makers are aware of the long-term interest in biotechnology for plant breeding. An appropriate system is being developed to monitor changes and implement new inventions.

7.2.3 *Impact of new varieties*

In the early 1960s, the International Centre for Maize and Wheat Improvement (CIMMYT) suggested testing dwarf wheat cultivars developed in Mexico. In large-scale trials, some Mexican cultivars, such as Sonora-64 and Lerma Rojo-64, were found to yield significantly more under irrigation and high dosages of fertilizers than the indigenous tall cultivars. Therefore, the Government decided to import 18 000 tonnes of these cultivars in 1965/66 through the National Seeds Corporation (NSC). The import of wheat seed from Mexico, in fact, marked the beginning of the Green Revolution in India. In 1966 the HYV Programme envisaged that by 1973/74, 25 million hectares would be sown with HYVs of wheat, rice, maize, sorghum and pearl millet. This marked massive expansion of the seed production programmes by the private and public sectors.

The maximum impact of the HYV programme has been in wheat, where the coverage was 83% of the cropped area by 1985/86. Rice was next with about 57% and coverage under other cereals ranges between 30 and 46% (Table 7.5). Many farmers have changed to these improved varieties since the inception of the programme in 1966. The figures presented do not indicate the seed replacement rate.

Table 7.5. Total area cultivated and under HYV programme India, 1984-1985.

	Total area cultivated (mln ha)	HYV programme	
		area (mln ha)	proportion of total area (%)
Wheat	23.1	19.2	83.1
Rice	40.9	23.4	57.1
Sorghum	15.8	6.1	38.5
Pearl millet	10.7	5.0	46.7
Maize	5.9	1.8	30.7

Source: Ministry of Agriculture, 1987.

7.3 Seed industry

7.3.1 Historical development

India has a comparatively long history in seed industry development. The Food Grains Policy Committee, set up in 1947, submitted its report in April 1948. The main objective was to suggest policy measures for increasing food production. Some plant breeding had been undertaken under British rule. The Committee regarded the 'improved varieties of seed' as a means of increasing production. It stated that 'improved seeds raise the yield per acre by about 10%'. About 7.5% of the major food crop areas were sown to improved varieties in 1940.

Between 1947 and 1956, seed production differed little from that before Independence. In a review of the progress of the First Five-Year Plan (1951-1956), the Planning Commission observed that little progress had been made in seed multiplication and distribution. In the Second Five-Year Plan (1956-1961) it was envisaged that each National Extension Service Block should have a seed farm, seed store and a 25-acre farm for seed multiplication. Seed testing laboratories were also planned. Rs180 million was provided for seed production and related activities, of which Rs 167 million was for seed farms and the remainder for seed distribution. However, because of escalating land costs during the Second Five-Year Plan period, only 2 551 of the 4 328 seed farms planned could be established. The seed farms have not been effective and in the 1970s, with the rise of scientific breeding and creation of supporting activities for the seed industry, most of them stopped seed production.

In 1959, at the Government's invitation, the Ford Foundation examined the food production problem and outlined a strategy. Extension workers at each level were to be responsible for informing farmers about the use of improved varieties, the Agricultural Departments would take responsibility for seed certification and the cooperatives and private growers would guarantee seed supply. Development of certification standards, seed laws and seed testing laboratories in each state was also recommended. A suitable economic climate should be created in which the cooperatives and private seed dealers could contribute effectively to seed production and distribution programmes. The progress made during the Second Five-Year Plan was not encouraging, because needs of farmers were not satisfactorily assessed. The central nature of the programme made it difficult to avoid bureaucracy in communicating with the basic level.

Establishment of the National Seeds Corporation. Established in 1963, the National Seeds Corporation Ltd (NSC) is entirely owned by the Government under the Companies Act of 1956. With an initial capital of Rs 50 million, NSC began as the central agency for promotion of the seed industry in India, to initiate measures for the production of high quality seed and, in particular, to produce, process, and market hybrid seed (Sengupta, 1986). Later the corporation took responsibility for

producing and distributing certified seed of various crops. It is also involved in the multiplication of pre-released varieties of all India importance. Until the establishment of the State Seed Certification Agencies (SSCAs) in the 1960s and 1970s, NSC functioned as a certification agency in different states.

National Seeds Programme. With a loan from the World Bank, the Government of India launched the National Seeds Programme (NSP) in 1967 with the following objectives:

- to strengthen breeder, foundation and certified seed production by the NSC, State Farms Corporation of India (SFCI), State Seed Corporations (SSCs) and private companies;
- to turn the NSC into the primary coordinating body for planning and advisory services for seed production, processing and marketing;
- to create and strengthen facilities for seed testing, certification and seed technology research.

It was not envisaged that the NSC would be involved in seed production (except for vegetable seed) and certification. Instead, the NSC would be concerned with interstate seed marketing. In states without a seed corporation, seed would be marketed by the NSC, which would also coordinate production of foundation seed, operation of a buffer stock scheme and provide technical and advisory services to private companies and SSCs. However, to date the NSC is still involved in seed production, and 13 SSCs and 19 SSCAs have been established under the programme. Another phase of the NSP started in 1987 with ICAR funding, to expand infrastructural facilities for seed production and distribution to states not covered by the NSP.

The Tarai Development Corporation was established in 1969 with assistance from the World Bank. Renamed in 1978, the UP State and Tarai Development Corporation Ltd was the first attempt to organize seed production on the philosophy of 'Compact Area Development', and involved G.B. Pant University of Agriculture and Technology, Pantnagar, the progressive seed growers of the area and the NSC. Facilities for seed production were developed on 16 000 hectares, including 5 000 hectares of the university farm.

The Seeds Act and the Seed (Control) Order. Under the 1966 Seeds Act, which became effective in October 1968, labelling of seed sold in the market became compulsory, while seed certification was voluntary. Most vegetable and flower seed sold is labelled, while seed of cereals, pulses, and oilseeds is certified. Farmers have shown confidence in certified seed. During the production period, seed crops are inspected two to three times a week at different stages of crop growth to check genetic purity, incidence of diseases, weeds. If the crop meets the pre-specified field standard, a representative seed sample is sent to the Seed Testing Laboratory. If the sample meets a pre-set standard, then the certification agency of the State permits seed to be sold as certified seed. In 1983 the Government passed the Seed

(Control) Order and seed was declared an essential commodity. Production of certified seed is of great importance, at least for wheat. Certified wheat seed in India has proved to give significantly higher yield than farmer-saved seed.

Under the Seeds Act, seed below the standards set for germination and purity cannot be sold or exhibited for sale. While according to the act, certification is voluntary, and accurate labelling is compulsory. The bulk of vegetable seed and most flower seed is sold as labelled seed. Only germination and analytical purity are tested. Seed of many varieties not entered in coordinated trials, and thus not released and notified, is also sold as labelled seed. There is no plant variety protection act in India. Most private companies have expressed the wish for variety protection. However, most varieties and hybrids used by private companies have been developed by the public sector.

State Farm Corporation of India (SFCI). In 1969 the Government established the State Farm Corporation of India to manage 13 central state farms. The corporation has been entrusted with the production of breeder, foundation and certified seed of primarily food, fodder and fibre crops. Some 21 500 tonnes of seed of pulses, oil crops, cereals, fibre crops and vegetables was produced in 1985/86. The seed production target for 1986/87 was 26 400 tonnes, about 4% of the total quality of seed produced in India.

7.3.2 Institutional framework and government policies

Many organizations are involved in the development and release of new varieties. The All India Coordinated Crop Improvement Projects are responsible for testing and identifying varieties for release. Agricultural Universities and ICAR institutes coordinate the plant breeding programmes and have major responsibility for basic and applied breeding work. The direction and speed of the development of the Indian seed sector is largely determined by public sector institutions. The structure of the Indian seed industry is presented in Figure 7.3.

Testing, release and notification of new cultivars. The Central Varietal Release Committee was established in October 1964 within ICAR, and in November 1969 its functions were taken over by the Central Seed Committee established under the 1966 Seeds Act (Tunwar & Singh, 1985). A Central Subcommittee on Crop Standards, Notification and Release of Varieties was established to make recommendations on the release and notification of cultivars of national importance, minimum standards for germination and purity of released and notified cultivars, delimiting the regions for cultivation of each approved variety, and the particulars of the 'label' in respect of notified varieties.

Before release, varieties are tested for three years in All India Coordinated Research Projects. Based on performance, they are identified for release for a specific agroclimatic region, and subsequently tested at the government farms for

adaptation (adaptation trial). Simultaneously, seed is produced by the SFCI for distribution in 5 kg mini-kits to farmers for testing.

Breeder seed is produced by the agricultural universities and institutes which developed the particular variety. A variety found to be superior in adaptation and mini-kit trials is proposed for release by the coordinated project. The proposal is

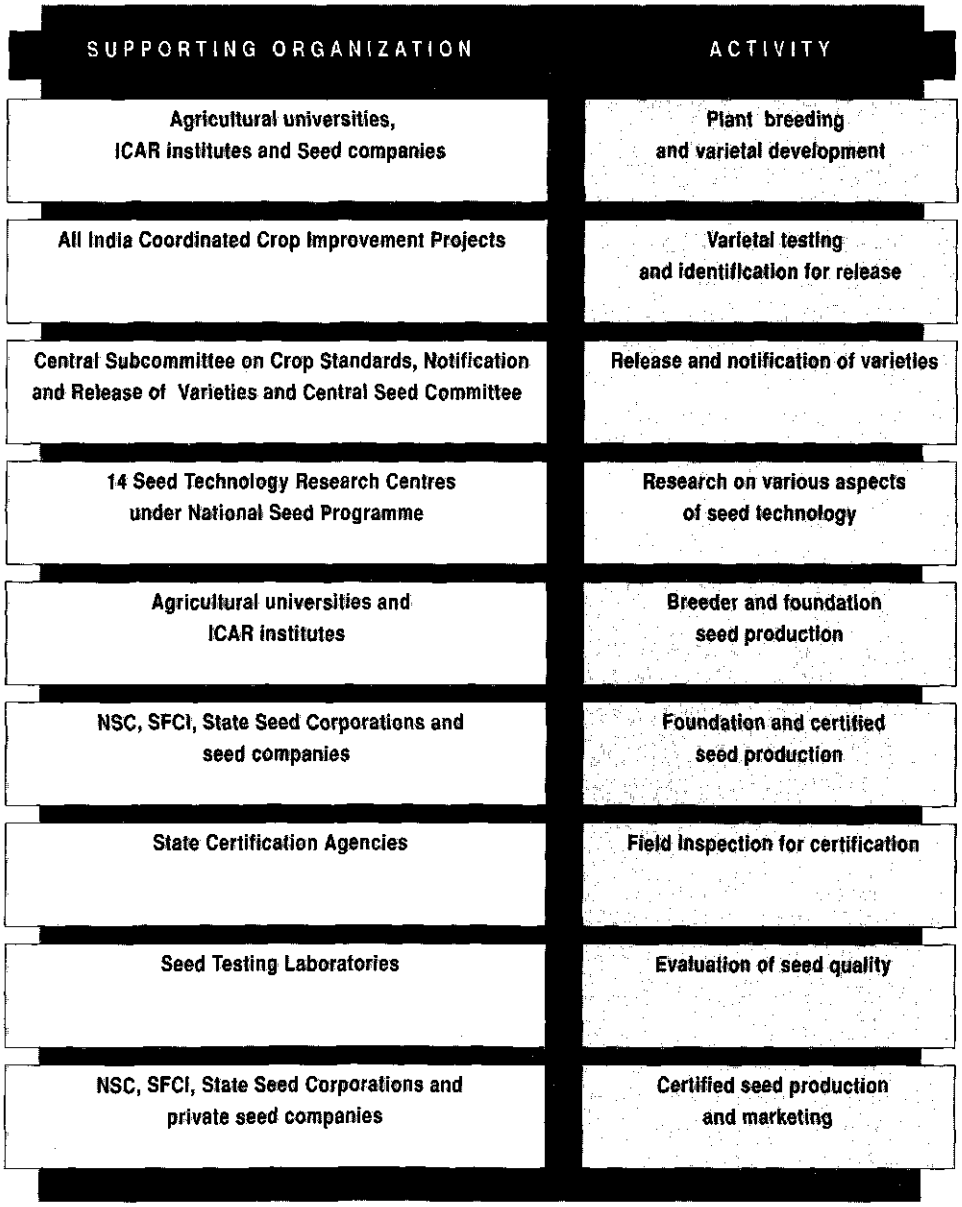

Figure 7.3. Structure of the Indian seed industry.

examined by the Central Subcommittee on Crop Standards, Notification and Release of Varieties, which comprises scientists, directors of agriculture and seed certification agencies, seed companies and farmers. The Deputy Director General (Crop Sciences) of the ICAR is the chairman of the committee. A variety found to be superior to the existing ones is recommended by the Central Subcommittee to the Central Seed Committee for release and notification. A variety becomes eligible for certification only after notification. In total, 2 004 cultivars of 106 crops have been released and notified (Tunwar and Singh, 1985). Many cultivars no longer grown will be eliminated from the list as soon as a system of denotification becomes operative. The procedures for release and notification are many and are time-consuming to implement.

Since its inception, the seed industry has been developed by the Central Government in New Delhi. Decentralization in planning has largely been neglected. This 'top-down' approach has hampered efficient development of plant breeding, seed production and seed marketing systems directed to the needs of the majority of farmers.

Private companies either have their varieties released and notified according to the established procedure for seed production, or sell labelled seed which have not been released and notified. Cooperation between private and public seed companies, and between private seed companies and governmental control stations, has never been optimal in India because of conflicting interests in plant breeding programmes and seed testing procedures and above all, seed marketing strategies.

System of seed production. In India, the consecutive generations in seed production are breeder, foundation and certified seed. This system operates for all seed produced, although most vegetable seed producers sell labelled instead of certified seeds.

The requirements for breeder seed are received by the Seed Division, Ministry of Agriculture. These indents are compiled and sent to ICAR for organizing production, and subsequently to the respective crop coordinators, who plan the production programme with the help of the respective breeder at the annual workshop of the All India Coordinated Research Projects. The breeder seed production programme, which comprises 33 units, is constantly monitored. Breeder seed is mainly produced by the agricultural universities and research institutes, and in some cases also by SFCI, NSC and SSCs.

Breeder seed is produced by a qualified plant breeder, working full time on developing superior varieties with the assistance of a team of scientists. Currently, breeder seed is not certified but is monitored for quality during production by a joint inspection team comprising of the crop breeder, producing breeder, one representative of each of the crop coordinating projects, the SSCA, and NSC. However, there is a strong move towards bringing breeder seed production within the purview of seed certification.

Breeder seed is supplied to the NSC, SFCI, SSCs and reputed private seed

companies for the production of foundation seed. According to the Ministry of Agriculture, 391 tonnes and 2 364 tonnes of breeder seed were produced in 1981/82 and 1985/86 respectively. Up to 30% was rejected because of disease, poor seed quality as a result of bad weather, and low genetic and physical purity. Major problems in breeder seed production are the isolation requirements; lack of supervisory assistance and funds; lack of nucleus seed; lack of planning for production, distribution, seed processing and disposal; and in the case of potato seed, virus infection. The price of breeder seed is fixed by the Ministry of Agriculture, and should be 50% higher than that for NSC foundation seed. However, the price of breeder seed varies substantially. The production of foundation seed is certified. Seed is produced by the agricultural universities, NSC, SFCI, SSCs and a few reputed private companies. The SSCs produce foundation seed to meet local requirements, while foundation seed of national varieties is produced by the NSC and SFCI. Preference for the production of foundation seed is given to the agricultural universities because of their expertise and technical competence.

Certified seed is produced by the NSC, SFCI, SSCs and private seed companies. The SFCI produces certified seed on its own farms in different parts of the country, for example, Rajasthan, Haryana, Uttar Pradesh, Tamil Nadu, Punjab, Madhya Pradesh and Assam. The NSC, SSCs and private seed companies produce certified seed mostly through contract growers. The SSCs produce the bulk of agricultural seed, in particular wheat and rice, as well as hybrid varieties of sorghum, millet and maize.

Seed certification and quality control. Seed certification consists of inspection of the seed crop by the SSCAs during appropriate stages of growth. In states without a seed certification agency, this is done by the NSC. Seed certification is not optimal and many problems are incurred during the process.

Seed quality analysis is carried out in the Seed Testing Laboratories in different states. There are 74 such laboratories, of which 54 are authorized to test seed quality under the Seeds Act. Normally, germination, analytical purity and seed moisture content are tested. Some laboratories also have facilities for seed health testing. Based on the report of field inspection and seed testing, the certification agencies issue the certification tag to seed meeting the minimum standards prescribed by the Central Seed Committee. Certification standards are constantly under review and the Central Seed Committee is at present revising minimum standards.

Seed pricing policies. Prices of agricultural commodities are determined on the basis of recommendations made by the Commission for Agricultural Costs and Prices, in consultation with the State Governments, relevant central ministries and the Planning Commission. Each year the Government announces procurement and support prices for major agricultural crops and organizes purchase operations

Table 7.6. Procurement/support price of grain, sale price of certified seed and seed/grain price ratio, India 1986/87.

Commodity	Support price (Rs/kg)	Certified seed price (Rs/kg)	Seed/grain price ratio
Rice, common variety	1.46	3.75	2.6
Wheat	1.62	3.95	2.4
Hybrid sorghum	1.32	13.90[a]	10.5
Hybrid pearl millet	1.32	9.76[a]	7.4
Red gram (pigeon pea)	3.20	10.50	3.3
Green gram (mung bean)	3.20	10.00	3.1
Black gram (urd bean)	3.20	11.00	3.4
Soya bean (yellow)	2.90	8.30	2.9
Hybrid sunflower	3.50	38.50[a]	11.0
Safflower	4.00	7.00	1.8
Rape and mustard	4.00	9.50	2.4

Sources: Own survey and NSC data, 1987; support price from the Commission for Agricultural Costs and Prices, 1987.

a. Average for private and public seed companies.

through public agencies, such as the Food Corporation of India. This is to ensure farmers of remunerative prices, to encourage them to invest and to produce more, and to safeguard the consumers' interest by making supplies available at reasonable prices.

The Government of India does not set seed prices; the NSC, SSCs, private companies and other organizations are free to determine their own prices. Nevertheless, the price declared by the NSC and the SSCs influences those set by private companies. Normally the cost of certified seed is two to three times higher than the procurement and support price of the grain. The prices of hybrids are not related to the support prices (Table 7.6). Seed prices of non-hybrid varieties offered by the NSC and SSCs are quite high compared with the price of grain. This may be an important reason for the low annual replacement. On the other hand, the NSC and SSCs have not been able to offer lower prices because of the high cost.

In conclusion, because of the prevailing price structure for quality seed, poor seed quality control, and bureaucratic procedures for seed release, farmers have been reluctant to buy seed in large quantities. Apart from the high-input farming systems in the Northern Plains, the main seed used is that saved by farmers.

7.3.3 Private sector involvement

Initially, the private seed industry was active only in the production of vegetable and flower seed. Until 1939, most vegetable seed was imported from Australia, West Germany, the United Kingdom and the USA. With the outbreak of the Second World War, vegetable seed production was developed in the North-West

Frontier Province (Quetta, now in Pakistan) and Saharanpur (Uttar Pradesh). In 1945 a few enterprising seedmen developed temperate vegetable seed production in Quetta and Kashmir, establishing contacts with foreign seed firms and developing export markets for Indian vegetable seed. Over the years, several firms have organized vegetable seed production.

Establishment of domestic private seed companies. In the past 15 years many private companies have been established in India. Production and marketing of hybrid agricultural seed (such as sorghum, pearl millet, maize, sunflower and cotton) and hybrid vegetables have expanded considerably. Due to the high profit margin, private seed companies have concentrated on hybrid varieties that have in-built protection, making it impossible for farmers to reproduce them. The Government has tried to create a favourable atmosphere for the growth and development of the private seed sector, and public institutions are providing loans for such development. Yet most new varieties used and produced have been developed by public sector organizations. In our own survey, some private companies reported collaboration with foreign organizations, especially companies in oilseeds and vegetables, which are based in the USA. The private companies have developed at least 122 varieties: 55 of vegetables, 39 of millet, 13 of cotton, nine of oilseeds, four of fodder and two of pulses. About 70% of these varieties are hybrids.

In 1986, the Government decided to provide private seed companies with breeder seed of self-pollinated varieties of wheat and rice. However, because of a surplus of wheat seed in 1984/85, most of the private seed companies did not increase production of breeder seed of wheat.

The largest company, Maharashtra Hybrid Seed Company (MAHYCO), based in Bombay and distributing seed throughout India, had estimated seed sales of US$ 30 million in 1987/88. Most private seed companies are still in an early stage of development. Several seed companies in industrialized countries have established contacts with these companies in India, mainly to participate in the development of the emerging commercial seed market.

Emergence of foreign seed companies in India. Multinational companies, such as Hindustan Lever (Unilever), Sandoz, Ciba Geigy and Cargill, have plant breeding programmes in India, although participation in seed industry development is a fairly new phenomenon. The only major foreign seed company is Pioneer Hi-Bred, the largest seed company in the world. Smaller foreign seed companies have also shown interest in establishing a subsidiary in India. Most of the public and a quarter of the private institutions in our survey thought that transnational companies would start activities in India. Some said that the process had already started but would continue slowly because major areas are cultivated by marginal farmers whose socio-economic situation demands a low-cost production technique not offered by foreign companies. Further, bureaucratic and inefficient organization of public institutes restricts their entrance, while profitability is the only motive for transna-

tional corporations. Some respondents thought that the entry of the transnational corporations would depend on government policy. Most institutions, public and private, thought it desirable to increase collaborative programmes with biotechnology companies and research institutions in Europe and the USA. Only 8% of the public institutions considered this to be undesirable.

The major reasons mentioned for collaboration were:
- to develop a biotechnology programme for pulses;
- to gain access to advanced technology for progress;
- to increase training of Indian scientists;
- to accelerate agricultural research programmes;
- to compete in the international seed market;
- to breed better disease-resistant and pest-resistant varieties, including hybrids;
- to facilitate recombining characters in vegetatively propagated crops, rapid multiplication of identified genotypes with less variability, and exploitation of somaclonal variability.

The position of foreign seed companies has been a matter of constant debate in the past years. In September 1988 the Ministry of Agriculture announced a new policy for seed development, aimed at liberalizing seed imports and stimulating foreign involvement in the development of the industry (Seed Tech News, 1988). This policy has been criticized in India because it will lead to high dependency on the technology and imported seed of foreign companies, and undermine the policy of developing indigenous technology.

7.3.4 International cooperation in the seed industry

Many public institutions have collaborative projects with IARCs. The All India Coordinated Crop Improvement Projects on millet and sorghum have a collaborative research programme with ICRISAT, Hyderabad. The rice improvement programme collaborates with IRRI, Philippines, and the Central Potato Research Institute with the International Potato Centre, Lima, Peru; the Wheat Research Programme collaborates with CIMMYT, Mexico; the Barley Research Programme with ICARDA, Libyria; the Assam Agricultural University with AVDRC in Taiwan and with IRRI; the GB Pant University with IDRC, Canada; the Narenda Dev University of Agriculture and Technology, Faizabad (Uttar Pradesh) with CGIAR members ICRISAT, IRRI and IITA, Nigeria, the Rajendra Agricultural University, Pusa (Bihar) with IRRI, ICRISAT and CIMMYT.

The World Bank and other foreign agencies have invested considerably in seed production facilities, such as the Tarai Seed Corporation. Transfer of seed related technologies has been important in establishing the Indian seed industry. Still, the Indian policies have been based on 'self-reliance'. The Indian seed industry is largely protected from foreign competition. Apart from seed multiplication for export, mainly horticultural seed, export is negligible; India has so far not been able to meet the international quality standards for seed trade.

7.4 Seed supply and demand

7.4.1 Assessment of demand

Assessment of seed requirements is critical to the success of a seed programme. However, the factors determining seed demand are complex and not easy to quantify. Seed demand depends largely on price, timely monsoon, and spread of disease. Demand for hybrid seed is comparatively easier to estimate than for non-hybrid seed, since hybrid varieties are replaced every year. Assessment of seed demand of non-hybrid crops depends on the annual seed replacement of existing varieties by fresh certified seed; replacement of seed with a new variety or a new crop; and increase in seed use as a result of extension of the area cultivated. Demand is also influenced by seed quality, the farmers' conviction of the advantages of quality seed, and price in relation to the benefits derived.

According to the assessment of the Indian Institute of Management, Ahmedabad, the seed requirements in 1985 would be 1.86 million tonnes, about four times higher than the requirement estimated by the Government of India (Asopa & Desai, 1973). The total quantity of seed sold in 1984/85 was 490 000 tonnes and the production figure for 1985/86 was 550 000 tonnes (Table 7.7). In general, demand assessment has been too optimistic. Most estimates presuppose an annual replacement of about 20-25% of all seed requirements. In practice, annual replacement is far lower, and for basic food crops seldom exceeds 5-10%.

Demand forecasting has proved to be difficult. For example, in 1983/84 a shortage of wheat seed resulted in a higher target for seed production. Consequently, this led to higher production of wheat seed in 1984/85 which could not be sold, and resulted in a substantial carry-over of wheat seed throughout the country. The NSC alone lost about Rs 22 million in 1985/86. Thus, there is a need to evolve proper procedures for demand forecasting. Private seed companies, farmers' cooperatives, and individual farmers should be more involved in developing seed

Table 7.7. Seed production (1000 t) of improved varieties[a], India, 1980-1987.

	Certified seed	Labelled seed	Total
1980/81	189.5	60.6	250.1
1981/82	171.7	126.3	298.0
1982/83	249.7	170.9	420.6
1983/84	272.3	177.7	450.0
1984/85	348.3	136.3	484.6
1985/86	486.4	63.7	550.1
1986/87 (provisional)	n.d.	n.d.	558.1

Source: Ministry of Agriculture, 1987.

a. Cereals, pulses, oilseeds, fibre crops and fodder crops.

n.d.= no data.

distribution systems in India. They are more flexible towards the demand and can cover sections of the market that public institutes cannot serve.

The bulk of the seed produced is cereals, particularly wheat and rice. Wheat alone makes up approximately 30% of total seed produced. There is no seed import for cereals, pulses and other agricultural crops. India has exported seed of these crops to several developing countries in Asia and Africa, but no data are available on seed imports and exports.

Data on vegetable seed production are also not readily available. However, information obtained during interviews indicates a large market for improved vegetable varieties including hybrids. Many private seed companies operate in this market. Most of the plant breeding is done by public organizations such as IARI in New Delhi and the Indian Institute of Horticultural Research (IIHR) in Bangalore, and the seed is multiplied and marketed by private companies. Hybrid vegetable varieties are in short supply, although the great demand has resulted in large-scale seed imports. Plant breeding by public and private companies, and other research efforts have been initiated in order to attain self-sufficiency in hybrid vegetable seed. Non-hybrid varieties are largely developed by public organizations. The total market value of vegetable seed as estimated by the seed companies is presently about Rs 1 billion.

Production and distribution of improved varieties, including hybrids has grown considerably. The commercial seed market in India is estimated to be worth Rs 5-6 billion. Data for selected crops are given in Table 7.8.

The potential commercial market is difficult to assess, but based on the research

Table 7.8. Estimated market of selected hybrid and non-hybrid varieties, India, mid-1980s.

	Volume (1000 t)	Value (Rs mln)
Non-hybrid varieties		
wheat	158.0	650
rice	132.0	550
vegetable varieties	n.a.	750
coarse cereals varieties	50.0	200
pulses	23.0	250
groundnuts	38.0	300
Hybrid varieties		
sorghum	25.0	400
maize	13.0	150
pearl millet	15.4	150
cotton	3.4	350
vegetables	n.a.	250

Source: Agrawal, 1988.
n.a. = not available.

of the past five years, Indian seed industry sources expect the commercial seed market to increase to Rs 24-30 billion by 1995-2000 (estimates from country-survey, 1987). Planning in this way may lead to great problems, however, because of the many factors inhibiting growth, particularly on the demand side.

Important constraints were identified in the surveys carried out. Most public organizations found that in increasing improved seed production, the extension efforts and advertisements through radio and television should be strengthened. Other suggestions included are increasing storage facilities, improving seed quality, introducing compulsory crop insurance for improved varieties and create efficient distribution systems.

Private seed enterprises consider that the most important barrier to increasing the use of improved varieties is non-availability, insufficient quality and quantity, and the inadequate infrastructure. Interestingly, private seed companies feel that the price of improved varieties is not too high to increase use. The explanation is that they produce for the market of hybrid varieties, where the price of seed and grain is not interrelated.

7.4.2 Traditional seed supply systems

Traditional seed supply systems refer to seed retained by the farmers for the following growing season and farmer-to-farmer seed exchange. These seed supply systems are very important in Indian agriculture; every year more than 85% of the seed used is produced by the farmer (Banerjee, 1984). For wheat and rice these estimates are even higher (Table 7.9).

The traditional seed supply system is important in view of the low replacement in non-hybrid crops. Assuming a 5-10% annual growth in seed sales of improved varieties, traditional seed supply will still be important at the end of this century. Thus, action has been taken by public agencies involved in seed production to develop models for improving traditional seed supply systems in six districts in different states under operational research projects and 'Lab to Land' programmes.

Table 7.9. Distribution of certified seed as a proportion of total seed requirement, India, 1986-1987.

	Area cropped 1986/87 (mln ha)	Seed rate (kg/ha)	Seed required (1000 t)	Seed distributed (1000 t)	Proportion of requirement distributed (%)
Wheat	23.07	100	2 307	158	6.8
Rice	40.31	30	1 209	132	10.9
Sorghum	15.78	10	158	49	31.1
Millet	10.68	4	43	24	56.2
Maize	5.87	20	117	15	12.8
Pulses	22.80	30	684	23	3.4

Source: Ministry of Agriculture, 1987; data on pulses from NSC.

To overcome one of the most common problems, seed storage at the micro-level, IARI has developed a low-cost storage structure called PUSABIN for on-farm storage of seed.

7.5 Major results and constraints in seed industry development

Despite considerable progress, the use of seed of improved varieties has lagged far behind estimates made a decade or so ago. Seed production in 1985 was 28% of this estimate (Table 7.10). To reach the NCA target, seed production of improved varieties should grow by almost 13% annually up to the year 2000. Most SSCs are incurring losses for various reasons, such as the production of seed of self-pollinated crops (high volume/low profit trade), high overheads, and unused processing capacity.

A long tradition of seed industry development, together with the industry's scientific and technological basis, places India in a good position to restructure its seed sector according to prevailing needs. There is an appropriate supporting infrastructure, but training and refresher courses have to be expanded to meet growing needs. Attention must also be given to the developing a network of seed storage facilities, and a methodology for forecasting seed requirements in order to prevent economic losses. The economic and technical limitations to expanding irrigation means that the next increase in agricultural production must come from rainfed areas. The seed industry should respond to this by developing appropriate technology for crop and seed production under these conditions.

Most private and public institutions see genetic erosion as a threat to agricultural production. To overcome this, infrastructural facilities to collect, evaluate, catalogue and conserve germ plasm should be expanded. A larger number of cultivars of diverse genetic background need to be developed, instead of the one or two being released as at present.

Table 7.10. Estimated seed requirements, 1985 and 2000, and production, 1985 (1000 t).

	Estimated requirement		Production 1985	Proportion of requirement produced (%)
	1985	2000		
Cereals	719.6	977.0	261.1	36.3
Pulses	150.7	306.0	20.9	13.9
Oilseeds	225.1	438.0	65.3	29.0
Fibre crops	96.1	240.0	14.1	14.7
Other	99.0	247.0	0.7	0.7
Total	1 290.5	2 208.0	362.1	28.1

Sources: Estimates NCA, 1976; Ministry of Agriculture, 1987.
Note: Based on replacement rates given in NCA report, 1976.

Even though most farmers use seed retained from their own fields or obtained from local sources, India has a well-developed formal seed supply system built up over the past 30 years. Most activities, from plant breeding to seed marketing, are undertaken by the public sector. However, lack of flexibility of organizations in this sector and the high cost structure have hampered development of an effective marketing system. High seed prices unrelated to actual demand, and bureaucracy, especially towards domestic and foreign private seed companies, have also impedimented the seed industry.

A selective approach to open up the industry to domestic and foreign companies will undoubtedly increase the effectiveness of the formal seed system and might, in the long term, make India a significant seed exporter in the region. In September 1988 a new seed policy was implemented to make the seed industry more competitive through selective import measures and to encourage joint ventures between domestic and foreign companies. The infrastructure is there to improve the seed industry. Yet because of the importance of the informal seed supply systems, efforts need to be directed to decentralization in order to prevent increasing disparities between the formal and informal seed supply systems.

8 Seed industry in Thailand[4]

8.1 Role of agriculture in the Thai economy

The Thai economy has enjoyed steady growth throughout the past two decades, performing well during the vicissitudes of the world economy compared with other developing countries. The average growth rate of the GDP was one of the highest in the Asian countries, especially during 1980-1985 when it was 5.1%. Annual growth of GDP was 7.4% between 1965 and 1980. The agricultural sector showed a slower growth rate compared to the industrial sector. Nevertheless, the agricultural GDP grew annually by 4.9% between 1965 and 1980 and by 3.7% between 1980 and 1985, which was considerably higher than in neighbouring countries. Maintenance of high economic growth was achieved by taking advantage of rich resources, such as abundant fertile land. The increase in agricultural exports enabled the economy to maintain a stable exchange rate which led to a relatively low level of inflation and enhanced growth of the non-agricultural sector. Some figures illustrate how the agricultural sector's share of the GDP has declined steadily over the past two decades; a trend which will continue. In 1960 its contribution to GDP was about 40%; by 1985 this had fallen to 19.5%. In the mid-1980s the agricultural labour force still constituted almost 70% of the total labour force, although this percentage was over 85% in the mid-1960s (World Bank, 1985).

Thailand is a net exporter of agricultural products and a net importer of manufactured products. Crops, such as cassava and rubber, are grown solely for export. Thailand is one of the few countries in the developing world with a food surplus. Food crops and processed food make up about 50% of the total export value. Although this figure has remained more or less constant, there has been a substantial change in composition. The share of rice has declined from about 40% in the 1950s to less than 15% in recent years, while the proportion of processed food has increased considerably (Table 8.1).

Government policies stimulated the expansion and diversification of exports to

4. This chapter is based on research undertaken by Dr S. Setboonsarng, Thailand Development Research Institute, Bangkok, Thailand and Dr. S. Wattanutcharya and Mr. B. Puthigorn, Kasetsart University, Bangkok, Thailand. For a detailed account of this research project see: Seed industry in Thailand: structure, conduct and performance. IVO, Tilburg, the Netherlands, 1988.

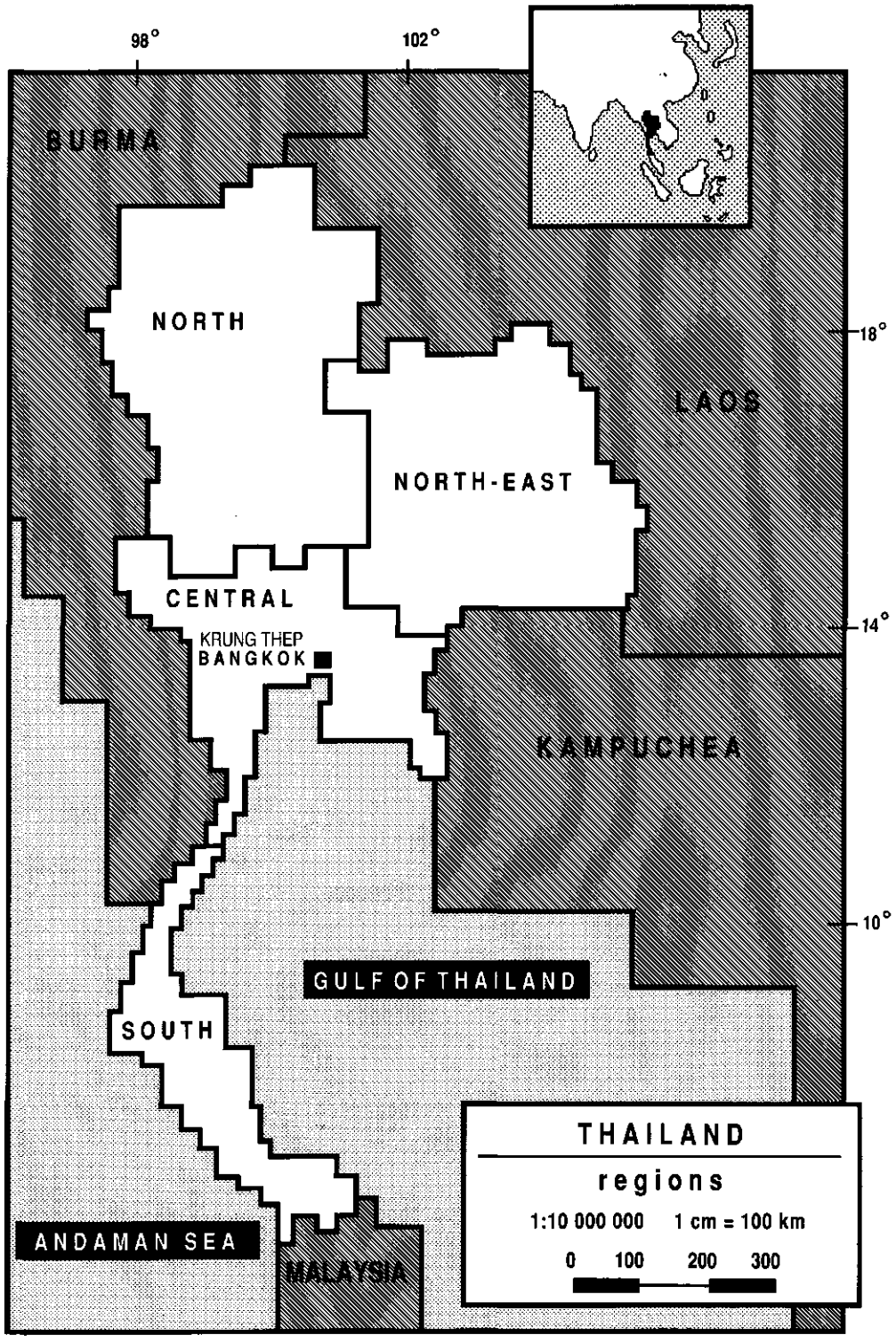

Figure 8.1. Regions of Thailand.

Table 8.1. Proportion of food crops and processed food of total agricultural exports, Thailand, 1960-1985.

	1960/70	1970/80	1980/85
Food and processed food	50.8	50.1	49.2
Rice	29.3	15.1	14.3
Tapioca products	5.3	10.3	10.2
Sugar	0.6	6.0	4.5
Maize	9.9	7.4	5.2

Source: Bank of Thailand, Monthly Bulletins.

maintain steady growth. Export taxes on traditional agricultural commodities (such as rice and rubber) acted as indirect subsidies. For other agricultural commodities, taxes lowered production costs and thus speed up the process of diversification.

8.1.1 Land use, holdings and fragmentation

About 38% of the 51 million hectares is arable land; the remainder consists of forest (30%), national parks (5%) and unclassified land (27%). The total cultivated area increased from about 7.5 million hectares in 1960 to 14.6 million hectares in 1985 (Table 8.2). The average annual growth rate of about 3.4% has been unmatched in other Asian countries.

Expansion of the cultivated area mostly results from the increase in area of field crops which occurred in three distinct periods. It began with the expansion of maize in the early 1950s, and again in the early 1970s. The second period was expansion of cassava in the late 1960s, and the third period was the sugarcane expansion in the early 1970s. The direct consequence of this growth in cultivated area was a relatively low output per hectare, although Thailand had the highest output per worker in Asia.

In Thailand most farmers are smallholders depending on many crops and agricultural activities, while large-scale farmers tend to specialize in one particular crop. The average farm size ranges from 1 to 5 hectares, the number of marginal farms

Table 8.2. Proportion of total area cultivated with major crops, Thailand, 1960-1985.

	Total area	Proportion(%)					
	(1000 ha)	rice	maize	cassava	sugarcane	soya bean	other
1960-1965	7 574	84.6	5.8	1.3	1.8	0.3	6.0
1965-1970	9 029	79.8	7.9	1.6	1.3	0.5	8.9
1970-1975	10 606	74.9	10.3	3.2	2.2	0.9	8.5
1975-1980	13 039	70.8	10.4	6.6	3.7	1.0	7.4
1980-1985	14 645	66.4	11.5	9.0	3.8	1.1	8.1

Source: Office and Agricultural Economics, Ministry of Agriculture and Cooperatives, 1986.

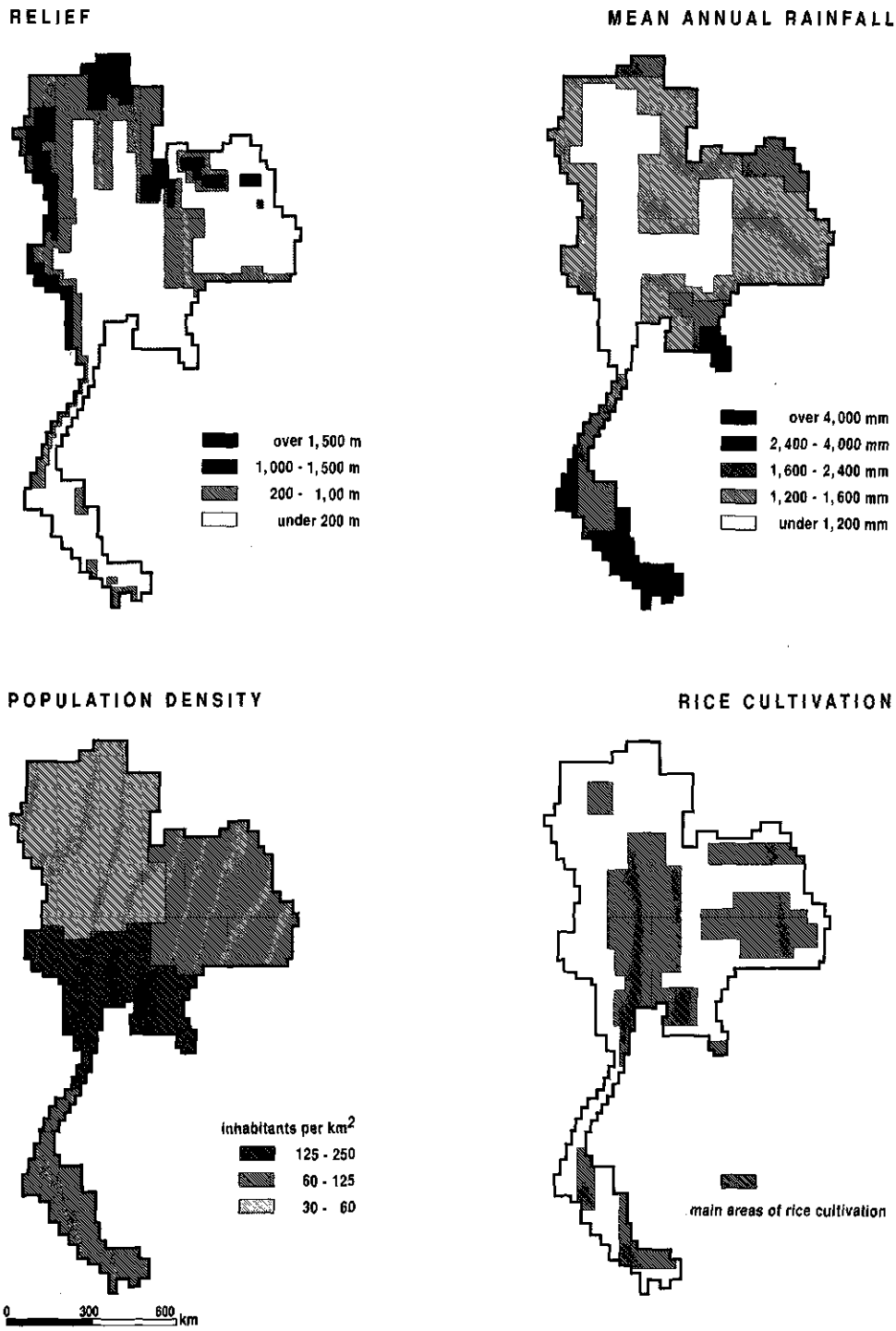

Figure 8.2. Thailand: relief, main annual rainfall, population density and rice cultivation.

being low compared to other Asian countries. This pattern (Table 8.3) will alter in the near future when land is no longer abundantly available. Without the luxury of much land, the use of modern technology, especially high yielding varieties, will be the essential source of growth for the agricultural sector.

8.1.2 Growth of production

Growth in agricultural production in Thailand has been above the world average for some decades. This steady growth in spite of the economy's openness to the world market and fluctuation in international commodity prices can be explained by two factors: firstly, product diversification in the agricultural sector and secondly, government pricing policies which have reduced the effects of fluctuating world prices on the domestic prices (Siamwalla & Setboonsarng, 1987).

Diversification of production has allowed a high degree of flexibility. This is not immediately obvious from a comparison of the value added share of various components in the agricultural sector. The total contribution of crops, livestock, fishery and forestry to the GDP has altered only marginally in the past two decades. The most significant changes have occurred in crop and livestock production.

8.2 Agricultural research and development of new varieties

8.2.1 Structure of agricultural research

Government policies during the past two decades have drawn resources from the agricultural sector, directly by taxing agricultural exports, and indirectly, by protecting the industrial sector. Investment incentives and import tariff protection were available to the import-substituting industries during the 1960s and 1970s. The Government has now turned to promoting export industries. The overvaluation of foreign exchange, which has protected the import substituting industries, has made the price of the agricultural product less attractive on the world market and became

Table 8.3. Size and distribution of agricultural holdings, Thailand, 1963 and 1978.

Size class (ha)	Proportion of holdings (%)		Proportion of land area (%)	
	1963	1978	1963	1978
< 0.3[a]	–	1.6	–	0.0
0.3 - 1.0	15.2	14.3	2.5	2.3
1.0 - 2.4	30.6	27.4	13.0	11.4
2.4 - 4.8	28.7	29.0	26.6	25.7
4.8 - 9.6	20.0	21.4	35.7	36.3
> 9.6	5.6	6.3	22.2	24.3

Source: Agricultural Census, 1963 and 1978, National Statistical Office, Thailand.
a. Farms less than 0.3 ha not included in the 1963 Agricultural Census.

an implicit tax on the agricultural sector (Siamwalla & Setboonsarng, 1987).

The Government transfers resources to the agricultural sector through public investment programmes. Apart from irrigation, investment in agricultural research and extension are important activities benefiting the sector. Although investment in agricultural research is small given the importance of this sector, there is a steady growth trend. Expenditure increased from 0.5% of the agricultural value added in 1975 to 0.75% in 1984 (Isarangura, 1986).

Foreign agricultural research institutes have played an important role in Thai agricultural research, although their involvement is small in terms of expenditure (1-2% of the total budget). They provide genetic material, experts and collaborative research. Most of Thailand's agricultural research is conducted by the public sector, the major problem being lack of cooperation among agencies.

8.2.2 Conventional plant breeding: organization of research

At present some private companies are involved in limited plant breeding of cash crops such as maize, sorghum, flowers and vegetables. Most research and breeding is still carried out by the public sector, mainly by the Department of Agriculture (DOA) of the Ministry of Agriculture and Cooperatives. Research concentrates on applying new knowledge about plant breeding to Thai agriculture. Basic plant breeding research is done by universities such as Kasetsart and Chulalongkorn in Bangkok, Chiangmai in the north, Khon Kaen in the northeast, and the Prince of Songkhla University in the south, which specialize in the crops common to their region.

Since 1972, the Department of Agriculture has organized plant breeding in response to the growing demand for applied research in crops other than rice. At present, research is undertaken by six institutes working on rice, field crops, horticulture, rubber, farming systems, and mulberry and silkworms. Each institute is responsible for research, technology development and technology transfer specific to their assignment, although in practice the research overlaps.

Rice research. The Rice Research Institute, established in 1935, is currently responsible for all aspects of rice research and development. There are six regional research centres and 18 experimental stations throughout the country. Rice research is the most important activity of the DOA.

Field crop research. Increased cultivation of maize and other field crops has necessitated participation of the public sector in research and extension of these crops. Although work had been done previously on field crops, this was not recognized as a separate research activity until 1972. The Field Crop Research Institute was established in that year, concentrating particularly on maize and sorghum. The institute is composed of seven research centres which control a further 12 satellite research stations. Each research centre concentrates on one or two field crops, in

addition to a range of multidisciplinary research activities. The satellite research stations are mainly regional testing sites supporting this research. One of their major tasks is to supply sufficient quantities of seed of recommended crop varieties to the Department of Agricultural Extension (DOAE) to meet farmers' requirements. Seed is supplied to farmers in the vicinity of the field crop research centres and stations.

Horticultural research. Fruit and other horticultural crops account for approximately half the total value added in the agricultural sector. The Government has put little effort into research on these crops, partly because they are used mostly for domestic consumption. However, fruit and flowers have gained a larger proportion of agricultural export. The Horticultural Research Institute now has six research centres with ten satellite experimental stations throughout the country[5].

8.2.3 Impact of new varieties

Most rice seed used by the farmer is selected and retained from the previous harvest. Although there is a long history of public research to improve rice varieties, much could still be done in view of the importance of rice in the economy. Farmers frequently use new varieties of rice and other crops, but seed replacement is low (Wattanutchariya, 1987).

8.3 The seed industry

8.3.1 Institutional framework and government policies

Thailand's seed industry was established in 1976 with the formulation and implementation of the National Seed Programme (NSP) to coordinate the activities of various government agencies involved in seed production and distribution.

The NSP aims to promote the use of high-quality seed, thereby increasing farmers' productivity and income, to multiply high-quality varieties developed by the DOA and other research institutes and to encourage farmers, agricultural institutes and the private sector to produce high-quality seed for distribution on the domestic and foreign markets.

To achieve these objectives, the NSP must develop improved varieties, produce foundation seed, supply legume inoculants, multiply improved varieties, dry, process, market, and distribute seed as well as train and inform the farmers. The National Seed Committee (NSC) carries out the tasks laid down in the NSP. Most importantly, it generates and manages financial support for seed development in

5. For more information on the organization of agricultural research in Thailand, see Setboonsarng et al., 1988.

the public sector. The NSC is headed by the Director General of the DOAE. The Seed Division of DOAE is responsible for seed production, while the DOA produces and maintains breeder and foundation seed. The Seed. Division obtains foundation seed from the DOA and distributes it to the appropriate seed multiplication centres throughout the country. Each centre contracts farmers to grow foundation seed, and buys back the following season's seed at 10% above the market price. The seed is then processed and stored ready for distribution. Since the first seed centre was built in 1975, the number has increased rapidly to 20 throughout the country (Table 8.4).

The NSC has generated financial support from international funding agencies: USAID has granted loans, as have other international agencies. The Japanese International Cooperation Agency (JAICA) helped to establish a maize seed centre (Seed Centre no. 5) at Lopburi in 1978. The European Economic Community (EEC) supported establishment of the Seed Centre no. 6 in Phattalung in the south in 1983; and the Overseas Economic Cooperation Fund (OECF) financed 12 seed centres during 1983-1986. The latest USAID Phase II loan financed two additional centres, at Chiangmai in 1983 and at Kalasin in 1984. Construction of the centres was completed in 1986, but some are still inoperative because the Civil Servant Commission has to approve the plant before personnel can be contracted. Inflexibil-

Table 8.4. Seed Centres of the Seed Division (DOA) and sources of funding, Thailand, 1986.

Seed Centre location	Rice	Maize	Mung-bean	Soya-bean	Sor-ghum	Cotton	Vege-tables	Ground-nut	International source of funding
Pitsanulok	*	*	*	*	–	–	–	–	USAID
Nakhorn Ratnakhorn	*	*	–	–	*	–	–	*	USAID
Lampang	*	–	–	*	–	–	–	*	USAID
Chainat	*	*	*	–	*	*	–	–	USAID
Lopburi	*	*	–	–	–	*	–	–	JAICA
Phattalung	*	–	*	–	–	–	–	*	EEC
Chiang Mai	*	–	–	*	–	–	*	*	USAID
Payao	*	–	–	*	–	–	–	*	OECF
Kampaengphet	*	–	–	*	–	–	–	*	OECF
Ubon Ratchathani	*	–	–	*	–	–	–	*	OECF
Roi-Et	*	–	–	*	–	–	–	*	OECF
Udonthani	*	–	–	*	–	–	–	*	OECF
Kalasin	*	–	–	*	–	–	–	*	USAID
Phrae	*	–	*	*	–	–	–	–	OECF
Nakhonsawan	*	–	*	*	–	–	–	–	OECF
Surin	*	–	–	–	–	–	–	*	OECF
Khon Kaen	*	–	–	–	–	–	–	*	OECF
Sakon Naknon	*	–	–	–	–	–	–	*	OECF
Chonburi	*	–	*	*	–	–	–	–	OECF
Ratchaburi	*	–	*	*	–	–	–	–	OECF

Source: Department of Agriculture Extension, 1987.

ity of government regulations undermines the effectiveness of the public seed programme.

Improved varieties are released regularly from national and international research programmes. Governmental support of the seed industry can be summarized into two areas:

Seed production: Department of Agriculture invests in research to develop new varieties and research programmes at universities provide breeder seed.

Seed legislation: There is no seed certification system in Thailand and thus producers are responsible for the quality of new seed. Nevertheless, the seed trade is subject to some regulation. The Seed Law of 1965 specifies minimum germination rate and purity for 'controlled seed'. Before public sector releases, a new variety must undergo a regional varietal test. The private sector has been pressing for seed certification, but as yet DOA has not been able to respond because of a lack of manpower. Since 1988 the Department has formally accepted seed from private companies for the regional varietal tests. The results of these trials are made public, as was the case for the recommended varieties.

8.3.2 Private seed industry

Agricultural research in the private sector and production of improved varieties are not well documented (Pray, 1987), but private sector research is increasing. For example, many fruit varieties have become available in spite of limited public research in this area. Private seed companies in Thailand can be divided into three groups. This division is based on the company's stage of development, which is reflected in its main supply source. Data presented in this section were drawn from a survey conducted as part of this study.

Domestic seed collection and import (Group I). Companies obtaining most of their seed through domestic production and doing business in their own localities have been classified as group I. Usually they have been in the seed business for one or two years and have on average three to six permanent employees. These companies are agricultural input distributors and local grain traders who clean, select and condition grain prior to selling it as seed. Seeds not available on the domestic market, such as some vegetable seeds, are imported. At this stage a marketing infrastucture is laid down and market information is collected.

Domestic seed production (Group II). When the market becomes sufficiently large, the seed companies begin to develop and produce a few specific varieties. The investment is great, especially in acquiring knowledge and technical information on a specific crop. Thus each company focuses on only a few crops. Entry at this stage is relatively easy and activities are still concentrated on the domestic market. Generally these companies have been in business for two to five years and employ on average 15 permanent and 9 temporary workers.

Specialization (Group III). If sales of certain crops expand and new varieties become popular on the domestic market, a company will specialize, and the sale of other products will gradually be reduced. Once this position is reached, competition decreases. At this stage companies are active in plant breeding, seed selection, production, processing, storage and marketing. Distribution networks and close links with the international market are well established. A company may specialize in more than one crop, and within one crop several companies keep pace with each other in technical development, thus providing some competition. These companies have been established for 10-60 years and have on average 55 permanent (range 20-117) and 50 temporary (range 10-70) employees.

Most domestic seed companies are in the first and second stages of development. Of the registered seed companies in 1984/85, most still collect and import seed, mainly vegetable and maize (Table 8.5). Some are also active in ornamental plants, for example orchids, but these non-food crops are not included in this study. Many companies have not yet specialized and continue to deal in both vegetable and field crops.

The large number of seed companies suggests that entry into the industry is not difficult. The Government has a relatively open policy on foreign investment in the seed industry. In the past decade many foreign companies entered the Thai seed market. Both many foreign and domestic companies have acquired Board of Investment (BOI) privileges, especially for export production. The number of companies does not reflect the actual degree of competition. In practice, each market is dominated by a few companies with technical sophistication in marketing and/or production.

Private firms dominate the trade in vegetable seed because the market for each type of seed is too small to justify public research. A vast range of vegetable seed

Table 8.5. Number of seed companies in Thailand classified by activity.

	Seed collection	Seed import	Seed export
Vegetables	31	23	13
Maize	29	4	5
Field crops (other than maize)	14	2	2
Rice	2	0	0
Maize and other field crops	7	3	5
Vegetables and maize	14	6	4
Vegetables	15	2	2
Other	18	13	3
Total	130	53	34

Source: Setboonsarng et al., 1988.

Notes: Marketing Organization for Farmers (MOF), is a registered seed collector and importer, but is not included as a private company. Subsidiaries of a parent company are counted separately.

is imported resulting in little advancement in domestic production technology. Private research and development in plant breeding for both hybrid and non-hybrid vegetable varieties began only in the past decade. This slow development is due partly to the small domestic market but also to the low price of imported seed. The recent incentive in production technology resulted from the entry of foreign seed companies.

Custom seed production, the multiplication of seeds, especially hybrid varieties, for re-export by foreign private seed companies, is new in the seed industry. Production and export of hybrid tomato seed has risen from 4 tonnes in 1985 to 6 tonnes in 1986. Custom seed production services in foreign countries also produce vegetable seed, for example tomato, suitable for Thailand. Introduction of Suwan I, an improved maize variety released by the National Maize Research Centre in 1975, marked the beginning of modern private maize seed companies. Many international companies began operating in Thailand at that time. To promote the private sector, a Seed Club was established in the early 1980s through the initiation of the Seed Division, DOA. Field crop companies participated actively in the Seed Club. Although larger in number, vegetable seed companies were more passive. Competition in the private seed business has increased in recent years with the growing number of companies. Involvement in main crops varies greatly, depending on each company's technical and economic constraints (Setboonsarng et al., 1988).

8.3.3 Seed pricing and marketing policies of specific crops

Rice. Basmati rice from South India is a relatively new crop in Thailand. Basmati rice varieties have long, slender grains that elongate to about double the size when cooked and are strongly aromatic. Private companies develop and distribute seed to contract farmers and buy back the produce. They do not buy from farmers not under contract because of the difficulty of assessing crop quality. The price the farmer is offered is based on the world market price, as most Basmati is exported. There is ample demand for the lower quality of this special type of rice which is grown in Thailand. All Basmati rice seed companies have their own experimental plots, but the degree of sophistication varies. Investment in research is small because the key factor in competition is not seed quality but the slow process of training and selecting good farmers. Moreover, without variety protection development of better varieties of this self-pollinating crop may not significantly benefit a company.

Maize and sorghum. The private sector dominates the maize and sorghum seed markets. Competition among companies is keen, both in non-hybrid and hybrid markets. Hybrids of maize and sorghum are now widely used. Seed sales of hybrid maize increased from 30 tonnes in 1981 to 2 500 tonnes in 1985 and of hybrid sorghum from only 20 tonnes in 1980 to at least 600 tonnes in 1985. Non-hybrid maize is still considerably more popular than hybrid varieties, as demonstrated by

the increase in sales of Suwan maize seed from 2 500 tonnes in 1980 to 15 600 tonnes in 1985 (Boonsue, 1985).

Seed price is partly determined by production costs, which vary from company to company. These include purchasing seed from contract farmers and processing or conditioning. Large firms usually have higher fixed costs because of investments in research and development. Small firms are not capable of producing hybrid seed because of the expense of maintaining adequate research facilities, inbred line research and employment of technicans.

Non-hybrid maize seed is easily produced. Small companies can enter the market by purchasing foundation seed from the public sector, for instance from Kasetsart University, and multiplying the varieties through contract farmers. With lower processing costs, they can sell seed at lower prices. Smaller companies are normally restricted to the local market because of limited production capacity.

Seed price is also determined by supply and demand in a particular year. For example, the grain price in 1986 was extremely low. The following year many farmers switched to other crops, while some retained their seed. This decline in seed demand resulted in an excess supply and lowering of prices by seed producing firms in 1987 (Table 8.6). The seed price for sorghum is stable and depends on the import price from Australia and USA.

Table 8.6. Retail price of improved varieties, grain prices and ratio seed/grain prices, Thailand, 1986 and 1987 (baht/kg)

	Seed prices		Grain price	Seed/grain price ratio	
	public	private		public	private
1986					
rice	7	–	2.3	3.0	–
maize ('Suwan')	2	14	1.9	6.3	7.4
hybrid maize	–	35	1.9	–	18.4
sorghum	7	–	1.8	3.9	–
hybrid sorghum	40	–	1.8	–	22.2
soya bean	13	14	6.1	2.1	2.3
mungbean	16	10	6.4	2.5	1.6
groundnut	14	13	7.1	2.0	1.8
1987					
rice	7	–	2.4	2.9	–
maize ('Suwan')	10	8	1.6	6.3	5.0
hybrid maize	–	24	1.6	–	15.0
sorghum	7	15	1.5	4.6	10.0
hybrid sorghum	–	38	1.5	–	25.3
soya bean	13	15	6.2	2.1	2.4
mungbean	16	18	5.9	2.7	3.1
groundnut	14	13	5.0	2.8	2.6

Source: Producer prices from Ministry of Agriculture and Cooperatives, 1987.

Table 8.7. Research budget and staff of large seed companies, Thailand, 1988.

Company	Research budget (baht mln)	Permanent staff				Temporary staff
		PhD	MS	BS	others	
Pacific Seed	3	–	3	1	3	12
Ciba-Geigy	7-8	1	2	5	–	60
Charoen Phokhaphan	n.a.	1	3	5	–	20
Pioneer	5	2	4	6	–	30
Cargill	–	1	–	5	–	15
Thai Seeds	1	–	–	2	4	10

Sources: Chitsingh, 1988; Setboonsarng et al., 1988.
n.a. = not available.

To justify a higher price for a hybrid variety, the yield has to be much higher than that of the non-hybrid variety. Price determination for hybrid varieties of maize and sorghum is related to the price of non-hybrid varieties. If the price of non-hybrid varieties increases, then that of the hybrid can also be set higher. An increase in the price of the hybrid variety would require a much higher yield than that of the non-hybrid variety.

The influential public programme on open-pollinated (non-hybrid) maize that produced Suwan, serves as the main mechanism in determining the price of maize seed. Since small firms with low operation costs can produce non-hybrid varieties, Suwan prices are kept closer to their marginal production, processing and marketing costs. The relatively high yield of Suwan varieties puts pressure on hybrid yield, the potential being about 35% higher than that of the open-pollinated varieties. However, production costs (fertilizer, pesticide and labour) are also about 20% higher. Net gain from hybrid varieties is, therefore, small and thus the seed price cannot be very high. Most companies producing hybrid maize report losses and are forced to also sell non-hybrid maize. Profit from the non-hybrid Suwan maize varieties is used to offset loss on hybrid seed production. However, building a marketing infrastructure by selling non-hybrid maize seed can pay off in the long-term when the right hybrid is developed. To maintain their market share, large private companies emphasize product quality. Therefore, they have to invest in laboratories for quality control (Table 8.7) while smaller companies pay less attention to product quality. Moreover, they can easily change brand names of products when farmers lose interest in a particular brand.

Larger companies (Group III) distribute seed mostly through provincial merchants, but medium-sized and smaller non-specialized companies (Group I and II) use mainly local dealers as their linkage to farmers (Table 8.8).

Sales promotion is important in the private seed business. Specia-lized maize seed companies use different strategies. Representatives visit farmers and give seed

Table 8.8. Distribution channels of private seed companies, Thailand.

Distribution channel	Major groups of seed companies (%)		
	I	II	III
Local dealer	50	65	13
Provincial merchants	15	–	56
Cooperatives	5	10	5
BAAC[a]	–	10	18
Direct sales to farmers	30	15	8
Total	100	100	100

Source: Setboonsarng et al., 1988.
a. Bank for Agriculture and Agricultural Cooperatives.

for demonstration so that farmers can observe the differences between new varieties and those currently used; this is the strategy of direct contact with farmers. Every large company uses advertising, produces leaflets, as well as radio and television programmes. Services and gifts are another strategy: this may incluse free gifts or lotteries, credit to dealers or farmers, and the return of unsold seed. Finally, smaller companies often use discount techniques; they can make special offers because of their lower management costs. Farm demonstration is the most effective sales strategy, but is also time-consuming and costly. Most companies use this method to penetrate the market. Once the benefits of a new variety are known, other strategies are used to increase sales. Through competition among seed companies, farmers are better informed about cultivation techniques.

Vegetables. Keen competition in the vegetable seed market necessitates each company finding the best and cheapest source of seed supply. Unlike the maize seed market with many competitors and homogeneous seed quality, this market is small and seed quality varies. Price is set on the basis of import prices and production costs as well as other companies' selling prices. Brand-name seed prices usually differ; the more established brand is used as a guide to determine the price of other brands. Until recently most hybrids were imported. The dominant position of vegetable seed in total seed imports is shown in Table 8.9. Vegetable seed exports are produced under contract for foreign seed companies, known as custom seed production (see subsection 8.3.3).

Seed companies buy from two main sources: domestic producers either contracted or not; and from foreign custom seed growers in Thailand or other foreign companies. Less than half of the vegetable seed on the market is produced domestically. Hybrid seed production requires higher technical support in plant breeding and cultivation than non-hybrid vegetable seed. Domestic companies imported hybrid seed until they gradually developed experimental plots. They were able to use custom seed production services in the USA, Australia and Europe.

Table 8.9. Seed imports and exports, Thailand, 1985.

	Value (baht mln)	Quantity (t)
Imports		
Vegetable seed of which:	62.7	558
chinese mustard	7.1	40
radish	5.4	60
chinese kale	7.7	139
cauliflower	2.8	4
cabbage	19.4	16
watermelon	4.8	18
onions	4.2	4
Other field crop seed:		
maize	10.3	11
sorghum	35.9	1 499
Exports		
Vegetable seed	39.2	1 241

Source: Ministry of Agriculture and Cooperatives, 1986.

Investment in vegetable seed germ plasm and plant breeding is a recent phenomenon. Until the late 1970s, seed companies gave higher priority to innovative marketing strategies than to investment in research and production technology. Research activity was stimulated by the East-West Seed Company, a joint Thai-Dutch firm, which recognized the potential of vegetable seed production in Thailand (Groot et al., 1988). The example of East-West stimulated all large domestic companies to expand their plant breeding capabilities.

Product differentiation has been important in the vegetable seed market. Vegetable farmers distinguish seed by brand and will switch brands if they or their neighbours experience problems. Usually, they find good quality seed by trial and error. Brand loyalty makes it difficult for a new company to enter the market. As with maize, the best promotion strategy is demonstration in farmers' fields, followed by direct sales to key dealers and growers. To keep their clientele, large vegetable seed companies must also advertise as widely as possible.

8.3.4 International cooperation in the seed industry

Bilateral and multilateral projects, together with substantial foreign aid and loans, have been crucial in the establishment and stimulation of the Thai seed industry. Cooperation with the IARCs of the CGIAR has also been important. Collaborative projects have been established with organizations such as IRRI, CIMMYT and ICRISAT and also Asian Vegetable Research and Development Center has an outreach programme for vegetables.

International seed trade. Thailand is both an importer and exporter of seed. Hybrid sorghum is the largest import and, together with maize, makes up 40% of all imports. The remaining 60% comprises various types of vegetable seed (Table 8.9). In 1964 the Seed Law was passed requiring importers to register with the Seed and Agricultural Control Subdivision of DOA, and to observe specified quality standards. At that time there was a minimal import tariff of 6%. Subsequently seed imports, especially sorghum and maize, increased in quantity and value. With the fall of sorghum and maize grain prices in 1987, these seed imports reduced.

8.4 Seed supply and demand

Seed requirement is calculated from the amount of seed required per hectares and the area to be planted. Rice is the largest crop, requiring about 317 000 tonnes of seed annually over the last five years, followed by maize, requiring 46 000 tonnes annually (Table 8.10). Farmers meet most of their need by retaining seed from the previous season. Lack of high-quality seed has been a major constraint to increasing agricultural production (Cherm Sengtien, 1977).

Commercial market potential is estimated at 25% of the total seed requirement for most major crops. The commercial market share of vegetable seed is highest with 50% replacement, followed by sorghum and maize.

8.4.1 Public sector seed production

In 1986 the public sector supplied only 5% of total seed requirements. Rice seed production is the most important activity of the public seed sector. The 8 400 tonnes produced in 1987 is about 60% of the total seed produced by the public sector (Table 8.11). Maize seed production was 2 700 tonnes in 1984 but has since declined, mainly because of the lower seed demand induced by a decrease in the maize price.

Table 8.10. Seed requirements for major crops in Thailand, 1986.

	Area (1000 ha)	Average annual requirement (1000 t)[a]		
		1971-1975	1976-1980	1985
Rice	9 376	251.1	291.1	317.1
Maize	1 600	28.6	34.2	46.5
Sorghum	240	2.4	3.5	5.8
Mung bean	448	5.1	9.8	13.7
Soya bean	208	4.5	5.7	10.6
Groundnut	160	15.1	13.3	15.5
Vegetables	125	–	–	1.9

Source: Seed Division, 1986; Office of Agricultural Economics (MOAC).

a. Based on seed rates per ha: rice 31.25 kg; maize 25 kg; sorghum 18.75 kg; mungbean 25 kg; soya bean 43.75 kg; groundnut 125 kg.

Table 8.11. Production of improved seed (t) Seed Division, Thailand, 1987.

	1984	1985	1986	1987	Proportion of total seed use (%)[a]
Rice	3 776	3 787	4 706	8 425	3.0
Maize	2 706	2 619	2 493	2 097	16.3
Soya bean	800	666	1 448	1 507	33.1
Groundnut	619	164	357	1 187	26.0
Mung bean	431	369	586	878	12.1
Sorghum	14	14	21	4	1.5
Other[b]	143	6	200	40	n.a.
Total	8 489	7 625	9 811	14 138	3.4

a. Derived from seed requirements presented in Table 8.10.
b. Mainly sesame and vegetable seed.
n.a. = not available.

Production of soya bean, the third largest crop, has increased rapidly, especially since 1985 when intervention in the import of soya bean and soya meal pushed up the domestic price. The drought relief programmes' promotion of soya bean cultivation also contributed to the increase in production by the Seed Division.

Groundnut seed production depends heavily on weather conditions. Seed demand has increased rapidly in the past few years, especially for crops grown for direct consumption and export. Greater production has created an increase in the seed requirements. The public relief programme in response to the drought of 1986/87 has increased demand for both groundnut and mung bean seed. The Seed Division also produces small quantities of sorghum seed, mainly because the crop is drought tolerant and is usually grown as a second crop at the end of the wet season. In addition, the research effort on maize has a strong effect on sorghum. The Seed Division has started multiplication of new crops, including wheat and sesame seed, but most efforts are still concentrated on the first five crops.

Production of vegetable seed by the Seed Division is in an early stage of development. Processing equipment has been obtained at Seed Centre no. 7, but lack of manpower has severely limited its use. At full capacity the centre could process most of the vegetable seed needed in Thailand.

8.4.2 Traditional seed supply systems

Despite the release of many modern varieties, demand for improved seed in the major field crops is low, except for maize. Over 95% of rice seed, for example, is still retained from the previous harvest. There is little information available on the evolution and effectiveness of the traditional seed supply systems in Thailand.

However, because of the importance in rice cultivation, for instance, these systems should be given more attention in policy making.

8.5 Major results and constraints in seed industry development

The public sector has been most active in promoting the use of improved seed. The NSP produces and distributes improved seed to the farmer at a low price, the Seed Law sets minimum standards for some seed, and the Seed and Agricultural Imputs Control Subdivision of DOA requires the registration of all seed companies. There is little private sector involvement in the non-hybrid crops, apart from maize, but research in vegetable seed is gaining in importance.

Public seed distribution and pricing have a direct influence on supply and pricing in the market. By adjusting production or price, the public sector can influence the behaviour of the private sector and help prevent distortions in the market. In practice, output of the public seed programme is determined by requests from other public agencies and the Seed Division's production capacity. Impact on the private sector has low priority, if it is considered at all. Given its present restraints the public seed programme cannot enhance development of the private sector.

The public sector suffers from operational inefficiency. Production costs of groundnut and rice seed, for instance, are higher than selling prices (Wattanutchariya, 1988). This is caused by rigid governmental regulations at a routine operational level and in the incentive structure. The paperwork processed by the seed centres is greater than that of any seed company. This bureaucratic system is costly in materials, personnel and, most importantly, time. The time required to make any change, minor or major, renders it difficult for the public sector to adjust to rapidly changing market conditions. This problem cannot be solved by flexible leaders and equipment as Gregg recommends (1988). The incentive structure of the seed centres is a more fundamental problem. The Civil Servant Commission promotion scheme is based on quantity, not quality of work, thus producing 'more' is in the interest of the public sector personnel. The public seed production needs an alternative incentive scheme more suitable to its objective.

A long-term excess capacity problem may arise for the seed centres. While requests from public agencies determine demand for seed, production capacity is governed by a long-term plan. Since these requests are project-oriented and sometimes uncertain by nature, (Emergency Relief Programme, for example) they tend to decline with time. Production capacity, on the other hand, is increasing. Gregg (1988) suggests that once the seed centres reach excess capacity they should provide technical support to the private sector. If this is their long-term objective, then seed centre facilities should be designed differently.

Foreign lending agencies also stimulate growth of the public seed programme. Most seed centres have been built with foreign loans. The NSC should pay closer attention to long-term needs and let funding come as a consequence of the national plan. In particular, foreign training assistance should be given more emphasis than

the acquisition of modern equipment which may not be appropriate for the economic condition of the nation.

There are cost-benefits associated with the public seed programme that have to be carefully weighed to determine the optimum short and long-term level of public involvement in seed production. Apart from producing and distributing seed, the public sector should provide a basic infrastructure for the private sector. There is underinvestment in activities such as germ plasm collection and basic research in plant science because they do not provide immediate results and thus are not a popular public expenditure.

In the past, the private seed sector concentrated on vegetable seed and the market was dominated by a few large companies. Now there are many seed companies in both vegetable and field crops. Although each section of the market is still dominated by a few large companies, competition is keen. By specializing in a limited number of crops, a small company can create a market for itself.

The seed market is expanding rapidly because of the farmers' growing awareness. This results partly from advertising and other sales strategies to stimulate interest. The seed companies are reported to spend as much as 10-20% of their revenues on sales promotion campaigns. As the market expands, a higher degree of specialization among seed companies will follow.

International accessibility through seed imports and foreign investment has led to fast development of the private seed sector in recent years. The transfer of technology from foreign companies to their subsidiaries or counterpart companies is not as important as the technological development that all companies have achieved in the past five years. The long-term impact that companies will have on seed supply is still not clear.

Seed certification is not favoured by the private sector because the value of certification is considered less than its cost. Competition depends heavily on brand name. An emblem of certification on a seed package adds little to farmers' confidence in the product. In many countries seed certification is carried out by a seed traders' association or club. With an expanded market and greater knowledge about seed by a larger number of farmers, a privately run seed testing network could be established in Thailand to assure seed quality in the market.

The Thai seed industry has undergone a huge transformation in the past five years. Modernization has begun, for better or worse. The sophistication of the farmers, local seed agents and seed companies is increasing rapidly. At this rate, Thailand should be able to establish itself in the international seed community within a decade.

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