Overseas Development Institute

THE SEED SECTOR IN DEVELOPING COUNTRIES:

A FRAMEWORK FOR PERFORMANCE ANALYSIS

Elizabeth Cromwell, Esbern Friis-Hansen and Michael Turner

Working Paper 65

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PREFACE AND ACKNOWLEDGEMENTS

This Working Paper presents the results of the first phase of a three part study of seed sector re-structuring in developing countries undertaken under the auspices of the Overseas Development Institute as an Extra-Mural Contract for the UK Natural Resources Institute. Other Working Papers describe the results of country studies conducted in Malawi, Zimbabwe and Zambia in the second phase of the study, which used the analytical framework described here to assess the seed sectors in these three countries and, in particular, to assess the relative influence of organisational structure on performance.

Thanks are due to the UK Natural Resources Institute for funding under the Agronomy and Cropping Systems Programme of the Resource Assessment and Farming Systems Strategy Area which fully funded the cost of the study. The authors also wish to thank the staff of all the many institutions involved in the seed sector in Europe, North America and the developing world who gave up time to provide valuable information and advice during the course of the study. At ODI, thanks are due to Virginia Ball and Geraldine Healy, who spent many patient hours preparing this Working Paper for publication.

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The views expressed in the report are those of the authors and do not necessarily reflect those of the UK Natural Resources Institute, the Overseas Development Institute, the Centre for Development Research or the University of Edinburgh. Comments are welcome and should be addressed directly to Elizabeth Cromwell at ODI.

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ADD	Agricultural Development Division (Malawi)
ADMARC	Agricultural Development and Marketing Corporation (Malawi)
AFC	Agricultural Finance Corporation (Zimbabwe)
AOSCA	Association of Official Seed Certifying Agencies of the USA
ARPT	Adaptive Research Planning Team (Zambia)
ASAR	Association of Rural and Artisan Services (Bolivia)
CDC	Commonwealth Development Corporation (UK)
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIP	International Potato Centre (Peru)
CMB	Cotton Marketing Board (Zimbabwe)
CIMMYT	International Maize and Wheat Improvement Centre
DUS	Distinctiveness, Uniformity and Stability
EEC	European Economic Community
ENDA	Environment and Development Activities—Zimbabwe
FAO	UN Food and Agriculture Organisation
GMB	Grain Marketing Board (Zimbabwe)
IARC	International Agricultural Research Centre
ICD	Industry Council for Development (US)
ICRISAT	International Centre for Research in the Semi-Arid Tropics
IDS	Institute for Development Studies (UK)
ILEIA	Institute for Low External Input Agriculture (Netherlands)
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
IVO	Development Research Institute (Netherlands)
JAICA	Japanese International Cooperation Agency
KSC	Kenya Seed Company
KGGCU	Kenya Grain Growers Co-operative Union
MBCR	Marginal Benefit-cost Ratio
MIND	Mindoro Institute for Development (Philippines)

MLARR	Ministry of Lands, Agriculture and Re-settlement (Zimbabwe)
MNC	Multi-national Corporation
MOA	Ministry of Agriculture
MRR	Marginal Rate of Return
NGO	Non-Governmental Organisations
NPV	Net Present Value
ODA	Overseas Development Administration (UK)
ODI	Overseas Development Institute (UK)
OECD	Organisation for Economic Cooperation and Development
OECF	Overseas Economic Cooperation Fund (Japan)
PBR	Plant Breeders Rights
PRONASE	National Seed Company (Mexico)
PSC	Punjab Seed Corporation (Pakistan)
SADCC	Southern Africa Development Co-ordination Committee
SEFO	Forage Seed Company (Bolivia)
SSC	State Seed Corporation (India)
SSMS	Smallholder Seed Multiplication Scheme (Malawi)
STIP	Seed Technology and Improvement Programme (Nepal)
SIDP	Seed Improvement and Development Programme (FAO)
TOSCA	Tanzania Official Seed Certification Agency
TVC	Total Variable Costs
USAID	United States Agency for International Development
VCU	Value for Cultivation and Use

1. INTRODUCTION

During the last decade, many developing countries have initiated programmes of structural reform in order to correct the severe macro-economic imbalances that developed during the 1970s and 1980s. The content and consequences of these reform programmes have been explored in a large and growing literature including, for example, Commander, 1989; Mosley, Harrigan and Toye, 1991; Kikeri, 1990; and Bourgignon and de Melo, 1991.

An important part of these programmes has been a reduction in the role of the state in economic activity in general and, given the dominance of the agricultural sector in developing country economies, in agricultural produce marketing and input supply in particular. This has already directly affected the seed sector in a number of countries, including Chile, The Gambia, India, Malawi, Mexico and Nepal, and there is likely to be further re-organisation elsewhere, including in Ghana, Côte d'Ivoire and Nigeria, in the near future.

The pressure for market liberalisation is based on the belief that economic growth can best be restored by increasing competition in product and factor markets through opening them up to the private sector. However, results so far have been mixed, causing the assumptions on which this belief is based to be questioned. In particular, there are doubts as to whether the private sector is willing and able to fill the gap left by departing state enterprises; whether, in the absence of sufficient competition, the old state monopolies are in danger of being replaced by new private ones; and whether past problems with state participation in markets are more to do with the way government bureaucracies have developed than with the principle of economic regulation itself.

At the same time, there is concern that, in the short- and medium-term, the pursuit of increased macro-economic efficiency does little to solve the problems of the poor, rural majority of the population in developing countries. With the margin of cultivation now approaching in many countries, future agricultural growth must increasingly come from intensified land use, but this cannot happen on any widespread scale until more successful efforts are made to meet the specific needs of resource-poor, small-scale farmers with respect to agricultural technology and supporting agricultural services.

Improved seed is often considered to be one of the most important technologies in this regard [ICD, 1987; Rajbhandary *et al.*, 1987; World Bank, 1984]. On the one hand, as long as other factors are non-limiting, it is the genetic quality of seed that places the upper limit on crop yields and therefore on the productivity of other agricultural inputs and cultural practices within the farming system. On the other hand, improved seed can make a substantial contribution to productivity independent of other purchased inputs, which is of particular benefit in resource-constrained small farm environments.

Of all the agricultural services, however, the difficulties with organising effective seed delivery, particularly for poor small-scale farmers, have been under-estimated in comparison with the attention devoted to, for example, agricultural produce marketing, fertiliser delivery, credit and extension services. And within the seed sector itself, more attention has been devoted to the physical aspects of production, processing and storage than to the difficult organisational issues which it is essential to address if the sector is to function well. As a result, many developing countries have persisted, in the apparent absence of alternatives, with loss-making parastatal seed companies, despite the failure of these companies to meet the needs of small farmers effectively. For example, the Tanzania Seed Company recently made losses of around TShs 5.8 million (£14,000) in the process of supplying less than 15 per cent of Tanzania's estimated seed requirements [Budden, 1986]. Similarly, the Seed Multiplication Unit of the Department of Agriculture in The Gambia recorded a turnover of less than 10 per cent of its D400,000 (£25,000) expenditure in 1985 whilst having 'a very limited impact on the national seed supply position' [Republic of The Gambia, 1987].

For these reasons, a number of countries are now embracing privatisation and/or seed market liberalisation as potential solutions to under-performance in the seed sector. But it is by no means certain that this will produce a practical improvement in the efficiency and equity of seed sector performance, any more than it has for the other parts of the economy that have been targeted for this type of re-organisation. This highlights the importance for successful reform of fully investigating the organisation and structure of the seed sector, and the way this influences performance, in order that the investments already made in capital equipment and human resources can be used to best effect in the changing economic circumstances.

This is the background to the research project of which this Working Paper is the first product. The overall aim of the project is to advance understanding of the structure and performance of the seed sector in developing countries - and in Eastern and Southern Africa in particular - with respect to the desirable relative roles of different types of organisations in meeting the seed needs of small farmers.

The specific objectives of the project are:

- to establish performance criteria for the seed sector in developing countries;
- to define the relationship between performance and the organisational structure of the seed sector;
- to identify the organisational structures that are most successful in meeting the seed needs of small farmers;
- to assess the scope, if any, for promoting improved seed sector performance through organisational change.

It is hoped that the project will also contribute more broadly to two areas of the wider debate concerning agricultural development in the small farm sector of developing countries. One is that concerning the scope for improving overall agricultural service delivery through organisational change, and specifically through reducing the role of the public sector in favour of the private sector. The other is that concerning the characteristics of new agricultural technology which are necessary for it to be successfully incorporated into small farm farming systems.

The research task has been divided into three phases. The first, on which this Working Paper reports, is a comparative analysis of available documentary evidence of past and present seed projects and programmes with the specific objectives of:

- establishing the desirable economic functions of organisations within the seed sector in developing countries and appropriate criteria for measuring their performance with respect to these functions;

- developing an analytical framework that identifies the factors influencing the performance of organisations within the seed sector and the linkages between them;

- creating a practically implementable methodology for assessing the comparative influence of these factors on performance in individual developing countries.

The second phase of the research task is field work investigation, in Malawi, Zambia and Zimbabwe, to compare the influence of the different factors identified in the analytical framework as determining seed sector performance, to reach country-specific conclusions concerning the wider research objectives. Reports for each of these countries appear as separate Working Papers in this series. The countries have been chosen to enable comparisons to be made between different approaches to seed sector organisation within broadly similar agro-ecological and socio-economic conditions.

Finally, in the third phase a synthesis is made of the framework development and field work investigations, to reach more generally applicable conclusions concerning the wider research objectives, and to assess the implications of these conclusions for the wider debate concerning agricultural service delivery and small farm technology development in developing countries.

Athough it is given numerous other names as well - for example, 'high yielding variety', 'modern variety', 'quality seed' - the product of the formal agricultural research system and the organised seed sector is commonly referred to as 'improved' seed and this is the convention followed in the present study. A detailed discussion of the concept of improvement in seeds is given in Chapter 3.

The research deals with cereal and legume crops propagated by true seed, which together account for virtually all the activities of national seed programmes in developing countries and are the crops of greatest importance in most small farm farming systems. Of course, in a number of countries vegetatively propagated crops such as potatoes and cassava are also very important - but they present entirely different technical seed problems and are therefore omitted from the present study. Neither are the more specialised seed crops, such as vegetables and pastures, considered in detail as they too have quite different economic characteristics. Nonetheless, it should be recognised that such crops, especially vegetables, may play an important role in the overall marketing strategy of some seed companies and they may make a significant contribution to turnover and to profits. Industrial crops, such as cotton, are omitted because for these crops seed supply and purchase of the final crop is usually closely controlled by large processing companies which, as for vegetable and pasture seeds, creates a very different economic environment for seed transactions.

A recurrent theme in the research is the success or otherwise of formal sector seed activities in meeting the seed needs of small farmers. We use the term 'small farmers' to refer to the specific group of small-scale, semi-commercial farmers that is defined as the necessary focus of the study in Chapter 2. We use 'formal sector' to refer to the activities of formally-constituted seed organisations (seed firms), compared to informal sources of seed such as on-farm saving, swops between neighbours, etc. This distinction is explored in more detail in Chapter 2.

Over the last decade in particular, many formal sector seed organisations have taken on a global trading perspective, as multinational chemical companies have bought into the seed sector in order to diversify their product base and to capitalise on the gains to be made in the seed sector from developments in the field of biotechnology. This global perspective has brought an important new dimension to seed sector analysis which has been investigated in a number of other seed studies [see, for example, Pray and Ramaswami, 1991; Jaffee, 1991]. However, it is not one that can be explored adequately within the scope of the present study and we therefore confine our analysis to the domestic demand and supply situation operating in individual developing countries.

A potential problem with the kind of generalised analysis that the research is designed to contribute to, is the substantial differences in the historical development and in the current context of seed sector organisation in different developing countries. Of particular significance for this study is the contrast between the well-developed private sector multiplication and distribution systems of a number of Asian and Latin American countries, based on Green Revolution technology, and the continuing dominance of parastatal seed organisations in sub-Saharan Africa. The more rapid spread of Green Revolution technology in parts of Asia and Latin America was aided by the relative homogeneity of the farming systems in those areas, in comparison to those in Africa, and by the early progress which was made by international centres in breeding improved and stable varieties of wheat and rice. This task is much more difficult in maize (the staple food crop in much of Africa) unless recourse is made to hybrid varieties, a strategy which continues to arouse controversy. All these factors limit the opportunities for transferring the lessons of seed sector experience from one continent to another. Therefore an important function of the present research is to highlight the specific agricultural, social and economic context of seed sector successes and failures in individual developing countries, in order to establish clearly the conditions required for successful replication elsewhere.

The present Working Paper draws on a broad range of evidence from Asia and Latin America and Africa to place organisational issues in the seed sector in context. In Chapter 2, the links between small farmers and the formal seed sector are identified and explored. Chapter 3 discusses the influence of different biological and technical principles on the economics and organisation of seed multiplication, processing and distribution, with a particular emphasis on the nature of improved seed and the organisational requirements for successfully making it available to small farmers.

In Chapter 4, evidence from a wide range of seed projects and programmes in different developing countries is used to assess the contexts in which different organisational approaches have been successful for the various components of the seed sector. The aim of this Chapter is to present plenty of practical examples of the different factors contributing to success and failure in the seed sector in different situations. Chapter 5 considers the wider national economic and policy context in which the seed sector in developing countries operates and the influence this has on the ability of the sector to reach small farmers.

Finally, building on the preceding technical and the structural analysis of the seed sector, Chapter 6 defines the desirable national development and firm-level efficiency functions of the sector and derives quantifiable criteria for measuring performance with respect to these functions. These are then worked into a full analytical framework for performance assessment. The chapter includes discussion of suitable approaches to collecting the data required for evaluating each criterion, of what the criteria individually reveal about performance and of the linkages between them.

2. SMALL FARMERS AND THE SEED SECTOR

For many centuries, the genetic improvement of crops depended on farmers' selection of locally adapted materials, often referred to as land races, using visual characteristics such as yield, grain size and colour. Similarly, the distribution of seed was a farmer-based activity, with limited diffusion occurring by means of farmer-to-farmer exchange and local trading in markets. It was not until Mendelian genetics, and subsequently the science of plant breeding, was understood in the late nineteenth century that systematic crop improvement started in Europe and North America.

Over the last thirty years, the establishment of international agricultural research centres under the Consultative Group for International Agricultural Research has enabled these techniques to be used to produce improved seed varieties relevant to farming systems in the developing world. This in turn prompted the establishment of organised seed production and distribution in a number of developing countries, to process and distribute improved seed. Sales of improved seed in developing countries now account for 12 per cent of global commercial seed sales, worth nearly US$4 billion annually [Groosman *et al.*, 1988].

The involvement of multi- and bilateral aid projects in the organised seed sector in developing countries has been substantial and has included, for example, support to 60 countries under the FAO Seed Improvement and Development Programme (1972-84); to thirteen national seed projects and 100 other seed-related projects funded by the World Bank (1975-85); and long-term support to the seed sector in 57 countries from USAID (1958-87).

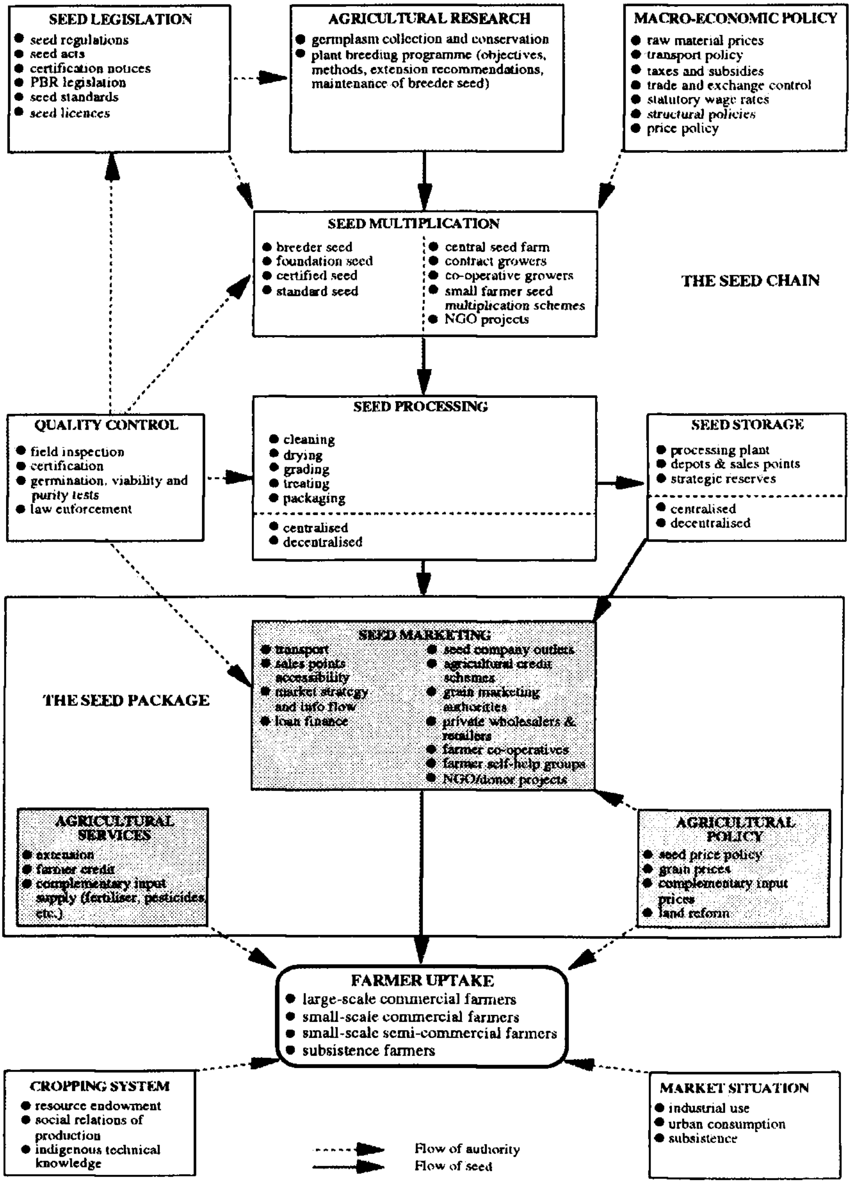
In many parts of Asia and Latin America there are now numerous formal sector seed organisations, both government and privately operated, providing a wide range of seeds through relatively well-developed distribution systems to various categories of seed user [Goodman, 1987]. In Africa, however, less than one third of the countries surveyed by the FAO Seed Improvement and Development Project in 1984/85 had established formal seed production and distribution facilities for major food crops and less than 10 per cent of total cropped area was under improved varieties [FAO, 1987]. With very few exceptions, the majority of formal seed sector activity in Africa remains in government hands.

2.1 The formal seed sector

The formal seed sector can be defined as a framework of institutions linked together by their involvement in or influence on the multiplication, processing and distribution of improved seed [Walker, 1980]. These institutions are many and diverse and include not only those directly involved in the multiplication, processing, distribution and quality control of seed but a range of linked institutions at national and sectoral level that, whilst not integral components of the seed sector itself, exert an important influence on the sector's performance. This is illustrated in Diagram 2.1.

Two key characteristics may be distinguished: **longitudinally**, from germplasm manipulation to eventual purchase by farmers, seed production proceeds through successive generations and a sequence of linked operations which form a **CHAIN**. At the same time, and considering the farming system as an integrated whole, successful seed supply depends on strong

Diagram 2.1: The seed sector - a framework approach



Source: Cromwell, Friis-Hansen and Turner, 1992.

latitudinal linkages to other services which collectively form a **PACKAGE**. The success of any one component of the formal seed sector is thus strongly influenced by the performance of the other components and by the strength of the linkages between them: the sector as a whole is only as successful as its weakest link. These linkages are a significant distinguishing feature of the seed sector and all decisions made at each stage of seed sector development have to take adequate account of them.

Within the more narrowly defined group of seed organisations (seed firms) that are directly involved in the multiplication, processing and distribution of seed, three basic forms of ownership and organisation can be identified:

(a) **public sector seed organisations** : this category includes departments of a line ministry (usually the Ministry of Agriculture), in which case it is directly dependent on the government budget, and parastatal enterprises, in which case it has financial autonomy although its operational strategies are still determined by official policy rather than by the market situation alone. Examples include the Seed Multiplication Unit of the Department of Agriculture in The Gambia, PRONASE in Mexico and the National Seed Corporation in India.

The degree of government control and investment varies between countries and indeed may change over time, in response to changes in economic policy and external pressures. Policy often has a significant influence on seed pricing. Profit-making is not usually the primary objective of this type of seed organisation, although importance may be attached to full cost-recovery. Serving all categories of seed user, and particularly those less able to participate in commercial seed markets, can be an important part of the mandate of public sector seed organisations. This can oblige them to deal in a wide range of seeds, including those that are relatively high cost to produce (for example, groundnuts) and/or relatively low value (beans, rice, etc.).

(b) **private sector commercial seed companies** : this category includes both multi-national companies (MNCs) (such as Pioneer which operates in Egypt and Nigeria, and Cargill in Tanzania, Malawi and Pakistan), and indigenous small- and medium-scale seed enterprises. For both types of company, profitability is an important objective. The commercial nature of these companies dictates a market-oriented operational strategy which gears production to providing those types of seed for which there is effective commercial demand and which are profitable to produce (for example, hybrids, vegetable seeds, etc.). Consequently, their activities are normally targeted to specific market segments or crops and, being structured on a strictly profit-making basis, they may be relatively opportunistic.

(c) **community-oriented seed organisations** : this category covers a broad range of indigenous organisations, including co-operatives, community organisations and church groups, involved in the seed sector for primarily developmental rather than commercial reasons and often supported by foreign or local non-governmental organisations (NGOs). Examples include ENDA in Zimbabwe, MIND in The Philippines and SEFO and ASAR in Bolivia.

These represent a different approach from the public sector and commercial organisations described above and have usually developed to fill a gap in the seed market unserved by either of these. In particular, community-oriented organisations often operate at a localised level which can enable them to meet the needs of seed users who, because of their location, lack of resources, etc., are poorly served by other types of organisation. Seed producers or users may themselves control these organisations, or alternatively external organisations provide resources and support. In some cases these activities have their origins in a communal desire to be more self-sufficient; in other cases, they simply act as intermediaries in the production and distribution chain of the national seed programme. Community-based seed activities can be involved in the genetic conservation of traditional landraces (something which is becoming increasingly popular with many NGOs). This is by definition antagonistic to the spread of 'improved' seed and some community-oriented organisations consider such a strategy to be important for the sustainability of traditional small farm farming systems, given the increased dependency and risk that the use of improved seed can involve.

2.2 Traditional seed systems

All the above categories of seed activity contain an element of organisational planning. However, it is essential to recognise the important role of the **informal seed sector** in supplying many small farmers' seed needs in developing countries. The informal sector includes all the other methods, such as retaining seed on-farm from previous harvests, farmer-to-farmer seed exchange based on barter, social obligation, etc., by which farmers can obtain their seed requirements. Although these systems are not formally structured, they account for the majority of seed sector activity in most developing countries and can involve well-established and elaborate mechanisms for the diffusion of seed over relatively wide areas. In Malawi, for example, only just over one third of all bean seed used by small farmers comes from the National Seed Company of Malawi and two thirds comes from neighbours, relatives and other local sources [Cromwell and Zambezi, 1990]. In Ethiopia, a recent seed survey found that between 25 per cent and 50 per cent of small farm households borrow or buy seeds every year but most transactions take place between neighbours and relatives; farmers say they prefer this system because they can see the crop stands from which the seed is taken [Singh, 1990].

Due to lack of control or facilities, it is not always possible to produce high quality seed successfully at farm level and the seed that is produced and distributed in this way is often of uncertain quality. But for seed users who are not regularly served in any other way, informal sector activities are the ultimate source of supply. They are therefore an important consideration in analysing seed sector organisation and performance. They have five key characteristics distinguishing them from the formal seed sector:

(a) they are **traditional**: not necessarily static over time in the way they operate, but well-established and often elaborate structures, based on and developing out of the traditional channels of information and exchange existing with the community;

(b) they are **informal** or semi-structured in their organisation, changing between locations and over time, and not subject to the same rigidities of ownership and control as formal sector organisations;

(c) they operate mainly, although not exclusively, at the **community level**, between households within one community, although lines of supply may extend over a relatively wide geographical area;

(d) a wide variety of **exchange mechanisms** are used to transfer seed between individuals and households, including cash sales, barter and transfers based on social obligations;

(e) the individual **quantities** of seed thus exchanged are often very small compared to the amounts formal sector organisations typically deal in.

This categorisation of the seed sector is an aid to analysis rather than a precise classification: in practice there can be considerable overlap between the objectives and structures of individual organisations. In Zimbabwe, for example, the largest seed enterprise, the Seed Co-op, is a membership producer co-operative but it operates virtually identically to (and competes with) the many private commercial seed companies which also distribute improved seed in the communal (small farm) areas [Friis-Hansen, 1990]. In The Gambia, on the other hand, although the supply of improved seed is now largely the responsibility of four non-governmental organisations which have stepped into the gap left by government and are running decentralised systems according to their own needs, most of them are hierarchically structured and are organised on similar lines to the government service [Wiggins, 1992].

In general, the operational objectives of seed organisations, and therefore their organisational structures, are largely determined by the nature of the interest group controlling them. This gives the organisations different comparative advantages in performing the various activities within the seed chain and in supplying different types of seeds to the various categories of seed users in different farming systems. In addition, within one seed sector, different types of organisations are often responsible for separate elements in the seed chain and package and some elements are intrinsically more susceptible to private sector involvement (e.g. marketing) than others (e.g. quality control).

2.3 The market for improved seed

The strongly segmented nature of the demand side of the market for improved seed is an important distinguishing feature of the seed sector. Four main categories of seed user can be identified:

(a) **large-scale commercial farmers** : mostly located in relatively high potential areas with well-established market infrastructure, their main operational objective is to maximise marketable surpluses. The purchase of improved seed from the formal sector is an important means of achieving this; it also offers managerial convenience and flexibility (no need to allocate scarce resources to producing or storing farm-saved seed; no need to be tied to a limited number of seed varieties). Commercial farmers' individual seed orders tend to be large and their main requirement is for high-yielding varieties. Although numerically the smallest, through their buying power this group has historically exerted a strong influence on the directions pursued by plant breeders and on the way commercial seed organisations have developed; the most well-known products of this influence are the hybrid maize varieties which emerged from breeding work undertaken in Kenya and in Rhodesia (Zimbabwe) in the 1950s and 1960s. This influence waned in many developing countries in the 1960s and 1970s as a result of land reform and the greater participation of public sector, non-market oriented organisations in the seed sector.

State farms, when present, fall into the same category, being large, regular seed purchasers and therefore often having an influence on the seed programme out of proportion to the area of land they actually cultivate - as was the case for the Ethiopian Seed Corporation in the 1980s, for example.

(b) **small-scale commercial farmers** : also aim to maximise marketable surpluses but, due to the smaller scale of production, a more labour-intensive mode of production is usually practised and individual seed requirements are smaller. These farmers are also a relatively attractive market for commercial seed organisations, although a more highly developed distribution system is usually required in order to reach them. In many developing countries, particularly in Asia, this group and its buying power, although small, is growing rapidly.

(c) **small-scale semi-commercial farmers** : operate in a pattern of production geared primarily to satisfying domestic consumption needs for food and other natural resource products, and strongly influenced by social relations of production, but including some commercially-oriented activities. Many semi-commercial small farmers have very limited cash resources and are located in areas of limited agricultural potential, remote from market infrastructure. Increased use of improved seed may have significant potential for increasing productivity for this group but their ability to make use of formal sector seed organisations, both public sector and commercial, is constrained by the difficult physical and economic environment in which they operate.

(d) **subsistence farmers** : in most developing countries, few purely subsistence farmers remain, because the level of market penetration means most farmers are now integrated into the commercial economy for at least some consumption goods, and therefore for a proportion of production activities. Most save their own seed on-farm or rely on the informal sector for their seed needs and there are particular difficulties associated with producing and distributing seeds for this group using formal sector organisations. Until their wider resource constraints are more directly addressed and they are able to participate more fully in conventional markets, supplying subsistence farmers through public or commercial seed organisations is unlikely to be feasible - although there may be an important role for community-oriented organisations that can work to alleviate these constraints at the same time as making improved seed available.

It is the third category - small-scale semi-commercial farmers - who constitute the largest single group of seed users in parts of the developing world. In Africa, for example, this category is estimated to include more than 60 million farmers, equivalent to 50 per cent of the total farming population; worldwide, it is estimated that over 300 million people live in areas of low agricultural potential [Mellor, 1988]. The improved delivery of seed to these farmers therefore presents a major challenge for the formal seed sector and for this reason it is the seed needs of this category of farmer that are the major focus of this study.

2.4 Small farmers' seed needs

The attitude of farm households towards technical innovations, such as improved seed, is determined by three factors in particular: household production objectives; resource allocation mechanisms in the wider economy; and relative factor scarcities and opportunities for maximising household utility from their combination.

2.4.1 Small farm farming systems

☐ *Resource endowment*

With respect to **land**, small farm households are typically located in relatively fragile agro-ecological environments - with low and uncertain rainfall and low inherent soil fertility, etc. This means production risks are correspondingly greater than for other categories of seed user. Whilst in Asia, holdings are relatively small due to absolute shortage of land, in Africa this is more often the result of labour constraints. This, coupled with the prevalence of traditional tenure arrangements in many parts of sub-Saharan Africa, means that the opportunity cost of land is typically relatively low - although there are important exceptions where the margin of cultivation is now being reached. This has a knock-on effect on the incentive to adopt agricultural innovations, particularly those, such as improved seeds, which are primarily land-augmenting in nature [Hayami and Ruttan, 1971; Low, 1986].

Household **labour** is much more limited in the African context, both relatively in comparison to land and absolutely for many small farm households - particularly those headed by women. This has a negative effect on improved seed use because, in order to benefit from their higher potential yields, many improved varieties require increased labour, compared to traditional land races, for spaced planting, extra weeding, fertiliser application and harvesting. In many areas, the interaction of relatively high off-farm wage rates and employment opportunities with prevailing household resource allocation strategies (see below), means that this shortage is exacerbated with respect to domestic food crop production by the involvement of a proportion of household labour - often the most productive - in off-farm employment.

Cash surpluses from own-holding production are usually very limited within African small farm farming systems, resulting from the combination of poor quality land and shortage of labour. At the same time, remittance incomes from off-farm employment are frequently small in practice. With more limited access to sources of credit, compared to other farm households, the **capital** resources small farm households have available for investment in improved technology are often very small. Therefore, management decisions are dominated by the implications of the allocation of capital resources for returns to cash expenditures.

☐ *Management strategy*

The dominant production objective of many small farm households is not profit- but utility-maximisation, with utility being defined in terms of risk-avoidance and other non-market attributes as well as income [Henry, 1988; Wolgin, 1975]. Thus resource allocation decisions are based on minimising variation in income rather than maximising mean income, although this means production and income will be lower in years with good or average agricultural seasons. At the same time, consumption as well as production objectives are taken into consideration - and the social relations of the household with the wider community still exert an important influence on the decision-making process.

Reflecting the relatively greater labour scarcity on small farm holdings, the management objective is to maximise household utility per unit of labour time rather than per unit of land. Connected to this, and as part of households' risk-spreading strategy, the small farm household is a multi-enterprise production unit, involved in activities off the farm as well as a wide range of activities on-farm. Within the household, the time of different individuals has different opportunity costs, according to their off-farm employment potential, prevailing off-farm wage rates and the relative returns to the type of crops that can be grown in the agro-ecological zone in which the household is located. This means resource allocation decisions are based on maximising utility to the production unit as a whole and, depending on the particular situation with respect to these different factors, can mean that the utility-maximising overall economic organisation of the household includes a relatively minor role for on-farm food crop production and relative under-utilisation of available land resources. In these circumstances, the value of land-augmenting technical innovations, such as the use of improved seed, is likely to be relatively limited [Low, 1986; Collinson, 1989].

☐ *Market situation*

The allocation of resources made by small farm households to meet their production objectives within given resource endowments is critically determined by their market situation. This has various dimensions.

It affects the overall value of involvement in food crop production compared to other activities. A key influence is the security of retail food markets, permitting the allocation of household labour to other activities - with the security of making up the deficit in domestically produced food with purchased supplies. And the level of wage rates and employment opportunities in the off-farm labour market influences the utility of devoting time to domestic production compared to off-farm labour, as we saw above [Hyden, 1984].

The market situation also affects the utility of increasing production of particular crops within the farming system, by using improved seeds for example, through the nature of product markets. A functioning product market must exist for a crop for it to be worthwhile producing beyond domestic consumption requirements. The nature of demand, whether for industrial use, urban sales or domestic consumption, also determines the attributes required of the crops offered for sale. And relative prices, and changes in them over time, determine the attractiveness of one cropping pattern over another.

In the African context, there can be serious market failures and high transaction costs associated with market participation for small farmers [Collinson, 1989]. This calls into question issues to do with the nature of the state and its efficacy in supporting and controlling market dysfunctions. In this respect, small farmers are particularly influenced by policy towards the provision of extension services, input distribution systems and transport infrastructure as well as those relating to producer price levels.

Thus, although the spread of improved seed in the small farm sector does not technically require a market-oriented mode of production, the relative attractiveness of improved seed to small farmers is in practice very much dependent on the market situation in which they operate.

☐ *Social differentiation*

We described above how household strategy with respect to food crop production is significantly influenced by the availability of household labour. Thus resource allocation decisions will vary with the course of the domestic development cycle of individual households over time. However, there is also social differentiation within the small farm community as a whole and thus the relative importance of different factors in influencing resource allocation decisions varies between households. Larger households will base decisions on returns per unit of land rather than labour; more commercialised households aim to maximise total income, including income from off-farm sources, not just subsistence production. This directly affects the uptake of improved seed and also, crucially, means different types of household require different types of support in encouraging uptake [Low, 1986].

Field-based observations in many regions have identified this. For example, in East Africa, separate studies in Kenya, Tanzania, Zambia and Malawi have found that there is a 'ladder' of technology adoption amongst small farm households [Allan, 1968; Jones, personal communication; Marter and Honeybone, 1976; Cromwell and Zambezi 1990]. For the smallest and most resource-constrained farmers, the bottom rung of the ladder is improving the standard of crop husbandry practices such as time of planting, spacing and weeding. The incremental yield this brings forth should allow progress to the next rung of the ladder: the purchase and application of chemical fertiliser. It is only for households in which the yield-increasing potential of both these innovations can be fully exploited that the use of improved varieties becomes a useful strategy.

Thus the nature of the household production unit and the environment in which it is operating generate special features of the small farm seed market.

2.4.2 Small farm seed needs

- *Types of seed*

The genetic characteristics of seed provided by the organised sector have to be compatible with the physical characteristics of the environment in which it will be used (i.e. soil type, rainfall, temperature, day length, insolation). The difficult agro-ecological conditions under which small farm households operate, and the number of separate agro-ecological niches within the small farm farming system, require types of seed that it is often difficult or expensive to produce within the formal seed sector.

The major difference between the economic conditions of small farm households and other categories of seed users is their primary objective of minimising risk by ensuring yield stability between seasons, rather than maximising yield between environments. This can result in a mismatch between the types of seed the formal sector produces and those preferred by small farmers, thus limiting the use small farmers can make of improved seed. In practice, small farmers usually maintain a very broad portfolio of varieties, to cope with production variability and to fill specific end use and agro-ecological niches, and will often assimilate an improved variety into this on a limited scale to avoid sacrificing overall variability.

At the same time, the total range of objectives is much broader than ensuring yield [CIAT, 1982; Johnson, 1989; Dougnac and Kokwe, 1988] which, for reasons discussed in Chapter 3, means many of the improved varieties the formal sector offers will not be appropriate.

The constraint imposed by shortage of labour and capital also determines the need for improved seed to have minimal requirements for additional labour and complementary inputs, whereas the potential of many improved varieties is maximised only with substantial additional inputs.

- *Quantities of seed*

Individual small farm households require commensurately smaller total quantities of improved seed and this increases both the cost of transporting a given quantity of seed, i.e. to a large number of distribution points, and the cost of packaging - into many small packs. Within their total seed requirement, small farmers may need small quantities of several different individual varieties, as we saw earlier.

The quantities required may be further reduced if the varieties on offer require the application of complementary inputs to show a production advantage over farm-saved seed. Thus, although improved seed itself is a relatively scale-neutral innovation and therefore accessible to smaller farmers, because many improved varieties are not factor-neutral, smaller farmers are at a relative disadvantage in making use of the complete package.

Total demand is also much more variable in small farm farming systems due to the greater inter-seasonal variation in growing conditions in agro-ecological zones in which small farms are typically located. The extent to which sectoral policies relating to producer prices, credit, etc. ameliorate the potential impact of this production risk is thus an important influence on small farmers' willingness to use improved seed.

In practice, small farmers very rarely aim to achieve 100 per cent replacement each year so demand will always be less than total planted area, the extent depending on the ease of on-farm multiplication and storage, the multiplication factor of the crop in question (small farmers will often purchase only enough to multiply up to meet their requirements in the following season) and the sowing rate (small farmers are often more prepared to purchase seed for crops with lower sowing rates) [Heisey, 1990].

- *Physical access: location and timeliness*

Distribution is frequently identified as a bottleneck to small farmer use of improved seed, regardless of the type of organisation involved, due to the particular logistical and communications difficulties associated with serving this category of seed user. The remoteness of many small farm households from transport and market infrastructure means that often they cannot be reached through the normal retail distribution system and investment in seed distribution points is required. This, together with the small quantities required, makes a significant addition to the costs of providing them with improved seed.

Timeliness of distribution is particularly critical for small farm households because they have insufficient cash resources to be able to bear the cost of storing seed for long periods and inadequate on-farm storage facilities to maintain seed quality over extended periods. At the same time, in the fragile environments in which they operate, having seed available for timely planting is critical to obtaining full benefit from its use; in a typical small farm maize farming system in Zambia, for example, each day's delay in planting was estimated to reduce eventual yields by 3 per cent [Edwards, Gibson, Kean, Lubasi and Waterworth, 1988].

- *Price*

Although small farm households have an external services cost handicap, i.e. they cannot benefit in the same way as large farms from bulk orders, etc. [Ghatak and Ingersent, 1984], in very general terms demand for improved seed can be relatively inelastic with respect to price, the reason for this being that seeds represent a relatively small proportion of total production costs, even on small farms. This is particularly the case for seed of crops, such as sorghum, which have relatively low sowing rates (see Chapter 3). However, there are some important qualifications.

Price sensitivity is much greater in locations where the crops grown by small farmers have breeding systems which permit on-farm maintenance of varieties, and thus create a substitute for improved seed. This would apply to rice, wheat, groundnuts, etc. in contrast to, for example, non-hybrid maize or millet. It is also higher in locations, typical of many small farm farming systems, where agro-ecological potential is fairly limited, thus limiting the benefit of using improved seed. Where seed sales are based primarily on the physiological quality of the seed, rather than any genetic improvement, cash-constrained small farmers often perceive little benefit in purchased seed as compared with that which they could save themselves. They may also compensate for uncertain quality by using a rather higher sowing rate.

Demand for seed is sensitive not only to changes in the price of seed itself, but also to changes in the price of other factors and products in the small farm farming system. This includes complementary inputs and grain producer prices and thus demand will be particularly influenced by government intervention in the price mechanism (administered input and product prices, direct taxes and subsides etc.) in these markets.

Furthermore, as farmers do not obtain utility from the use of improved seed *per se* but rather from its attributes that provide utility in farm production activities, demand for improved seed is strongly influenced by the availability of alternative means of providing these production attributes. This means in practical terms that, as the utility of improved seed is derived from its characteristic as a land-augmenting technology, demand will decline if the relative prices and availabilities of other land-augmenting technologies become more favourable, even if these are no direct substitute for seeds in the farming system.

And lastly, because of their management strategy, small farmer demand for improved seed is influenced by changes in the prices small farm households face in their consumption activities - such as changes in real income and relative consumer prices etc. - as well as those in their production activities faced by all categories of seed users.

□ *Quality*

It is possible to make a case for the less strict application of quality standards to seed destined for the small farm market in order to make sufficient quantities quickly available. However, there must still be enough attention to quality to ensure the product is consistently superior to that which small farmers can themselves maintain - because of the importance of perceived rather than actual value in the seed market. For small farmer seed users, this is particularly important due to their reduced ability to absorb risk within the farming system; thus, if they once lose confidence in improved seed they will quickly stop using it. Official quality control schemes such as 'certification' are vulnerable to such bad experience by farmers, particularly when the distribution system is lengthy and uncontrolled.

3. BIOLOGICAL AND TECHNICAL PRINCIPLES

The technical function of formal sector seed production is to multiply up the small quantities of improved seed released by breeders to the quantities required to supply farmers. The term 'seed technology' covers all the activities necessary for the fulfilment of this task and may be regarded as the bridge between research and agriculture along which varieties and seeds travel.

The nature of improved seed as an economic good is significantly determined by technical factors associated with its multiplication, processing and distribution. In particular, these factors determine the attitude of farmers towards the product of the organised seed sector (the features they require of seed from this source) and the way in which production has to be organised.

Farmers' main objective in using seed from the organised seed sector is to obtain one or more of the following benefits:

- a new variety for the first time;
- a type of seed that cannot easily be produced on-farm, for biological or climatic reasons;
- seed of better quality than can be produced on-farm.

The fundamental requirement of the formal seed sector is therefore that it should supply a product that is proven to be 'improved' in at least one of these ways, compared to that which farmers can themselves provide. There is no inherent advantage in formal sector involvement in seeds in the absence of this.

3.1 The nature of improved seed

There are two sources of improvement in seeds, which together make up the 'quality' of seed:

- the **genetic information** contained within the seed itself;
- the **physical and physiological** attributes of the seed lot - purity, germination capacity, vigour, health and freedom from disease.

These are independent of each other but both are required for improved seed to contribute fully to better crop production performance. Thus genetic quality is the ultimate determinant of performance but, if physical quality is poor, the benefit of improved genetic potential cannot be realised. However, the relative importance of genetic and physical quality varies, and formal sector seed production has to be sensitive to this: in one farming system, the most important need may be for seed with assured genetic potential; in another, the genetic quality of an established variety may be quite adequate but storage difficulties or pest and disease problems may still enable the formal seed sector to supply a useful product, by concentrating on physiological quality. This in turn affects the type of variety best suited to meeting these needs. If based on genetic quality, profitable formal sector seed production depends largely on being able to offer hybrid varieties because these have recurrent sales potential.

The concept of 'variety' (a theoretically infinite population of individuals sharing a defined set of characteristics) is fundamental to formal sector seed production and is one of the major factors distinguishing it from informal seed supply systems, which use less precise material of local origin. The availability of genetically superior varieties from the research system is a major impetus to the establishment and sustainability of the formal seed sector. At the same time, an over-emphasis on genetic progress can create tensions within seed organisations. From the **marketing** perspective, it is profitable to trade on novelty by constantly providing new varieties, even if the real advantage to farmers is small (the example of rice in South East Asia is frequently quoted in this context). However, for ease of **production**, a few really successful varieties - and here **SR52** hybrid maize in Zimbabwe is often cited - are preferable.

If seed demand is based primarily on physiological quality, recurrent sales should be more secure, because quality is relatively difficult to control in on-farm seed production whereas the formal seed sector can provide high levels of management throughout the production cycle - and can back this up with laboratory testing. Soyabean is an example of a seed which farmers may find difficult to store themselves. Furthermore, chemical seed treatment that provides protection during germination and early plant growth can be a real benefit that farmers cannot easily obtain in other ways, in areas where soil-borne pests and diseases are a major factor contributing to poor emergence. However, because germination is relatively unstable and strongly influenced by events in the external environment, a highly responsive management system is required to maintain seed quality and this can be difficult to accommodate within the bureaucratic decision-making structure of public sector seed organisations. Often, the unreliable quality of seed from public sector organisations is in practice one of the biggest disincentives to farmers using improved seed.

Although there are important exceptions, in many cases farmers do not handle seed saved on-farm substantially differently from the part of the their harvest used as grain [Dougnac and Kokwe, 1988; Johnson, 1989] and they therefore consider grain which remains uneaten at the time of sowing to be effectively 'seed'. This linking of seed with grain is a critical influence on their willingness to use improved seed, which is more expensive and often less readily available than food grain. In particular, it means that improved seed has to provide a clear improvement genetically or physically on what can be produced on-farm.

Because the majority of seed quality attributes are not outwardly visible, this linking of seed with grain also means that demand is based on **expectations** of how seed will perform. It is therefore essential for the formal seed sector to maintain a reputation for consistency in the supply of genuinely improved seed, in order to gain farmers' confidence in the value of using it.

3.2 Breeding improved varieties

Agricultural research institutions, and particularly those concerned with plant breeding, have a major influence on the formal seed sector through their responsibility for providing improved varieties. Indeed, the analogy of the seed technology bridge conceives the formal seed sector as providing a secure and coordinated pathway along which new varieties can pass from research into agriculture.

It is beyond the scope of the present study to review the techniques employed and facilities required by plant breeders to achieve their objectives. However, as a general observation, it may be said that agricultural research activities in developing countries, while often enjoying status because of the 'scientific' nature of the work, in practice commonly suffer from a serious lack of resources and are relatively unproductive. Because of the high costs of establishing a complete indigenous research system in each developing country, which would create excessive demands on human and financial resources, the International Agricultural Research Centres of the CGIAR system are intended to generate material and information which can be incorporated in national agricultural research systems in developing countries relatively easily. In the context of plant breeding, which is usually the largest single activity within research programmes, the IARCs release advanced breeding lines or populations which are incorporated into national breeding programmes for further selection and/or evaluation. This system is well illustrated by the many IRRI rice varieties which have been released over the past 25 years. Another example is the **Veery** family of wheat varieties released by CIMMYT and introduced in many different developing countries.

In some parts of the developing world, especially in South-East Asia, the 'Green Revolution' was a milestone in the progress of agricultural technology: average yields of wheat and rice in Asia and Latin America have increased more over the last 25 years than over the whole of the last 250 years [Lipton and Longhurst, 1989]. However, with hindsight its benefits have been widely debated, particularly when viewed in a social context [see, for example, Conway and Barbier, 1990; Lipton and Longhurst, 1989; Farmer, 1977]. Regardless of its impact on farmers, the Green Revolution has had an important effect on formal seed sector development by stimulating demand for new varieties and mechanisms for distributing them. In most developing countries no such mechanisms existed at the start of the Green Revolution in the 1960s and the upsurge of seed development projects in the early 1970s was prompted by a desire on the part of governments and donors to rectify this deficiency. However, the Green Revolution phenomenon was not observed to any significant extent in Africa and it cannot be considered to have had a direct effect on the evolution of the formal seed sector in that continent, not least because the methods used to develop the high-yielding wheat and rice varieties that contributed to the Green Revolution in Asia and Latin America are of limited application to increasing yields of the major African food crops such as maize, sorghum and millet.

A successful plant breeding programme depends on producing varieties which show clear improvements over existing material in one or more important attributes, without significant loss of any other qualities which farmers regard as essential. Selection programmes practised by plant breeders to develop these varieties depend on applying a few measurable selection criteria at an early stage in the programme in order to reduce the number of lines to manageable proportions. As a result of this strategy, much useful material is probably discarded because of the practical impossibility of testing it in all the locations where its merits may be recognised. This is a fundamental dilemma in plant breeding and one which is of crucial importance to supplying the seed needs of smaller, poorer farmers.

While total yield is usually the first breeding objective, the quality of the harvested product, crop maturity times, disease resistance and many other agronomic characters must all be considered. Agricultural research institutions and formal sector seed organisations use yield in terms of output per hectare as the major measure of variety performance, reflecting commercial farmers' concerns to maximise returns per unit area. Yield trials conducted under high input conditions and replicated across a wide range of agro-climatic environments are the usual means of identifying varieties with wide adaptability and high potential yield. This means that research institutions and trial systems tend to select as 'improved', and recommend to the formal seed sector for multiplication and distribution, the limited number of varieties able to show a good yield response under favourable husbandry practices across a range of different environmental conditions.

In addition, in order to facilitate control over the seed production process, varieties are normally expected to show a high level of genetic conformity in an attempt to emulate the Distinctness, Uniformity and Stability (DUS) criteria by which new varieties are evaluated in most developed countries.

However, in farming systems which are less intensive, or less commercialised, a much broader range of criteria is used to assess performance. Varieties are required to provide a stable yield when intercropped and at low levels of input use, including limited labour for husbandry practices, and across seasons within a specific environment. Because the negative effect of untimely crop husbandry or poor or deteriorated soil fertility (which, for various reasons commonly pertain in small farm farming systems [Carr, 1989]) is much greater for high-potential varieties than for local landraces, farmers' traditional seeds can out-yield high-potential varieties under typical small farm conditions. Varieties with a range of genetic variability, or highly adapted local landraces, will often meet small farmers' needs better than the more uniform ones identified for use by the formal seed sector. For example, the major conclusion of the USAID-funded Kitale maize breeding project in Kenya, with respect to the relevance of hybrid maize for the needs of small farmers in Kenya's arid and semi-arid lands (the project itself focused on the higher potential areas) was that, in fact, 'The perfect maize for semi-arid areas is [traditional varieties of] sorghum' [Johnson, 1980].

Furthermore, small farmers often assess yield itself in terms of the utilisable portion of the crop left after storage and processing, rather than output per unit area at harvest, and this too can favour traditional over improved varieties. Probably the best known example of the influence of this on the adoption of improved seed is the continued preference of small farmers in Southern Tanzania, Eastern Zambia and Malawi for the local hard white maize varieties over the high-yielding dent maize hybrids, because the latter crumble to unusable powder when pounded using traditional methods [Kydd, 1989] (although these processing requirements are now being addressed in Malawi in a maize breeding programme designed to generate flinty hybrids).

A wide range of other attributes are also taken into account by small farmers. A typical example of the effect of this on the utility of new varieties is provided by the 'model' sorghum varieties developed for small farmers by ICRISAT. Because these are dwarf varieties, whereas in small farm farming systems in Africa long stems are preferred for use as fencing material, and because they have been bred for pure stand cultivation, whereas on small farms they are usually intercropped, these varieties have had very low uptake in Africa despite being bred specifically for small farmers.

Thus it is clear that there is a potentially considerable mismatch between the type of varieties produced and favoured by existing research and trial systems, and those required by small farmers.

Attempts to overcome this problem must rely on bringing farmers' judgement to bear on the selection programme, either by enabling them to assess early generation material in the research station or, better still, by allowing them to grow small plots on-farm for similar purposes. An example of the successful use of this approach is outlined in Box 3.1. The conventional on-farm trials programme does not fulfil the same need, however, because in general most of the selection process has been carried out by the time new varieties are placed in such trials.

From an organisational point of view, a general problem of plant breeding is this need to ensure an effective feedback mechanism from farmer to breeder, in order that farmers' specific requirements and their reactions to newly released varieties can quickly influence the on-going selection programme. It is typically a strength of commercial seed companies that they ensure direct contact between marketing staff and plant breeders in order to ensure that this communication of demand works smoothly. In contrast, breeders working in public sector research stations are often not subject to such pressures because they are in quite separate divisions of the Ministry of Agriculture from extension staff and are not necessarily working in a demand-driven environment.

The effectiveness of this feedback mechanism is influenced by the collaborative proximity of farmers and breeders, the influence and vociferousness of farmers themselves and the complexity of their requirements. In practice, this usually means that commercial farmers with better resources and better access to research stations are able to influence plant breeders more easily. It is equally true that they are more likely to have clear and generalised requirements which reflect the needs of an organised market. By comparison, the more complex and diverse requirements of small farmers are less easily accommodated by breeders. Culinary and organoleptic properties, the use of crop by-products and the storability of grain may all assume greater importance for small farmers and may be more difficult for the breeder to respond to. This problem is exacerbated where small farmers are in areas of great agro-ecologic diversity, particularly hilly regions, where traditional varieties are likely to be highly adapted and where extension services are relatively weak.

In some countries, particularly in Asia and Latin America, commercial seed companies have circumvented this problem by devoting resources to breeding and selection work themselves. From the available evidence [see, for example, Echeverria, 1989; Pray, Ribeiro, Mueller and Rao, 1989], it appears this can substantially improve the speed with which new varieties are developed and their relevance to particular market niches. However, this is a very high cost option that is not readily open to public sector seed organisations, which are unable to fully recoup costs from commercial sales. Furthermore, the market orientation of commercial seed companies means that their involvement in breeding will tend to be directed towards the requirements of commercial farmers and towards the most profitable varieties - neither of which, in most cases, coincide with the needs of small farmers.

Box 3.1: Strategy for farmer participation in rice breeding in rainfed areas of India

Rice breeding in India is centralised and the variety release committee officially releases only a few varieties each year. Variety trials and evaluation are carried out at experimental research stations and, even though these are located in different agro-ecological zones, they do not cover the full range of cultivation conditions of resource-poor farmers. While varieties in advanced trials are evaluated and selected for release under good environmental and husbandry conditions, stresses commonly present under resource-poor farm conditions include:

- Soil with phosphorus, iron and magnesium toxicities, or high salinity or alkalinity;
- Deteriorated soil structure with low content of organic matter and poor drainage;
- Higher incidence and different composition of pests, disease and weeds;
- Higher baseline levels of pathogens, nematodes and weed seeds.

Scientists from Narendra Dev University of Agriculture and Technology in the Eastern Region of Uttar Pradesh embarked in the mid-1980s on a decentralised and participatory approach comprising five stages:

(i) Diagnosis of the shortcomings of the existing approach in specific locations;
(ii) Analysis of germplasm used by farmers;
(iii) Matching of characteristics of farmers' varieties with those of the pre-release breeding lines available from experimental station breeding programmes;
(iv) Distribution of small batches of improved material to farmers for trials under their own management;
(v) Evaluation.

Evaluation trials of advanced pre-release varieties were conducted by 59 farmers using their existing management practices. The objective was to enable the farmer 'to select those genotypes with better performance *per se* rather than genotypes which perform better in a higher-input management environment that he may be unable to sustain once external support is withdrawn'. The first year's preliminary result showed a marked difference in selection criteria between farmers and the research station. The research station had emphasised high yields under line-sown pure stands under favourable soil conditions and over a moderate-to-long growing period. Farmers had selected a shorter period of maturity so that sufficient soil moisture remained for planting winter crops. Other selection criteria arrived at through discussions with farmers were: high seedling vigour to better compete with weeds and intercrops; high germination under seasonally unstable conditions; and drought tolerance. A striking feature discovered was that farmers demanded and used a number of varieties to suit different intra-village micro environments, while the research station and seed industry only released and multiplied a few varieties.

Source: Maurya, Bottrall and Farrington, 1988.

3.3 Seed production for different crop species

Two fundamental characteristics of crop species determine the scale and complexity of seed production, namely the breeding system of the crop and its multiplication factor. These and other important biological features of the major food crops grown in small farm farming systems are summarised in Table 3.1.

3.3.1 Multiplication factor

This is the net increase in the quantity of seed achieved in one generation and it determines the number of generations required to produce seed in usable quantities. Breeding institutions

Table 3.1: Important biological features of major crop species

	Hybrid Maize	*Open Pollinated Maize*	*Sorghum/ Millet*	*Wheat*	*Rice*	*Beans*	*Groundnuts*
Breeding System	Controlled Pollination	Cross Pollination	Intermediate	Self Pollination	Self Pollination	Self Pollination	Self Pollination
Sowing Rate per ha	Medium (20 kg)	Medium (20 kg)	Low (10 kg)	High (100 kg)	High (50 kg)	High (100 kg)	High (125 kg)
Multiplication Factor	High (100)	High (100)	High (100)	Low (25)	Medium (50)	Medium (50)	V. low (<10)
Rate of Deterioration	Very Rapid	Rapid	Medium	Slow	Slow	Very Slow	Very Slow
Frequency of purchase	Annual	2 years	3 years	4 years	4 years	Variable	Variable
Availability of Improved Varieties	Many	Many	Few	Many	Many	Few	Few
Justification for purchase	**Essential**	**Good**	**Variable**	**Poor**	**Poor**	**Poor**	**V. poor**

are not in a position to produce enough seed to satisfy total national requirements and typically, three to five generations of multiplication are needed to achieve this.

Crops, such as maize, sorghum and millet, which have a high multiplication factor (normally correlated with small seed size and low sowing rate per hectare) are easier for the formal seed sector to deal with because fewer multiplications are required and, at each stage, there are smaller quantities to process, store and distribute. Because of the low sowing rates, the purchase cost to farmers as a proportion of total production costs per hectare is normally lower and therefore it is feasible to charge a higher price for such seed. This is a considerable attraction to commercial seed producers.

Grain legumes are characterised by low multiplication factors, because of their large seeds and low yields, and these are consequently the least attractive crops for commercial seed companies to handle. The extreme example is groundnuts, with a multiplication factor of less than 10 and a bulky seed which is prone to mechanical damage. Formal sector groundnut seed production is frequently justified on the grounds that there is a strong demand for such seed. However, in practice there are very few organised groundnut seed schemes which are economically sound and demand is usually more a reflection of undersupply in the foodgrain market than of specific demand for groundnut seed. Furthermore, the technical justification for such schemes is weak since the crop is strongly self-pollinated (see below) so farmers can maintain seed successfully on-farm themselves.

3.3.2 Breeding system

This determines the ease of maintaining the genetic integrity of a variety and consequently it affects seed quality as opposed to the quantitative aspects of seed production. The majority of cereal crops, including rice, wheat and barley, are normally self-pollinated, as are virtually all legumes. The exceptions which are cross-pollinated include maize, sorghum, millet and sunflower and, in the legumes, faba (vicia) beans and pigeon peas.

Generally, self-pollinated crops are easy to handle because they naturally exist as pure lines and are genetically homozygous. If variability does occur from any source (such as from occasional cross-pollinations, mutation or mechanical contamination), it is usually visible and can therefore be eliminated in the process of 'roguing' which is a routine activity in organised seed multiplication. Self-pollinated crops require isolation only to the extent of a physical barrier sufficient to avoid confusion with adjacent crops at sowing and harvest time. It is therefore quite possible to maintain self-pollinating varieties in excellent condition for many years. In the mid-1970s, for example, samples of the barley variety **Proctor** in Kenya and Ethiopia were found to be perfectly maintained some twenty years after their original release from the UK. Even when varieties have become seriously mixed as a result of uncontrolled multiplication, they can be quickly purified provided that a detailed varietal description exists.

Because of their natural mechanisms of self-pollination, it is complicated and expensive to manipulate these crops on a field scale to produce hybrids, although hybridisation is routinely carried out as part of plant breeding. The notable exception to this is rice, for which hybrid varieties have been available in China for over twenty years - but this technology has not spread to other rice-producing areas. For wheat, barley and virtually all legumes, there are no hybrid crops and no prospect of them in the foreseeable future.

Cross-pollinated crops are more difficult to manage within the formal seed sector because they are intrinsically variable, as a result of their genetic composition, and they are prone to contamination by foreign pollen. To minimise this risk, seed crops have to be isolated from others of the same species. If contamination does occur, it is less easily detected due to the variability which already exists within the variety. The traditional varieties of crops of this kind are 'open-pollinated populations', within which variability is restricted to certain limits to enable the variety to be identified. Such populations can be very difficult to manage because they tend to become more variable in successive multiplications. This variability also makes roguing a difficult task in crops such as maize which, because of its size, is less easily scanned in the field than, say, rice or wheat.

The response to this problem has been to attempt to restrict variability within narrower limits, by means of synthetic or composite varieties, but these still present management problems because of the sustained technical input required to maintain and multiply them. Commercial seed companies are reluctant to undertake this work when equal effort can produce a hybrid which has the benefit of extra vigour and can be sold at a much higher price. There are few examples of well-managed composite varieties - although the maize varieties **Suwan 1** and **Suwan 2** which have been used in Thailand for some years with considerable success are a notable exception. The maize variety **Katumani** is also a composite and this has been maintained satisfactorily in Kenya. However, there are several other old composite varieties still in use in Africa which are now of very uncertain genetic status.

The ultimate solution to the problem of genetic variability is to produce hybrid varieties by controlled crossing of parent lines. This is a labour- and management-intensive activity but does have the advantage of being definable, compared to the techniques required for open-pollinated varieties. Definability is a factor of considerable importance because the formal seed sector cannot deal easily with the intrinsic genetic disorganisation of open-pollinated varieties. Furthermore, hybrid technology has both agronomic (higher yield) and commercial (annual replacement) advantages and therefore, since the technical opportunities to produce hybrids by controlled pollination exist in precisely those crops which are more difficult to handle conventionally, these technologies have spread rapidly to all candidate species.

The benefits of hybrid technology vary significantly between the different categories of seed users. For commercial farmers, the need for annual replacement is not a great burden in comparison to the benefits of higher potential yields and greater crop uniformity, which is particularly useful for mechanised harvesting. Indeed, such farmers may attach considerable value to the convenience and flexibility of purchasing their seed requirements annually. In small farm farming systems, however, annual replacement can be difficult to achieve (or to justify) because of the greater cost involved and because of the physical difficulties of access to formal sector seed outlets. The benefits may also be much smaller given the more labour-intensive production methods and the lack of complementary inputs common on small farms. Nevertheless, there can be particular crop-specific benefits from the use of hybrids, such as reduced crop losses from bird attack in sorghum and sunflower resulting from uniform maturity, which are of real value to small farmers.

3.4 Generation control

The concepts of seed technology as a bridge between plant breeders and farmers and of the 'seed chain' have already been introduced. At a practical level this prompts a system for identifying the generations of multiplication between breeders and farmers. The control of this multiplication process through a limited number of named generations is a vital aspect of quality control within organised seed production since it means that the origin of a given crop is always known and faults can be traced. Seed certification provides a comprehensive quality control procedure, involving both field inspection of seed crops and the laboratory testing of seed samples, and is the conventional means for doing this. This requires a standard nomenclature; the two internationally recognised systems are outlined in Table 3.2.

Table 3.2: Major nomenclatures for seed generation control

Generation	*OECD*	*AOSCA*	*Responsibility*
1	Breeders	Breeders	Breeder responsible for producing breeder seed from original parental or nucleus material and for maintaining this latter to provide fresh releases.
2	Pre-basic	[No direct equivalent]	In the US system, the second generation may be a later multiple of breeder or an earlier multiplication of foundation seed.
3	Basic	Foundation	Selected growers produce this generation from supplies provided by the breeder and under their close supervision.
4	Certified 1	Registered	Produced on large-scale by seed organizations and sold for commercial crop production. Number of generations of multiplication depends on multiplication factor of particular species but should not be more than 2.
5	Certified 2	Certified	Further multiplications outside this controlled generation system, or multiplications that failed to meet quality control standards, are not certified. To maintain this system of multiplication requires a regular release of breeder seed.

Note: OECD = Organization for Economic Co-operation and Development
AOSCA = Association of Official Seed Certifying Agencies of the USA

There are two underlying principles involved in generation control:

- the number of generations is limited to the minimum necessary to produce sufficient seed for farmers without placing undue demands on breeders;

- 'recycling' of seed at the same generation level is prohibited - it must always proceed down the generation sequence.

Thus, if a variety deteriorates through contamination during multiplication, the damage caused is limited and soon passes out of the system, as fresh stocks of breeder seed are released each year.

Generation control has several implications for formal sector seed production. On the supply side, it makes effective linkages between the seed producing organisations and the seed certification agencies critically important. It also requires that seed organisations have the capacity to estimate demand for certified seed at least two years in advance, in order to plan breeder and basic seed production accurately. On the demand side, certification is (in principle) an important aid to marketing by providing reassurance of seed quality to the purchaser.

3.5 Technical and economic interactions

Biological factors have a key influence on the costs and benefits associated with seed production. Seed costs are often considered in the form of grain:seed price ratios. Using this approach, in very general terms it is possible to rank the comparative cost of producing different species and varieties of improved seed, as shown in Table 3.3.

Table 3.3: Minimum grain:seed price ratios for different crops

Crop	*Ratio*
Single cross maize hybrid	1:5
Three way cross maize hybrid	1:3
Double cross maize hybrid	1:2
Groundnuts	1:2
Wheat	1:2
Rice	1:2

Note: Factory gate cost (i.e. processed and packed)
Ratios in developed countries are often higher.

Thus, the relative attractiveness of seed production to different types of organisation is crop-specific. It also depends on the nature of the cropping pattern in a particular location. Improved seed of species with high multiplication factors and low sowing rates, such as maize, sorghum and millet, is cheaper to produce and cheaper for farmers to use. These open-pollinated species also have greater recurrent sales potential than self-pollinated species such as rice, beans and groundnuts. But their production is more difficult to control, so commercial seed companies will tend to promote the use of hybrid varieties of these species, which are more costly and may therefore limit small farmers' opportunity for using improved seed.

Where the major crops in the farming system are self-pollinated, recurrent sales of improved seed often depend on the ability of the formal seed sector to provide a steady flow of new varieties to maintain farmer interest. In this case, for the purposes of national development, it may be more effective to devote resources instead to strengthening on-farm seed production and storage facilities. Practical examples of the relative attractiveness of different types of seeds to different types of farmers and seed companies are given in Tables 3.4 and 3.5.

Table 3.4: Source of seed for communal farmers in Zimbabwe (% farmers using)

Source	*Maize*	*Sorghum*	*Sunflower*	*Groundnut*	*Cotton*
Farm-saved	2.1	56.1	50.4	71.5	3.0
Local farmer	-	8.8	19.5	11.1	1.5
Local trader	13.1	5.3	6.5	7.0	1.5
Local store	14.8	3.5	1.2	1.2	13.6
Co-op union	13.1	1.8	2.6	4.7	22.7
Urban store	25.9	-	1.2	0.6	7.6
Farmers co-op	25.4	5.3	2.6	1.7	13.6
GMB/CMB	-	14.0	-	0.6	36.4
Seed co-op/ AFC loan	5.5	-	1.7	-	-
Drought relief	-	5.3	14.3	-	-

Source: Friis-Hansen, 1990

Notes: GMB = Grain Marketing Board
CMB = Cotton Marketing Board
AFC = Agricultural Finance Corporation

Table 3.5: Source of seed for major food crops in India

	Total seed Planted ('000 tonnes)	*Commercial Suppliers Quantity ('000 tonnes)*	*Commercial Suppliers Value (Rs m)*	*Public Sector Suppliers ('000 tonnes)*
Wheat	2,088	138	650	105
Rice	1,025	132	550	52
Sorghum	992	25	400	9
Maize	150	13	150	4
Millet	110	15	150	6
Pulses	677	23	250	14
Groundnuts	635	38	300	14
Other oilseeds	176	16	200	9

Source: Pray, 1990

It is clear that improved seed production opportunities are location-specific both in a technical and in an economic sense due to the influence of environmental conditions on production costs, seed quality and market requirements. Environmental conditions also determine the cost of seed processing and storage and they determine whether farmers' main need is for genetic or for physiological improvement in seed quality. In hot, humid conditions, and where a long gap between harvest and planting season makes on-farm seed storage problematic, the more sophisticated processing and storage technology available to the formal seed sector may give it a clear advantage. On the other hand, for regions where the dominant crops can be stored successfully on-farm, the benefit from purchasing seed that has usually been stored for long periods and transported over considerable distances, adding significantly to costs, may be small. The example of rice in lowland tropical environments, especially where double cropping is practised, illustrates this very well.

These few examples serve to show the importance of technical considerations in assessing the potential viability of, and therefore the most appropriate organisational structure for, supplying improved seed to small farmers in developing countries. In many developing countries, there is an obvious trade-off between the type of seed that can be produced and sold easily and profitably and that which can make the greatest contribution to national agricultural development.

Finally, the discussion in this Chapter has shown that effective linkages between seed organisations and the other institutions with a role in making improved seed available in developing countries are critically important for various technical reasons. In particular, it has shown the importance of effective linkages with agricultural research institutions, with quality control agencies and with agricultural extension services.

4. ORGANISATIONAL ISSUES

In order to develop a framework of analysis that can be used to assess the impact of seed sector structure on performance we need a clear understanding of what constitutes the various components of the sector, the nature of the linkages between them and allied institutions and the organisational approaches that appear to work best in different circumstances.

In this Chapter, we highlight the experience of particular seed projects and programmes in dealing with organisational issues where this may be of wider relevance for the sector.

4.1 Seed multiplication

The level of development of formal sector seed multiplication varies substantially. In many countries in Asia and Latin America, multiplication by formal sector seed organisations provides a significant proportion of total national seed requirements; in Africa, however, few countries have established formal sector capacity so far. And even in countries where this is well established, it tends to concentrate on commercial crops, rather than small grains or legumes which are important for household food security and sustainable farming in small farm areas.

Thus many small farmers still rely on retaining seed from previous harvests. For self-pollinated crops, which can be successfully maintained and multiplied in this way, farm-saved seed is often more suitable for small farmer needs with respect to local environments, farm practices and culturally specific end-uses. Thus, to sell their product, formal sector seed multiplication systems have to produce seed with both genetic and physiological characteristics proven superior to those of retained seed in order to compete with it.

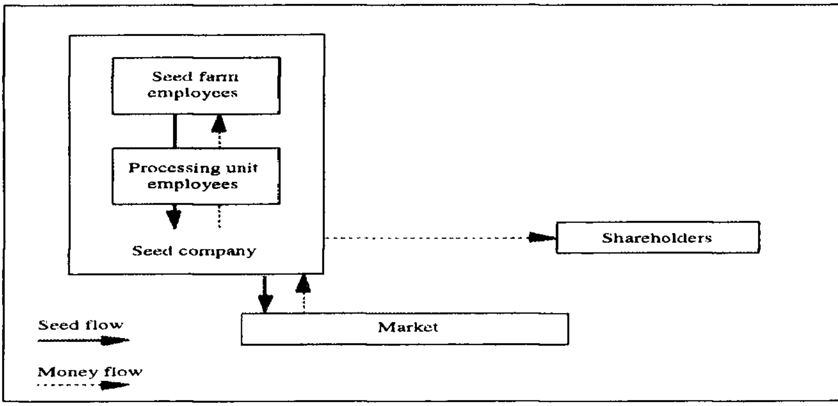
Formal sector seed multiplication is commonly carried out as a three generation process, as was illustrated in Table 3.2. The multiplication process is undertaken over three to five years, with each stage undertaken concurrently. As the product is a living organism, it is of paramount importance that it is treated correctly at each stage. This is an important difference between seeds and other purchased agricultural inputs, such as mineral fertilisers and pesticides.

The agronomic practices required to produce good quality seed are well known [see, for example, Wellving, 1984; OFSP, 1988]. However, the importance of attention to detail should perhaps be emphasised. For the majority of grain crops (whether cereals or legumes), seed multiplication is essentially similar to grain production but with some extra care necessary to ensure the quality of the end product. The issue which is of particular relevance to this study is the extent to which that attention can be maintained in different production systems. It is a basic assumption that the formal seed sector provides a multiplication system competent to assure quality, although this is not always achieved in practice. If alternative and less organised systems of seed multiplication are to be recommended, their greater geographical dispersion may make it difficult to ensure good production standards.

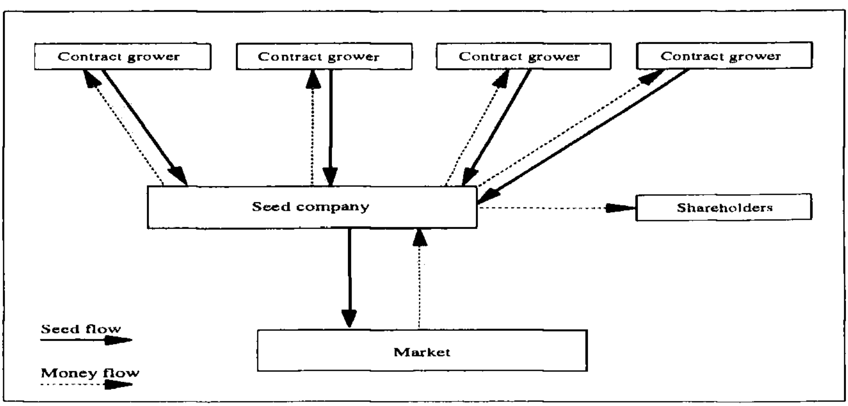
Seed multiplication can be organised in a number of different ways: Diagram 4.1 shows three ways which represent different levels of centralisation and forms of ownership. Breeder seed

Diagram 4.1: **Models of organising seed multiplication**

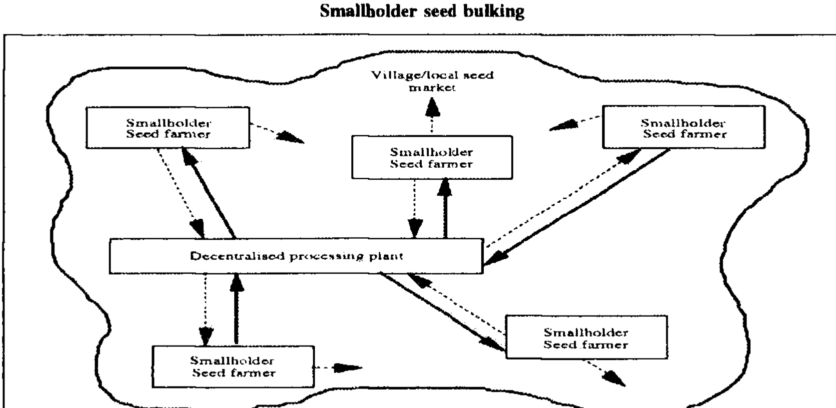
Seed farm



Contract growers



Smallholder seed bulking



and foundation seed production always has to be centralised to ensure adequate control and it is the latter stages, the bulking up of certified seed, for which different organisational opportunities exist:

(a) **Seed company farms** represent the most centralised form of seed multiplication. All stages are carried out at a central large-scale farm under one management, which has significant advantages for the ease and cost of controlling production. However, the feasibility of centralised seed multiplication depends on whether agro-ecological conditions permit all production to take place in one location, and on the level of market dispersion, and therefore the cost implications of serving the market from one location. Furthermore, on public sector seed farms it has often proved to be difficult to control quality and costs effectively using bureaucratic management methods.

(b) Use of **contract growers** is probably the most common form of organising seed multiplication. Seed companies contract farmers to bulk up foundation seed to certified seed under strict control by the company and by the national seed quality control authorities and growers are paid a premium price for the extra effort in producing a seed, rather than grain, crop. This allows for better tailoring of quantities produced to meet demand but can be more costly to administer (for example, seed inspection takes place over a much wider area) and involves the added cost of growers' premiums. Contract production is standard practice in developed countries and evidence in developing countries suggests that it is also preferred there, although it may be more difficult to operate in a less sophisticated economic system.

The difference between the contract system and cooperative forms of organisation is purely one of ownership - in this case, it is the farmer growers themselves that own the umbrella seed organisation; the two models are very similar in terms of flow of seed.

(c) **Decentralised seed multiplication** can be organised in a number of different ways. The basic concept is that the bulking up of certified seed is done by small farmers. Seed produced under decentralised schemes is usually sold within the same zone as it is produced and can be a useful means of reducing transport costs and increasing the availability of seed in more remote areas. It also enables small farmers to share in the returns to seed multiplication.

There is no single correct and most efficient way of organising seed multiplication: different organisational forms are more suitable in different local conditions. The significance of these different production systems lies in their cost implications.

In theory, contract production should approximately reflect the true production cost of seed since it is normally related to equivalent grain price plus a premium to cover the extra costs incurred. Problems can arise, however, when it is not the price of the grain crop but that of some other more profitable crop that can be produced on contract growers' land, which determines their willingness to produce seed (this has been the case in Malawi, for example, where National Seed Company of Malawi contract growers typically decide maize seed acreage as a residual after allocating land to tobacco production).

Production on seed farms is normally more costly because of the overheads of farm management and fixed labour costs. However, on government farms public sector accounting systems can mask the true costs of multiplication and the price of seed can be determined by arbitrary reference to the grain price.

The importance of certification in controlling seed multiplication has already been emphasised. In principle, this control should be applied much more easily on company seed farms. However, this is not always the case and contract growers, provided that they are adequately supervised and rewarded, often produce better quality seed. Another peripheral benefit of contract growing is its extension/promotion role in enabling nearby farmers to see good crops of improved varieties growing for seed. The same applies to decentralised seed production.

Two major factors influence the economy of seed multiplication and thus the appropriateness of different organisational forms:

(a) The **density, size and proximity of the market**: this plays a crucial role in determining whether centralised seed multiplication is commercially viable for different markets. Transport of seed over long distances from a central seed multiplication unit to sales locations greatly increases costs. Many commercial and public sector seed companies will prefer centralised multiplication because it is easier and cheaper to control the multiplication process using this approach. However, it is rarely a commercially viable option to serve the small farmer market from a limited number of central seed farms because this market is often small, widely dispersed and in relatively remote areas.

(b) The significant differences in the **technicalities of seed multiplication** for different types of crops: commercial seed companies are strongly biased toward production of hybrids, in order to secure sales through the requirement for annual replacement. This is a more management- and labour-intensive activity than, for example, multiplying open- or self-pollinated varieties, and thus commercial seed companies will often wish to organise multiplication centrally, which can preclude them from serving the small farmer seed market. This is also the case for multiplying disease-free, high-quality bean seed, for example, since this requires advanced management, to avoid seed-borne diseases, which is difficult to provide in decentralised multiplication schemes.

    However, decentralised seed production by public sector organisations or community organisations could play a much more prominent role in producing the improved open- or self-pollinated varieties that are more suitable for small farmers' use, as these varieties require less intensive management. This particularly applies to groundnut seed multiplication, for which centralised schemes have often failed to deliver cheap, good quality seed, as the handling and transport of groundnut seed is very costly and cumbersome.

Two countries' experiences with decentralised seed multiplication are illustrated in Box 4.1.

Box 4.1: Comparative experiences with decentralised seed multiplication in Malawi and Nepal

In the early 1980s the National Seed Company of Malawi was able to produce sufficient seed for maize and tobacco but not for wheat, rice and groundnuts. In an attempt to increase seed availability, the government initiated a smallholder seed multiplication scheme (SSMS) for groundnuts.

The basic goal of the SSMS was to decentralise seed production so that each Agricultural Development Division (ADD) would be self-sufficient in improved seed of acceptable quality. ADD extension staff select and supervise small farmers participating in the scheme. Each is supplied with foundation seed sufficient for 0.4 ha and during the season a decentralised seed control unit inspects the crop which is accepted or rejected as seed after harvest. The accepted crop is bought from the farmers at a price slightly above that of the official marketing board.

SSMS groundnut seed production

	1984/85	*1985/86*	*1986/87*
Number of farmers passed	341	3,714	1,902
Number of farmers failed	22	323	188
Area of crop passed (ha)	139	1,486	824
Seed production (tonne)	95	1,083	594
Average yield (tonnes/ha)	0.68	0.73	0.72

From the yields and pass rates indicated, it is clear that from a technical point of view decentralised production can be highly successful. Furthermore, all the SSMS seed has been sold, demonstrating the scheme has been filling a real demand for seed. Thus, after the concept of SSMS proved to be workable in two ADDs during the 1984/85 season, it was expanded to four ADDs in 1985/86. However, due to the difficulty of organising such a decentralised system through the top-down administrative structure of ADMARC - the national agricultural marketing parastatal - which had been chosen to administer the scheme, it had to be repeated on a reduced scale in the 1986/87 season. In addition, the SSMS tasks to be performed by ADMARC personnel and facilities have been added to their normal workload which has put pressure on resources, due to the time and costs involved in carrying out the various activities for the numerous smallholder seed producers.

Small farmers in the hilly parts of Nepal live scattered and have not reached a level of market involvement which makes large-scale commercial seed organisation possible. Realising seed supply from the lower lying plateau areas would be unworkable, the Seed Technology and Improvement Programme (STIP) - under the Agricultural Input Corporation - established 20 mini-seedhouses in 1980, located in 20 of the 40 hill districts. This eased the seed supply in the vicinity of the mini-seedhouses only; moreover, potential obstacles emerged, in the form of transport and management. In 1985, the area of rice and maize under improved varieties was 15-20 per cent, and the seed supply of the Agricultural Input Corporation only sufficed for two per cent of this area.

The focus has today shifted to village-level seed production, where micro-sized private producer-sellers are encouraged to multiply seed. The producer-seller system builds on traditional farmer-to-farmer seed exchange. Instead of multiplying and processing seed in bulk at one location, these processes are decentralised to the village level. The producer-sellers cater for localised demand, which greatly minimises the distribution and transport problem. Incentives offered to them include priority access to fertilisers and chemical inputs, seed inspection and technical support from extension workers and technicians and no price control. The technology used to produce improved seed on the village level is simple and cheap, including metal bins for seed storage and seed fumigators made from 200 litre drums. By 1987, some 30-50 smallholder farmers participated as producer-sellers of seed in each district and were responsible for 60 tonnes of wheat seed each representing a saving of Rs 2-3,000 [US$ 118 at 1987 prices] on the cost of seed portered in from the plateau areas.

Sources: Sibale and Mtambo, 1989; Rajbhandary, Ojha and Bal, 1987

4.2 Seed processing

In its widest sense, seed processing covers all operations that are carried out after harvest with the objective of improving the quality of the seed lot. The main components of processing are drying, cleaning (separation of desirable from undesirable particles such as inert material, alien seed, small and lightweight seed), followed by chemical treatment in some situations and by packaging.

As well as obviously directly affecting seed quality, the way in which processing is carried out is one of the more important determinants of seed production costs. In particular, the distance over which seed is transported from producing area to processing plant to seed users, and the capital-intensity of the processing system used, have a major influence on costs.

Where seed crops are grown on contract, growers themselves will normally be expected to dry the crop to a safe moisture content after harvest (usually by relatively simple methods) since this may be critical to the eventual quality of the seed produced. Some growers may undertake pre-cleaning of the seed lot, again by traditional methods, to improve purity and thus to obtain a higher seed premium. However, most processing operations take place in a processing centre; in the formal seed sector it is assumed that all seed passes through such a plant before it is sold to farmers. The size and annual throughput of such plants, and their location, thus have a profound effect both on the organisation of seed production opportunities and on the seed distribution system.

The processing plant can be the largest single capital investment in the formal seed sector because, for many of the separation activities, it is not technically possible to produce high quality results without using mechanised equipment. However, this does not necessarily mean that the only alternative is a large, complex, capital-intensive plant. In fact, this assumption has been a major cause of high costs and poor processing performance where it has been decided to use imported 'state of the art' equipment. Plants have often been too big for local requirements and, because their size dictates processing is centralised at one location, transport difficulties have exacerbated their underutilisation. This, and the seasonality of seed processing, has made them a big financial burden on the formal seed sector.

This was identified as one of the major causes of poor financial performance in the first and second National Seeds Projects in India. For example: Punjab State Seed Corporation was provided with 5,000 tonne plants totalling over 25,000 tonnes total capacity but actual annual throughput was never more than 4,000 tonnes; similarly Haryana SSC had 40,000 tonnes capacity to process 10,000 tonnes of seed annually [World Bank, 1987a]. In contrast, the national seed programme in Bangladesh (also financed by The World Bank) has many relatively small and simple processing centres, each serving a limited area although sending seed further afield to make up local deficiencies.

An alternative strategy is to use mobile seed cleaners to supplement, or even to replace, static processing plants. These have all the necessary equipment mounted on a truck or trailer and can be moved to collecting points such as co-ops, subject to local road conditions. This is an attractive strategy in principle, and it has been tried in countries as diverse as Bangladesh, the Yemen and Jordan. However, there are few examples of its successful implementation in developing countries.

Chemical seed treatment is practised routinely for certain crops where there is a common pest or disease which can be controlled easily by a relatively cheap product. However, it introduces some controversial issues. For example, since the seed treatment materials are seldom manufactured locally, they represent a continuing foreign exchange burden. More importantly, in the context of this study, seed treatment may represent a divisive issue in the marketing of seed: it may be acceptable for relatively organised systems which can supervise the handling of the seed prior to selling, but it can be much more risky where seed is widely distributed to subsistence farmers. In this case, the uncontrolled conditions in which treated seed may be stored and transported in the distribution chain may present several points of risk to human health.

Packaging is the final stage in seed processing and it has strong forward linkages to marketing. Indeed, the economic - rather than the technical - importance of packaging is an aspect of seed processing which is sometimes overlooked but which can have a significant impact on the subsequent ability of seed companies to market seed successfully.

For example, many international standard sizes for seed packs are based on requirements for at least one hectare (and often more) but, in many developing countries, very small average holding sizes mean that the area planted to any one crop will be considerably smaller than this. These pack sizes are therefore disadvantageous to small farmers in two ways: first, small farmers are unlikely to be willing or able to buy more seed than they need, so they will forego the use of improved seed; second, farmers may get involved in using parts of packs split up by neighbours or middlemen traders. This introduces the danger of contamination and deterioration and can result in loss of farmer confidence in the quality of certified seed. The usual rationale for avoiding small packs is that they are uneconomic to produce and deliver. However, their higher unit cost has to be offset against the increase in sales they will produce. In the case of Seed Co-op in Zimbabwe, for example, 500g, 2kg and 5kg maize packs have in fact become a significant profit centre [Friis-Hansen, 1990]. The Kenya Seed Company has also had a long and successful experience with small 'urban' packs of its hybrid maize varieties.

There is a prevailing belief in decentralising seed processing but this is not necessarily relevant in all circumstances. On the other hand, in many developing countries major (often donor-financed) capital investments in processing have already been made and it is assumed that, in any re-organisation of the formal seed sector, these facilities will continue to be used, rather than embarking on completely new alternative schemes. The key factors that need to be assessed when determining the best strategy for organising seed processing are as follows:

(a) the **geographical concentration of the producing area**: if the multiplication sites are dispersed over a wide area, it is difficult to justify the substantial additional transport costs involved in moving seed from a large number of dispersed sites to one central processing plant. This is especially true for relatively low value seed of self-pollinating crops, for which demand is particularly sensitive to price.

(b) the **complexity of the technical processing task**: the bias towards more capital-intensive processing systems has partly arisen from the traditional view of processing as a complex task involving a number of operations most effectively carried out by machine. But this does not have to be the case: some of the operations - such as sizing - can be missed out if the seed is going to be used in small-scale rather than mechanised agriculture. In addition, the complexity of the processing task is significantly influenced by climate - in some areas there is scope for greater use of simple, low-cost processing systems operated by small-scale farmer producer/processors, in order to reduce costs and improve the availability of seed. Some examples from Asia and Africa are illustrated in Box 4.2.

Box 4.2: Decentralised seed processing in Asia and Africa

In the Philippines, farmers themselves - rather than macro-level projects and programmes - have played a large part in organising seed production. After the introduction of **IR8** rice in the 1960s, medium-scale farmers formed Seed Growers Associations and now produce the bulk of certified rice seed. Although fifteen large-scale processing centres were provided under Japanese aid in the 1970s, these have remained underutilised as it is uneconomic for farmers to transport seed to and from these centres - and they can produce seed of adequate quality using small-scale processing systems devised on-farm supplemented with mobile cleaning units. These require minimal capital investment, using labour-intensive methods to process seed using a simple system of sieves and fans. Output of 20 sacks/day is sufficient to keep pace with requirements.

In Nepal, after experiencing great difficulty with delivering rice seed from the large-scale projects in the plains to the more remote areas, the development of a low-cost processing 'kit' for rice consisting of drum seed treaters, seed bins, sampling probes and moisture meters, has made a substantial contribution to the success of initiatives to decentralise seed production using small-scale producer-sellers in the hill areas.

In Zimbabwe, the dominant seed organisation, Seed Co-op, has financed the local development of technology suitable for decentralised maize seed processing, in order to reduce the transport component of processing costs and improve the availability of seed in communal areas. Although the equipment is of a size and cost (Z$30,000 [US$ 13,000 at 1990 prices]) that precludes its use by very small-scale farmers, it has had considerable knock-on benefits in terms of generating off-season agricultural employment.

Sources: Rajbhandary, Ojha and Bal, 1987; Friis-Hansen, 1990.

The critical factors here are:

- **the number of crop species for which seed has to be processed**: although most major crops can be processed through the same type of equipment, there are more separations to be maintained if there are a large number of crops;

- **which species these are** : the mechanical processing task for groundnuts, for example, is technically much more demanding than for other crops;

- **whether chemical treatments as well as mechanical cleaning and grading, etc. are required** : for example, in areas with prevalent soil-borne diseases or other pests that can seriously affect germination. This is because it is harder to organise the supply of chemicals to large numbers of small plants and more equipment and skill is required to apply them accurately.

(c) the **level of transport development**: if transport is a major constraint to timely delivery of seed from the processing plant out into the field, and the technical requirements of processing permit, placing processing facilities nearer to the areas where the seed is to be used may be more effective. This is economic even where producing and using areas are not contiguous and the seed has to be moved from one to the other because, compared to other commodities, the bulk and weight reduction in seed processing is small, so there is no obligation for processing to take place near to multiplication sites. Another option, where the capital costs of establishing numerous small plants are high and where the technical processing task is relatively uncomplicated, is the provision of mobile seed cleaners able to tour a number of multiplication sites in one local area. As was shown in Box 4.2 these have been used with some success to process rice in the Philippines.

(d) **macro-economic policy**: because processing is relatively demanding of labour and capital for fixed equipment and chemicals, performance with respect to processing costs is also dependent on the levels at which prices for these resources are set and their availability at national level and therefore macro-economic policy exerts a strong influence.

These factors determine the opportunities for using different organisational structures to process seed. At the same time, the success of the processing component is influenced by the nature of its linkages with other parts of the seed sector, and in particular the linkages with four of these:

(a) **processing is a service function for multiplication**: this means the organisation of the two components has to synchronised, particularly with respect to the quantities of different types of seed to be produced and where this is to be done. However, processing cannot compensate for bad seed, so it also means its contribution is very dependent on the quality of the field production activities.

(b) **processing and storage go hand in hand**, given the seasonal nature of the production process and the sensitivity of the product. Therefore, the options for organising the processing component depend critically on the quality and distribution of storage facilities. In particular, the difficulty and cost of organising local-level storage can be a significant constraint to decentralising processing. This is illustrated in Table 4.1 with reference to the experience of the SADCC countries:

(c) Where substantial investments in processing plants have been made, the quality of the product must be assured and this requires that the other parts of the seed chain influencing the ultimate quality of the product must be operating effectively. This applies particularly to the **quality control services**. It requires both control built into the mechanical processing system - keeping the progress of individual seed lots through the system separate by adequate cleaning of the equipment (and sufficient records to be able to identify each lot) - and sufficient resources for independent quality control authorities to maintain an adequate presence in the plant. Where resources to do this are limited and/or there is a large number of different types of seed to be processed, the opportunities for successfully decentralising processing to a large number of dispersed plants are more limited.

Table 4.1: **Processing and storage facilities in SADCC countries**

	Angola	*Botswana*	*Lesotho*	*Malawi*	*Mozambique*	*Swaziland*	*Tanzania*	*Zambia*	*Zimbabwe*
Drying									
Natural	V	V	V	V	V	V	V	V	V
Artificial	(X)	X	(X)	X	(X)	V	X	X	V
Need for artificial drying	V	X	V	V	V	V	V	V	V
Processing									
Centralised	X	V	V	V	V	V	X	V	X
Decentralised	V	X	X	X	X	X	V	V	V
Suitable Storage									
Seed Company or projects	X	V	X	V	V	V	X	V	V
Distributors	X	X	X	X	X	X	X	X	X
Seed Security Storage	X	X	X	V	X	X	X	X	V

Key: V = present X = absent (X) = present but not installed

Source: DANAGRO, 1988a.

(d) These are all backward linkages however there is also one very important forward linkage: between processing and **marketing**. Because not all aspects of seed quality are visually obvious, successful marketing is particularly dependent on maintaining farmer confidence in the value of the product [Douglas, 1980]. One of the requirements for this is the provision of packs small enough to be usable on small farms. The mechanical processing itself, together with the quality of the multiplication system, is also important in achieving this with respect to size - and clean seed in particular is important in guaranteeing farmers 'value for money'. At the same time, cheap seed dressing introduced into the processing system can contribute both directly to the benefit of formal sector seed production for farmers and indirectly to their allegiance to its products, by aiding product identification. For example, The Kenya Seed Company has done this with considerable success by establishing a monopoly on imports of blue-green seed dye so that only the Company's seed had this distinctive colour [Gerhart, 1975].

4.3 Seed storage

The main impact of storage on the formal seed supply system is through physiological effects on seed quality. In many tropical countries high temperatures, and particularly high relative humidity, cause a rapid loss of germination after harvest unless special measures are taken to prevent this. All the technical knowledge exists to prevent this deterioration, both for the short- to medium-term needs of seed suppliers and for long-term storage as well. However, the cost of installing and operating controlled environment stores in tropical countries is very high and this is seldom an economic approach if real costs are to be passed on to farmers.

Thus, with the exception of some stocks held by plant breeders, almost all cereal seed in developing countries experiences ambient atmospheric conditions throughout its life. The only significant interventions to improve or maintain quality are the use of drying at intervals to reduce moisture content and the use of plastic-lined sacks to reduce moisture uptake in dried seed. This latter approach can have real benefits which can last for a sufficient time to protect seed for much of the delivery process, but its application depends on the availability of the appropriate materials - or sufficient foreign exchange to import them.

Apart from biological deterioration in store, the physical and logistical aspects of seed storage are closely linked to the size and location of processing plants, as discussed in the previous Section. In environments where there is a defined wet and dry season, the entire seed crop exists in store between harvest and sowing - a period which ranges from four to eight months depending on location. A small part of this crop may be on farms but the majority is in stores at the processing centre or elsewhere in the collection and distribution system. The stores are frequently not well designed or managed, particularly those which belong to other organisations than the seed companies themselves (which is often the case). Risks include exposure to rain, insect and rodent attacks and contact with other materials such as fertilisers. The larger the processing centre, the more complex is the collection and distribution chain, and the greater the risks to which seeds are likely to be exposed.

The sector has three different kinds of storage needs:

- storage at the processing plant;
- transitional storage between processing plant and sales points;
- storage of strategic seed reserves to maintain national seed security for years of poor harvests or severe pest attacks.

The quality of storage influences the physical availability of seed to farmers and their confidence in its quality. At the same time, poor storage adds to seed companies' operating costs if stocks have to be written off due to loss of viability. Seed, as a living organism, is especially susceptible to bad handling and poor stock rotation.

Some storage requirements - store capacity, humidity and temperature control, etc. - require technical solutions: appropriate design, sufficient funds for capital expenditure, and so on. In fact, seed processing and storage are two components of the seed sector where technical equipment needs can be as important as managerial issues. But organisational requirements, which often receive less attention in practice, are also very important and can make the difference between successful and unsuccessful storage, regardless of the type of technology used. Important issues in this category include the location and distribution of seed stores, the delegation of executive responsibility for their management and routine attention to store hygiene.

Locational issues are important because transport is such a big proportion of total seed organisation costs, so that the correct siting of stores in relation to the producing areas, the processing plant(s), the main areas of demand and the more remote regions that need to be served is a critical task. In a recent evaluation of India's two National Seeds Projects, for example, the logistical problems and high transport costs associated with the organisation of storage centrally for certain State Seed Corporations was found to be a major cause of poor performance [World Bank, 1987a].

In practice the organisation of seed storage is rarely considered in relation to the specific requirements for good storage needs alone but is pre-determined by the organisation of the seed sector as a whole. Thus, where the production of improved seed is primarily in the hands of commercial organisations, delivery is most often through a network of private traders or dealerships and the enterprise itself will supervise closely the conditions under which seed is stored. On the other hand, public sector organisations frequently feed their product into the government agricultural marketing system, particularly where programmes for the distribution of agricultural inputs on a package basis are operating, and therefore have little control over storage arrangements.

The way storage is organised at the processing plant is dependent on the nature of the processing operation: it has to be near the plant and will be decentralised only if processing is. Also, to cope with the large quantities of seed typically produced, and the high quality standards that have to be maintained, it usually has to be of a relatively technically advanced design.

However, there is considerable scope for different approaches to organising transitional storage. Responsibility for transitional seed storage (distribution depots, etc.) is often delegated to other organisations, such as grain marketing parastatals, which already have well-developed storage networks, in order to reduce fixed costs. Decisions about this kind of delegation of managerial responsibility are important because they involve balancing a certain reduction in fixed costs against a potentially serious loss of quality, because maintaining seed quality in store requires careful stock management - with respect to regulating the storage environment, stock rotation and handling, etc. - which may not be available in organisations normally dealing with less sensitive commodities. Box 4.3 illustrates the experiences of three countries with this.

To be of real benefit to seed users, and particularly to small farmers who have little surplus to allocate to maintaining large seed reserves on-farm, the formal seed sector is often expected to store strategic seed reserves, over and above normal carry-over stocks, for use in emergencies. The necessary size and location of these reserves depends primarily on agro-ecological factors such as regional variations in the probability of drought; the prevalence of pests and diseases able to wipe out complete harvests of the main staple; and the multiplication factors of the major food crops (low multiplication factors slow down the process of stock replacement necessitating larger reserves). It is also determined by socio-economic conditions including the size of the population at risk and their distribution and the level of transport development.

In most developing countries, these conditions necessitate much larger reserve stores than in developed countries with temperate climates; these are costly for individual seed organisations

Box 4.3: Comparative experiences with organising seed storage in Tanzania, The Gambia and Kenya

The problems with storage experienced by Tanseed, the national seed parastatal in Tanzania, are typical of those facing many public sector organisations. The company has four main storage depots, all attached to processing plants, where seed is held before dispersal to sales points at six branch depots, a number of retail shops and the national co-operative societies. Hybrid and composite maize are the major seeds traded. Because there are only three to four months between harvest and planting time in which to complete collection, processing and distribution in a large country with severe transport problems, Tanseed's concentration of processing and storage means there are always late deliveries which are left unsold and in store until the next season. Few of the stores have proper humidity control so it is very difficult to maintain viability. Added to this, stock control (labelling, record-keeping etc.) is poor and the national seed quality control authority, TOSCA, is unable to fulfil its role effectively with respect to re-certification of remaindered stocks. This has created a situation where unsaleable deteriorated stock is a large drain on the company; in 1982/83, for example, stocks of viable seed had to be written down from 1,915 to 1,346 tonnes, adding TShs 1,595,000 [US$ 125,900] (27 per cent) to total estimated operating losses.

In The Gambia, similar problems with the supply of rice seed through official channels led the government to institute a parallel programme of supporting local construction and maintenance of village-level seed stores. By 1987, 573 new village seed stores had been built in co-operation with local farmers and were being maintained by the Department using a mobile repair team from their Engineering Unit and free distribution of sprays and store chemicals, and were considered to be having a positive impact on the quality of seed available at village level. However, as part of the 1985 national economic recovery and structural adjustment programme, the Department's budget for these activities has been cut by 50 per cent and operations have had to wind down.

In Kenya, the Kenya Seed Company - a locally-owned enterprise in which the government has a majority holding - has from its inception encouraged the development of small-scale retail outlets for seed and, by 1988, there were over 4,500 small retail stores and co-operative societies stocking KSC maize seed - the Company's major product. But problems have been experienced with the transitional storage between the Company's four main storage depots and the retail outlets, which is organised by the parastatal Kenya Grain Growers Co-operative Union. KGGCU has to lease private storage to supplement capacity at its own 50 branches and has found that poor conditions at this level have resulted in large-scale deterioration, to the extent that over 50 per cent of the seed returned to KSC (the Company will accept unsold seed back for credit notes) is rejected.

Sources: DANAGRO, 1988c; CDC, 1984; Republic of the Gambia, 1987; Ruigu, 1988.

to maintain and can jeopardise their financial performance. Kenya's strategic maize seed reserve, for example, cost KShs 30 million [US$ 2,490,000] in 1982. Thus, in practice, the burden this represents is often dealt with by agreeing a smaller notional quantity of seed to be carried over by the seed organisations from one harvest to the next. However, where it is decided that national development considerations must override operational efficiency, and a proper reserve must be maintained, some degree of government support for this function is necessary; either in the form of a subvention to cover the associated costs (as in Kenya's case), or by taking over responsibility for this function itself.

On the basis of this and more general evidence from other countries, three factors appear to be critical in determining the success of different approaches to improved seed storage:

(a) the **distances involved** and the **level of transport development**: if seed has to be transported long distances from processing plants to sales points and the level of transport development is poor, there will be much greater need for transitional storage to ensure timely supply.

(b) **crop-specific factors**, particularly the length of the growing season of the major crop and its replacement rate, influence the required storage capacity. Long growing seasons limit the time available for processing and distributing seed in time for planting and usually mean that, for timely supply, a proportion has to be held over from the previous season. And the more frequently seed has to be replaced, the greater the necessary seed stocks will be for a given year.

Crops also vary in the storability of their seed and this affects the formal seed sector directly and also indirectly, via the ability of farmers to store their own seeds. Thus a crop such as rice, which is relatively easy to store in tropical conditions, is more difficult to sell since farmers can carry over their own seed stocks. In contrast, soya bean is notoriously difficult to store and projects which have sought to introduce this crop into new areas have had to incorporate a strong seed storage element to ensure that sufficient planting material is available to farmers.

(c) **climatic factors** influence the length of the growing season too but also determine the complexity of store design. Seed is hygroscopic and storage life is halved for every one per cent increase in seed moisture content between five and 14 per cent moisture and halved for every 5°C increase in storage temperature up to 50°C so in particularly hot, humid climates optimal storage requires expenditure on specialised humidity and temperature control. In practice, however, the expense of this is often considered too great for it to be used and, more commonly, seed is stored in grain stores with very little modification, and consequently suffers considerable losses from deterioration.

Climatic factors also influence storage capacity requirements as, where particular varieties are season-specific, demand for improved seed will be higher because farmers find it harder to keep seed on-farm, as we saw earlier in the case of Bangladesh.

Because much of the total storage capacity is often closely associated with the processing centre, the particular climatic conditions prevailing at the centre assume special importance. In countries with large variations in altitude, quite small distances can bring substantial changes in climate. A well known example of locational effects of this kind is the Tanzania Seed Company processing centre at Morogoro. The climate in this area is said to be particularly hot and humid, whereas at higher elevations not far distant, natural storage conditions are far better. Although this is a factor which affects any seed activity, the formal seed sector is intrinsically more vulnerable because of the concentration of seed at a few sites.

By influencing the size of the necessary seed stock, where it is needed and the complexity of maintaining it in good condition, these factors determine the type of organisational structure most appropriate for the storage function. However, storage performance will also be strongly influenced by its linkages with other components of the seed sector, and five in particular:

(a) **accurate demand estimates** are critical for avoiding the additional burden of dealing with unsold stocks at the end of the season. Whether these are the responsibility of the extension service, input marketing agencies, or the seed organisation itself, a system of information flow must be in place for accurately assessing the use of improved seed on farms by region - not just extrapolating demand from population censuses and theoretical replacement rates.

(b) the **seed quality control authority** must be able to monitor stocks in store, and particularly carry-over stocks. Loss of quality during storage, for whatever reason, presents a serious threat to the validity of certification schemes. Seed may be certified and labelled using the correct procedures but may deteriorate in the months that intervene before sowing. Although complete loss of quality is unlikely, there is still a possibility that some farmers may purchase certified seed of indifferent quality which detracts from the overall reputation of the system. Given the importance of reputation where quality is concerned, if resources for doing this are limited, this should be considered a severe constraint to the decentralisation and dispersal of storage capacity.

(c) storage feeds directly into the **distribution network** - therefore having an efficiently functioning storage system will contribute to the performance of the seed sector as a whole only if this latter is also functioning efficiently, and able to deliver all the supplies of improved seed available on time and to the locations required.

(d) the opportunities for greater **participation of village communities or small traders** in dispersed storage depend on the availability of low-cost storage technologies, to substitute for the standard store designs that become irrelevant and costly at this scale, and on the availability of loan finance for seed stocks, as funding the long period of time over which stocks have to be maintained in the seed sector can be a critical constraint to small-scale operators. A frequent solution is, however, to minimise the storage time with traders so that the quality of storage at this stage in the distribution process is not so critical to the success of the national delivery system as a whole.

(e) in addition to these technical factors, seed storage has strong **financial implications**: most seed production systems are seasonal in nature, reflecting the seasonality of crop production, and this affects the annual cash flow pattern of the seed companies. For commercial seed companies, the costs of carrying large stocks for several months at high interest rates can be crippling, and for government seed companies there is a risk that insufficient budget allocations are made to cover the stocks required. These problems are made worse by the need to dispose of some seed stocks as grain due to deterioration in store and/or excess production due to poor demand estimates. This emphasises both the special nature of improved seed as a marketable commodity and the critical importance of accurate demand prediction.

4.4 Seed distribution

Seed distribution comprises all those activities involved in the physical distribution and marketing of seed to farmers. Seed distribution systems are therefore one of the most important components of the formal seed sector - because they are the major point of contact between farmers and the seed producing organisations. Thus, as well as their direct function of ensuring the timely distribution of improved seed to all the locations where it is required, seed distribution systems have an important indirect function as channels for the flow of information concerning farmers' seed needs, with respect to type and quantity, between the farmers themselves and the producing organisations. Their performance is critically determined by the ability of the other components in the seed sector to provide them with the right type of seed in the right quantities at the right price for timely distribution to seed users. Nonetheless, as a generalisation it is poor performance within the distribution system rather than inadequacies in the seed production system that is more often cited as the most severe constraint to seed sector performance as a whole. It is also this part of the seed chain which has tended to have had relatively little attention devoted to it when national seed sector plans have been drawn up: seed distribution is 'the poor cousin' in most seed programmes [Prain and Uribe, 1991] despite the fact that much of the crucial work in seed programmes concerns reaching the users of the seed and does not begin until after the seed itself has been produced [Rhoades, 1989].

Within the seed chain, the activities involved in distribution and marketing form a sub-chain with three distinct stages: from processing plant to bulk distribution point; from these to retail outlets; and from retailer to seed user. Each stage comprises different types of activities. This adds to the complexity of organising distribution effectively as it is often most appropriate to use different types of organisation, rather than one single structure, to deal with different parts of the seed distribution chain.

The major organisational alternatives in the seed distribution chain are: the direct distribution of seed by seed companies themselves, through their own outlets; and systems where the responsibility of the seed company stops at providing seed for other organisations to deliver. These other organisations can be public sector (national agricultural marketing authorities, agricultural credit schemes, sector- or area-specific agricultural projects, etc.) or commercial (individual or multiple outlet specialist seed retailers or general traders). To date, the nature of the organisations used for seed production has tended to determine the type of organisations used for distribution. Thus private sector seed companies have tended to use private sector distribution channels, whilst seed parastatals have supplied other agricultural parastatals. Table 4.2 shows the distribution structure in practice in three different developing countries.

The formal seed sector is not the only source of seed for farmers, however, and in many countries, depending on the types of seed required and the general trading environment, the major source is in fact farm-saved seed and seed distributed through a variety of informal transfer and exchange mechanisms. Thus the organisation of formal sector seed distribution has to be planned in the context of the existence of this substitute channel; in certain situations it may in fact be more effective to devote resources to strengthening informal distribution systems rather than to developing parallel organised seed distribution.

Table 4.3 shows some of the approaches to organising different parts of the seed distribution chain that have been used in developing countries. Clearly, different organisational approaches meet the objectives of efficient and equitable seed distribution better in different circumstances. The factors determining this can be grouped into three main categories, as

Table 4.2: Distribution structure for improved seed in Pakistan, Sierra Leone and Tanzania (% improved seed distributed [volume])

	Pakistan (Wheat)	*Sierra Leone (Rice)*	*Tanzania (Maize)*
Seed company	14	17	57
Agricultural parastatal or project	58	54	2
Agricultural development banks	1	nil	nil
Private traders	27	17	nil
Farmers' associations	nil	9	42

Sources: Heisey, 1990; Bockari-Kugbei, 1989; Budden, 1986.

described below. The first set influences the ease with which different types of organisation can reach small farmer seed users and their comparative advantage in doing so; the second set influences the attractiveness to the distributing organisation of serving this category of seed user.

4.4.1 Exogenous factors

- *Market size* determines the cost and profitability of seed distribution and is a function of, amongst other things, population density and the level of commercialisation in the local economy. On both these counts, the small farmer seed market scores badly and is likely to be an unattractive financial proposition. For private sector organisations this is because, unless the cost of the investment is compensated for by the profitability of the seeds provided, the large investments in transport and distribution points required to reach scattered farmers in remote locations can result in only a small increase in sales. For the public sector, funding such investment effectively is often beyond the capacity of departmental budgets.

  One of the possible solutions in these circumstances is to organise distribution, through the provision of incentives if necessary, through existing networks such as those of general retail traders. An alternative, which can be more appropriate if the types of seeds required can be maintained relatively easily on-farm, is to strengthen informal seed distribution mechanisms.

- The *species and varieties of seed required* also influence the attractiveness of different seed markets to different types of organisation. Small farmers typically require small quantities of a large number of varieties to fit the numerous niches in their complex farming systems. Also, they are very selective in their use of the formal seed sector because of the cost and risk associated with doing so within marginal farming systems.

Table 4.3: Typical delivery structures for improved seed

	Main activities	*Storage quality & capacity*	*Timeliness of delivery*	*Density of outlets*	*Seeds suitable for small farmers*	*Retail seed price*	*Product promotion incl. pack size, complementary inputs*	*Demand estimates*
Seed organisation outlets:								
• commercial	1, 2, 3, 4	Usually good	Usually located at plant so delivery not an issue	Limited - near to plant	Sometimes	May be high	Usually good	Often rely on private traders
• public sector	1,(2),(3),(4)	May be poor	Ditto	Ditto	Usually	Frequently controlled	Often poor	Often rely on extension service - poor
Seed Growers Associations	1,(2),(3),(4)	Often limited	Local sales only	Local sales only	Sometimes	May be high	Often by word-of-mouth	Good, but for local sales only
Agricultural parastatals	2, 3, 4	Good capacity but poor quality	Often poor	Usually good	Usually	Frequently controlled	Often poor	Often poor
Agricultural projects, MOA local offices	(2),(3), 4	Usually limited - rely on other organisations	Variable	Project sales only	Usually	Often controlled	Variable	Often inaccurate if large area
Agricultural banks, credit schemes	4	Usually rely on other organisations	Usually rely on other organisations	Variable	Usually cater for more commercialised small farmers	Depends on source of seed	Minimal except when providing complete input packages	Limited to immediate clientele
National agricultural co-ops	2, 3,(4)	Good capacity but poor quality	Often poor	Usually good	Usually, but often unsuitable for agro-ecological zone	Depends on source of seed	Ditto	Often poor
Agricultural merchants	(2),(3), 4	Limited but good quality	Usually good	Often good but biased to higher potential areas	Usually cater for more commercialised small farmers	May be high	Usually good and often supply complementary inputs	Usually good although limited to immediate clientele
General traders	(2),(3), 4	Ditto	Ditto	Ditto	DItto	Ditto	Often good	Ditto
NGO projects	1,(2),(3), 4	Ditto	Usually good	Project sales area only	Usually	Often subsidised	Usually good	Ditto
Local farmers organisations	1,(2),(3), 4	Limited by lack of resources and of specialist knowledge	Often good by depends on source of seeds	Ditto	Usually	Usually at cost from source of seed	Technical info. may be limited but other aspects good	Ditto
Village seed banks	1,(2),(3), 4	Ditto	Ditto	Ditto	Usually, but subsequent village level maintenance may lead to deterioration	Ditto	Ditto	Ditto

Notes: 1 Seed production; 2 Delivery from seed organisation to wholesale outlets; 3 Delivery from wholesale to retail outlets; 4 Delivery from retail outlet to seed user; ( ) Uncommon

Thus, for example, for self-pollinated crops farmers will often use farm-saved seed unless there are proven new varieties that they wish to invest in; in addition, they will purchase not their total seed requirement but only enough to multiply up to meet their needs; and small farmers are easily deterred from using improved seed if quality and timeliness of distribution are not consistently good.

Thus because the species and varieties required by the small farmer seed market are large in number and variable, this market is often not cost-effective for the formal seed sector to supply. The formal seed sector is more likely to succeed with seeds of species with high replacement rates; for a small number of varieties of wide geographical applicability; for the same varieties over time; for seeds with a controlled production system (e.g. hybrids); and for supplying relatively large quantities to individual users. The implications of this for different types of seed organisations are considered in the discussion of market development strategy below.

☐ *Institutional and price policies* affect the relative ease with which different types of organisation can operate. Seed price policy is one factor which has a particularly significant impact; this is discussed in Section 5.2. The appropriateness of different organisational structures for seed distribution is also affected by the stage of development of the wider economy, thus varying between countries, and within countries over time. (This is discussed in Section 5.4.)

4.4.2 Factors specific to the distribution organisation

☐ The differences between the *market development strategies* of different types of seed organisations create marked differences in the relative attractiveness of the small farmer seed market to them. Commercial organisations seeking not just cost-effective but profitable markets will be much less willing to deliver seed to small farmers. However, the complexity of the small farmer market means that well-functioning channels for gathering information about their specific needs and rigorous quality control and attention to the timeliness of distribution are critically important for the effective distribution of their seed needs. Public sector organisations, whilst perhaps in a better position to bear the costs of operating in this market, may not be as efficient at providing these requirements due to their bureaucratic decision-making structures [ICD, 1987; World Bank, 1987a and b; USAID, 1987]. Therefore it may be more appropriate to encourage private sector participation by reconciling the differences between their market development strategy and the nature of the small farmer market with suitable policy incentives.

☐ Seed companies' internal *seed demand estimates* are the mechanism by which the demand and supply sides of the seed sector are linked together. These estimates therefore have a pre-eminent importance in determining the success of seed distribution. Accurate estimates are particularly important in the seed sector because of the long time lag in the multiplication of breeders and basic seed to certified seed, so deficiencies cannot be compensated for quickly.

Various different methods of estimating demand for improved seed are in common use. In declining order of accuracy these include projections based on past sales adjusted for the known rate of technology adoption; conducting sample surveys of farmers; relying on the opinion of seed market experts; projections based on past sales only; and estimates based on sales targets set by government or by seed companies.

Lack of accurate estimates is one of the biggest constraints to effective seed distribution. Often this is because the necessary data does not exist - in which case estimates have to be based on theoretical assumptions (e.g. the ideal replacement rate rather than that used in practice) or extrapolations from short-term trends (e.g. previous sales plus 10 per cent) which do not accurately reflect the situation in practice. Or it is because responsibility for this function has been allocated to organisations unable or unmotivated to perform it effectively. In particular, it has been found that estimates from government agricultural extension services and from primary co-operative societies are rarely accurate. Demand estimation is one area where greater private sector involvement is considered to be the only really successful approach to achieving significant improvements [ICD, 1987; World Bank, 1987a and b; Kalende, 1989].

- Adequate *product promotion strategies*, that highlight the benefits of using improved seed are another particularly important aspect of seed distribution both because of the difficulty of making information available within the small farm community and because seed is very location-specific compared to other products, requiring targeted information about its use and benefits in particular situations. This can be the responsibility of the distributing organisations themselves or the extension service, depending on the structure in operation. However, farmer-to-farmer contact is still the most frequent channel for communication about seed technology (see Section 5.3). Promotion is considered to be one of the weakest aspects of public sector seed distribution systems [ICD, 1987; Menon, 1983] and, again, this relates in part to the need for flexibility and responsiveness in the approaches adopted.

  Often it is the private sector that can achieve this most successfully. The experience of the Kenya Seed Company is particularly illuminating. It set about achieving its aim of having 'every stockist an extension agent' by providing a range of flexible incentives to stockists including attractive margins, the acceptance of returned stocks and a line of stockist credit [Gerhart, 1975]. Public sector organisations find it much harder to achieve this kind of flexibility and, even where promotion budgets are available, planned activities are often not approved quickly enough and the budgets remain unspent [World Bank, 1984]. More usually, these organisations will rely on the extension service for promotion, rather than being able to offer incentives themselves, which has severe limitations of its own.

4.4.3 Backward and forward linkages in seed distribution

Whichever organisational structure is chosen for delivering improved seed to small farmers, its performance will be strongly influenced by the strength of its linkages with other specific components of the seed sector: seed distribution is the one stage in the seed sector chain where links with both the demand side and the supply side of the market are critically important.

Box 4.4: Four alternative approaches to seed delivery for small farmers

As in many other countries, the limited budget and bureaucratic approach of the public sector extension service in Kenya severely limits the capacity of the service in providing small farmers with a regular supply of improved seed and this has traditionally been left to the private sector which may not service small farm areas. In Eastern Province, one approach to improving public sector performance that is being proposed is the use of mobile distribution units to tour rural centres on market days. It is hoped this will not only cut operating costs by tapping into a market channel that small farmers are already using but also increase the number of farmers that can be reached with limited resources, for the same reason.

After Independence in Zimbabwe, concern that small farmers' seed needs would not be met by the wholesale and retail seed delivery system dominated by commercial organisations caused the government to intervene in the market, to create controlled area monopolies for each enterprise - with the obligation to serve all categories of farmer within their target area. This has successfully ensured the delivery of seeds to small farmers by the private sector, with the advantages of superior timeliness and quality control, as the enterprises are willing and able to cross-subsidise this from the more profitable parts of their business within their area.

In The Gambia, with the inability of the MOA Seed Multiplication Unit to keep pace with the demand for certified seed, the unsatisfactory performance of the Co-operative Union in seed marketing and the budgetary constraints to strengthening village-level seed production and storage, the latest development has been to add seed distribution to the responsibilities of NGOs already involved in agricultural work. Action Aid, Catholic Relief Services, Save the Children Fund and the Freedom from Hunger Campaign now account for 50 per cent of national certified seed production for maize, rice and groundnuts and have geographical zones of responsibility for distribution at village level. There have been some problems with quality control and co-ordination, and this level of involvement is unlikely to be sustainable in the long run, but it is now accepted in The Gambia that organising seed distribution through NGOs is a useful approach to overcoming the immediate constraints to development imposed by the poor access of small farmers to improved seed. The particular advantages include the better manpower and transport resources and level of funding of the NGOs and their stronger awareness of needs and constraints resulting from their focus on grass roots work.

In Peru, the Institute for Agricultural Research, the International Potato Center and Swiss Development Co-operation have initiated a project to build instead on the informal seed distribution systems, to which 90 per cent of the high altitude small farmer potato production area is connected, because of the dislocation of this from the formal seed supply system based in the coastal areas and the particular need, for potatoes, for clean stocks due to their many disease problems. The project sells basic seed to small farmers through the extension service and government and NGO projects. Only three conditions are attached to its use: it should be sold on at a price reflecting its superior quality; only small amounts are to be sold to individual buyers; and (for phytosanitary reasons) no seed is to be multiplied below altitudes of 3,000m. How it is distributed within the community is left entirely up to the farmers themselves. A follow-up study two years after the start of the project found that, through normal informal distribution mechanisms, seed which was originally supplied to 6 communities and 15 individuals had reached 14 communities and 191 individual farmers. It also calculated that, over the average seven year renovation period, each farmer derived, at 1987 prices, $241 benefit from the initial outlay of $3 for 20 kg of project seed. In this way, building on the existing informal seed distribution systems had, for the potato crop, radically improved the availability of improved seed and enabled small farmers to derive real benefit from using it - given that a significant constraint to increasing potato productivity was the lack of disease-free stocks.

Sources: Johnson, 1989; Friis-Hansen, 1990; Henderson, 1990; Scheidegger, Prain, Ezeta and Vittorelli, 1990.

Demand side issues were the focus of Section 2.3.

On the supply side, distribution and marketing organisations can only deliver the types, quantities and quality of seed that have been produced earlier in the chain. Therefore a large part of their performance is reliant on the right decisions having been made at the multiplication, processing, storage and quality control stages - although an effective distribution system should be able to influence this by gathering information about farmer demand and feeding it back up the chain. This is particularly important with respect to ensuring that the types of seed supplied have the characteristics required by small farmers (including details such as pack size) and that supply is consistent both in timeliness and quality.

Links with organisations supplying the other components of the package of services required by seed users are equally important in determining the success of seed distribution; these are discussed in Section 5.3.

It is impossible to draw general conclusions about the most appropriate organisational structure for seed distribution to small farmers because of the range of location-specific influential factors and the complexity of the distribution mechanism: in any one country, different structures may be appropriate for different stages in the distribution chain and for different locations. But it is clear that small farmers have special needs and the additional cost of the special distribution and marketing required to meet these needs can be so substantial as to make it impossible to provide them without targeted interventions in the market, to provide controls and incentives that will better tailor the activities of seed organisations to the needs of small farmers. Four examples of some of the experimental approaches that have been tried successfully recently in different developing countries are illustrated in Box 4.4.

5. ECONOMIC AND POLICY CONTEXT

This Chapter sets the formal seed sector in its wider macro-economic context and includes discussion of the main policy variables influencing the sector and their impact.

5.1 Seed Acts and statutory controls

5.1.1 Seed quality control procedures

Seed quality control involves two main tasks:

- **field inspection** : the primary objectives of conducting field inspections are to confirm that the seed crop is of the designated variety and that it has not been contaminated genetically or physically beyond certain specific limits, as this is difficult to assess in the laboratory after harvest;

- **analytic and technical services for certification** : the technical and analytic services for all other quality attributes are carried out in seed laboratories, where seed samples can be tested more accurately.

The seed testing laboratory is one of the essential elements of any national seed programme and finance for this has been a standard component in donor-financed seed projects. The fundamental basis of seed testing is the use of controlled and standardised conditions in order to ensure consistency in the results obtained. In addition, there is a need for standardisation in the assessment of the tests so that variations in results due to individual judgement are reduced to a minimum. It follows that the reliability and overall value of such test results depends both on the facilities available and on the skill and training of the staff that use them. While good facilities can certainly make the task easier, good staff can often compensate for material deficiencies.

Besides the technical competence of the seed laboratory staff, the extent to which they conduct their work independently is critically important. Conventional wisdom suggests that seed quality control must be managed separately from the production and marketing of seed in order to avoid pressure being exerted. While these effects are probably exaggerated, there can be little doubt that a quality control laboratory intimately associated with a production organisation and without external scrutiny is liable to be compromised.

In virtually all developing countries, the seed quality control service or agency is a department of the Ministry of Agriculture and is funded entirely by government. While its activities extend throughout the seed chain, it can ultimately be regarded as a subsidy to marketing, which it is intended to support. This dependence on government funding makes the service vulnerable to general budgetary constraints and, at a local level, to competition for resources such as vehicles and fuel. Field inspections are particularly at risk because of the absolute need for mobility where contract growers are used. On occasions, the control of seed crops becomes the responsibility almost entirely of staff of the seed producing organisation. The long-term solution to this problem lies in charging for quality control services on a cost-recovery basis and in ensuring that the revenue is recycled within the service. However, that situation is difficult to accommodate within government budgetary procedures and it does increase the eventual cost of the seed produced.

Two countries' differing experiences with dealing with seed quality control are illustrated in Box 5.1.

Box 5.1: Comparative experiences with maintaining quality standards in Mozambique and Nepal

Seed production and distribution were very limited in pre-Independence Mozambique. Small quantities of foundation seed were imported, but no coordinated seed production took place. In 1971, the first small seed laboratory was established but with unqualified staff and insufficient equipment. A full-scale Seed Service was not established until 1981. The Maputo laboratory has an annual capacity of 5000 purity and germination tests, and two satellite laboratories have an annual capacity of 2000 tests each. The Seed Service had a professional staff of four in 1981; the staff had grown to twenty-five by 1990.

The absence of an efficient seed service has been highly detrimental to agricultural development in Mozambique. Over the years, Mozambique has imported large quantities of seed which have been not only low quality, but in some instances varieties unsuited for human consumption - such as the hybrid maize grain from Zimbabwe sold in Mozambique as improved open-pollinated maize seed. In another instance, groundnuts not suited for human consumption and with very low germination rates were imported from Sudan. Because Mozambique lacked the capacity to test seed quality and determine the variety of imported seed, these seed lots were accepted, high prices were paid for them, and worst of all, the seed was distributed to farmers. Moreover, sufficient precautions were not taken against seed-borne diseases. During the period of 1982-1985 alone, the loss from importing seed of inadequate quality was estimated at US$4.5m (not including the harvest loss by farmers, which is unknown but probably even higher).

The Seed Technology and Improvement Programme in Nepal has, on the other hand, instead made attempts to adapt seed quality standards to the practical conditions of decentralised seed supply to subsistence farmers in the hill areas. Two extra categories of seed (source seed and improved seed) have been added to the three common categories (breeder seed, foundation seed and certified seed). Only breeder seed and foundation seed are produced centrally under high quality standards, while the three remaining categories are produced in the districts under adapted seed standards.

Certified seed is produced on contract basis by 5 to 10 selected farmers with large holdings in each district. Field inspection, supervision, germination tests and certification are done locally by district technicians. The certified seed is stored in the district mini-seedhouses or on-farm in metal bins. For simplicity and to keep seed prices low, the certified seed is not labelled and bagged, since the district technicians are able to ascertain the identity of the bins containing the certified seed. All certified seed is used by selected medium size farmers to produce *source seed* (second generation certified seed). Seed purity and viability are ensured through roguing, field visits, careful harvesting and threshing and, for maize, proper isolation in time or distance. The seed is dried in the sun and stored in metal bins made air tight with plastic sheets. District technicians and extension workers supervise the production of source seed, but no specific field inspections or germination tests and certification are made. The source seed is distributed and sold to a large number of producer-sellers of seed located in scattered villages. With supervision by extension workers, these farmers produce *improved seed*, which they sell directly to neighbouring farmers.

Sources: Tarp, 1990; Rajbhandary, Ojha and Bal, 1987.

There are two main sets of reasons for the poor performance of seed quality control services in developing countries:

- they are frequently *insufficiently financed* : this seriously limits their ability to conduct their designated tasks efficiently. Field inspections require frequent and timely access to transport and, where this is not available, quality control is not able to fulfil the requirements of the law. Inadequate funding of seed laboratories has a similar effect. They are most likely to retain their standards and integrity when there is a large centralised group of experienced analysts with adequate independent access to financial resources to run the service and who can provide mutual support and exchange information. This is most likely to occur in a well-serviced national seed testing station. The limitation of this approach is that if most or all the seed samples from the national programme have to pass through a central laboratory, then there can be an unacceptable delay in returning the results to the processing centre which is handling the seed. At worst, this can lead to a situation in which the seed laboratory is useful only as a historical record of what has been produced and sold.

  Small seed laboratories more widely dispersed and closely associated with each production centre would provide the rapid response required by production and marketing managers, but at the risk of some loss in the reliability of results. Many projects have or wish to have regional 'mini-labs' to solve this problem. Further decentralisation of production activities, ultimately to many small local schemes, which is attractive in terms of production economics, raises concomitant problems of maintaining quality standards. This is a key organisational issue which requires careful consideration if decentralised or local seed schemes are to be advocated.

  A knock-on effect of insufficient financing is that sometimes, in an effort to satisfy demand, or, less scrupulously, to profit from demand, seed companies and small retail traders distribute low quality uncertified seed that has not been the subject of independent quality control. This, in the long run, severely damages prospects for growth in the use of formal sector seed.

- they *replicate international quality control standards* : in developing countries, this is not necessarily the most appropriate approach to the immediate task of making sufficient quantities of improved seed available to small farmers. In recognition of this, an FAO expert meeting in 1986 endorsed the concept of 'quality declared seed', where the seed supplier is given the responsibility of specifying qualifications and standards.

  This alternative system of seed quality control is less of a burden for governments to implement and similar voluntary certification schemes have worked well in developed countries for many years. In this way, high quality standards are emphasised for breeder and foundation seed, while legislation and procedures are more flexible for the multiplication of seed by and for small farmers.

  There is an interdependence between quality control standards and seed legislation and this has a strong influence on the options for re-organising quality control to be more cost-effective and suitable for small farmer needs.

5.1.2 Seed legislation

Because seed is a particularly vulnerable product (because it is prone to deterioration in storage) and because its quality is not easily assessed by visual means, the purchase of seed by farmers always involves an element of risk. The passing of laws relating to seed quality in many European countries in the early part of the twentieth century was a response to this problem and was one the earliest examples of consumer protection.

The common assumption with respect to seed legislation is that agricultural development is best served by 'excluding seed of low and uncertain quality from the market' [Delouche and Potts, 1971]. To achieve this, seed laws seek to regulate every step in the seed chain, including release of varieties through variety performance testing; standardising procedures for seed multiplication, processing and marketing; and specific quality standards for marketed seed. Seed inspectors ensure that the conduct of seed multiplication, processing and distribution complies with the law and seed legislation and regulations determine the number of field visits required by seed inspectors for a given seed crop.

An alternative approach is 'truthfulness-in-labelling'. This is a less stringent concept, requiring only that all seed produced and sold to farmers is labelled, specifying seed quality standards and identifying the person or company producing the seed.

Two types of seed legislation exist and complement each other:

- **Sanctioning (enabling) legislation** authorises activities such as foundation seed programmes, seed certification schemes, seed testing laboratories, etc.;

- **Control legislation** regulates distribution and marketing of seed and may also control import and export of germplasm and commercial seeds.

The major elements of seed legislation in developing countries are illustrated in Box 5.2.

The purpose of seed legislation is to protect the farmer from inferior products and to achieve this controls may be imposed on two areas of activity:

- **Seed control** : the quality of seed sold to farmers - based on laboratory testing;

- **Variety control** : the varieties available including their botanical characteristics and their merit for farmers. These are reflected in two distinct elements of variety assessment known as DUS (Distinctness, Uniformity and Stability) and VCU (Value for Cultivation and Use). Varieties which satisfy both requirements are approved by a national Variety Release Committee.

These two aspects of quality control can be applied independently but in practice they are frequently drawn together in the process of certification. This is ultimately represented by a label (tag) which is recognised by farmers and is effectively a token of the entire technical system. Certification has been called 'the grease that keeps all the gears working together'

Box 5.2: Components of seed legislation in developing countries

Quality control and assurance is a key element in all organised seed activities. The problem in achieving this is that seed quality is a complex concept [Thomson 1979] and some of its most important elements (for example germination percentage, variety identity and health status) cannot be assessed by visual inspection of the seed. The risk of physiological deterioration under adverse environmental conditions introduces a further element of uncertainty for those who store, sell and eventually use seed.

Primary seed legislation usually takes the form of a *Seed Act* which enables the Ministry of Agriculture to control various aspects of the seed production, processing marketing system which ultimately influence the quality of seed offered for sale. This control is exerted by means of *Regulations* made under the Seed Act, which specify in detail the procedures to be adopted or standards to be achieved. The simplest of these are minimum standards for purity and germination of the major crop species; within this, the purity standards may specify maximum permitted levels of contamination by certain injurious (noxious) weeds and by seeds of other crops. Originally, seed legislation covered only those attributes which could be assessed by examining a representative sample of a **seed lot** in a laboratory, the most important being:–

- germination percentage (under optimum conditions);
- purity (all aspects, including weed seeds);
- seed health (freedom from specific seed-borne diseases);
- moisture content.

Subsequently, as more varieties have been released by plant breeders, it has become important to guarantee the identity of the seed, but this can only be reliably assessed by inspecting the **seed crop** growing in the field. This was the origin of *Certification*, the seed crop being 'certified' with regard to its correct naming or 'authenticity'. In due course, certification has evolved into a comprehensive package of quality control measures covering both field crop and seed lot standards. Thus seed regulations may now prescribe the procedures or standards required for –

- crop inspection;
- the sampling of seed lots;
- seed testing;
- the labelling of packages.

In addition to these technical matters, they may also apply organisational or administrative control over, for example: the registration of seed companies and merchants; and seed import or export.

While seed legislation may be a valuable support for those who have to apply the quality control system, it is possible to operate *Voluntary Standards* for many years, if these are seen to be practical and acceptable to the parties concerned.

Where there are commercial/private seed companies, these generally have their own internal quality control system which can be better equipped than that provided by the government. In developed countries, there is a tendency to place much greater reliance on the quality control system of companies, driven by market competition, and to reduce the role of government. This may also be an attractive path for developing countries to follow in the current policy climate, but is should be approached with some caution.

It is also fashionable for quality control services to be charged for, with the eventual aim of full cost recovery. While this may have benefits in terms of financial security and efficiency, it may prove difficult for developing countries to achieve in the short term, except in the case of hybrid crops where there is greater flexibility in seed pricing.

Very few developing countries have established *Plant Breeders Rights* although it has been the subject of lengthy debate in several countries. PBR enable individuals or organisations to register new varieties, bred inside or outside the country, and claim legal ownership and remuneration for use of seed of the variety. PBR can be obtained for a long period, commonly 20 years, during which the breeder has the sole right to multiply and sell the variety, or to licence others to do so. For varieties released by government breeders, PBR could be issued to the Ministry of Agriculture thus enabling some financial return on their investment in plant breeding. The breeding of F1 hybrids provides an alternative means of controlling seed multiplication and these varieties are not normally subject to PBR. Plant Breeders Rights apply only to individual countries in which they are obtained; there is no international mechanism for their enforcement or for the collection of royalties.

A *Variety Release Committee* is responsible for releasing varieties for multiplication and certification. To register and release a new variety, the breeder has to submit information regarding origin, breeding methods, performance and morphological characteristics, to prove a variety is superior to others in at least one aspect. It is desirable to limit the number of varieties released by withdrawing old varieties as new ones are introduced.

[CIAT, 1991]. Legislation may also cover the inspection of processing plants, but this is only a supporting element in the general quality control package, aimed at minimising contamination, particularly by other varieties.

Another separate area of legislation may affect the seed industry. This is Plant Breeders' Rights, which aims to provide property rights for breeders and thus enable them to collect royalties on the sale of their varieties. This has been a subject of active discussion in some developing countries for several years but so far none have passed such legislation. Indeed, the diverse and dispersed structure of the farming community would make royalty collection and enforcement very difficult and of questionable value. It is a highly contentious issue, being intimately linked with he question of genetic resources, the activities of multinational corporations and the inherent rights of farmers as custodians of crop diversity [Cooper *et al.*, 1992]

5.1.3 Transfer of technology: the case of seed legislation

Seed legislation is often seen as an indicator of progress in the establishment of a national seed industry. Virtually all developed countries have some seed legislation in place whereas in developing countries the situation is much more variable (Table 5.1 shows the state of seed legislation in countries in the SADCC region, for example).

Table 5.1: Comparative status of seed legislation in SADCC countries

	Angola	*Botswana*	*Lesotho*	*Malawi*	*Mozambique*	*Swaziland*	*Tanzania*	*Zambia*	*Zimbabwe*
Seed Law:									
Seeds Act	X	V	X	X	X	X	1973	1967	1965
Seeds Regulations	X	X	X	X	X	X	V	V	V
Regulations for Multiplication	X	V	X	V	X	V	V	V	V
Standards for Seed Quality	X	V	C	V	V	V	V	V	V
Release Procedures	X	V	X	V	X	X	V	V	V
Field and Seed Inspections	X	V	V	V	X	V	V	V	V
Seed Testing	V	V	V	V	V	V	V	V	V
Seed Testing Laboratories (nos)	1	1	1	1	1	1	2	1	2
Plant Breeders' Rights	X	X	X	X	X	X	V	X	V
Plant Quarantine	X	X	X	V	X	X	X	V	V

V = present X = absent

Source: DANAGRO, 1988a

Some seed projects, particularly in the early years, attached high priority to the formulation of seed legislation, which was seen as an essential platform for marketing. However, in many cases effective marketing systems have still to be established. There is probably very little antipathy to seed legislation and, in countries where it does not yet exist, the slowness of the legislative process is often the major cause: legislation prepared in draft form is often adopted by those within the seed sector as a set of working standards, although without the ultimate force of law. This situation works effectively in many countries.

In many developing countries, seed quality control systems and the associated legislation have been established over the last two decades with the assistance of international donor agencies. The legislation has been made on the basis of an international standard pattern and the seed quality standards have been adopted from Europe or North America. The FAO Seed Improvement and Development Programme (SIDP), for example, has directly assisted in preparing draft seed legislation in many of the 60 countries with which it has been involved; numerous other donor projects and programmes have provided similar assistance.

This has led to some confusion in the nomenclatures used, as illustrated in Table 5.2.

Table 5.2: Comparative seed nomenclatures in Asia

Definition	*Multiplication step*	*China, Rep. of Indonesia Japan, Thailand*	*India*	*Korea, Rep of Philippines Sri Lanka*	*Nepal*	*Pakistan*
1st generation seed supplied by plant breeder for multiplication	-	Breeder seed	Nuclear seed	Breeder seed	Breeder seed	Pre-basic
2nd generation multiplied under the plant breeder's care or by a special agency	1st step of multiplication	Foundation seed	Breeder seed	Foundation seed	Foundation seed	Basic seed
3rd generation multiplied by seed farms or seed enterprises for multiplication and sale or further multiplication	2nd step of multiplication	Stock seed	Foundation seed	Registered seed	Certified seed	Approved seed
4th generation multiplied by seed growers, seed farms or seed enterprises for sale or distribution to cultivators	3rd step of multiplication	Extension seed	Certified seed	Certified seed	Certified seed	Certified seed

Source: Yamashito in Asian Productivity Organisation, 1987.

Another disadvantage of the transfer of technology approach is that the quality standards and procedures laid down in developed country seed legislation are often excessively rigorous: this may reduce the practical value of the legislation or bring it into disrepute as well as inhibiting the production of sufficient quantities of improved seed in developing country conditions.

In particular, this approach can inhibit the use of more decentralised forms of seed production using, for example, small farmers to bulk-up improved varieties. Formal seed standards are in any case often less relevant for small farmers than for large-scale commercial farms: uniformity in seed size, for example, which facilitates mechanised planting, is of limited relevance for the majority of small farmers in developing countries who still sow crops by hand.

Seed quality control legislation and procedures must be practically possible to implement and should promote rather than inhibit diffusion of improved seeds. Some developing countries are already taking steps to revise legislation to achieve this. For example, in Zambia, the problem of inherited excessively rigorous variety release procedures inhibiting the flow of new varieties to farmers has been resolved by revising the 1967 Seed Law to permit a two-tier release system. Now, varieties can be multiplied up and distributed as commercial (non-certified) seed in advance of their completing the full four years of National Performance Trials needed for official release, in order to speed up the provision of improved seed [DANAGRO, 1988d]. In other countries, however, this type of problem continues to hamper speedy seed sector development. In India, for example, the 1966 Seed Act dictates that the national Variety Release Committee has first to 'notify' a variety before it is officially allowed to be multiplied and this notification has to be based on two years' performance in multi-locational All-India Variety Trials. Thus, in India's case changes in the Seed Act may be needed if a more sensitive variety control system is to be implemented.

5.2 Price policy

We can build on the findings of Chapters 3 and 4 to trace the cost build-up through the seed sector as a whole and thus the influence of price policy on the opportunities for providing seed to small farmers more efficiently and effectively.

5.2.1 Seed production costs

Basic seed for multiplication is in most developing countries still obtained at nominal cost from the national agricultural research institutions. This is regarded as a service function of public sector plant breeders which they often lack the resources to perform properly in practice.

Seed crop husbandry costs vary considerably between species and varieties, but they are always higher than for producing a grain crop. One of the most substantial extra costs is labour, particularly for hybrids. A seed crop of the Zimbabwe single-cross maize hybrid **SR52**, for example, requires 110 days labour per hectare per year - accounting for 35 per cent of total variable production costs - compared to 34 days for a grain crop of the same variety [Friis-Hansen, 1990].

Whether multiplication is undertaken directly by the seed organisation or through contract growers is one of the most important influences on seed production costs. In the latter case, the price paid to growers must provide a premium of at least 15-20 per cent over prevailing grain prices to compensate for the extra cost and effort involved in producing a seed crop. Depending on grain prices, this can represent a substantial additional cost to seed companies -

but inadequate premiums can jeopardise seed supply. There is wide variation in premiums, partly caused by differences in growers' bargaining power; in some cases, such as some of the State Seed Corporations in India, growers' ability to influence premiums has made them the major beneficiaries of formal seed sector activity [World Bank, 1987a].

Transport costs are another major component of total seed production costs in developing countries, reflecting the long distances and high vehicle wear and tear on poor roads involved in moving seed from multiplication site to processing plant and distribution points. The spatial organisation of processing and seed distribution exerts a critical influence on this.

Besides the transport component, seed processing and storage components of the seed chain can involve high capital costs and depreciation charges for the necessary specialist buildings and equipment. Finance charges on storage alone can account for 10 per cent of total variable costs. But, at the same time, it is relatively easy for high overhead charges to absorb operational inefficiencies in this stage of the chain. For example, Tanzania Seed Company allows a 100 per cent mark up on ex-plant maize seed over the price paid to growers whereas Seed Co-op in Zimbabwe is able to put on a mark-up of less than 13 per cent [Friis-Hansen, 1988 and 1990].

Distribution and marketing costs vary greatly according to the organisational structure of the distribution system, both in terms of operational efficiency and in terms of the level of commission that has to be paid to wholesale and retail seed distributors. Where public sector companies are responsible for all stages of seed distribution, difficulties with transport planning can add substantially to costs, in terms of unsold and spoilt seed stocks. On the other hand, where public sector seed companies rely on distribution through private dealers, their inability to offer adequate commission can be a strong disincentive to traders to deal in improved seed, thus limiting its availability to farmers.

Where commercial companies control distribution, on the other hand, traders can often extract relatively high commissions from seed distribution activities. In Zimbabwe, for example, retailers' commissions are over 20 per cent for maize seed in certain areas [Friis-Hansen, 1990]. The fact that commercial companies nonetheless find a ready market for their product suggests that price is not, however, a major criterion influencing farmers' decision to use improved seed for some crops.

5.2.2 Retail seed prices

The sum of all these cost components is the basic cost of producing improved seed that is fed into retail seed price calculations. This cost is profoundly influenced by the organisational issues described in Chapter 4 and by the technical differences between different species and varieties of seed. It is also - and perhaps even more importantly - influenced by the level of profit margin that is acceptable to different types of seed organisation:

- *Commercial companies* have to cover all costs and risks in their retail seed price and attempt to maximise profits. In a competitive market, this means juggling costs and levels of output to equate marginal costs with marginal revenue; in practice, however, few seed markets are perfectly competitive and many commercial companies try to influence retail seed prices to further strategic objectives by, for example, maintaining price differentials between different market segments, offering discounts, etc.

☐ The seed pricing objectives of *community-oriented seed organisations*, on the other hand, vary according to their mandate. If the mandate is to act as a selling organisation for producer members only, a profit-maximising price will be pursued; if there are consumer members as well, however, the profit objective will be balanced against the need to provide cheap seed to consumers.

☐ In many developing countries, the *government* frequently intervenes in price-setting to ensure that the development objectives that seed companies acting on their own might ignore are met. Typical development objectives include:

- ensuring adequate income for participants in the sector, especially contract growers, small-scale processors and small traders;
- ensuring sufficient supplies of seed;
- encouraging farmers to use improved seed in order to increase productivity, to improve household and national food security;
- fulfilling macro-economic policy objectives with regard to agricultural production and cropping mix.

Intervention can be achieved directly through restricting participation in the seed sector to public sector organisations. In this case, the pricing objective is usually to ensure an equitable distribution of improved seeds to all categories of farmers whilst at the same time covering production costs, rather than to make a profit. The exact balance between the conflicting objectives of cost-recovery and equitable seed distribution is, however, often poorly defined and results in poor performance on both counts. A recent survey of the seed sector in developing countries concluded that

> 'We do not have any reference from our experience .... of any seed production and marketing parastatal that has been economically viable, without receiving subsidies from government, in any country in the developing world'. [Grobman, personal communication.]

Alternatively, the government can intervene indirectly through control of the price-setting mechanism. The objective in this case is to ensure that seed prices are set with regard to the effects on the economy as a whole and on the welfare of farmers, as well as on the profitability of the seed companies. Indirect intervention of this type typically takes one of the following forms:

- controlling the cost build-up through the seed chain through setting maximum seed prices at each stage, to facilitate cost recovery by seed companies restricted to charging low retail seed prices;

- guaranteeing minimum seed prices at each stage in the seed chain to support the incomes of growers, processors and distributors and covering the resulting gap between production costs and retail seed prices with direct subventions to seed companies or with subsidies on retail prices;

- controlling retail seed prices to encourage uptake by small farmers and meeting the gap between retail prices and production costs as above.

5.2.3 Price-sensitivity of demand for seed

So far, we have discussed the influence of price policy on the seed sector solely in terms of its impact on the attractiveness of the formal seed sector to different types of organisations, via its influence on companies' internal price structure. But price policy also influences the attractiveness of improved seed to farmers through its effect on agricultural factor costs and product prices.

Factor prices (fertiliser prices and land prices) are dealt with in Section 5.3 and Section 2.3 respectively. Here, we concentrate on the impact of price policy on the relationship between retail seed prices and producer grain prices.

Farmers' decisions about using improved seed are always made by comparing the expected relative costs and benefits of doing so, as for any other innovation in the farming system. This creates an immediate distinction between subsistence and marketable crops, with improved seed less likely to be attractive for subsistence production unless it provides greatly superior benefits in terms of yield or other attributes. This is illustrated clearly in the case of sorghum and millet, for example, where demand for improved seed is much greater in India, where there is a commercial market for the crops, than in Africa where sorghum and millet are still primarily subsistence crops [Pray, Ribeiro, Mueller and Rao, 1989]. For marketed crops, the prevailing level of producer grain prices and the likely trends in them therefore have a key influence both on farmers' decisions about using improved seed and on the price elasticity of demand for seed - although this also varies to some extent between types of crops, as we saw in Chapter 3.

At the same time, the different costs of producing different species and varieties determine the price seed organisations require. This was illustrated in terms of grain:seed price ratios in Chapter 3. However, these ratios are often departed from substantially in practice (examples from Africa are illustrated in Table 5.3). This is either because of inefficiencies or because of additional value-added in the production process (e.g. from seed treatments, etc.). It is also significantly affected by controlled agricultural producer prices, in countries where these operate. Where grain prices are kept artificially low to cater for urban consumers, for example, it can be impossible to provide seed within the acceptable price ratio and this has a critical impact on uptake, particularly by small farmers.

Price policy thus has an important effect on small farmers' demand for improved seed. However, for the majority of small farmers it is the price of other agricultural inputs and of agricultural products - and therefore the impact of policy on the prices of these commodities - that has the greater impact on improved seed uptake. Other things remaining equal, demand for improved seed is relatively inelastic with respect to own price (see Section 2.3). The only

Table 5.3: Price ratio for grain versus seed in different African countries

Grain:Seed	*Kenya*	*Zimbabwe*	*Malawi*	*Ethiopia*	*Uganda*	*Sudan*	*Tanzania*	*Botswana*	*Burundi*	*Lesotho*
Sorghum:										
Hybrid		1,8				1,3				1,5
Variety	1,2	1,3W 1,5R	1,3	1,15	1,4	1,15	1,5	1,5	1,5	
Maize:										
Single X Hybrid		1,9								
Double X Hybrid	1,2									
Triple X Hybrid		1,4		1,3						
Synthetic										1,6
Variey	1,18				1,2*		1,5	1,3	1,15	
Millet:										
Variety					1,3	1,2	1,5	1,5		

Notes: * To some extent subsidised W = White R = Red

Source: Longmire, 1987.

important exceptions to this are those farmers for whom resource constraints are so severe that cash returns to agricultural production are minimal. In this case, even a small increase in the price of improved seed can mean investments in improved seed are no longer financially viable.

5.2.4 Reconciling development and efficiency objectives through the price mechanism

Resolving the inherent conflict between the twin objectives of achieving both an efficient and an equitable seed sector through pricing policy, and what trade-off between the two is acceptable, is often not directly addressed when seed price policy is formulated. Three countries experiences with the problems this causes are illustrated in Box 5.3.

There are three problems in particular:

- ☐ *inadequate margins* between production costs and retail seed prices discourage the participation of commercial companies in the seed sector. This can be damaging because, as we have seen earlier, some seed activities are better performed by this type of organisation. Low margins can also jeopardise seed quality, which is particularly serious because of the dependence of the formal seed sector on its reputation for quality for ensuring future growth.

- ☐ *over-subsidisation* : heavily subsidised retail seed prices are now considered to be unnecessary as an inducement to seed uptake by farmers but impose a heavy cost on government and can damage the growth of the formal seed sector in the long run. This

Box 5.3: Seed pricing in Pakistan, India and Zimbabwe [see Appendix Tables 1-3]

Attributable production costs for the Punjab Seed Corporation, Pakistan include fixed procurement prices and growers' and dealers' premiums and exclude capital costs for the seed farms and processing plant and a proportion of other overheads, which are cross-subsidised by a more profitable cotton seed operation. All other attributable costs are uncontrolled. The difference between production costs and controlled retail seed prices is covered by subsidy so that the grain:seed price ratio remained low at 1:5 (compared to 1:7-12 worldwide). Despite this, PSC has a serious problem with unsold stocks - even though production stands at less than 10 per cent of total demand in the Province.

One of the major causes was identified as being insufficient consideration of the impact of pricing policy on the market and proposals for change include: better control of production costs, rather than relying on cost-plus pricing; higher dealer margins (previously seed margins were around 2.5 per cent compared to 20 per cent for fertiliser); and increased retail seed prices - because there is considerable evidence farmers are in fact willing to pay higher seed prices and this will make seed more widely available in the long run.

The first and second National Seeds Projects in India attempted to replicate the successful Tarai Development Corporation organisational model in nine other states. The intention was for each State Seed Corporation to operate more or less commercially, fixing prices to cover fixed and variable costs and give a return on capital. But in practice, government intervened by controlling seed retail prices, requiring that the higher production costs of the SSC shareholder growers be absorbed internally and by setting production targets. In some cases, these were artificially high to meet demand for traditionally low margin crops - such as paddy and wheat - that had been fuelled by subsidised producer prices; in others, they were low - as in the case of hybrid cotton - because, although there was proven demand, the crop was considered not to fit well into the established cropping pattern. This mismatch between the efficiency objectives set for the SSCs and the subsequent equity functions imposed on them had brought many to the brink of financial collapse by the end of the project period, the implication being that government has to be prepared to back its policy decisions in this area financially.

Seed Co-op in Zimbabwe has experienced similar difficulties in its retail seed price negotiations with government. In this case, the government has set prices to provide a profitable return according to its own estimates of production costs. In practice, however, the need for the Co-op to offer increased margins to its contract growers to ensure sufficient seed supplies, has increased production costs so that it has made a net loss in the last four years. The situation has now been resolved by a 22 per cent increase in the growers margin allowable by government.

Sources: Heisey, 1990; ICD, 1987; World Bank, 1987a and b; Friis-Hansen, 1990.

is because the economic return on farmers' investment in improved seed can be higher than for any other purchased farm input [FAO, 1987]; because seed is a small proportion of total production costs for farmers; and because numerous studies have demonstrated the willingness of farmers to pay relatively high prices for certain seeds, notably hybrids, when their advantages are clear. Kenya Seed Company, for example, is allowed to set retail seed prices to reflect actual production costs, resulting in retail seed prices for hybrid maize some four times prevailing grain prices [Douglas, 1980]. Despite this, demand has consistently outstripped supply and there has been widespread adoption in the small farm areas.

Thus heavy subsidies are not in all cases necessary to promote the use of improved seed and can in fact act as disincentives to using improved seed properly, as has been the case with the improved seed distributed free in Côte d'Ivoire, for example [Gale *et al.*, 1984]. At the same time, subsidies limit returns to seed companies and increase uncertainty for farmers, thus generally discouraging the creation of an dynamic formal seed sector in the long run.

- ☐ price calculations for public sector seed companies based on *cost-plus pricing* can disguise the impact of operational inefficiencies on retail seed prices, or on the budgetary cost of subsidising them, and can be difficult to complete accurately. In particular, the temptation is to ignore fixed costs and to continue with inefficient practices, such as high staffing levels, to meet other macro-economic objectives such as full employment.

Price policy can thus have a significant impact on the growth of the seed sector and the use of improved seed by small farmers. Decisions relating to agricultural price policy must therefore be based on careful analysis of their likely impact on the seed sector. Three guiding principles may be identified:

- ☐ the inherent conflict between the objectives of efficient seed organisations and effective seed distribution to small farmers means the best solution is not necessarily to end public sector involvement in the seed sector altogether but to *restructure price incentives* better to guide the activity of numerous different types of organisation, so that each can best exploit its comparative advantage;

- ☐ the difficulty of marrying retail seed prices with prevailing grain prices, in situations where the latter are controlled, means more attention needs to be paid to convincing farmers of the difference between improved seed and grain and raising their *perception of the value of improved seed.* This requires both better promotion of the potential advantages of improved seed and an absolute guarantee from the seed producing companies of its superior quality compared to seed saved on-farm;

- ☐ *price policy needs reviewing regularly* as the formal seed sector develops, in order to keep pace with changes in the costs of and demand for improved seed. This takes the form both of promoting different types of seed, through price policy, at different stages (not attempting a 'great leap forward' to 100 per cent adoption of new varieties within a short space of time, for example) and of adapting producer price policy to create the appropriate grain:seed price incentives. For example, the failure of the Kenyan government to change maize producer price policy in the late 1970s from one geared to a situation of shortage to one dealing with surplus is considered to have caused a major disruption to the otherwise rapid diffusion of hybrid maize [Johnson, 1980].

5.3 Agricultural services

In most developing countries, the majority of small farmers still obtain the necessary agricultural support services, such as credit, extension and input supply, from government departments or agencies. The traditional wisdom concerning the function of these agricultural services with respect to the formal seed sector is that the extension service has to persuade farmers of the benefit of using improved seed; that agricultural credit must be available to enable farmers to purchase the seed; and that farmers need a range of complementary inputs (particularly fertiliser) in order to make maximum use of improved seed - and smoothly functioning distribution systems for these must be in place.

In this Section, we review the evidence from three major surveys of small farmer uptake of improved seed - of semi-dwarf wheat seed in Pakistan [Heisey, 1990] and of hybrid maize seed in Kenya [Allan, 1968; Gerhart, 1975] - which sought to question these assumptions.

5.3.1 Agricultural extension

The alternative to the conventional wisdom concerning extension advice about improved seed and how to use it best is that, as long as using improved seed brings real, reliable benefits within the small farm farming system, extension advice is irrelevant because most farmers can obtain all the information they require through informal channels within the community. According to this argument, the issue becomes one of ensuring the relevance of improved seed to the small farm system rather than ensuring the existence of a well-functioning extension service.

Various conclusions can be drawn from the available evidence concerning the importance of the different functions of the extension service for use of improved seed by small farmers.

Extension advice cannot provide the substitute motivating force for adoption, if improved seed is failing to do this because the seed technology on offer is technically and/or economically irrelevant to the small farm farming system. In the Pakistan study, for example, it was farm size, the yield superiority of the new seed and its sensitivity to planting date that were found to be more significant influences on adoption, among farmers already aware of the new seed, than contact with the extension service [Heisey, 1990]. In Kenya, Gerhart also concluded extension advice was not the decisive factor [Gerhart, 1975].

However, farmers often need technical advice about how to use improved seed and the extension service can have a valuable 'information' function to perform in this respect. The importance of this function depends on the degree of change to traditional husbandry techniques involved in moving over to using improved seed. Replacing local maize seed with hybrid varieties, for example, is generally considered to be the agronomic equivalent of introducing a completely new crop into the farming system and, to be successful, must be accompanied by dissemination of information about the new techniques and husbandry practices involved [Gerhart, 1975; Edwards, Gibson, Kean, Lubasi and Waterworth, 1988].

But public sector extension and the promotional activities of the seed companies themselves are to some extent substitutes, so the extent extension is required depends on the level of this kind of activity in the seed sector itself. Coupled to this, it is the informal information channels which are the most important to the majority of small farmers. So in practice the 'promotion' function of the extension service can be relatively unimportant too, as the evidence from the Pakistan study illustrates (see Table 5.4).

But this very much depends on the stage of the innovation cycle that the small farm community is at. The provision of information and other promotional activities by the extension service is needed much more in the early stages of introduction, as early adopters depend on this whereas later adopters can make greater use of informal channels [Heisey, 1990].

Table 5.4: Source of information about new wheat varieties among adopters in Pakistan (% of farmers)

Source	*Rice/wheat zone*	*Cotton/wheat zone*	*Irrigated zone*
Other farmers	69	48	57
Extension service	14	30	28
Seed depot	9	8	7
Radio	8	12	4
Other	nil	2	4

Source: Heisey, 1990

As well as channelling information about improved seed from the seed organisations to farmers, the extension service is frequently used as a vehicle for the flow of information in the opposite direction: about the desired attributes of seeds and varieties from farmers to the breeding and producing components of the seed sector, for both technology development and demand estimates. Theoretically, extension services are in a strong position to fulfil this function as they are in direct, independent contact at grass roots level with a large proportion of the potential client group for improved seed. In practice, however, budget restrictions and lack of incentives to do this, compared to more immediately pressing basic extension tasks, often limit the effectiveness of the extension service in this respect.

5.3.2 Farmer credit

The view that credit is essential for small farmers to be able to use improved seed is entrenched in many government departments of agriculture. But, in practice, this view is debatable. The evidence from the Pakistan and Kenya surveys is that the availability of credit is not, in fact, a significant variable explaining the adoption of improved seed by small farmers, compared to others such as agro-climatic zone, farmer education, etc. [Gerhart, 1975; Heisey, 1990]. Rather, the critical function of credit in the seed sector is to improve the **availability** of improved seed rather than its direct uptake - by enabling small retail traders to fund the storage and stocks necessary to operate as seed stockists [Gerhart, 1975; see also Section 4.4].

Two factors are significant here. First, improved seed accounts for a very small proportion of total production costs within most small farm farming systems [Edwards, Gibson, Kean, Lubasi and Waterworth, 1988]. Example evidence from Kenya is presented in Table 5.5.

Second, the available evidence suggests that, contrary to the usual assumption, improved seed such as the formal seed sector supplies can provide a production benefit, albeit limited, even without the more expensive complementary inputs with which it is usually packaged. This is discussed further below.

Table 5.5: Seed costs as proportion of total variable costs in Kenya (Kshs per ha)

Crop	*Variable costs (A)*	*Seed costs (B)*	*B as proportion of A (%)*
Maize	9,366	188	2.0
Beans	1,838	138	7.5
Sorghum	1,619	75	4.6
Sunflower	4,522	120	2.7
Wheat	6,268	599	9.6

Source: Ruigu, 1988

Note: 1985 prices KShs 16.45=US$ 1

Thus, the cash cost to small farmers of deriving benefit from using improved seed is relatively small and probably explains why, in many cases, the availability of farmer credit is not a pre-requisite for adoption. However, this implies not that there is no need for farmer credit in the seed sector but that requirements should be assessed in detail on a case by case basis.

Some of the situations where credit is likely to be necessary include where the dominant variety is a hybrid requiring annual replacement; where there are a large number of small farmers in the process of moving from a subsistence to a market-oriented pattern of production (i.e. for whom even small cash outlays can be difficult); and where there are strong agro-climatic or socio-economic reasons for using seed with the full package of recommended complementary inputs. It is in this latter situation that lack of credit to cover the much higher costs of these inputs can be a real constraint to use of improved seed. For example, one of the Kenya studies found that fertiliser was five times more expensive than seed to apply at the recommended levels and this was a significant factor explaining the lower use of hybrid seed amongst small compared to large farmers [Gerhart, 1975].

5.3.3 Fertiliser

The basic assumption guiding the organisation of very many of the distribution systems for the best-known of all improved seeds, the high-yielding varieties of the Green Revolution, has been that they must be supplied in a package of inputs as it is only by modifying the production environment through the use of fertiliser, irrigation water etc. that farmers will obtain the full benefit of these seeds [Innes, 1988]. In very many seed sectors, this has been taken as given and much time and energy has been devoted to devising and distributing the appropriate fertiliser packages to accompany improved seed.

However, where this assumption has been put to the test by examining the agronomic context on-farm as well as the maximum yield response to inputs, the supply of fertiliser can appear much less critical for the benefit small farmers derive from improved seed, as long as the seed varieties on offer are well-adapted to the small farm environment. The most celebrated example of this kind of test are the 'diamond experiments' conducted by Alistair Allan for **H611** hybrid maize in Kenya in the late 1960s [Allan, 1968]. Summarised results from these are given in Box 5.4.

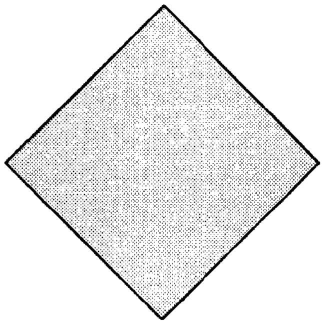
Box 5.4: Kenya 'maize diamond' experiments showing relationship between husbandry, physical inputs and yield

A. Bad husbandry, local maize seed, no fertiliser

8.8 bags/acre

B. Bad husbandry, hybrid seed, fertiliser

14.6 bags/acre
(66% increase)



C. Good husbandry, local seed, no fertiliser

21.8 bags/acre
(148% increase)

35.8 bags/acre
(307% increase)

D. Good husbandry, hybrid seed, fertiliser

Factor	*Treatment*	*Yields lbs/acre*	*Added return shillings/acre* [a]	*Added cost shillings/acre* [b]
Time of planting	Start of rains	5,200	270	Very little
	4 weeks later	3,040		
Plants per acre	16,000	4,580	115	8
	8,000	3,770		
Type of seed	Hybrid	4,860	175	12
	Local	3,380		
Amount of weeding	Three times, early	4,640	130	20
	Once, late	3,600		
Phosphate per acre	50 lb	4,160	10	32
	None	4,080		
Nitrogen per acre	70 lb	4,380	65	72
	None	3,860		

Source: Allan, 1968.

Notes: (a) At 1966 price of 25/- per 200 pound bag.
(b) Based on costs of inputs required and estimated labour costs.

The 'diamond experiments' showed conclusively that, although fertiliser makes a significant contribution to increased maize yields at high husbandry levels, the net benefit to small farmers of following recommended applications at the lower husbandry levels usually prevailing on-farm, is far less profitable. Conversely, this suggests that at lower husbandry levels, it is more constructive to devote resources first to improving husbandry practices (weeding, spacing, etc.) and only after this to start acquiring and applying fertiliser.

The importance of fertiliser supply for the seed sector depends very much on the seed and the agro-climatic situation in question. It is particularly important in areas where monocropping using high yielding varieties is the norm and in better rainfall areas where it can improve yields on poor, moderate and even good soils when used sensibly. But the evidence presented above suggests that fertiliser use also depends very much on the level of development of small farm husbandry systems and existing use made of improved seed. Where these are both low, fertiliser can be much less of a priority and farmers will adopt each element of the package according to its own merits [Gerhart, 1975].

5.4 Macro-economic policy

Macro-economic policy has a fundamental influence on the formal seed sector in developing countries due to the typically high level of involvement of the state both in resource allocation and directly in production itself throughout the economy. The two areas of particular importance are policy towards the ownership and organisation of production and factor and product price policy.

Table 5.6: Growth in private sector seed sales in India 1985-87 (tonnes)

	1985	*1986*	*1987*
Pearl millet			
Private companies	1,012	3,228	4,787
State seed corpns.	10,070	8,870	9,046
Sorghum			
Private companies	2,018	4,333	7,202
State seed corpns.	18,900	na	na

Source: Pray, Ribeiro, Mueller and Rao, 1989.

The largest components of formal sector seed production costs are labour, transport and imported inputs such as seed treatment chemicals. The prices of all of these are often manipulated by government to fulfil macro-economic objectives relating to employment policy, conservation of foreign exchange, etc. and this significantly influences cost build-up within the seed sector. At the same time, eventual retail seed prices can be similarly affected, with the intention of encouraging national agricultural development and/or maintaining a consistent relationship between seed prices and administered grain prices (see Section 5.2).

Policy towards the ownership and organisation of production is, in many developing countries, the single most important influence on the overall structure of the formal seed sector. Typical policy tools include incentive pricing, through the manipulation of the incidence of taxes and subsidies, and direct controls on production and through market regulation. Seed Co-op, for example, is Zimbabwe's largest seed company, responsible for 95 per cent of national maize seed sales, of which 85 per cent are in the communal (small farm) areas [Friis-Hansen, 1990]. An important factor contributing to Seed Co-op's success in attracting sufficient contract growers and in keeping retail prices relatively low is considered to be the tax-exempt status granted to co-operative organisations in Zimbabwe.

India provides another example of the importance of structural policies. The liberalisation of policies towards the private sector in the late 1980s has brought forth a large expansion in private sector seed companies, both established companies and new entrants, as is illustrated with reference to sorghum and millet seed sales in Table 5.6.

6. A FRAMEWORK FOR PERFORMANCE ANALYSIS

6.1 The organisation and structure of the formal seed sector

Our objective in this first phase of research has been to use the available documentary evidence to develop an analytical framework for assessing seed sector performance in developing countries that identifies the key components of the seed sector, the factors influencing the performance of seed organisations and allied institutions and the nature of the linkages between them. From this it is possible to define the desirable economic functions of the seed sector with respect to seed delivery to small farmers and, thus, a methodology for assessing the relative influence of different factors on performance and therefore the scope for organisational change to improve performance.

We have identified three key features of the structure of the formal seed sector: the three main types of **seed organisation** involved in the multiplication, processing and distribution of seed; the four different categories of **seed users**; and the distinctive technical and economic **characteristics of improved seeds** as compared to other goods supplied through organised markets. These three features mean the seed market is characterised not only by the market imperfections typical of factor markets in developing countries in general, but also by those specifically connected with seeds as an economic good. These are summarised in Box 6.1.

In particular, we have found that small farmers of the type we are concerned with have particular seed requirements. The seed distribution system must be tailored to the specific climatic and socio-economic conditions under which small farmers operate. Timely delivery is especially critical, as is the delivery of varieties appropriate to small farm farming systems, which, together with seed pricing, has to be co-ordinated with the produce marketing situation facing small farmers. If complementary inputs are required, these need to be delivered in a co-ordinated way. Sufficient back-up must be provided to seed organisations to guarantee the production of high quality seeds.

Developing this understanding is a step forward from the typical supply-side analysis of the seed sector in developing countries which focused almost entirely on the formal institutions involved. In particular, it shows how both resource allocation mechanisms and factor returns in the wider economy and events in the informal seed sector feed into small farmer decisions about using improved seed, making attention to the nature of macro-micro linkages (particularly market failure) critical in seed sector analysis. To be of practical value for policy-making, however, this understanding needs translating into a set of **indicators** that can be used meaningfully to assess seed sector performance.

In practice, the functions seed organisations are expected to perform are often not defined clearly and this makes a realistic assessment of the causes of poor performance difficult, particularly when the execution of one function is likely to influence performance with respect to another. Once these functions are defined, however, it becomes much easier to establish indicators for performance assessment to give clearer insights into the causes of poor performance and particularly into whether the problems lie inside the seed organisations themselves or in other components of the seed chain and package.

Box 6.1: **Seeds as an economic good**

Supply

- Seed is a living organism which is highly sensitive to mistreatment and therefore requires particularly careful handling during production, storage and transport to maintain purity and viability. It also deteriorates over time. This means the quality of seeds is much more difficult to control than that of manufactured goods.

- The seed production process is not controllable, due to the influence of weather and the inherent genetic variability in plants, unlike that for industrial goods which is much more standardised; and the production process has to change frequently to cope with new seed varieties. In addition, the seeds that are easiest to produce may not be those most demanded by farmers.

- Seed production is a primarily management- rather than capital- intensive activity. In particular, intensive management is essential during seed multiplication to maintain genetic purity and during storage and transport to maintain viability.

- Seed production is seasonal and so, depending on the crop in question, timeliness of processing is critical in order to ensure timely distribution and marketing. The seasonality of seed production also increases the cost of storage and reduces flexibility in the management of production.

- The market is geographically dispersed and the individual quantities required are small, so distribution costs are high. In addition, it is segmented with a number of different categories of users each with different production requirements and abilities to pay, including a large segment of small-scale, poor farmers.

- Lack of effective demand is a major constraint to the development of sustainable seed markets in many parts of the world and in sub-Saharan Africa in particular.

- The characteristics required of seed are more location-specific than those required of other agricultural inputs; the output of the world seed industry is more differentiated, agricultural zone-by-zone, than any other agricultural input industry. This necessitates more attention to market research and targeted production promotion as well as a structure of production that can provide a range of crops and varieties.

In turn, this clarifies the extent to which changing the structure of seed organisations is likely to contribute to improved performance with respect to these functions or whether other changes will also be needed. Therefore it is essential that any assessment of the scope for organisational change to improve performance in the seed sector must first accurately distinguish the causes of poor performance.

6.2 Defining seed sector functions

Assessments of seed sector performance vary according to the perspective of the assessor: seed companies are usually primarily concerned with profitability; farmers are concerned with

Demand

- Farmers can, and very many still do, obtain their seed requirements from their own saved seed for many crops and remain independent of the organised sector, which is not an option for many other goods. Thus the seed system has to produce a product that is clearly superior to what farmers can save themselves, otherwise demand will be small and financial viability will be compromised by large quantities of remaindered stocks. Thus, the market is very sensitive to quality and price.

- Quality refers to both increased yield and yield stability, both actual and - often more importantly - perceived, associated with the use of improved seeds. This latter is critically influenced by extension and sales promotion.

- Demand for seed is derived from demand for its ultimate benefits (namely its ability to increase production and income) so demand is negatively affected in environments where the ability of the product to deliver these attributes is not certain (ie in environments where there is production risk).

- The cost of seed is a small proportion of farmers' total costs of production, therefore demand may be expected to be relatively inelastic with respect to own price within a certain price range (although more elastic above this due to the existence of substitutes). The frontier of this range depends on farmers' perception of the benefits of improved seed. Probably more important than own price elasticity of demand, however, is cross price elasticity of demand with respect to grain prices. The level of market development for the grain product also exerts a significant influence: farmers are more likely to purchase seed for crops for which there is an established market outlet.

- Although improved seed itself is highly 'divisible', yields and therefore the overall profitability of using improved seeds are not scale or factor neutral because they depend on the use of complementary inputs and additional labour, which are easier for larger farmers with larger cash resources to obtain. This has an important influence on the comparative demand of different categories of seed users.

- The influence of transaction costs on demand is one of the most significant differences between dc and ldc seed sectors: in ldcs, farmers' restricted zone of mobility, combined with the poor level of penetration of the distribution system, can exert a substantial negative influence on demand for seed.

- Demand is significantly influenced by exogenous factors, specifically inter-seasonal variations in harvest caused by variations in weather, and will thus fluctuate from year to year for reasons other than changes in price. This is particularly important in developing countries where inter-seasonal variations in weather can be substantial.

- Demand is seasonal so timeliness of distribution is critical in satisfying demand.

easy access to cheap reliable supplies of good quality seed. For policy-makers in developing countries, the major concern is usually with the seed sector's contribution to overall national development. Given the increasing importance for national development of enabling small farmer output to be maximised, this translates into a particular concern with how well the seed sector meets the specific seed needs of this category of farmer.

In this context, the two main functions that the formal seed sector in developing countries is expected to perform can be defined as:

- a **firm-level efficiency function**: the production of improved seed in a way that allows the full recovery of fixed and variable production costs;

adjusted for

- a **national development function**: the distribution of the varieties and quantities of good quality improved seed required by small-scale semi-commercial farmers in a timely manner to appropriate locations at prices farmers can afford.

6.3 Primary indicators for performance assessment

The standard measurement of firm-level efficiency, which is also relevant in the seed sector, is whether in a competitive market, the individual seed company produces at a level where

$$AR=MR=MC=AC$$

where AR = average revenue (price)
MR = marginal revenue
MC = marginal costs
AC = average costs

assuming that the company is technically efficient in seed production, factor costs are 'market' prices and not distorted and product prices are 'market' prices and not distorted.

The optimal supply of improved seed for each crop for national development purposes will depend on:

- the **area planted** to each crop, discounting any distortions in this caused by policy interventions;

- adjusted for the **availability of improved varieties** for each crop that are relevant to farmers' needs;

- resulting in the optimal **proportion of area** per crop that should be covered by improved seed (allowing for the relative suitability of the available varieties to different zones, the need to maintain genetic diversity, etc.);

- translated into the **quantity of improved seed** needed annually (area x sowing rate x replacement rate).

This calculation has to be done separately for large-scale commercial farming areas, small-scale commercial, small-scale semi-commercial and subsistence areas. For our purpose, the emphasis is on accurately assessing the improved seed requirement for small-scale semi-commercial farmers.

6.4 Secondary factors influencing performance

A comparison of the two calculations outlined in the previous Section will usually reveal a divergence: the quantity of improved seed of different crops that the seed companies choose to produce rarely equates to the quantity small farmers' require. This may be the result of **seed companies' internal inefficiencies** and related supply-side distortions. This is the typical interpretation of poor performance in the seed sector and results in the kind of initiatives to transfer ownership of seed companies to the private sector that have become common in developing countries recently.

However, there are a number of other factors which have an important influence on seed sector performance. Differences between the optimal and actual use of improved seed are also explained by demand-side factors which create a divergence between the optimal area sown to improved seed at national level (for national food security) and that planted with improved seed at household level (for maximisation of household utility). This occurs when:

- the **household-level benefits of using improved seed** such as increased grain yield, increased yield of other biomass, increased value of production (for organoleptic, storability, etc. reasons) and other indirect benefits (early maturity, pest/disease resistance, etc.);

are not outweighed by

- the **household-level costs of using improved seed** measured by the seed price compared to the consumer grain price, the incremental input costs (including labour, timeliness of field operations, etc.), non-financial costs such as the risk of crop loss and the risk of late/non-arrival of seed and fertiliser.

This dilemma is well summarised in Rhoades [1989]: 'The real challenge of seed programmes is to produce a downward spread to common growers for major national payoff'.

Another important aspect of the seed sector's national development function relates to the government budget. This requires that the revenue from and the expenditure on the seed sector are optimised where

- **government revenue from the seed sector** including plant breeders' rights; charges from quality control services; taxes on seed companies; direct and indirect taxes on the value of small farmers' incremental production arising from using improved seed; foreign exchange earnings from seed exports;

is greater than

- **government expenditure on the seed sector** including provision of free source seed; free quality control services; direct or indirect subventions to seed companies; subsidies on seed prices (for example, free seed distribution); foreign exchange spent on seed imports.

Any potential differences between optimal firm-level production and optimal national supply of improved seed should be removed by the application of appropriate policy incentives and controls. In practice, however, this is often not the case and policy interventions can increase the divergence between firm- and national-level optima, as we saw in Section 5.2, for example, with respect to price policy.

6.5 Methodology for performance assessment

The indicators of performance with respect to the functions of the seed sector outlined above can be investigated in a three stage approach to analysis as follows:

I. What is the optimal use of improved seed for national development purposes and to what extent do current formal sector seed production and sales achieve this?

II. To what extent has this been influenced by the performance of the seed sector with respect to variety, quantity, quality, access, timeliness, price and efficiency? (An assessment of the fiscal situation can be added here if required.)

III. To what extent is this the result of the influence of the **external variables** relating to location-specific agro-ecological and socio-economic factors; national macro-economic, agricultural and seed sector development policy; the linkages between the seed companies and allied institutions; and **internal variables** relating to the internal efficiency of the seed companies?

6.6 Data needs

The specific data needed for each stage of the assessment are as follows.

Stage I

Area planted to each crop; for each crop, availability of improved varieties that are relevant to farmers' needs; relative suitability of the varieties available to different agro-ecological zones; influence of concerns about genetic erosion; recommended and actual sowing rate per crop; recommended and actual replacement rate per crop, for large-scale commercial farming areas, small-scale commercial, small-scale semi-commercial and subsistence areas.

Stage II

- **Varieties of seed required**: typical cropping pattern; function of each crop economically (domestic food consumption, other domestic end uses, used for non-grain biomass, sold (for what?)) and agronomically (agro-ecological zone, husbandry requirements - labour, other inputs); varieties of each crop used by farmers grown to fulfil these functions; how well improved varieties available from formal seed sector fulfil these desired functions.

- **Quality of seed required**: quality attributes desired by small farmers for each variety (genetic, physiological); relative importance of each; how well formal sector seed provides these attributes; how this compares with quality of farm-saved seed.

- **Quantities of seed required**: from Stage I above. How easily required quantities are obtained from the formal sector (pack size, etc.).

- **Timeliness of delivery**: for each crop/season, period during which small farmers wish to be able to obtain seed; whether improved seed arrives at this time every year, most years, rarely or never.

- **Accessibility of delivery points**: where small farmers want to be able to obtain improved seed from: type of outlet (public sector, commercial, community organisation, other) and physical location/distance from household. Where seed is obtained from at present; perceived advantages and disadvantages of this source.

- **Retail seed prices**: price small farmers currently pay for purchased seed (by variety). Expenditure on seed as a proportion of a) total costs of production and b) income. How much small farmers would be prepared to spend on improved seed if income was a) double b) half this. Maximum price small farmers would be prepared to pay for purchased seed at present levels of income and other production costs. Source of seed were retail prices for improved seed to exceed this. Quantity of improved seed small farmers would be prepared to buy if prices were a) double b) half this.

- **Costs of production**: whether fixed and variable costs of seed activities are covered at prevailing factor and product prices, for each organisation involved in multiplication, processing and delivering improved seed. Changes in this over time. This can be detailed by activity as in Box 6.2.

Stage III

To what extent can poor seed sector performance be attributed to:

- **location-specific factors**:

  a) agro-ecological factors: for example, the varieties of seed small farmers require may be expensive to produce or saved easily on-farm; climatic conditions may make production and/or storage of seed difficult/expensive; the complexity of the agro-ecosystem may necessitate many different varieties; its riskiness may be a disincentive to small farmers using scarce resources to buy seed.

  b) socio-economic factors: for example, the small farmer seed market may be too small numerically, either absolutely or relatively (compared to the demand from other categories of seed user), or in terms of effective demand, to be attractive to formal sector organisations; the level of transport and communications infrastructure may mean serving the small farmer market is difficult/expensive; small farmers may require variety attributes other than yield, which the formal sector is unable or unwilling to provide.

- **the national economic policy framework**:

  a) macro-economic policy: for example, economic incentives may favour one type of organisational structure over another; trade and exchange control, statutory wage rates, transport and communications policy may preclude economically efficient seed production at prevailing factor and product prices.

Box 6.2: Tracing the build-up of costs through the seed sector

Seed multiplication

Basic/foundation seed procurement price

Crop husbandry costs
- labour
- variable inputs (fertilisers, pesticides, *etc.*)
- supervisory management
- depreciation on machinery and equipment
- land rents

or
- growers' premium
- supervisory management

Processing and storage

Transport from multiplication site to processing plant/store

Processing costs
- labour
- variable inputs (fuel, packaging, treatment chemicals, *etc.*)
- depreciation on buildings and equipment
- cleaning losses, wastage, *etc.*
- processors' margin

Storage costs
- labour
- variable inputs (fumigants, *etc.*)
- finance charges
- depreciation on buildings and equipment
- humidity and temperature control

Distribution and marketing

Transport from store to wholesale and retail distribution points

Marketing costs
- variable costs (documentation, *etc.*)
- promotional activities
- maintenance of distribution points
- allowance for unsold seed, wastage
- distributors' commissions

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Critical seed prices in the cost build-up process

1. Basic/foundation seed procurement price.
2. Price of seed ex-seed farm/contract grower.
3. Seed price ex-processing plant.
4. Seed price to wholesale and retail distributors.
5. Seed retail price.

b) agricultural policy: for example, policy may be a disincentive to the use of purchased seed by small farmers via its influence on factor costs (land tenure, complementary input prices, etc.) or via its influence on product prices
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(compared to consumer prices of main food staples and taking into account the security of retail food markets, off-farm wage rates and employment opportunities, etc.). Policy may also have a direct disincentive effect via its influence on retail seed prices compared to producer prices, complementary input prices, etc. This can be a particular problem where policy distorts the prevailing cropping pattern from the agro-ecological and socio-economic optimum.

c) seed sector development policy: for example, policy may impose additional economic costs on seed organisations without compensation. For example, product price controls, obligations to produce low margin seeds or to operate strategic seed reserves may preclude economically efficient seed production at prevailing prices. Or seeds legislation may be inappropriate to the needs of the sector.

- **linkages with allied institutions**: for example, agricultural research institutions may fail to provide varieties with attributes required by small farmers; distribution channels for improved seed may have suitable varieties available but fail to reach small farmers in a timely manner at the necessary locations; distribution channels for complementary inputs may be ineffective; extension services, agricultural credit institutions, etc may be malfunctioning in terms of providing the necessary support to the seed sector.

- **the internal efficiency of seed companies:** the seed organisations themselves may not be operating inefficiently, assuming undistorted factor and product prices; particular activities may be the major source of inefficiency (see Box 6.2). This may be attributable to:

a) insufficient resources to devote to production: either because of an absolute shortage of resources or because of resource allocation decisions taken elsewhere (are decisions delegated to the appropriate level? Do decision makers take sufficient account of the seed companies resource needs?);

b) lack of technical competence in seed activities (inadequate training);

c) managerial dysfunctions within the seed company due to inappropriate incentive and control structures, the structure of the organisation, its systems and procedures, its culture and values. Symptoms of this would include: neglect of duties; lack of initiative; failure to report or address problems; confusion over responsibility; failure to delegate, etc.

6.7 Data collection

6.7.1 Data sources

The initial source of primary information for Stage I is likely to be a small farmer survey. The survey should be conducted in representative small farm areas, chosen to represent the major agro-ecological zones and farming systems.

The most appropriate survey technique will depend on the particular situation and on the resources available. One possible approach is to start the survey in each area with a group interview at village level, to identify key general issues. This would be followed by household level interviews with key informants (in each household, both those responsible for resource allocation and those directly involved in crop production, where these differ) to discuss these issues in more detail, using a format loosely structured to cover the subjects outlined in Stage I above. In consultation with the relevant field staff, households would be chosen to be representative of modal small-scale semi-commercial farms with respect to holding size, cropping pattern, labour availability, etc. as represented in recent survey data.

The evidence from the farmer survey would be compared with and amplified by existing secondary data sources, such as agricultural survey data, other published survey results and research work related to crop use and small farmer seed preferences, etc., and also by interviews with staff at the key seed sector institutions. These might include:

- **Ministry of Agriculture**: small farmer credit administration, small farmer fertiliser suppliers, Planning Units; Department of Agricultural Research: relevant regional or commodity Agricultural Research Stations, Seed Technology Units, Adaptive Research Teams; selected field staff.

- **National seed company/ies**: government-run, parastatal, multi-national and local private companies and community-oriented seed organisations including international and national NGOs, producer co-operatives, church groups, etc.

- **Seed distributors**: headquarters and depots of national agricultural marketing parastatals, wholesale and retail seed traders.

The main aims would be to obtain as much quantitative evidence of seed sector performance as possible and to verify interpretations, where quantitative data is in short supply, by repeating questions at different stages in the seed chain.

6.7.2 Data gathering approach

In the absence of both existing baseline data and the potential for large sample survey work with which to establish objectively the relative influence of different factors on performance, Stage III is likely to consist mainly of interviews with the different groups involved in the seed sector (as above) to gather qualitative evidence. The aim here would be to build on the knowledge and experience of these different groups to weigh up the different explanations of performance offered.

Following the methodology outlined above is likely to require about six weeks data gathering, and more if a statistically-valid small farmer sample is surveyed. At least one month would need to be allowed for data analysis and writing-up. The timing of in-country data-gathering is important for work relating to the seed sector: the best results are likely to be achieved if survey work and institutional interviews can be conducted at the start of seed selling season, when seed needs will be paramount in the minds of farmers and seed company staff.

Almost certainly it will be necessary to rely on the intermediate indicators of economic efficiency collected in Stage II (see Section 6.6) because final indicators of performance, such as the benefit stream generated by the incremental yields derived from small farmers' use of quality improved seed, is likely to be reduced from its maximum potential by these factors. Thus in terms of better understanding of how a sustainable seed supply system for this group of farmers can best be operated, it is necessary to understand these factors and the influence they have as well as to calculate the size of the net quantitative benefit. However, if the data is available, Appendix 4 shows how this can be used to compute a full-scale cost-benefit analysis for the service the formal seed sector provides to small farmers.

6.8 Data interpretation

Using this analytical framework will identify the key factors influencing seed sector performance and their relative importance. From this assessment can be extrapolated:

- the best means of improving performance and the relative role of organisational change in this;
- the type of organisational change that will ensure seed needs of small farmers are most efficiently met in a particular context (the relative role of different types of organisation within each component of the seed sector in different contexts).

Likely areas to address include:

- ☐ is there a continuing role for direct public sector participation in seed multiplication, processing and delivery?
- ☐ could policy changes create more effective incentives for and controls on the participation of other types of formal sector seed organisation in the small farmer seed market?
- ☐ in particular, could greater encouragement of decentralised, small-scale seed activities make a significant contribution to performance?
- ☐ is there a justification and a mechanism for supporting informal sector seed activities?
- ☐ to what extent is a blend of these approaches required, with different organisational structures promoted for different activities within the seed sector?

The assumption is widespread that increasing private sector involvement will improve performance in agricultural markets, including seed markets. From a technical perspective, the evidence from this study suggests that this could result from technical constraints in seed multiplication, processing and distribution and the corresponding need for seed companies to have a highly responsive organisational structure. In particular, there is a need for seed company management to be market- rather than production-oriented and geared to responding to the special needs of different categories of seed users. This, because of the nature of the seed production process, implies the need for the delegation/decentralisation of financial and managerial control. This has led some observers to conclude that, for many activities within the seed sector, public sector involvement is less appropriate. For example, the World Bank concluded that in the case of the national seed project in Pakistan, 'The weaknesses of public sector ownership were to largely nullify the project' and further that 'This kind of industry does not lend itself well to the limitations of normal bureaucratic procedures, working hours and financing' [World Bank, 1987b].

However, the evidence in the present study, suggests strongly that these conclusions are not universally applicable and that much depends on the historical development of the sector over time, on the way the linkages between different parts of the sector have been organised and on the particular agro-ecological and economic circumstances. In many situations, it seems that a less dogmatic approach is likely to be more successful. The evidence indicates that a straight transfer of ownership and control from the public to the private sector is too simplistic an approach, because there are numerous causes of poor performance in the sector - not all of which can be traced to inefficiencies within the seed organisations themselves.

This perspective shows that the critical policy question with respect to ownership and control in the seed sector is not which particular organisational structure is most appropriate but what **blend** of organisational alternatives is likely to optimise performance of the sector as a whole. Therefore the task is to identify the appropriate division of responsibility between government, private sector and farmers' organisations. For some general activities such as quality control, and for some specific ones, such as basic plant breeding for non-marketed food crops, direct public sector participation is likely to be required as other types of organisation are unwilling or unable to become involved. For others, such as multiplication of certified seed and marketing, other organisational forms may be more appropriate - not only explicitly commercial but also decentralised, small-scale farmer-controlled structures. In this case, the policy question becomes how to create the appropriate mix of statutory controls and economic policy incentives to ensure the efficient and effective operation of these organisations and how to define the acceptable trade-off, from a national development perspective, between the efficiency with which these organisations operate and the equity with which they serve different categories of seed users. As we saw earlier, each type of seed organisation has its own preferred client group.

One of the most critical influences is the specific nature of the linkages between the seed organisations and the allied institutions in the sector and the factors influencing these. Indeed, there is considerable evidence to suggest that whilst the internal organisation of seed companies themselves does have an important influence on their performance, the performance of the sector as a whole is equally if not more significantly determined by the structure of these linkages and, in particular, the responsiveness of the other institutions to seed users' expressed needs.

Given these particular requirements, some measure of official support and co-ordination is very often needed for seed delivery for this category of seed user to compensate for the disequilibrium between costs and benefits of seed supply and seed use accruing at national, seed organisation and household level.

Two countries differing experiences with achieving a workable organisational mix in the formal seed sector are illustrated in Box 6.3 and Box 6.4.

Box 6.3: The formal seed sector in Bolivia

According to a recent evaluation, the formal seed sector in Bolivia is achieving the goals set for it concerning quantity and quality of seeds supplied, dissemination of improved varieties and stimulating increased yields on small farms and has the institutional capacity to be able to continue doing this for the foreseeable future.

The 'built-in driving force' identified by the evaluation as having been responsible for this is the integration of public and private organisations in the seed sector structure. This, it is stated, has led to mutual support, efficient use of resources, formulation of cohesive plans and policies and co-ordination which has permitted a 'piling-up effect' with a greater cumulative effect of the organised seed sector than were isolated components trying to solve problems alone.

The evaluation goes on to point out that whilst the principle of integrating existing local resources to achieve common goals is readily accepted in principle in most developing countries, it is seldom put into practice. In contrast, the Bolivian seed programme has found a simple way of institutionalising this principle, by organising seed boards on a bottom-up basis, starting with regional boards in one region and expanding and triggering the formation of a National Seed Board.

The presence of the seed boards has allowed:

- decentralisation and regionalisation
- efficiency in resource identification and utilisation;
- cohesiveness in plans and policies
- flexibility
- stability.

These are seen to be key features that makes it possible to deal with agro-ecological variation as well as variation in research and development organisations throughout the country, in a way which improves the overall performance of the seed sector both with regard to national development and with regard to organisation-level efficiency.

Source: CIAT 1991.

6.9 Seed sector dynamics

One of the main requirements for successful performance analysis is an appreciation of the seed sector as a grouping of dynamic, developing structures - a 'stages of development' perspective [ICD, 1987]. From this perspective, the sector is seen as passing through a series of phases: 'learning', 'transitional', 'developing' and 'established'. In each phase, the appropriate organisational mix is different: perhaps government/parastatal control in the first case, followed by a gradual opening up to private sector participation and, ultimately, an organisational partnership, each having defined and complementary roles. Thus individual sectors are more accurately described by one or another at a given point in time. In many countries in sub-Saharan Africa, for example, the seed sector is still largely controlled by national parastatals and in the 'learning' phase whilst India can be described as in the 'transitional' phase following the liberalisation of the seed sector in 1986, and countries such as Mexico and Thailand have 'established' seed sectors with a complementary blend of activity.

Box 6.4: Private, public and donor involvement in the seed industry of Thailand

The objectives of the government of Thailand's seed programme are to promote the use of high quality seed in order to enhance the productivity and income of farmers. This is done through a two-string model where the Department of Agriculture develops and multiplies cheap open-pollinated seed, and at the same time, the government encourages private farmers, agricultural institutions and private companies to produce seed.

The public seed production is undertaken in 20 decentralised seed centres located throughout Thailand. These have by and large been financed by international donor organisations; Japanese International Cooperation Agency (JAICA); European Economic Community (EEC); Overseas Economic Cooperation Fund (OECF); and USAID. These centres select and contract local farmers to multiply seed and pay them a premium price of about 10% above the market price. More than 90% of the publicly produced seed is distributed at highly subsidised prices through government supported programmes such as the Rice Seed Exchange Programme, the Rice Promotion in Rainfed Areas Programme, the Cassava Replacement Programme and the Natural Disaster and Emergency Relief Programme.

In addition to this, a large number of both large, medium and small domestic seed companies exist in Thailand. Some of them serve the whole country with a number of crops, while others specialise in one or few crops and serve a limited area. Moreover, a number of trans-national seed companies are present in Thailand, offering their varieties and hybrids. Some 129 seed companies are licensed to handle vegetable seed and the competition is keen.

The public sector secures cheap open-pollinated seed of rice, maize, soyabean, groundnut and mungbean, which serve as an alternative to the more costly but better performing (hybrid) seed offered by the private sector. This has been the main mechanism in determining the seed price in the private sector. The price of hybrid maize seed from the private sector is at minimum 20% higher than the open-pollinated maize seed (**Suwan 1**, **2** and **3**) offered by the public sector, while the potential yield of hybrid maize is about 35% higher than the open-pollinated maize. Farmers thus have a real choice between the two types of seed and can decide whether the net gain will cover the extra seed cost and risk.

Source: Setboonsarng, Wattanutchariya and Puthigorn, 1988.

6.10 Conclusion

This study has developed a framework that can be used to assess the extent to which increasing competition in the seed sector, through opening it up to the private sector, will improve performance in terms of contributing to the continued expansion of improved seed use in an efficient way. The framework has a particular focus on the impact of changes in seed sector organisation on the small-scale semi-commercial farmers who form a majority in the agricultural sectors of most developing countries. By identifying the key factors influencing the organisation and structure of the seed sector, and their lines of causality, the likely impact of changes in the way the market for improved seed is allowed to operate can be extrapolated.

It is useful to examine the scope for privatisation in agricultural markets in developing countries in the context of the seed sector as it highlights many of the most important issues involved in the current debate: the nature of market failure; the shortcomings of complete reliance on the private sector; the potential contribution of a reformed public sector; and the extent to which structure and ownership are the major constraints to improved performance and therefore the extent to which privatisation or market liberalisation can bring about an improvement.

One of the most important implications of the interplay of structural and technical factors for the organisation of the seed sector is that different organisational alternatives are likely to be relatively more or less appropriate in different specific situations. As we have seen throughout the study, each component of the seed sector fits together with the others differently depending on the farming system and the wider economic environment. This means the task of identifying the most appropriate organisational structure is both complex and location-specific. Indeed even different activities within the chain and package in one sector can require different structures.

The next step is therefore to use the framework to test its robustness in practice, to refine it and to fill in detail about what is actually happening in seed sectors in developing countries that are currently being reformed. This has been the task of Phase II of the study. Phase II has been particularly useful in accumulating evidence of which kinds of organisation are better able to perform in different agro-ecological and socio-economic contexts. We have then, in Phase III, drawn up a final general assessment of the ways in which seed sector performance might be improved, that can be used by seed sector, agricultural and national economic planners in developing countries when seeking to improve the performance of the formal seed sector, at the same time as producing a final framework that can be used by individual countries going through this process.

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APPENDICES

Appendix Table 1:
Punjab Seed Corporation composition of retail seed prices for wheat 1980-87 (Rs per 90 kg bag)

Description	*1980-81*	*1981-82*	*1982-83*	*1983-84*	*1984-85*	*1985-86*	*1986-87*
Procurement price	112.50	130.50	130.50	144.00	144.00	157.50	180.00
Premium to growers	9.67	11.25	11.25	11.25	11.25	11.25	11.25
Procurement cost	16.57	15.36	14.11	15.12	15.75	15.14	13.86
Cost of jute bag	14.00	11.75	12.40	13.25	14.27	15.40	15.73
Sieving losses	0.00	0.00	4.68	3.40	3.42	3.66	4.10
Distribution cost	7.10	7.10	7.10	7.10	9.48	10.99	8.30
Commission to dealer	5.00	5.00	5.00	5.00	6.00	6.00	8.00
Interest on capital	9.02	8.16	10.13	11.92	11.97	12.87	14.36
Corporation overheads	6.94	5.94	7.79	7.48	15.04	14.58	13.20
Corporation margin	4.83	0.00	0.00	5.36	5.40	5.82	0.00
Total cost	185.63	195.03	202.96	223.88	236.58	253.21	268.80
Subsidy	15.63	18.03	18.03	18.03	11.56	6.21	0.00
Sale rate	170.00	175.00	184.93	205.85	225.02	247.00	268.80
Rs = US$1	17.88	11.67	13.08	14.02	14.39	16.17	16.65

Source: Heisey, 1990

Appendix Table 2:
Punjab Seed Corporation wheat seed sales 1979-86 (tonnes)

Year	*Target*	*Procured*	*Sale*	*Balance*
1979-80	4,100	4,100	4,100	0
1980-81	14,900	11,500	10,000	1,500
1981-82	22,400	19,800	19,600	200
1982-83	29,900	33,300	33,300	0
1983-84	44,800	44,200	41,100	3,100
1984-85	52,300	48,500	48,500	0
1985-86	52,300	44,500	41,000	3,500

Source: Heisey, 1990

Appendix Table 3:
Zimbabwe maize seed cost calculations 1982-89 (Z$)

	82/83	*83/84*	*85/86*	*86/87*	*87/88*	*88/89*
Seed Co-op						
TVC	795.50	932.43	n/a	1,327.93	1,458.85	1,630.57
Overheads	272.84	315.99	n/a	464.78	510.60	570.70
Cost of finance	222.33	240.52	n/a	119.51	131.30	146.75
Total cost/ha	1,290.72	1,488.94	n/a	1,912.22	2,100.75	2,348.02
Cost/pocket	43.02	49.64	n/a	63.74	70.03	78.27
Producer margin	4.30	4.96	n/a	6.37	7.00	7.83
Producer price	47.32	54.59	n/a	70.11	77.03	86.10
Seed co-op expenses	6.64	7.90	n/a	10.48	11.51	12.87
Total cost/pocket	53.61	62.49	n/a	80.59	88.54	98.97
Selling price	47.50	55.64	n/a	74.92	74.92	74.92
Net profit/pocket	-6.11	-6.85	n/a	-5.67	-13.62	-24.05
MLARR						
TVC	781.77	913.03	n/a	1,276.47	1,271.15	1,587.42
Overheads	291.77	160.51	n/a	446.76	514.90	555.60
Cost of finance	226.47	412.96	n/a	n/a	n/a	n/a
Total cost/ha	1,300.01	1,486.50	n/a	n/a	n/a	n/a
Cost/pocket	43.33	49.55	n/a	n/a	n/a	n/a
Producer margin	4.33	4.95	n/a	n/a	n/a	n/a
Seed co-op expenses	7.90	7.90	n/a	n/a	n/a	n/a
Total cost/pocket	55.56	57.45	n/a	66.20	71.14	n/a
Selling price	55.64	74.92	74.92	n/a	74.92	n/a
Net profit/pocket	0.08	17.47	8.72	n/a	3.48	n/a

Source: Friis-Hansen, 1990.

Note: pocket = 50kg; TVC = total variable costs.

Appendix 4: Example Seed Programme Cost-benefit Analysis

This Appendix demonstrates and explains how a full-scale cost-benefit analysis can be carried out for a regional or national seed project or programme, to support the type of performance assessment outlined in Chapter 6. The illustrative data used are adapted from a regional seed project in Nepal [see Cromwell, Gurung and Urben, 1992]. In this case, estimated real financial costs have been used because local factor and product market prices were considered to be relatively undistorted and because the primary concern was with the project's local impact. Where the main aim is to assess the national impact of a project or programme, and/or where market distortions are significant, it would be more appropriate to estimate shadow prices in order to determine economic costs.

The starting point is a computation of the net costs and benefits at household level for small farmer users of improved seed, and for contract seed growers if these are used. Examples are given in Appendix Tables 4.1 and 4.2.

For this exercise to be useful, great care must be taken to incorporate values for the non-financial factors outlined in Section 6.4 of Chapter 6. For example, greater risk of crop failure in poor seasons when using improved varieties can be represented as a yield deflator; the less preferred taste of improved varieties can be represented as a price deflator, etc.

Various other factors must be taken into consideration. Incremental yield estimates are critical and as much care as possible must be taken to ensure that the yield values used are those attainable on small farmers' fields (which may not be the same as those obtained by agricultural research departments' on-farm trials).

Grain price differentials may favour or disfavour improved varieties depending on local taste preferences. The price of improved seed will always be higher than the cost of local grain used as seed (this latter being the consumer grain price), except where subsidies within the seed production chain keep improved seed prices artificially low. The precise increment will vary between crops and according to government and seed company pricing policies.

Care must be taken to ensure that the sowing and fertiliser application rates used mirror local practice, as this can vary considerably between locations. For the contract growers in the project illustrated here, for example, the incremental cost of growing a seed crop is slightly reduced because of the traditional local practise of sowing grain crops at higher plant populations for subsequent thinning as green fodder.

For simplicity, the examples given here assume that in one year only one pure stand crop of rice, maize, wheat or potatoes is grown on each parcel of land. This is not realistic for most small farm farming systems, where multiple inter-planted crops are the norm. More accurate figures would be obtained by valuing total annual production costs and benefits from one hectare under the main cropping patterns; in this example, 'maize' could be replaced by 'maize/millet-lentils-fallow'.

The net incremental costs and net incremental benefits obtained from these calculations are then fed into the main cost-benefit analysis given in Appendix Table 4.3. However, as well as doing this, it is critically important to assess how small farmers are likely to react to these apparent costs and benefits of using improved seed. There are two main determinants of this:

farmers' reaction to the perceived risk associated with the change; and their reaction to the relative rate of return to different factors of production - both of which have been the subject of considerable theoretical and empirical debate.

Some of the most commonly used comparative indicators are illustrated in Appendix Table 4.1. The marginal cost-benefit ratio (MBCR) and the marginal rate of return (MRR) relate primarily to risk assessment. The MBCR shows the difference between the gross benefits and variable costs of using improved seed compared to using local varieties. In the example given here, changing to using improved maize seed is clearly not worthwhile. The MRR shows the percentage difference between the net benefits and variable costs. Green [1985] estimates that the minimum MRR required for hill farmers in Eastern Nepal to purchase improved seed is 85 per cent.

Ashworth [1990] suggests that in Zimbabwe a minimum MRR of 60 per cent is needed, even in relatively high potential areas, for small farmers to buy improved seed and secure an income equivalent to the minimum daily wage. He also argues that the minimum return needs to be as high as 100 per cent in less favoured areas, since the risk involved in these areas is considerably higher. This is in sharp contrast to the 10 per cent margin used by the Zimbabwe Agricultural Finance Corporation when calculating the break-even point for the various crop packs provided on credit to small farmers.

For small-scale semi-commercial farmers who have few resources under their control other than domestic labour and who are severely cash-constrained, neither of these aggregate indicators may be as relevant as the relative return to individual factors of production. This is clearly illustrated in Appendix Table 4.1, where returns to cash invested (in supplies of purchased seed and fertiliser) are high but returns to labour - which is the resource households generally have better access to - are much less and in all cases lower than the average daily off-farm wage rate of Rs 25.

This type of distributional issue is critically important in interpreting the overall results of the cost-benefit analysis. Turning to Appendix Table 4.3, we can construct this overall analysis using the seed users' and contract growers' data.

Start by calculating the total area of each crop that can be planted using the improved seed produced by the project. This requires annual project seed production per crop to be divided by the sowing rate for each crop and the result to be added cumulatively, allowing for the typical seed replacement rate used by farmers within the project area. For rice, for example, this might be as follows:

Appendix Table 4.4
Example calculation of improved seed area coverage

	Year 1	*Year 2*	*Year 3*	*Year 4*
Seed produced (tonnes)	10	15	20	25
Sowing rate (kg/ha)	50	50	50	50
Area coverage (ha)	200	300	400	500
Adjusted for replacement rate (4 years) (ha)	200	500	900	1100

The net incremental costs and benefits of using improved seed on this area can be taken from Appendix Table 4.1, to value production benefits and on-farm variable production costs, as shown in Appendix Table 4.3. Ideally, these costs and benefits should be valued only for that part of the project's seed production which is known to have been used as seed ie allowing for any spoilage in store, sales as food grain, etc.; in most cases, this will be difficult to assess and it will be necessary to approximate by valuing total seed production instead.

Where improving small farmers' incomes by involving them in seed production as contract growers has been an important project objective, it will be necessary in addition to measure the total area used for seed production in order to make a similar valuation of the net incremental costs and benefits of seed production, using the data from Appendix Table 4.2.

To these calculations, the costs of the project itself must be added. These are indicated in Appendix Table 4.3 under capital costs and project recurrent costs (salaries, etc.). Whilst these costs will occur only during the project life (Years 1-4 in the example given in Appendix Table 4.3), it is important to allow for the continuing occurrence of on-farm costs and benefits for the full life of the improved seed produced: this will vary between crops, depending on the seed replacement rate used by farmers in the project area.

Having estimated all the relevant costs and benefits, the project or programme can be subjected to the usual performance assessment, using the appropriate indicators. The example given here shows an internal rate of return of over 100 per cent which, in terms of conventional project analysis, is of course remarkably high. This illustrates two limitations to the use of conventional cost-benefit analysis for seed projects and programmes. Firstly, where data is poor, so computations have been based on best estimates, it will be important to carry out a thorough sensitivity analysis (not shown here); in the case of seed projects and programmes, the key variables to work on are yields, seed prices and grain prices. Secondly, even where data are known to be accurate, the long-term benefits of producing and distributing improved seed of varieties that are genuinely relevant to local small farmers' needs - as with agricultural research projects and programmes with the same ultimate aim - so obviously outweigh the limited project investment costs required, that this kind of analysis should be viewed more as a formality that has to be carried out before attention can be turned to the more important aspects of performance assessment illustrated in Chapter 6, than as an important end in itself.

Appendix Table 4.1
Partial budgets for seed users by crop (Rs/ha) in Nepal

	Rice		*Maize*		*Wheat*		*Potatoes*	
	Local	*Improved*	*Local*	*Improved*	*Local*	*Improved*	*Local*	*Improved*
Yield (kg/ha)	2500.00	3000.00	1300.00	1700.00	1100.00	2200.00	4000.00	8000.00
Less milling adj.(%)	40.00	40.00	10.00	10.00	10.00	10.00	0.00	0.00
Price (Rs/kg)	14.00	17.00	8.00	6.00	7.00	7.00	6.00	6.00
Total benefit	21000.00	30600.00	9360.00	9180.00	6930.00	13860.00	24000.00	48000.00
Seed amount (kg/ha)	60.00	60.00	30.00	30.00	120.00	120.00	900.00	900.00
Seed price (Rs/kg)	14.00	20.00	8.00	10.00	7.00	9.00	6.00	12.00
Seed cost (RS/ha)	840.00	1200.00	240.00	300.00	840.00	1080.00	5400.00	10800.00
Fertiliser (kg/ha)	0.00	60.00	0.00	50.00	50.00	50.00	0.00	0.00
Fert.price (Rs/kg)	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
Fert.cost (RS/ha)	0.00	351.00	0.00	292.50	292.50	292.50	0.00	0.00
Labour (days/ha)	81.00	108.00	122.00	162.00	95.00	126.00	169.00	225.00
Labour cost (Rs/day)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Labour cost (RS/ha)	2025.00	2700.00	3050.00	4050.00	2375.00	3150.00	4225.00	5625.00
Total variable cost	2865.00	4251.00	3290.00	4642.50	3507.50	4522.50	9625.00	16425.00
Net benefit	18135.00	26349.00	6070.00	4537.50	3422.50	9337.50	14375.00	31575.00
MBCR		6.93		-0.13		6.83		3.53
MRR		592.64		-113.31		582.76		252.94
Returns to cash invested		369.00		-96.23		318.87		140.98
Returns to own labour		14.01		2.49		4.93		8.47

Source: Adapted from Cromwell, Gurung and Urben, 1992.

Appendix Table 4.2
Partial budgets for seed producers by crop (RS/ha) in Nepal

Crop	*Rice*		*Maize*		*Wheat*		*Potatoes*	
	Grain	*Seed*	*Grain*	*Seed*	*Grain*	*Seed*	*Grain*	*Seed*
Seed yield (kg/ha)	0.00	1000.00	0.00	665.00	0.00	800.00	0.00	2800.00
Price (Rs/kg)	0.00	20.00	0.00	10.00	0.00	9.00	0.00	12.00
Grain yield (kg/ha)	1800.00	1200.00	1530.00	931.50	1980.00	1260.00	8000.00	5200.00
Price (Rs/kg)	17.00	17.00	6.00	6.00	7.00	7.00	6.00	5.76
Total benefit	30600.00	40400.00	9180.00	12239.00	13860.00	16020.00	48000.00	63552.00
Production costs								
Source seed (kg/ha)	60.00	50.00	30.00	30.00	120.00	100.00	900.00	1800.00
Price (Rs/kg)	17.00	20.00	6.00	10.00	7.00	9.00	6.00	12.00
Seed cost (RS/ha)	1020.00	1000.00	180.00	300.00	840.00	900.00	5400.00	21600.00
Fertiliser (kg/ha)	60.00	60.00	50.00	90.00	50.00	90.00	0.00	250.00
Fert.price (Rs/kg)	5.85	5.85	5.85	5.85	5.85	5.85	0.00	5.85
Fert.cost (RS/ha)	351.00	351.00	292.50	526.50	292.50	526.50	0.00	1462.50
Crop prot. (kg/ha)	0.00	10.00	0.00	2.00	0.00	0.00	0.00	2.00
Price (Rs/kg)	0.00	13.00	0.00	150.00	0.00	0.00	0.00	25.00
Cost (RS/ha)	0.00	130.00	0.00	300.00	0.00	0.00	0.00	50.00
Labour (days/ha)	108.00	120.00	162.00	180.00	126.00	140.00	225.00	250.00
Cost (Rs/day)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Cost (RS/ha)	2700.00	3000.00	4050.00	4500.00	3150.00	3500.00	5625.00	6250.00
Proc./mkting costs								
Extra transp./ha	0.00	60.00	0.00	72.00	0.00	140.00	0.00	2052.00
Extra transp.cost/kg	0.00	0.25	0.00	0.25	0.00	0.25	0.00	0.25
Extra transp.cost/ha	0.00	15.00	0.00	18.00	0.00	35.00	0.00	513.00
Store chems./ha	0.00	2.00	0.00	2.00	0.00	2.00	0.00	0.00
Store chems.cost	0.00	1.50	0.00	1.50	0.00	1.50	0.00	0.00
Cost/ha	0.00	3.00	0.00	3.00	0.00	3.00	0.00	0.00
Total variable cost	4071.00	4499.00	4522.50	5647.50	4282.50	4964.50	11025.00	29875.50
Net benefit	26529.00	35901.00	4657.50	6591.50	9577.50	11055.50	36975.00	33676.50

Source: Adapted from Cromwell, Gurung and Urben, 1992.

Appendix Table 4.3
Seeds programme costs and benefits (Rs'000 real prices) in Nepal

ITEM	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Total*
BENEFITS							
Rice	282.54	851.99	2280.69	5843.20	5983.53	5780.43	
Maize	357.08	1228.59	3115.42	9334.21	9706.38	9424.65	
Wheat	0.00	1707.07	3166.60	5187.66	5706.42	3757.14	
Potatoes	0.00	0.00	0.00	635.33	698.86	762.39	
Total	639.62	3787.65	8562.71	21000.39	22095.20	19724.61	75810.18
COSTS							
Capital costs							
Buildings	600.00	0.00	0.00	0.00	0.00	0.00	
Equipment	400.00	100.00	100.00	0.00	0.00	0.00	
Total	1000.00	100.00	100.00	0.00	0.00	0.00	1200.00
Recurrent costs							
On-farm costs							
Rice	30.54	92.09	246.50	631.55	646.72	624.77	
Maize	260.60	896.64	2273.65	6812.18	7083.79	6878.18	
Wheat	0.00	822.52	1525.77	2499.58	2749.53	1810.31	
Potatoes	0.00	0.00	0.00	254.02	279.42	304.83	
Total	291.14	1811.24	4045.93	10197.32	10759.47	9618.08	36723.18
Salaries and allows.	800.00	850.00	900.00	950.00	0.00	0.00	
Supplies and fuel	400.00	450.00	500.00	550.00	0.00	0.00	
Rent and repairs	100.00	110.00	120.00	130.00	0.00	0.00	
Contingencies	13.00	13.50	14.00	14.50	0.00	0.00	
Total	1313.00	1423.50	1534.00	1644.50	0.00	0.00	5915.00
Total costs	2604.14	3334.74	5679.93	11841.82	10759.47	9618.08	43838.18
Net cash flow	-1964.52	452.91	2882.78	9158.57	11335.73	10106.53	31972.00
NPV at 15%	15771.30						
IRR/100	1.34						

Source: Adapted from Cromwell, Guring and Urben, 1992.

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