Getting Genes:

Rethinking seed system analysis and reform for sorghum in Ethiopia.

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Dedicated to the memories of
Maria Jesús (Chusa) Ginés, and
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Abbreviations

AAU	Addis Ababa University
ADDP	Ada District Development Project
AISCO	Agricultural Input Supply Corporation
ALAD	Arid Land Agricultural Development
AMC	Agricultural Marketing Corporation
ARDU	Arssi Rural Development Unit
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AUA	Alemaya University of Agriculture
AVA	Awash Valley Authority
CADU	Chillalo Agricultural Development Unit
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
DA	Development Agent
DUS	Distinct, Uniform, and Stable variety
EARO	Ethiopian Agricultural Research Organization
EMTP	Extension Management Training Plots
EPID	Extension Projects Implementation Department
EPRDF	Ethiopian People's Revolutionary Democratic Front
ESE	Ethiopian Seed Enterprise (earlier, Corporation)
ESIP	Ethiopian Sorghum Improvement Project
F_1	Type of hybrid variety: denotes first filial generation
FA	Farmers' Association
FAO	Food and Agriculture Organisation of the United Nations
FBSPMS	Farmer-Based Seed Production and Marketing Scheme
FPR	Farmer Participatory Research
FSR	Farming Systems Research
FVs	Farmer Varieties
GDP	Gross Domestic Product
GxE	Genotype-by-Environment interaction
IAR	Institute of Agricultural Research (now EARO)
IBCR	Institute for Biodiversity Conservation and Research (includes former PGRC/E)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Center (Canada)
IMF	International Monetary Fund
MoA	Ministry of Agriculture
MPP	Minimum Package Program
MVs	Modern Varieties
NAIA	National Agriculture Input Authority
NARS	National Agricultural Research System
NCIC	National Crop Improvement Committee
NEIP	National Extension Intervention Program
NGOs	Non-Governmental Organisations
NSIA	National Seed Industry Agency (now NAIA)
NSIC	National Seed Industry Committee

NVRC	National Variety Release Committee
NYT	National Yield Trial
OECD	Organisation for Economic Co-operation and Development
PA	Peasants' Association (former name for Farmers' Association)
PADEP	Peasant Agricultural Development Extension Program
PADETES	Participatory Demonstration and Training Extension System
PC	Producer Co-operative
PGRC/E	Plant Genetic Resource Center of Ethiopia (now part of IBCR)
PHSE	Pioneer Hi-Bred Seeds Ethiopia
PMAC	Provisional Military Administrative Council
PPB	Participatory Plant Breeding
PVS	Participatory Varietal Selection
QPM	Quality Protein Maize
RADB	Regional Agricultural Development Bureaux
RAPD	Random Amplified Polymorphic DNA
RELC	Research Extension Linkage Committee
RRC	Relief and Rehabilitation Commission (now DPPC)
SC	Service Co-operative
SG2000	Sasakawa – Global 2000
SIDA	Swedish International Development Agency
SMS	Subject Matter Specialist
SSA	Sub-Saharan Africa
T&V	Training and Visit agricultural extension approach
TA	Technical Assistant
TCA	Technical Co-operation Association
UNDP	United Nations Development Program
USAID	United States Agency for International Development
V_E	Environmental variability
V_G	Genetic variability
WADU	Wolayta Agricultural Development
WANA	West Asia and North Africa region
YS	Yield Stability

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Chapter 1 Introduction: reforming breeding and seed supply, and the need for broad analysis.

1.1 Crop improvement, and its critics

Agricultural development remains at the heart of improving the well-being of the majority of people in the South. This is especially true for sub-Saharan Africa (SSA); most of the poorest are in rural areas, and low levels of non-farm investment mean they have fewer off-farm livelihood options than farmers in other regions. Over 70% of the population is involved in agriculture to some extent, and over 80% of consumption comes from local production (de Vries and Toenniessen, 2001). Improving the security of crop production is an essential part of tackling food security and extreme deprivation across the South, particularly for countries in SSA (Hazell and Haddad, 2001; UNDP, 2003).

Research plays a central role in agricultural development. Nearly all countries have established National Agricultural Research Systems (NARS), with institutes for research, education, and extension (Casas *et al.*, 1999; Pardey and Roseboom, 1989; Pardey *et al.*, 1997). The international community funds the centres of the Consultative Group on International Agricultural Research (CGIAR), which co-ordinate international-level research and offer support for NARS. Public-sector actors still dominate agricultural research and development in the South, though the private sector is increasingly involved (Pingali and Traxler, 2002).

Crop improvement is a key area of agricultural research. It involves selective breeding to identify and develop crop varieties, promoting these varieties and associated management strategies through extension, and providing seed (and other inputs) through supply systems. Crop improvement is generally the largest single area of activity in NARS – in Ethiopia for instance, over half of agricultural researchers work in crop breeding, or related departments like agronomy or crop protection (calculated from ISNAR, 1987; and Weijenberg *et al.*, 1995). The emphasis on breeding reflects seed's importance as an essential input for agriculture, whose physical and genetic quality affect crop performance throughout the season. Seed is generally considered to be the most affordable external input for farmers, and many of its benefits are assumed to be 'scale-neutral', so investments in crop improvement potentially can reach a wide range of farmers. While many other areas are also important for agricultural development – such as markets, credit supply, support institutions, and policies – access to appropriate seed is clearly the first step.

Crop improvement efforts have achieved a great deal. Breeders have produced new varieties (hereafter, Modern Varieties, or MVs[1]) for major crops, steadily increasing the yield potential of some crops over decades (for example, wheat, Slafer and Andrade, 1989; Austin *et al.*, 1980; Austin *et al.*, 1989; Silvey, 1986; many other examples cited in Heisey *et al.*, 2002: 48-49). Along with changes to input use and management, MVs increased production dramatically in many countries in the South. The Green Revolution, starting with wheat and rice in the 1960s, helped double cereal production by 1985 in the South (Conway, 1999). Successful breeding programmes have been credited with improving food security and decreasing the proportion of populations living in poverty (Lipton with Longhurst, 1989;

[1] Though "High Yielding Variety" is sometimes used, Modern Variety is the more widespread term and is preferred, as yield is not always the only goal of breeding programmes, nor do formally-released materials always produce high yield.

Evenson, 2000; Otsuka, 2000), while the yield increases produced by successful MVs are often used to show high returns to investment in agricultural research (e.g.. Maredia *et al.*, 1998; Heisey *et al.*, 2002; Morris, 2002). Thus, crop improvement would seem to be a very effective driver for development.

Crop development has not met with universal praise, however. Critiques of breeding and seed supply come from a wide range of perspectives, and can be grouped into three broad areas of concern, relating to:

- *effectiveness* in addressing clients' needs
- impact on *biodiversity*
- effect on farmers' *empowerment*

1.1.1 Effectiveness critique

The impact of crop development has been disappointing in many locations. Though the Green Revolution casts a long shadow, regions defined by highly-stressed or variable growing environments, diverse farming systems, and low input use generally have benefited little from crop breeding (Lipton with Longhurst, 1989).[2] Such conditions are found across all continents, but are especially common in SSA. For important crops in SSA, such as sorghum, MV adoption remains very low in many countries (Maredia *et al.*, 1998; de Vries and Toenniessen, 2001; Table 1.1). Such figures suggest that crop development has little impact in many locations.

There are many possible reasons for low impact. Farmers may not want MVs because they do not contain the traits most important to them: breeders often emphasise grain yield, yet other traits valued by farmers, such as taste, ease of processing, weed tolerance, or market-value may get short shrift (Haugerud and Collinson, 1990; Kornegay *et al.*, 1996; de Vries and Toenniessen, 2001; Conway, 1999). MVs may perform poorly in farmers' growing conditions, particularly when these conditions are unfavourable or involve few inputs (Ceccarelli, 1994). Efforts to supply MV seed to farmers have been beset by high transaction costs and market failure, limiting access to seed (Cromwell, 1993, 1996). Poor performance of MVs in unfavourable environments, and farmers' general low use of them in SSA mean that crop improvement has made only a small contribution to yield increases there (Dorward *et al.*, 2004), much less than elsewhere in the South over the last 40 years (Evenson and Gollin, 2003). For sorghum in SSA, average yields since 1980 have actually decreased (Ahmed *et al.*, 2000). Thus, where crop improvement has failed to deliver obvious benefits, critics often charge it with emphasising the wrong goals, ignoring important environmental variation, or failing to supply seed in an affordable and timely manner. Such critiques do not only apply to low-potential environments in SSA: farmers who can afford inputs or farm in much more favourable environments (e.g. the Philippines, Basillio, 1996; or Europe, Jongerden *et al.*, 2002) may also be dissatisfied with the MVs on offer.

[2] Regions poorly-served by agricultural research have been characterised as dominated by "complex, risk-prone, and diverse" farming systems (Wellard *et al.*, 1990; Cromwell, 1996), typically in reference to rain-fed SSA, alpine Latin America, and tribal Asia. "Resource-poor farmers" (Chambers *et al.*, 1989) has also been used to highlight those in all regions who have benefited less from research. Though such sweeping categories are not without problems, they clearly present more challenges to agricultural development than more uniform, favourable uniform situations.

Table 1.1 Estimates for adoption of modern varieties of sorghum in 1996 in Eastern and Southern Africa, (adapted from Maredia *et al.*, 1998, derived from ICRISAT and FAO estimates).[3]

Sub-region	Country	Area to sorghum (000 ha)	% to MVs (1995/96)
Southern Africa	Angola	110	9
	Botswana	83	24
	Lesotho	42	2
	Malawi	42	10
	Mozambique	376	4
	Namibia	13	0
	South Africa	155	77
	Swaziland	1	50
	Tanzania	663	2
	Zambia	42	36
	Zimbabwe	132	30
East Africa	Burundi	54	31
	Ethiopia	970	3
	Kenya	120	8
	Sudan	6300	1
	Tanzania	690	1
	Uganda	265	8

1.1.2 Biodiversity critique

A second line of critique is concerned with the impact of crop improvement on agricultural biodiversity. The most successful breeding programmes have generally promoted a small number of MVs from a few crops – predominantly wheat, maize and rice – often built upon a narrow genetic base (Cooper *et al.*, 2001). A more general concern is that breeding and seed supply decrease the diversity utilised in Farmer Varieties (FVs)[4]; storehouses of genetic diversity are abandoned in favour of MVs (Brush *et al.*, 1992; Einarsson, 1994; Bellon, 1996; Brush, 2000; de Boef *et al.*, 1993; Cooper *et al.*, 1992). Policies around seed supply and seed certification have also been criticised for restricting the range of genetic diversity supplied to farmers (Louwaars and Tripp, 2000; Witcombe *et al.*, 1998; Cromwell, 1996). Genebanks can help maintain valuable crop genetic diversity *ex situ*, but this strategy on its own is no longer considered adequate to ensure that diversity continues to be conserved and utilised (FAO, 1996; van Hintum, 1994; Wood and Lenné, 1997). Maintaining crop genetic diversity in farmers' fields, through *in situ* or on-farm conservation, is increasingly seen as an important complementary strategy to genebanks, keeping links between diversity and its dynamic agroecological and socio-economic environments, and increasing the amount of diversity available to farmers and breeders (Brush, 1995; Maxted *et al.*, 1997; Kothari, 1997; Almekinders, 2002; Almekinders and de Boef, 2000).

[3] Approximate figures, extrapolated from sample sites, which may give biased results: assessing adoption is discussed more in Chapter 3. Estimate for Rwanda omitted, as the cited figure of 117% appears highly questionable.

[4] Other terms, such as Traditional Variety or Landrace, face problems of definition (Zeven, 1998; Tripp, 1996b). Farmer Variety is preferred as it highlights the process of development, rather than any essentialist notion about the germplasm itself. As such, a FV could originally derive from an MV that was subsequently propagated – and modified – in farmers' own systems.

A third area of criticism concerns the involvement of farmers in agricultural research and development. Farmers' knowledge is increasingly appreciated, particularly their agency and innovation in shaping crop genetic resources (Richards, 1985; Biggs, 1990; Sumberg and Okali, 1997; Teshome, 1996). However, farmers generally have had little input into agricultural research, whether defining goals or evaluating outputs (Farnworth and Jiggins, 2003; Collion, 1994; Haverkort *et al.*, 1991). Some take a social justice perspective, arguing that neglecting farmers' participation in agricultural research erodes their knowledge and rights, leaving them disempowered in the face of formal institutions (Cordeiro, 1993; RAFI, 1996; PTA Network, 1996; Basillio, 1996; Berg, 1996b). Others emphasise more pragmatic reasons for involving farmers: to improve the impact or efficiency of agricultural research through obtaining farmers' input. These two perspectives on participation are often distinct in practice (Okali *et al.*, 1994), yet both seek a different division of labour in agricultural research, where farmers, and other clients, have a greater role.

These critiques are hardly new, but their volume has increased in recent years, leading to calls to reform crop breeding and seed supply so that there is greater involvement of farmers and other stakeholders (Eyzaguirre and Iwanaga, 1996a; Tripp, 1997a; de Vries and Toenniessen, 2001; Almekinders and Elings, 2001). This thesis concerns such reforms to crop development, exploring how new relationships between farmers and scientists could improve farmers' livelihoods. A wide range of initiatives to reform crop breeding and seed supply have emerged in the last decade. However, many of these efforts may not be as effective as they could be, as they are based upon only a partial analysis of the issues. I argue that a broader, trans-disciplinary analysis of the activities of both farmers and scientists in breeding and seed supply can offer a different perspective on problems, as well as potential reforms. Before outlining my framework for analysis, I summarise the main areas of reform to date, and highlight some gaps in the analysis and practice.

1.2 Predominant approaches to reforming breeding and seed supply

1.2.1 Participatory Plant Breeding

Participatory Plant Breeding (PPB) figures centrally in discussions about reform. Broadly-stated, PPB involves any approach that brings researchers into closer collaboration with farmers to do crop improvement.[5] Though farmer-scientist collaboration is hardly new (e.g.Collins, 1914; John H. Martin, 1936; Biggs and Gauchan, 2001; Schneider, 2002; Maat, 2001), Sperling and Ashby (1997: 199) are correct to assert that PPB is only 15 years old, in the sense that its emergence as a defined set of approaches, and its acceptance, is a relatively recent phenomenon. Since the 1990s, PPB has rapidly and dramatically risen to prominence, featuring in international workshops (e.g. Sperling and Loevinsohn, 1996; Eyzaguirre and Iwanaga, 1996a), large-scale programmes (CBDC, 1994; IPGRI, 1996; PRGA Program, 1997), and many projects (for examples of cases, see PRGA Program, 2001; Weltzien and von Brocke, 2001; Prain *et al.*, 2000; McGuire *et al.*, 1999).

The wide appeal of PPB partly stems from its ability to address all of the critiques listed above. Many argue that closer farmer involvement can make breeding more effective by

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[5] Competing terms include Participatory Crop Improvement (Atlin, 1997; Almekinders and Elings, 2001), and Collaborative Plant Breeding (Cleveland and Soleri, 2002b). While the latter has the advantage of not assuming precedence for either farmers' or researchers' knowledge or effort (*ibid.*: 14), I will continue to use PPB as the most widely-used general term.

raising breeders' awareness of the traits farmers desire, enabling decentralisation of activities to address smaller agroecological niches (i.e. by collaborating with farmers at multiple sites), or by facilitating diffusion of MVs or information (e.g. Kornegay *et al.*, 1996; Sthapit *et al.*, 1996; Ceccarelli, 1994; Witcombe *et al.*, 1999). Some look to PPB as a way to increase the amount of agricultural biodiversity utilised, or to support on-farm conservation. PPB could expand the range of MVs acceptable to farmers (Witcombe *et al.*, 2001), select FVs jointly with farmers to 'add value' to these materials so that farmers continue to use them (Voss, 1996; Tessema and Bechere, 1998), or it could develop links with farmers' dynamic management of crop genetic resources as a source of variation and continued adaptation (Eyzaguirre and Iwanaga, 1996b; Jarvis and Hodgkin, 2000; Almekinders *et al.*, 2000). Thirdly, some appreciate PPB's potential to empower farmers, by increasing their say in breeding and seed supply, enhancing their own technical skills, or by strengthening local institutions (Cleveland and Soleri, 2002a; Gómez and Smith, 1996; Rice *et al.*, 1998). Thus PPB figures prominently in discussions about reform because it resonates with a diverse array of contemporary concerns around crop development.

PPB has generated a diverse literature. Analytical overviews have classified efforts in terms of goals, agroecology, socio-economic context, or the nature of farmer participation (Sperling *et al.*, 2001). However, much PPB literature concerns methods, highlighting aspects such as the division of labour between farmers and researchers (e.g. Witcombe and Joshi, 1996; Witcombe *et al.*, 1996; Sthapit *et al.*, 1996), approaches to seek and interpret farmer input (Sperling *et al.*, 1993; Gómez *et al.*, 1995; Cleveland and Soleri, 2002a; CIMMYT, 2001), or breeding techniques for PPB (Ceccarelli *et al.*, 2001; Atlin *et al.*, 2001; Bänziger and Cooper, 2001). The other major theme in the literature is impact assessment, comparing PPB's effectiveness – and cost – in developing useful MVs, or the amount of diversity supplied to farmers, in relation to more 'conventional' breeding approaches (e.g. Lilja *et al.*, 2000; Johnson *et al.*, 2003; Witcombe *et al.*, 1999).

Many different approaches fall under PPB, where farmers and scientists collaborate at different stages, with different degrees of farmer participation. Some efforts pursue extensive farmer involvement, such as encouraging them to do selections among genetically segregating lines (e.g. F3 generation from pedigree breeding; see Sthapit *et al.*, 1996). However, farmer participation in most PPB projects has been a consultative add-on (*sensu* Biggs, 1989) to a 'conventional' breeding programme. The commonest PPB activities involve scientists asking farmers about their desired traits in a crop variety, or farmers evaluating materials developed by breeders. These materials can be released MVs, or potential candidate lines for release (i.e. non-segregating lines near the end of the breeding process). This activity is sometimes designated Participatory Varietal Selection (PVS) (A. Joshi and Witcombe, 1996). In a recent large-scale review of PPB projects, PVS featured in two thirds of them (Weltzien *et al.*, 2000).

However, PPB raises important questions. How far do PPB efforts go in reforming crop development? Are there trade-offs between different possible goals for reforms? PPB projects tend to emphasise productivity-enhancement, the main goal of conventional breeding, giving less consideration to other possible goals. Some literature explores impacts on biodiversity or farmers' level of input into research, or considers policy processes (e.g. Almekinders *et al.*, 2000), yet most practice and empirically-based literature focuses on the technical aspects of breeding, and on methods for organising farmer-scientist collaboration. While the concern with "doing things right" is welcome, the question remains whether such reforms are "doing the right thing". The underlying causes of problems for crop development in a particular location are not always analysed, nor are PPB and other reform approaches tailored to address specific problems. Rather, the assumption appears to be that "PPB is the method of recourse when classical breeding approaches have been tried and failed" (Weltzien *et al.*, 2000: xvii-xviii). Beyond the technical aspects of breeding, areas such as seed supply, farmers' own genetic resource management activities, the organisation of NARS institutions, and the wider policy processes that influence them generally receive much less attention in PPB theory or practice (McGuire *et al.*, 1999; Weltzien *et al.*, 2000). Considering that seed supply is also central, that PPB is fundamentally about linking to farmers' practices, and that lasting changes to NARS institutional culture is a common goal for PPB (Lilja and Ashby, 2000; Johnson *et al.*, 2003), such gaps in analysis or discussion are striking. However, this may simply reflect development practice more generally, where participation is often presented uncritically as the solution to myriad problems (Cooke and Kothari, 2001). Seeing farmer participation – particularly when standardised into a fixed package – as a panacea limits our understanding of its actual potential for improving crop development, and obscures the actual relationships and outcomes that derive from pursuing participation (Mosse, 2001; Upreti, 2001; Okali *et al.*, 1994). The actual problems facing a specific crop development programme need to be analysed before considering what sorts of reforms – whether PPB or something else – are needed.

1.2.2 Seed supply reform

Seed supply reform has also generated a wide range of literature and practice. These reforms usually aim to improve the efficiency and effectiveness of seed provision to farmers. With the withdrawal of the state from service-provision over the last 20 years, Non-Governmental Organisations (NGOs) and the market have become increasingly important in seed supply, alongside public-sector agencies (Cromwell *et al.*, 1993; Cromwell, 1996). Increasing the amount and diversity of seed supplied are common goals of reforms here, though farmers' often sporadic and unpredictable demand for MV seed presents challenges for supply-side solutions (Louwaars and Marrewijk, 1996; Almekinders and Thiele, 2003; Almekinders and Louwaars, 1999). These challenges are compounded by the financial and transaction costs associated with seed regulation and distribution, which can restrict both the diversity of actors involved in seed supply, and range of crops they supply (Louwaars, 1996b; Tripp, 1997a; Tripp and Rohrbach, 2001). For such reasons, policies and institutions receive more attention in the seed supply reform literature than in the PPB literature, and empirical studies of social relationships and policy processes exist for some countries (e.g. Omanga *et al.*, 1999; Rohrbach and Malusalila, 1999; Tripp and Pal, 2001; Lyon, 1999; David and Sperling, 1999). These studies highlight the specificity of each crop and country context, and the need for situated studies of the actual nature of farmers' demand for MV seed (Thiele, 1999; Almekinders and Thiele, 2003). However, for most crops and locations, there is still scant empirical study of farmers' seed management or demand, or of informal seed channels more generally (i.e. farm-saved seed, farmer-to-farmer exchange, local merchants), which supply approximately 80% of seed worldwide each season (van Gasbeek *et al.*, 1994; Cooper and Cromwell, 1994).[6] The limited information on farmers' perspectives and practices for most locations and crops, and on how these could relate to formal seed supply institutions, constitute important gaps in the discussion of seed supply reform.

[6] Solid data to support this figure are scarce, and the oft-quoted figure of 80% should be treated with caution. However, as I show with sorghum in Ethiopia, farmer and other informal supply channels can supply a much higher proportion of seed in many instances.

1.2.3 Limitations in analysis underlying reforms

Efforts to reform crop breeding and seed supply are important developments, and have had some notable successes. However, more general limitations in analysis may constrain the potential scope and impact of these reforms. Most reforms tend to concentrate on breeding or seed supply on their own, reflecting the institutional separation of these activities in NARS. Very few PPB projects consider changes to seed supply, nor do most seed supply reforms address the process of breeding (Weltzien *et al.*, 2000; L. Sperling, *pers. comm.*). Rather, 'modular' reforms are the rule, where a single practice in breeding or seed supply is changed, without fully considering how this might relate to other activities. Thus, while reforms may focus on the selection of advanced breeding lines to identify MVs for release, or on multiplying MV seed, other aspects, such as overall programme goals, the choice of germplasm or testing locations, or the influence of regulation and policy tend to receive less attention. By focusing on changing a single activity, modular reforms risk missing important interactions with other areas of breeding and seed supply, and can relegate broader institutional and political factors to the background.

The analysis underpinning these modular reforms seems to rely on conceptual models based around a single activity in breeding or seed supply, highlighting problems and identifying solutions for that activity in isolation. For instance, reforms to improve the effectiveness of breeding often assume that the main constraint is breeders' unawareness of the traits farmers desire in an MV; consequently, these reforms focus on organising sessions with farmers to learn about acceptable MV characteristics. Equally, seed supply reforms may assume that the primary problem is seed availability, and as a result work with farmers to multiply more MV seed. However, such assumptions tend to miss other complex factors shaping how the system functions, and suggest that simple conceptual models may not be that valuable as guides to reforming crop development. For instance, a 'typical' set of farmer-acceptable MV traits may be hard to define if such traits vary by season, local ecology, or the socio-economic situation of individual households. Also, the policies guiding breeding programmes and variety release committees may be as important in shaping the nature and diversity of material released as the decisions breeders make around which advanced lines to put forward for MV release. Similarly, farmers may have only sporadic demand for MV seed, and there may be important social or economic barriers limiting their access to this seed, thus simply increasing supply may do little to improve access to seed. Once the complexity of farmers' practices, policies, and institutional relations is recognised, the usefulness of simple conceptual models for linking problems with reforms is called into question. Thus while modular interventions that follow on from simple models may succeed on their own terms, they may miss wider issues affecting impact.

Another important gap in theory and practice is that there is little attention given to analysing institutions or social relations (McGuire *et al.*, 1999; Weltzien *et al.*, 2000). This prevents a richer understanding of the reasons underlying success or failure of reforms. Again, this follows a more general 'projectised' approach to development, which emphasises formal plans and toolboxes of methods, yet rarely considers the culture and politics of the organisations involved (Biggs and Smith, 2002). For instance, a project in India that pioneered PPB techniques was deemed 'successful', and its lucid technical discussions have certainly influenced many subsequent projects (Witcombe *et al.*, 1996; A. Joshi and Witcombe, 1996). Certainly, the PPB methods used played an important part in the project's success. Yet, Mosse (2003) argues that context-specific social and political factors were just as important in making the project work on the ground, and causing it be labelled a 'success'. The convergent interest of a key private-sector partner, who espoused participation to build its own patronage networks, played a role, as did the donor's desire for the participatory technology development approach it was championing to be seen as successful. This resulted in representations of goals and interpretations of activities that shifted through the life of the project, reflecting changing realities on the ground and shifting donor policies. Any analysis that neglects such institutional factors risks equating PPB success with the appropriate methodological toolbox for farmer-breeder consultation (as many subsequent PPB projects have done). This is too simplistic. The empirical literature on breeding and seed supply reforms does not usually analyse the main formal institutions involved, or how their history, culture, and the wider policy context influence their actions. If institutional change is the ultimate goal, then such social and political realities of institutions also need analysis. Without including institutions in the analysis, reforms are likely to remain piecemeal, and like so many other development interventions, fail to take root and effect lasting institutional change.

This lack of analysis of social relations and institutions also applies to farmers. The assumption that useful varieties and knowledge disseminate freely between farmers, or that a particular channel for seed or information is equally accessible to all, is still common. However, seed and information do not necessarily flow freely between households, but are part of a wider set of social relationships of exchange (Sperling, 1996; Richards *et al.*, 1997). This can affect how individuals gain access to seed (and related inputs such as relevant information about a variety), and has important implications for any reform to breeding or seed supply that seeks to work more closely with farmers.

1.3 Widening the analysis: formal and farmer seed systems

This brief review underscores some of the limitations of 'modular' reforms to crop breeding or seed supply based on simple conceptual models. If these efforts take insufficient account of the wider context – interactions between different formal research and development activities, farmers' own practices and knowledge in crop development, and the influence of policy and institutional factors – reforms risk being misplaced, or are unable to effect lasting changes.

This thesis takes a more systemic approach to analyse crop development and reflects upon possible reforms. The focus is broader than any single activity, but rather considers the entire *seed system* for a crop. The term seed system initially referred to the network of formal sector actors and institutions involved in supplying seed (Venkatesan, 1994), but increasingly the term can also refer to farmers' own seed provision activities, sometimes distinguishing this as the local, informal, or farmer seed system (e.g. Almekinders *et al.*, 1994; David and Sperling, 1999; de Vries and Toenniessen, 2001; FAO, 1998b; Louwaars, 1996a; Ndjeunga, 2002; Sperling *et al.*, 1996; Sperling and Cooper, 2003; Tripp, 1997a). However, I expand this term to include breeding as well, to reflect the functional inter-dependence of breeding and seed supply in formal research. Farmers' own seed selection, exchange and storage activities are even more closely linked, and distinctions between these different processes are often overdrawn when considering farmer practice. This broader framing of seed systems has started to appear in more conceptual discussions (e.g. Weltzien and von Brocke, 2001; Almekinders, 2001; McGuire, 2001a; Almekinders *et al.*, 2000), though there are still few empirical studies of specific systems.

The goal of this thesis is to develop a trans-disciplinary understanding of seed systems, in order to identify possible new relationships between formal and farmer seed systems that could enhance the sustainability of farmers' livelihoods. There are many possible strategies for reforming breeding and seed supply, and a diverse set of approaches is likely to be more useful than a single modular solution. This thesis takes a broad perspective, analysing both *formal* and *farmer* seed systems to explore the relationship between professional research and development practices and farmers' own activities. A broad analysis of the strengths and constraints of both formal and farmer systems can identify different strategies for linking them and highlight possible challenges facing reform. Thus, I adopt an *inductive* approach to reforming seed systems and achieving closer farmer-scientist collaboration.

The overarching research question is:

- How can a parallel analysis of formal and farmer seed systems contribute to our understanding of seed system reform? Sub-questions following from this include:
    - how does this approach help us better to interpret shortcomings in formal breeding and seed supply?
    - What areas of farmer seed systems are likely to play an important role in their sustainability?
    - What insights does such an analysis offer to understanding institutions and institutional change around seed systems?

These questions are explored using sorghum seed systems in Ethiopia as a case study.

1.4 Research approach

1.4.1 Ethiopia and sorghum

I concentrate on sorghum in Ethiopia as a specific case for analysing seed systems. Ethiopia and sorghum are particularly fruitful subjects for a number of reasons. Agricultural development is crucially important for Ethiopia. The sector is the mainstay of the economy, involving 85% of Ethiopia's labour force, and providing at least half the GDP (Belete *et al.*, 1991; World Bank, 1998). Nearly all Ethiopian farmers are smallholders. Poverty and food insecurity are central concerns, with some fearing the country may become chronically dependent on external support (IFPRI, 1990; FAO, 1998a). Consequently, the Ethiopian government has emphasised agricultural research, and the Ethiopian Agricultural Research Organization (EARO) is one of the largest NARS in SSA in terms of staff and budget (Weijenberg *et al.*, 1995). EARO scientists work on many different crop and livestock systems across a wide range of agro-ecological zones, with crop breeding a central activity.[7] EARO itself has a mandated role in policy formulation, and is a significant partner in international networks, such as the CGIAR and ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa). Seed supply is also dominated by public institutions such as the Ethiopian Seed Enterprise (ESE). Significantly, there have been major reforms in Ethiopia's formal seed system in recent years (World Bank, 1995, 1998), involving institutional changes and policy reform, and emphasising more participatory approaches to breeding and seed supply. Thus, Ethiopia's formal seed system is a highly relevant subject of study, highlighting the potential of publicly-supported agricultural development, as well as the challenges it faces.

Sorghum (*Sorghum bicolor* [L.] Moench) is also highly relevant for this study. Globally, sorghum ranks as the fifth most important crop (FAO, 2001). It exhibits great diversity and

[7] The classification used by EARO recognises 18 major agro-ecological zones and 49 sub-zones, reflecting great variations in elevation, temperature, rainfall, and soils across the country.

can tolerate many environments, including cool or waterlogged areas, though sorghum's drought-tolerance makes it particularly important in drier areas (Doggett, 1988; Harlan and de Wet, 1972; House, 1985). For this reason, sorghum is closely linked to food and livelihood security for farmers in the semi-arid tropics across Africa and Asia. In Ethiopia, approximately a million hectares are sown to sorghum, making it the third most important crop (CSA, 1997)[8], and a major staple in the diet. Ethiopia is a centre of diversity for sorghum, and the extremely diverse sorghum types found in the country are of global significance (Stemler *et al.*, 1977; Harlan, 1969; Ayana *et al.*, 2000). Ethiopian farmers have shaped and managed this genetic diversity, and continue to maintain a wide array of sorghum types on their farms (Seboka and van Hintum, forthcoming; Teshome *et al.*, 1999; Tunstall *et al.*, 2001). The farmer seed system for sorghum in Ethiopia is complex and dynamic.

In recognition of sorghum's importance in drought- and hunger-prone regions of Ethiopia, the government has given considerable support to breeding and seed supply (Gebrekidan, 1974). The breeding programme has received glowing commendations (Yemane and Lee-Smith, 1984) and is technically sophisticated, developing many MVs over the last 30 years. However, adoption of these MVs appears to be very low (Table 1.1), and the overall impact of the formal seed system has been questioned. In response, a number of reforms have been proposed for Ethiopia's formal seed systems that involve closer links to farmers seed systems, for sorghum breeding (e.g. Eshetu Mulatu, 1996), seed supply (Medhin and Gebeyehu, 2000), or conservation of diversity (Worede, 1993). Thus, sorghum in Ethiopia provides a rich example of existing and proposed reforms for linking formal and farmer seed systems.

Two districts (*Woredas*) from the same region, representing contrasting agroecologies, were studied as specific examples of farmer seed systems. Methods for research with farmers included surveys, semi-structured interviews, focus-group discussions, simulation exercises, and direct observation. The field locations and farming systems are described in Chapter 2. Interviews with key informants, analysis of reports and documents, and direct observations form the basis for the analysis of the formal seed system. Details of methods are summarised in Table 2.1. This thesis incorporates a wide range of themes, from breeding and seed supply to institutional politics and moral economies. Rather than review all of this at once, I consider the relevant areas of literature in subsequent chapters as specific issues are raised. However, I briefly discuss two theoretical issues that inform my overall approach: practice, and path dependency.

1.4.2 Practice

This thesis explores formal and farmer seed systems separately, though acknowledging that they are not completely distinct. A long history of association between farmers and scientists has influenced both systems. For instance, the development of professional breeding drew inspiration from farmer practices and FVs (e.g. Palladino, 1990; Schneider, 2002; Richards, 1997), while formal research activities have sometimes inspired farmer innovation (Biggs and Clay, 1981; Sumberg and Okali, 1997), or provided MV germplasm that eventually becomes considered part of the 'local' genetic heritage (Smale *et al.*, 1995; Budelman, 1983; Bellon and Brush, 1994; Song, 1998). My approach considers farmer and formal systems separately, though not in isolation, to emphasise the distinct institutions of each system, and different approaches to practice.

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[8] Only teff (*Eragrostis tef* (Zucc.) Trotter), and maize (*Zea mays* L.) are more common, with sorghum covering more area than maize in some seasons (Aberra D., *pers. comm.*).

A number of authors have remarked that activities for managing crop genetic resources are broadly similar in formal and farmer systems (e.g. Almekinders *et al.*, 2000; Jarvis and Hodgkin, 2000): the introduction of new diversity, recombination, seed selection, and seed exchange and storage all occur in both systems, shaping the nature and level of diversity that occurs in the field. However, details of practices for similar activities, and the underlying epistemologies, may differ between farmers and scientists, with important implications for collaboration between formal and farmer seed systems (Cleveland and Soleri, 2002a). Since I focus on a wide range of practices in genetic resource management, it was not always possible to explore epistemologies to the same depth as studies that focus on a single practice, such as seed selection (e.g. Soleri *et al.*, 2000; Soleri and Cleveland, 2001; Soleri *et al.*, 2002). Thus I emphasise practice in this study as the obvious entry point to analysing key processes in seed systems. Focusing on practice helps us to understand the impacts of "mundane activities of natural resource management" (Nyerges, 1997: 14), actions undertaker taken by agents within specific (though not necessarily fixed) socio-cultural contexts. Practices are informed by empirically-based knowledge about general phenomena, such as crop traits or environmental conditions, which can form the basis of farmer-scientist collaboration. However, more normative values that derive from policy discourses or social relations also guide practice. Starting from practice maintains the focus on concrete actions, but is also sheds useful light on both the generalised, empirically-based knowledge of farmers and scientists, as well as the values shaped by culture and institutions.

1.4.3 Interpretive flexibility and path-dependency

The research questions require a trans-disciplinary framework for analysis, one that integrates agro-ecological and social perspectives. The title "*Getting Genes*" alludes to this integration: both the content of technology (e.g. traits found within FV or MV seed), and its accessibility to poor farmers, are essential aspects for assessing a seed system. However, a trans-disciplinary approach goes beyond considering technological content and social relations separately, but seeks to understand how these technical and social factors interact to influence the content and accessibility of technology.

I draw upon social constructionism[9] to help in this trans-disciplinary analysis. Constructionism considers how social interactions shape both the development of technology, and the interpretation of its results (Pinch and Bijker, 1987; Woolgar, 1998; Winner, 1993). Its various forms generally show how facts and scientific ideas, held to be unequivocally true, are to some extent constructed through social relations (Hacking, 1999: 6-12; Knorr Cetina, 1995). Constructionism looks at the social organisation of the actors and institutions involved in shaping and interpreting technology, noting that different groups may perceive technologies differently (Bijker, 1993; Winner, 1993). This "interpretive flexibility" is a hallmark of constructionism, and clearly useful for understanding why different actors might interpret a technology very differently, and the problems that arise, when relevant social groups are excluded.[10] Constructionism does not deny the existence of a material reality, but rather explores how the natural world (and specific instruments or experimental designs; Gingras and Schweber, 1986; Pickering, 1995; Knorr Cetina, 1995) interact with society to influence how we interpret and order this reality in our own minds (Hacking, 1999). Thus, constructionism would say that the categories we use to understand the world are

[9] I follow Hacking (1999: 44-49), and use 'constructionism' instead of 'constructivism' to refer to theories of social construction, since the latter term also refers to a branch of mathematics.
[10] An example, mentioned later, is a bitter-tasting sorghum MV 'Seredo'. Breeders (and some male farmers) valued its bird-resistance, but most women rejected it as people-resistant, due to its poor food quality.

ontologically subjective (the category reflects historically- and socially-situated processes), but also *epistemologically objective* (the category still affects people and their behaviour) (Powell, 2001). Some examples might include 'high yielding variety' or 'model farmer': they have real impacts on people, yet specific institutions, empirical experiences, and discourses have played a role in creating these categories.[11]

One criticism of constructionism is that it takes insufficient account of impacts (Winner, 1993; Tranvik *et al.*, 1999), or of the path-dependent nature of technology. Pre-existing knowledge, embedded practices, standard equipment, and other aspects of the technology itself can serve to resist dramatic change in thinking or in practices (Russell, 1986). A well-known example is the investment software developers have already sunk into a platform such as Windows or Macintosh, constraining their scope for taking new directions. However, crop breeding, which involves long-term investment in particular strategies, also exhibits path-dependency. Path-dependency does not preclude change, but helps us understand continuity in institutional practice in science. This is particularly relevant when considering reforms whose success strongly depends on the ability of research institutions to change their practices (Hogg, 2001).

Therefore, my approach to constructionism gives technology some degree of autonomy in shaping social relations, so that the path-dependency and impacts of technology receive due consideration, along with the notion of interpretive flexibility (Tranvik *et al.*, 1999). For instance, this approach would highlight how different stakeholders perceive MVs, and analyse categories such as 'proper growing environment' in terms of the physical facilities available, empirical experiences from trials, and the influence of policies and international conventions in crop development, showing how the category 'proper growing environment' also influences how a breeding programme understands its own mission and level of success.

Using this broad trans-disciplinary framework, this thesis sets seed systems in a broader context of agro-ecology, social relations, institutions, and policy change. Doing so allows the strengths and constraints of both formal and farmer systems to be understood in a wider perspective, and helps identify new strategies for closer farmer-scientist collaboration. This approach also aims to avoid the hidden assumptions and simple functional models behind some efforts in seed system reform.

1.5 Organisation of the thesis

Chapter 2 describes the farming systems at the field sites in Western Hararghe Zone, Ethiopia. Building upon a description of the climate and ecology of these two contrasting field sites, the chapter highlights key risks, and changes to the system. On a technical level, farmers' cropping repertoires, cultivation practices, and sorghum diversity are a coping response to these risks. However, the role of social institutions for labour-pooling and input access, and livelihood diversification, are equally important, especially for supporting the poorest. By outlining risks, this chapter sets the context for discussing farmers' seed systems, and how their needs in sorghum may vary across time and across social conditions, two aspects of variation not frequently considered in PPB work. This chapter also points to how farming in highly uncertain conditions is more a performance than a plan (Richards, 1993), drawing attention to the importance of having access to appropriate types of sorghum that can

[11] Cleveland (2001) arrives at a similar conclusion when analysing the origins of different ideas about yield stability in crop breeding.

respond effectively to changing conditions. Thus, this chapter outlines the major challenges facing the sorghum seed system.

The following two chapters address formal sorghum improvement and seed supply, respectively, in Ethiopia. Both analyse practices and institutions, seeking to understand why impact appears to be so low in Ethiopia, despite long-established and technically-accomplished actors. Though the recent literature on reform to seed supply tends to analyse past shortcomings, it is still uncommon for PPB projects to do this with breeding. These chapters consider the problems most often highlighted in seed system reforms, but suggest that more fundamental institutional challenges, such as the high degree of centralisation, or rigid policy frameworks, pose greater problems to developing effective seed systems.

Chapter 3 explores the policy background to breeding and agricultural research in Ethiopia, both before and after the 1974 Revolution, and identifies key institutions. By analysing the history and development of the Ethiopian Sorghum Improvement Program (ESIP) in particular, this chapter shows how policies and institutions have shaped sorghum breeding, and how path-dependency works against changing breeding priorities. This contributes to the still sparse PPB literature on institutional change in PPB, showing how resources sunk into one line of research, how an institution's culture of critique, and how key actors and policy narratives can serve to spur or resist change in breeding priorities.

Formal breeders often reply, with some justification, that their carefully-selected varieties are indeed useful, but never reach farmers due to poor seed supply. Formal-sector systems for seed supply are usually considered separately in PPB, and Chapter 4 specifically explores the challenges facing formal seed supply with respect to estimating demand, meeting supply, and devising appropriate policy for controlling access and quality. Like the previous one, this chapter takes an historical approach to analysing key policies, institutions, and recent changes in policy and practice in Ethiopia. In particular, changes to seed laws, and to recent extension practice show the power of high level political commitment and policy narratives. The chapter shows how these changes miss addressing crops like sorghum, and may actually constrain the development of a seed supply system more responsive to farmers' needs.

Farmer seed systems are analysed in the following two chapters. Chapter 5 explores farmers' own methods of acquiring seed. While many PPB projects assume that 'farmer-farmer diffusion' will be an important mechanism for dissemination, and for scaling up of local participatory activities, understanding of how farmers acquire planting material is still limited. The chapter aims to expand this knowledge, showing that seed exchange remains an important, yet irregular channel for introduction of novel materials to farmers. Access to seed is important to individual farmers, yet not guaranteed, as this access depends upon social or financial assets, where poorer, or socially-isolated households may be most vulnerable. Inter-household patterns in seed exchange, and links between household wealth and preference for seed source, highlight the continued importance of social relations in seed exchange. This chapter explores these issues, in order to develop a deeper understanding of the nature of local demand for seed, as well as possibilities for local supply.

Chapter 6 addresses farmers' plant genetic resource management more broadly, looking at how farmer practices influence seed genetic quality and seed physical quality (e.g. health). Thus it explores the knowledge and practice involved in producing 'good seed', highlighting the importance of particular individuals in innovation. It examines farmers' knowledge and practices around naming sorghum varieties, maintaining variety purity, seed selection, and storage. A populist-oriented strand in PPB emphasises developing farmers' skills in collaboration with scientists. Frequently this focuses on seed selection, and involves a few especially enthusiastic and skilled farmers who represent 'local best practice'. Considering farmers' seed selection within a broader context of genetic resource management, as well as social relationships, allows me to reflect critically upon such a strategy, and consider other possible approaches for supporting farmer seed systems to improve the quality and diversity of local seed. 'Best practice', as it turns out, may not be that accessible, or that useful, to a majority of farmers, and some practices may be relevant only to very specialised individual activities.

Finally, Chapter 7 summarises the main findings. In light of these findings, I reflect upon the modular focus of most seed system reforms, and consider a more integrative approach for assessing the 'health' or sustainability of seed systems. I conclude by suggesting some key areas of investigation and intervention for future work.

Chapter 2 Farming Systems in West Harerghe: implications for sorghum seed systems.

2.1 Introduction

This chapter describes the farming systems of West Harerghe Zone, where farmer seed systems were directly studied. After a brief outline of field research methods, this account summarises the main physical conditions and farming practices in the study locations, and highlights agroecological and social variation, and how this variation affects farmers' strategies for coping with uncertainty. An important part of this coping is the management of sorghum diversity at the varietal level, and this chapter draws out some of the implications for farmers' demand for diversity, particularly for MV seed.

Socio-economic differences between households tend to be downplayed by Ethiopian scientists, but are nevertheless important in West Harerghe. This chapter also highlights important inter-household differences, and how the assets a household controls, particularly land, labour, and draught power, affect its strategies for coping with uncertainty. Socio-economic status also has a bearing on household seed security, and ability to access off-farm seed. By outlining the variability in West Harerghe farming systems, and longer-term trends, this chapter sets the context for examining seed systems for the main crop, sorghum.

2.2 Site selection and methods

Areas near Nazret, central Ethiopia, where formal sorghum breeding is headquartered, were not chosen, as sorghum is generally a secondary crop there (Regassa *et al.*, 1992). While some central Ethiopian districts such as Minjar and Welenchiti do focus on sorghum (Tillahun Mulatu *et al.*, 1996) these were also unsuitable for studying farmers seed systems, as their ecological and varietal diversity was low, and sorghum yields were well above national averages.[12] Instead, West Harerghe Zone, in the Oromiya Region approximately 250 km east of Nazret, was chosen as a more appropriate study area (Figure 2.1). West Harerghe includes examples of most of the sorghum growing environments found in Ethiopia, from dry lowland plain to cool eroded highlands, and sorghum is the dominant crop across all these environments. The region is also known for its sorghum diversity, and the challenges faced by its farmers are more representative of sorghum areas in Ethiopia: water stress in the lowlands; and pests, diseases, and low fertility in the highlands. Subsequently, sorghum yields are at or below national averages, with the lowland areas being at particular risk of crop failure and food insecurity. Finally, there is a small research station in Miesso, in the lowlands of West Harerghe that is involved in sorghum breeding, which enabled continued contact with breeders and other formal researchers for support and feedback.

[12] Based on field visits and key-informant interviews in both districts, 19-20 March 1998.

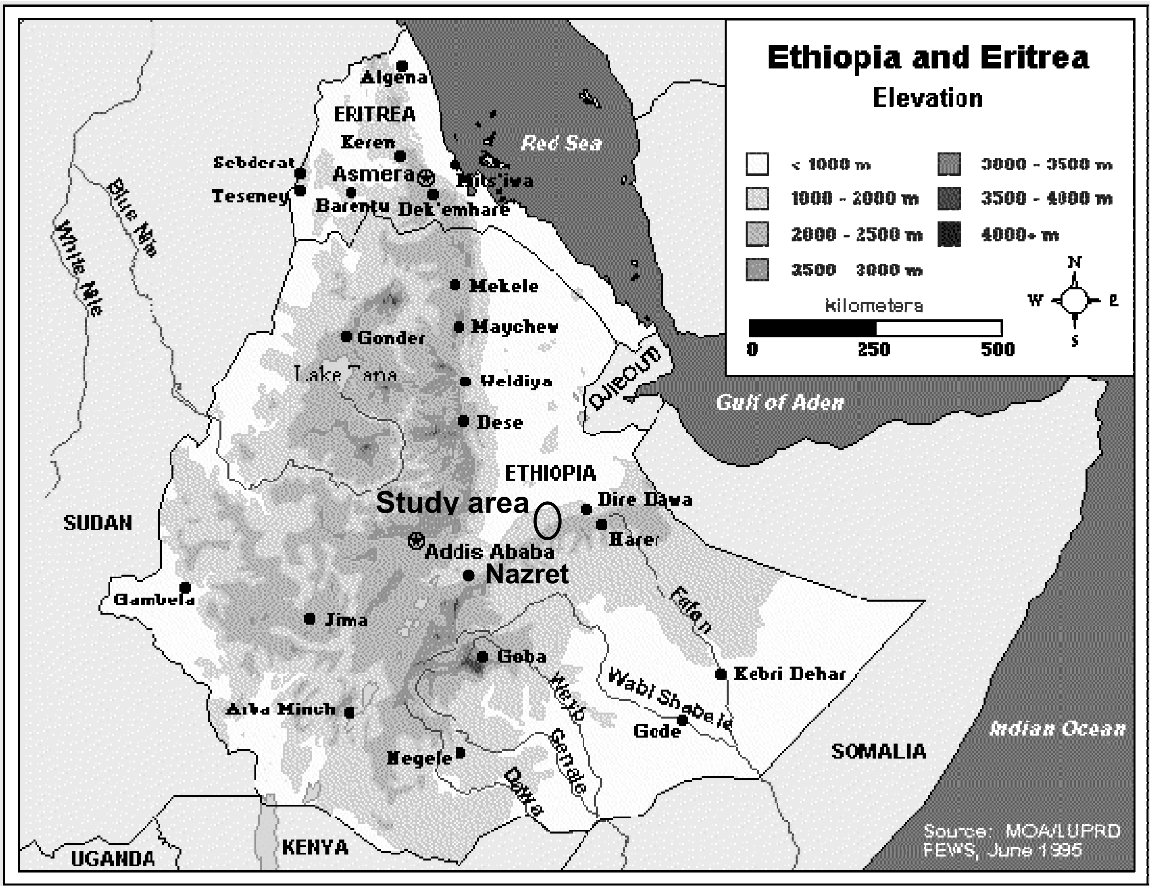

Figure 2.1 Relief map of Ethiopia, showing area of research (from FAO, Famine Early Warning Systems).

The fieldwork took place over 10 months in 1998/9, concentrating on two of West Harerghe's ten districts, or *woredas*, Miesso and Chiro, chosen to represent lowland and highland agroecologies respectively.[13] One Farmer Association (FA, administrative unit clustering several hamlets) was selected for more in-depth study in each *woreda*. In Miesso, this was Melkaa Horaa FA, found 5-9 km from the town of Miesso and the research station, typical of drought-stressed lowland conditions. In Chiro, Funyaandiimo was the focus FA, roughly 20 km from Asebe Teferi, the capital of West Harerghe Zone (Fig. 2.2)

[13] The adoption of a federal system with Regional States in Ethiopia in the mid-1990s created new administrative divisions, and some boundaries between Farmer Associations, *Woredas*, Zones, and even Regions continue to be redrawn. To the extent possible, I describe the boundaries as they existed in 1998.

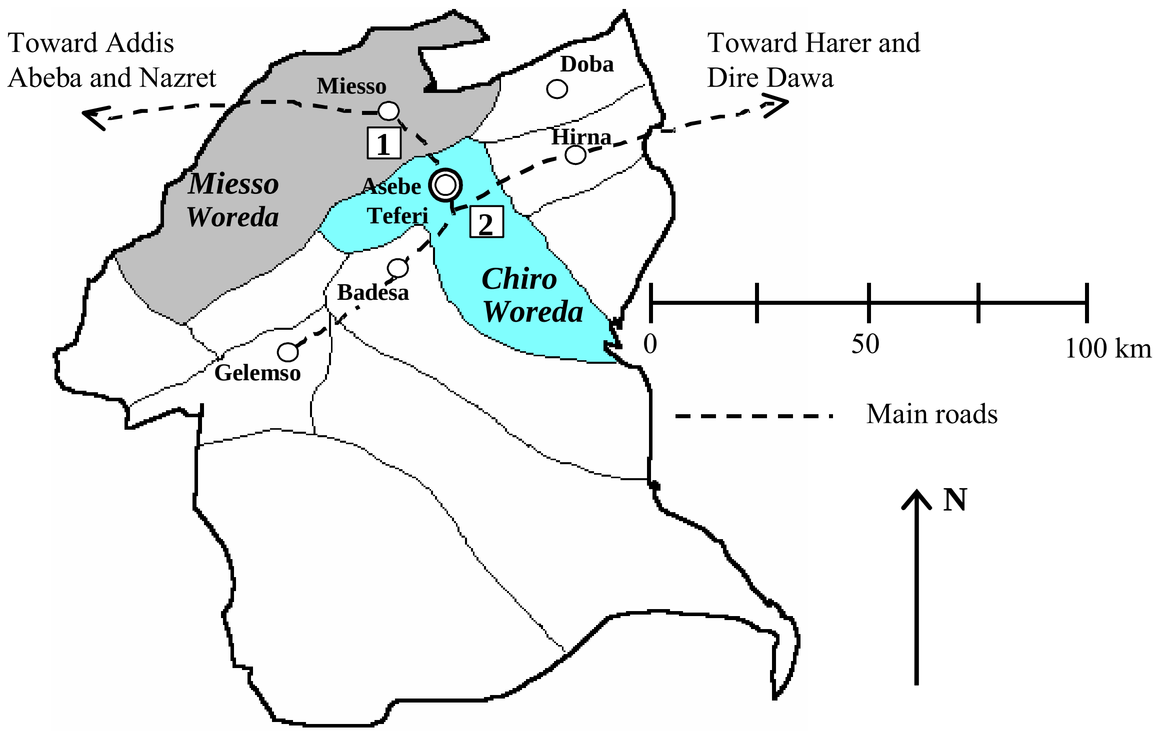

Figure 2.2 West Hareghe Zone, showing *Woreda* (district) boundaries, major towns and roads, and highlighting Miesso and Chiro *Woredas* and the Farmers' Associations for in-depth study, Melkaa Horaa (1) and Funyaandiimo (2), are indicated. Boundaries and scale adapted from ICRA (1996) and UNDP-EUE (1996), and are approximate.

Most study occurred in these two FAs, following the season from the May planting until well after harvest the following February. I stayed in the region much of this time, either in Miesso town, close to Melkaa Horaa, or in Funyaandiimo itself. My assistants lived in these communities and helped with translation from Oromo (though occasionally I conducted interviews directly in Amharic).

The study nested sampling at several levels, starting with semi-structured interviews of 141 farmers about variety use, seed storage, and seed access. This informed the design of all further samples. Focus group discussions occurred on soil classification, sorghum varieties, wealth ranking, and sorghum taxonomy in both FAs. I selected a subset of 21 farmers to follow more closely, chosen to obtain households with different local ecologies, wealth rankings, soil types, and sorghum diversity. I visited this subset regularly to observe flowering periods, selection and harvesting practices, and to ask more detailed questions about seed access. For 15 of these subset farmers, I recorded the dates for 50% flowering for all varieties in their fields, and in the fields of their immediate neighbours. Also, with 19 farmers from the same subset, I ran simulations of selection and discussed scenarios, to probe farmer views on the heritability of sorghum traits.

During harvest, I collected 81 sorghum accessions from farmers' fields in the two FAs, and the immediate surroundings. Samples from these accessions, were used to probe farmer naming systems, and knowledge of local diversity more generally. Finally, I administered a formal survey to 94 farmers in September 1998 on variety use, seed supply, seed storage, and seed access. This occurred over wider areas of Miesso, Chiro, and adjacent areas of West

Harerghe (near Doba and Badesa, Fig 2.2), to confirm trends within individual FAs. For simplicity, I refer to specific data by its source: individual interviews, focus group discussions, or subset farmers (all within the two FAs), germplasm collections (within Miesso/Chiro districts), or survey (surrounding districts). Table 2.1 summarises the various samples used.

Table 2.1 Summary of different samples of farmers in lowland Miesso and highland Chiro, mostly located in Melkaa Horaa and Funyaandiimo FAs, and overlapping, except for the survey.

Method	N sampled		Sampling location	Sampling criteria
	Chiro	Miesso		
Semi-structured interviews	57	84	Focus FAs	Random
Subsets for regular visits, discussion of seed access	10	11	Focus FAs	Based on wealth classes, soils, sorghum diversity, local ecology
Observe mid-flowering dates	6	9	Focus FAs	Taken from above subset of farmers
Selection and heritability questions	8	11	Focus FAs	Taken from above subset of farmers
Focus group discussions	varying	varying	Focus FAs	Chosen based on knowledge
Sorghum collections	30	51	Chiro and Miesso	Random, though deliberately seeking new types
Survey	40	54	Chiro, Miesso, and adjacent *woredas*	Random, stratified by location

2.3 Site description

2.3.1 Topography

The Chercher Highlands comprise a narrow east-west band of mountains stretching across the middle of West Harerghe, and neighbouring East Harerghe Zones, ending in a wider plateau around the city of Harer in the east (Figure 2.1). The mountains rise to 2000 metres above sea-level (masl), with some peaks over 3000 masl. Though the highlands descend gradually toward the south, the north side forms an escarpment, dropping abruptly several hundred metres to a lowland plain. The highland district studied, Chiro, is located in the upper slopes the highlands, while Miesso, the lowland district, is on the plain at base of the mountains (Figure 2.3).

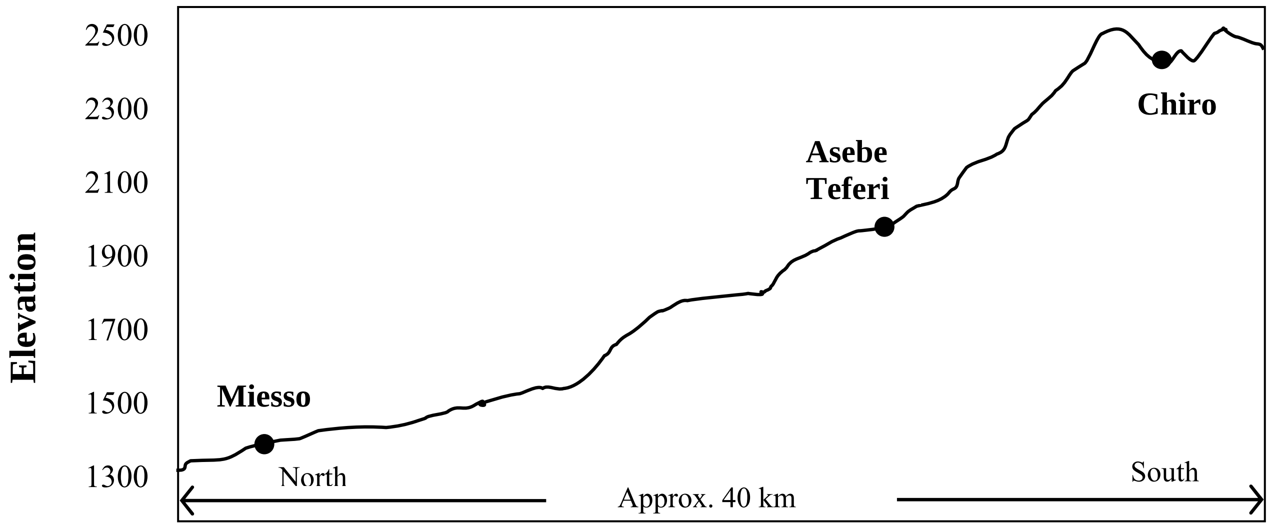

Figure 2.3 North-south transect from Miesso to Chiro, showing topography and Asebe Teferi, the capital of West Harerghe Zone.

Funyaandiimo FA, the focus site in Chiro, is a large bowl-shaped valley several km across, dropping from 2200-2300 masl at the sides to a flat valley bottom at 1900 masl. Steep, eroded hillsides are common, but the valley bottom has deeper and mostly fertile soils, though these are poorly-drained. Water sources, and communal grazing land, are also found in this valley bottom.

At the northern base of the mountains is an extensive plain, part of the Rift Valley (Figure 2.1). The area immediately adjacent to the highlands still receives enough rainfall to support cropping. Sorghum production is important in this area, sometimes called the Miesso-Assebot Plain, after the two main communities, whose elevation is roughly between 1300 and 1500 masl. Other areas north, east, and west of the Miesso-Assebot Plain are too arid to support crop production, and are mainly pastoral.

Melkaa Horaa FA, the focus site in Miesso, is found between 1350 and 1450 masl on the Miesso-Assebot Plain. Topography is flat to gently undulating, with small hills rising in the south of Melkaa Horaa, where the Chercher Highlands begin. Melkaa Horaa is at the eastern edge of the Miesso-Assebot plain, near the margins of the area able to support crops.

2.3.2 Climate and growing seasons

Altitude is the single most important factor affecting both temperature and rainfall in Ethiopia. In general, precipitation increases and temperature decreases with elevation, thereby creating a sharp contrast between highland and lowland agroecologies in the study area. The mean monthly daytime temperatures range from 12 to 20°C in the highest parts of the highlands to between 23 and 30°C in the lowlands (FAO, 1984).

Figure 2.4 shows mean monthly rainfall measured at Miesso town, and at the West Harerghe Zone capital of Asebe Teferi, 25 km but 500m higher. Asebe Teferi is only halfway up the escarpment, so areas above it – including Funyaandiimo FA – generally have higher rainfall levels than this. Figure 2.4 also shows the typical bimodal rainfall pattern in this region, with a short rainy season in March-April, and a longer one from mid-June through August and into September. The earlier short rains are generally less secure, with highly variable onset. The Amharic term for these rains, *belg*, is widely used to refer to the season and its associated crops. The longer season, called *kremt* or *maher* in Amharic, brings more steady, monsoon-type rains. These two seasons are separated by a relatively dry period in May and June.

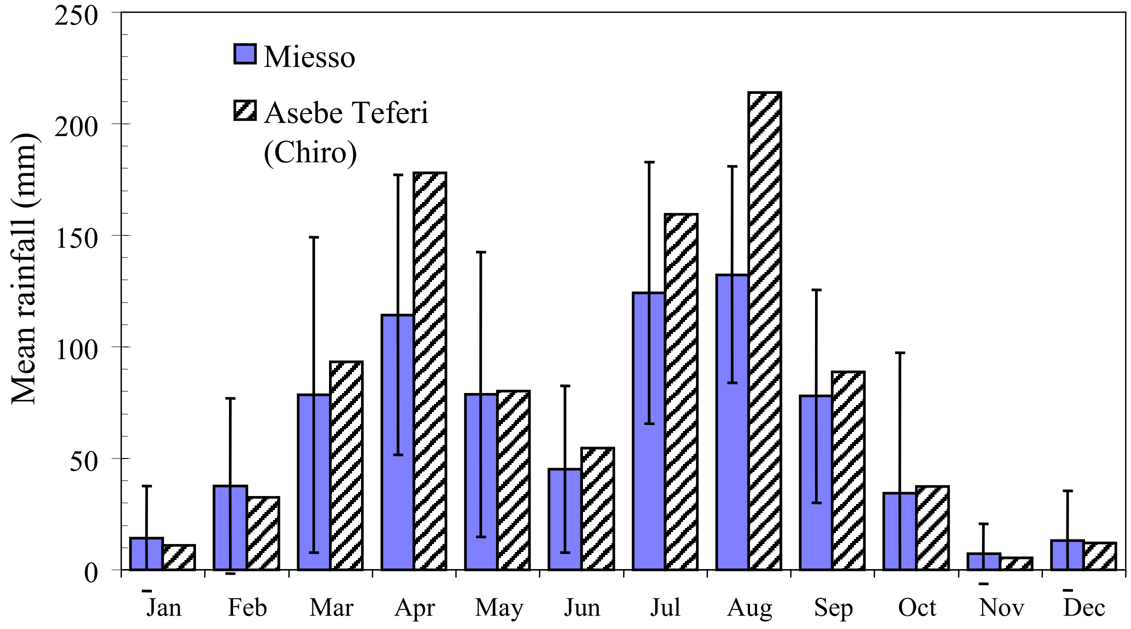

Figure 2.4 Monthly rainfall for Miesso town and Asebe Teferi, in Chiro*. Miesso: measured at Miesso Research Station, mean of 1982-1997, with standard deviations. Chiro: measured at Chiro high school in Asebe Teferi, through 1980s. (*Chiro data adapted from ICRA, 1996; variability not given).

Mean annual precipitation is over 1000 mm in the upper reaches of the Chercher Highlands, dropping to 700 mm on the Miesso-Assebot Plain. However, the date of rainfall onset, and its distribution through the season, are more important than total precipitation in determining the length of the growing season and cropping patterns for West Harerghe farmers.

The distribution of rainfall varies over space and time in both highlands and lowlands, but in the lowlands rainfall is considerably less predictable. Monthly rainfall data for Miesso town (Table 2.2) highlight this unreliability. Rainfall is generally dependable in the wettest months of the *kremt* season (July and August), while the *belg* period (March to April) has had some seasons with effectively no rain over the 15-year period assessed. Poorly-distributed rainfall over the past few seasons in the lowlands has contributed further to food insecurity (FAO, 2002).

Table 2.2 Monthly rainfall and number of days with rainfall for Miesso research station, 1982-1997. † Coefficient of variation (%).

Month	**Total rainfall**			**Number of days of rain**		
	Median	Range	CV †	Median	Range	CV
Jan	6.2	0 – 89	166	2.5	0 – 7	98
Feb	27.0	0 – 118	105	3.5	0 – 12	87
Mar	51.8	2 – 247	90	6	1 – 14	57
Apr	104.4	4 – 236	55	11	4 – 15	28
May	56.4	0 – 229	81	10	0 – 14	54
Jun	35.6	3 – 136	83	6	2 – 17	56
Jul	109.3	49 – 249	47	15.5	9 – 21	19
Aug	122.3	66 – 234	37	17	9 – 21	25
Sep	70.6	0 – 210	61	13	0 – 19	41
Oct	17.5	0 – 232	182	3	0 – 12	95
Nov	0.0	0 – 39	186	0	0 – 5	166
Dec	2.8	0 – 87	170	1	0 – 5	107
Total	**748.1**	**428 – 1156**	**29**	**93**	**56 – 102**	**17**

Farmers in both highlands and lowlands prefer long-maturing sorghum types, which requires eight or nine months to develop, as they produce more biomass and grain than fast-maturing sorghum. Long-maturing sorghum varieties are planted during the *belg* rains. If they establish, young plants of these varieties withstand the dry period between rainy periods and continue vegetative growth and flowering with the arrival of the main *kremt* rains.

For highland farmers, the *belg* season is relatively dependable, as is the timely onset of the main *kremt* rains. This means that most years have enough available moisture to support long-maturing sorghum varieties. In the highest areas, *belg* rains are sometimes substantial enough to support a crop on their own. So-called *belg* crops, like barley, mature quickly, allowing a second crop during the main rains. Nearly half of highland farmers in West Harerghe grow *belg* crops, on 13% of land area (Storck *et al.*, 1991). However, *belg* crops fail if they receive insufficient moisture. Nearly 50% of seasons in the Chercher Highlands cannot support a *belg* crop (Emana and Storck, 1992).

In the lowlands, farmers can also have a long growing season (seven to eight months in the best years). However, long-maturing sorghum can fail if the season is unfavourable. This may be due to the *belg* rains being insufficient for stand establishment before the mid-season drought, or due to pest attack on the seedlings. In such cases, lowland farmers have little choice but to re-sow fast-maturing varieties of sorghum or maize in July, with the onset of the main *kremt* rains. As with the highlands, *belg* rainfall is unfavourable roughly half the time.

Farmers in both ecologies claim that rainfall has become less dependable within living memory, particularly the *belg* rains (ICRA, 1996). A long-term decline in precipitation is difficult to confirm, due to high inter-seasonal variation (Mortimore, 1998). However, crop and variety repertoires have changed within living memory in a manner suggesting that crops receive less effective moisture than they used to (e.g. Miesso once supported *belg* crops, but this is no longer possible). Whether due to declining rainfall totals, poorer distribution, soil degradation, or a combination of factors, moisture stress makes both highland and lowland farmers less flexible in choosing crops and varieties than in the past. Highland farmers have less possibility of relay-cropping with *belg* crops, and thus rely more on long-maturing sorghum, since the early rains are still substantial enough to establish sorghum in the highlands. For lowland farmers, a poor *belg* rainfall means that early sowing is not guaranteed even for sorghum. Fast-maturing sorghum is becoming important as a means of drought escape for lowland farmers.

2.3.3 Soils

Soils in the region are quite varied. In the highlands, the upper slopes tend to have soils of intermediate fertility and drainage. The lower slopes include regosols, which drain well but have poor fertility, and vertisols. Finally, fluvisols are found in some valley bottoms in the highlands, and dominate the lowlands of the Miesso-Assebot Plain. Both vertisols and fluvisols are fertile, but their poor drainage requires rapid response in tillage, since they are only workable for brief periods of time following rainfall episodes (McCann, 1999). The valley bottom of Funyaandiimo FA, in Chiro, is water-logged for part of the season, while soil crusting is a major problem in Melkaa Horaa in Miesso.

Use of chemical fertiliser is very low, and mainly confined to participants in package programmes. Animal manure is often used for fuel, or spread on vegetable plots near the house, so soil organic matter and fertility on open farmland is declining in many locations (Wilbaux, 1986).

Soil degradation is a serious problem, affected by continuous cropping, low soil cover, and low organic matter content. This is a particular constraint in the highlands, where high rain intensity, steep slopes, and poor rainfall infiltration contribute to potentially high rates of erosion (Tolcha, 1991; cited inTefera *et al.*, 2002).

2.4 Population characteristics

2.4.1 Ethnic composition and settlement history

Most rural residents of West Harerghe are Oromo and Muslim,[14] and have been in the region since at least the mid-16th Century (Hassen, 1994; Jalata, 1993). Pastoralist by origin, they gradually shifted to plough agriculture after this period (McCann, 1995). Oromo farmers have only been in the lowland plains for a few generations, moving down from the neighbouring highlands, due to population pressure or other causes. There are still family ties and clan affiliations between lowland farmers and those further up in the Chercher Mountains.

Some settlers from northern Ethiopia arrived in the region after it was incorporated into the Abyssinian empire in the late 19th Century (Marakakis and Ayele, 1986). The great majority of these were peasant farmers and settled as smallholders in the highlands. Their ancestors remain as a small minority of Orthodox Christian Amharas whose farms are scattered among their Oromo neighbours, and who are well-integrated into Oromo social institutions (e.g. for labour-pooling). While Amhara farmers appear to have more ties to kin employed in urban areas, and may benefit from these links, their farms are not conspicuously larger, or better, than their Oromo neighbours. Wealth differences are discussed below.

[14] Ethnicity and religion co-mingle considerably in Ethiopia: many Oromos are Christian, for example, while some Amharas are Muslim.

2.4.2 Population, family size, and land holdings

Population density is greater in the highlands (Table 2.3), and my survey found significantly smaller farm sizes there (Table 2.4). However, farms in both locations can be very small, as the ranges in Table 2.4 indicate. A household's land is usually in a single plot, though sometimes spread over two or three plots. Family sizes average seven or eight, and half the population is under 15, so population growth will continue to be high (CSA, 1995). This, and the re-settlement of de-mobilized soldiers, places further pressures on available land, particularly in the highlands. While there is more land available in the lowlands, yields are also lower, while labour and draught power limit the amount under cultivation. In the highlands, the acute shortage of cultivable land has caused farmers to move on to steep slopes, and communal forest or grazing land have come into cultivation (ICRA, 1996). The loss of forest and grazing land increases sorghum's importance as a source of feed, fuel, and construction materials.

Table 2.3 Population estimates for study area, adapted from ICRA (1996).

Measure	Chiro	Miesso
Land area (ha)	164 700	213 400
Rural population (1996 est.)	356 000	101 000
Population density km^{-1} (1996 est.)	216	47

Table 2.4 Mean farm size (with standard errors), as given in 1998 survey by 41 Miesso and 53 Chiro farmers, and this land area expressed in terms of stated family size.

Measure	Chiro	Miesso
Mean farm size (ha)	0.64 (0.04)	1.27 (0.11)
CV (%)	45	54
Range	0.25 – 1.88	0.25 – 3.0
Farm area (ha)/person	0.13 (0.01)	0.21 (0.02)
CV (%)	79	58
Range	0.02 – 0.50	0.05 – 0.50

2.4.3 Wealth ranking

The level of assets a household controls obviously affects its overall vulnerability, but also has implications for the local seed system, particularly for seed exchange and household seed security. To understand how farmers see differences in household wealth and vulnerability in their own community, and the criteria they use, I organised wealth ranking exercises in both Funyaandiimo and Melkaa Horaa. In each location, several relatively well-off or relatively poor farmers were organised into separate focus groups, and asked to group their neighbours (65-86 households from a single hamlet) by wealth, using as many ranks as they wished. All focus groups decided upon four wealth rankings, distributing households more or less evenly among them (Table 2.5). Within each location, the better-off and the poorer focus groups arrived at very similar ranking criteria, and placed the majority (70-80%) of households in the same wealth rank.

Table 2.5 Description of wealth ranking criteria (I= wealthiest, IV=poorest), as agreed by focus groups of farmers, and the percentage of households in these ranks, from a sample of 86 households in Chiro and 65 in Miesso.

Wealth rank	Chiro		Miesso	
	Ranking criteria	**% of households**	**Ranking criteria**	**% of households**
I	'health + wealth', have ≥2 oxen, cash crops, metal roofing, employ labourers	26	Land, ≥2 oxen, have *chat* (*Catha edulis*, a cash crop); potential for surplus	31
II	'can solve problems': at least 1 ox, plus livestock, sometimes cash crops	24	Have 1 ox, or some livestock; no *chat*	24
III	Small farms, maybe 1 ox, but no cash crops; some work as labourers	21	Some livestock, but reserves depleted quickly	22
IV	Either no land or no oxen, depend on labour and family support to survive	29	No resources, no oxen; share crop or try to clear scrubland; all work as labourers	23

Farmer participants defined these wealth categories with reference to available resources and vulnerability to shock or stress. Important distinctions between households included how much land they controlled, ownership of oxen, other livestock, available labour, cash crops (coffee and chat in Chiro, chat only in Miesso), and the quality of their house. The very poorest often had no land and needed to rent or sharecrop, and lacked saleable assets ("they don't even have chickens!")[15]. This bottom category also included the old and the infirm who were unable to work their land. Roughly a quarter of households were ranked in this group (Table 2.5). Many of this rank work in casual labour off-farm, and thus may have little time for working on their own land. This has important implications for their ability to pursue time-consuming seed selection practices (see Chapter 6), or to qualify for government seed programmes, which require participants to be "full-time farmers" (see Chapter 4). Farmers agreed that the poorest group is most likely to be seed insecure. Those with some land, but limited other resources, were ranked in the intermediate categories. The wealthiest category have oxen and cash-crops, are generally prominent members of their communities ("we know their wealth…we know them by name"[16]), and rarely face total livelihood failure. Miesso farmers stated that only the top rank was able to purchase seed from the market at current prices. The wealthiest highland farmers in this category tended to have non-traditional houses with a zinc roof, a common indicator of wealth. In the lowlands, the most important indicator of wealth was livestock numbers. Some cautioned that these categories were fluid, and the death of a few livestock could cause someone's relative status to drop.

Agricultural research in Ethiopia tends to downplay the significance of wealth differences among farmers. The farmers chosen for research collaboration (e.g. to test or demonstrate technologies on-farm) are taken to represent a particular agroecology, not a particular socio-

[15] Wealth-ranking by richer farmers in Hulla-Hullo village, Funyaandiimo FA, Chiro, 19 July 1998.
[16] Wealth-ranking by poorer farmers in Hulla-Hullo village, Funyaandiimo FA, Chiro, 20 July 1998.

economic condition. Indeed, when it was proposed in a PPB design workshop I attended that research findings should be dis-aggregated by wealth and gender, researcher reactions ranged from dubious to hostile. The 1975 land reform may lead some to assume that significant wealth differences among farmers have been eliminated. However, it may also be due to the fact that research and extension interact mostly with wealthier farmers, and are simply less aware of the needs of the most vulnerable. For instance, as a basis for wealth ranking in Chiro, I used a list of all households in one village that the resident Development Agent had compiled as part of his work. However, the focus group farmers added another 24 households missed by this list, nearly 30% of the households in their village. Nearly all (83%) of the omitted households ended up in the lowest wealth rank, a clear example of an official blind spot toward the most vulnerable.

2.5 Farming systems

2.5.1 Crops

Sorghum is the dominant crop in Harerghe, covering over two thirds of the cropping area (Wilbaux, 1986; Kefyalew *et al.*, 1996). The region has roughly a quarter of Ethiopia's sorghum acreage (CSA, 1995). Farmers there appreciate sorghum's high production of grain and biomass, and its ability to tolerate water stress. Maize is also sown as a staple to over 20% of the area, and is appreciated for its early maturity and bird resistance.

Along with sorghum, highland farmers also plant a range of pulses, oilseeds, and sweet potatoes, while teff, barley and wheat are sometimes sown as *belg* crops in the highest areas. The crop repertoire for lowland farmers is more limited due to water stress, though beans, chick peas, sesame, and sweet potato are sown as secondary crops. Constraints on land mean fallow periods are short to non-existent, especially in the highlands (Table 2.4). Sorghum is often intercropped with legumes or maize (Storck *et al.*, 1997), though limited alternatives to sorghum preclude crop rotation. In both locations, sorghum is usually planted year after year in the same plot.

All crops can be marketed to some extent. Studies in the lowlands estimated that between 20% (Kefyalew *et al.*, 1996) and 50% (ICRA, 1996) of the sorghum harvest is immediately sold to repay debts. As a result, some households run out of grain for consumption before the next harvest, and may even have to consume their seed stocks. Highland farmers can also sell some of their sorghum harvest, though it is unlikely that many households sell such a large proportion at harvest when prices are at their lowest. Some better-off highland farmers sow cash crops to small areas (Table 2.5), mainly coffee (*Coffea arabica*) or *chat* (*Catha edulis*, a stimulant), both perennial shrubs, or vegetables such as shallots. Only a few lowland farmers in Melkaa Horaa can grow *chat*, as it requires irrigation (small hand-dug channels in this location); the few who have *chat* generally grow it for personal consumption, rather than sale.

2.5.2 Livestock

The farming systems are mixed, and livestock are an important part of local livelihoods. These include cattle, oxen, donkeys, and small ruminants. Good quality grazing land is scarce in both highlands and lowlands. Lowland farmers traditionally would practice transhumance, but in recent years Issa pastoralists from the neighbouring Somali region have violently resisted Oromo herds having access to their water or grazing areas (IRIN, 2000), reflecting a national trend towards formalising territorial boundaries for ethnic groups

(Clapham, 2002). Thus, the limited forage means that crop residues, particularly from sorghum, are important as a source of feed for livestock. This affects preferences for sorghum types (biomass production is important, not only grain yield) and management practices such as dense sowing rates.

Oxen are essential for land preparation, but ownership is low in both districts (Table 2.6). Repeated droughts and other shocks have restricted populations, and have led to emergency sales of oxen. Lack of a pair of oxen greatly restricts farmer flexibility in undertaking important cropping operations, particularly as rapid responses are required to rainfall events, especially on poorly-drained soils. The majority of farmers in both locations is constrained to some degree in the speed and ease with which it can undertake cropping activities.

Table 2.6 Oxen ownership in West Harerghe, from survey in Miesso, and from Development Agent records for Chiro. † Chiro data specifically for Funyaandiimo FA.

# of oxen	Chiro†	Miesso
≥2	34%	28%
1	26%	32%
0	39%	40%

2.5.3 Cropping activities

Seasonal calendar

Variable and unpredictable rainfall patterns have a large bearing on which crops farmers sow through the season, with important implications for seed acquisition, particularly for sorghum. Figures 2.5 and 2.6 give a general sorghum calendar for Chiro and Miesso in a favourable season. Farmers generally plan to sow long-maturing sorghum with the early *belg* rains in February-April. However, they have sequential responses to rainfall patterns. As noted above, if long-maturing varieties fail to establish, farmers usually re-sow fast-maturing sorghum varieties. These are only planted around June or July, as early sowings risk maturing ahead of other fields, and attracting severe bird damage.[17]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land prep.		-----										
Sowing				-----	-----							
Cultivation				-----	-----	-----	-----					
Tying stalks									-----	-----		
Harvesting											-----	-----
Threshing	--											--------

Figure 2.5 General calendar for major activities with sorghum in highland Chiro, in a good rainfall year.

[17] As Chapter 6 will show, photo-sensitive long-season varieties tend to flower at the same time, spreading the risk of bird attack more evenly across farmers and fields.

```
              Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
Land prep.       ----------------
Sowing                      -------------
Cultivation                         ---------------------------
Tying stalks                                                ----------
Bird scaring                                                     -------------
Harvesting                                                            -------------
Threshing                                                                   --------
```

Figure 2.6 General calendar for major activities with sorghum in lowland Miesso, in a good rainfall year.

In the lowlands, uncertain *belg* rains, and the general lack of oxen teams to ensure timely sowing, mean that early plantings of sorghum can often fail. In Melkaa Horaa, this occurs at least half the time. As in other dryland areas (Fujisaka, 1997), farmers respond to the contingencies of rainfall distribution as they occur. If *belg* rainfall continues, and there is sufficient seed, farmers often re-sow long-maturing varieties. This requires that they store enough seed for multiple plantings, or seek off-farm seed for this (as Chapter 5 will demonstrate). If plantings of long-maturing sorghum fail altogether, lowland farmers generally seek fast-maturing sorghum for the late rains in June-July. Fast-maturing sorghum generally has semi-dwarf stature, and its low biomass production lower its value for feed or fuel; nevertheless, will sow it for grain. Nearly all fast-maturing sorghum varieties are MVs. Few farmers save seed of this, as they prefer to obtain long-maturing sorghum in the hopes that the next season will be favourable, and possibly because of the poor storage qualities farmers associate with MV seed. Thus, farmers generally search for fast-maturing sorghum seed on short notice, usually after June. This presents a major challenge for seed access, particularly as nearly all farmers in a given area will be searching for seed at the same time if the early rains fail entirely.

Farming tasks

Only a handful of lowland farmers can hire tractors to cultivate their lands, so nearly all lowland and highland farmers prepare their land using a team of oxen. The local plough, the *maresha*, has been used for centuries in Ethiopia, and is highly adaptable (McCann, 1995). Land preparation requires the roots and stalk bases of sorghum and maize to be uprooted, followed by tillage. Heavy clay soils slow this task in the highlands, while land preparation is made more difficult by the spread of *Parthenium hysterophorous* (L.), a invasive weed irritating to the touch.

Almost all sow broadcast. Row planting requires considerable more labour, and farmers do not always perceive benefits that would justify the extra effort (Fujisaka, 1997); thus, most of the farmers who do sow in rows, do so as a requirement of participating in an input package programme. Sowing is often spread – or repeated – over several weeks, as a response to limited availability of labour or oxen, or to improve the chance of stand establishment early in the season (Wilbaux, 1986).

The amount of seed broadcast varies greatly, from 5 to over 30 kg seed/ha (Kefyalew *et al.*, 1996; ICRA, 1996 own observations) reflecting soil fertility, moisture, and household seed availability. Generally, farmers sow over 15 kg/ha, which is well above the EARO recommended rates of 5-10 kg/ha, in order to minimise the risk of poor germination and emergence. Later, thinning can occur where stands are too dense, which provides livestock fodder (indeed, Chapter 5 suggests that households with livestock have higher sowing rates for this purpose). Wilbaux's (1986) observations of several East Harerghe farms through the season showed high plant density post-emergence (80 000 – 300 000 plants/ha), which is thinned dramatically during the six- to eight-leaf stage, eventually reduced to an average of 30 000 plants/ha (Table 2.7). Final plant densities are a response to moisture and nutrient levels, and to competition with other plants. For instance, rainfall in East Harerghe was 550, 990, and 700 mm for the 1983-85 seasons, and Wilbaux estimated mean sorghum density at 25 000, 35 000, and 30 000 plants/ha, respectively. On-farm trials found no significant yield differences between variable planting densities and the fixed densities recommended by researchers (Lafleuriel *et al.*, 1985). This is probably due to farmers adjusting densities to seasonal conditions and local fertility levels, and their removal of weak plants (e.g. those affected by stem-borers) through the season. Variable sowing rates appear to be a strategy for coping with variable conditions, as well as for providing fodder. This tends to require higher than quantities of seed than recommended by research institutions, though sorghum's seed-to-harvest ratio (roughly 1:30) is favourable in comparison to crops such as rice (1:12 ; Richards, 1986) (see Table 5.1).

Table 2.7 Mean (with standard deviations) sorghum plant density, measured on several farms in East Harerghe during the 1986 season. Adapted from Wilbaux (1986).

Period of measurement	n	Mean sorghum density (1000s of plants/ha)
Before late May	49	168 (109)
Late May-late June	55	54 (23)
Late June-late July	56	40 (12)
Late June-late Aug.	68	33 (10)
Late Aug.-late Oct.	136	30 (9)

Harvesting is done with a local sickle, the *mencha*, cutting the stalks off above the ground. Stalks are stripped of leaves for feed, and sorghum stovers are saved for later use, for sale, for fuel or construction. Sorghum plants with juicy stalks (*tinkish* in Amharic, *ala* in Oromo) are often cut before the general harvest, to be chewed fresh like sugar cane. Some farmers also will select seed from these stalks before the general harvest, seeking to have some *tinkish/ala* in the coming season. The panicles are often removed before the stalks, and piled in the field. Selection for seed can occur at several points: plants may be marked in the field during the season, individual panicles may be removed just before the general harvest, panicles may be selected as the harvest is underway and put to one side, or panicles can be chosen from the pile of panicles after harvest. Chapter 6 discusses seed selection in more detail.

Sorghum is threshed on a threshing ground prepared with mud and dung, using sticks or oxen to trample the panicles. Grain that is not immediately marketed is stored, almost always in deep underground pits called *gurguads* (Kefyalew *et al.*, 1996; Wilbaux, 1986; Storck *et al.*, 1997). These control against rodents and weevils, and prevent theft, though subject to losses from insects and mould.

2.5.4 Biotic stresses

Pests

The stem borer is the most important pest of sorghum in all agroecologies, with separate species predominating in the highlands and lowlands (Table 2.8). Continuous cropping of sorghum, and in-field storage of stovers, have probably helped maintain high stem borer populations; farmers claim the pest has become an increasing problem in the last 30 years (ICRA, 1996). Sorghum varieties (FV or MV) vary in their resistance to stem borers. Though no variety has complete resistance (CIMMYT, 2001), some produce tillers, or compensate in other ways to stem borer attack.

Weevils are serious storage pests, and spur some farmers to sell grain early at lower prices (ICRA, 1996). As Teshome noted (1996), farmers distinguish variety-level differences in weevil resistance. Their knowledge was supported by laboratory assessments of different sorghum FV resistance to weevils (Ramputh *et al.*, 1999), which found the FVs farmers considered resistant had higher levels of soluble phenolic compounds, and suffered less weevil damage, than other varieties. Other pests, such as shootfly, African bollworm, or armyworm, occur at varying levels from year to year. Finally, bird pests, particularly Quelea, can attack in huge numbers, and are also capable of causing large losses.

Table 2.8 Main pests affecting sorghum in Ethiopia. *Priority is: X=low, XX=intermediate, XXX=high, ?=unspecified, based on rankings from an ICRISAT survey, reported in Hulluka, (1992) with additional input from Fredericksen. (2000) (Adapted from: (Fredericksen, 2000; El-Ahmed, 1996; Omer and Fredericksen, 1992; Geleta and Tanner, 1995; Tegegne *et al.*, 1995).

Pest	Latin name	Timing and focus of attack	Priority in Ethiopia*
Stem borers	*Chilo partellus* (lowlands); *Buseola fusca* (highlands)	Throughout season, most damage before flowering; attacks leaves and stalks	XXX
Shoot fly	*Atherigona soccata*	Before flowering; attacks developing stalks, leaves	XX
African bollworm	*Helionthis armigera*	During grain-filling; attacks panicle	XX
African armyworm	*Spodoptera exempta*	Throughout season; attacks leaves	?
Sorghum midge	*Stenodiplosis sorghicola*	During grain-filling; attacks panicle	X
Primary weevils	*Sitophilus graniarus, S. oryzae, S. zeamais*	In field and storage; infests grain	XXX
Secondary weevils (flour beetles)	*Tribolium castaneum; Oryzaephilus surinamenis; O. mercator*	In storage; feed on surfaces, dusts, and damaged grains	?
Rodents		In storage; feed on stored grain	?
Birds	*Quelea quelea*	During grain filling; consume grain	XX

Diseases

Some diseases, such as the smuts (Table 2.9), affect sorghum in all agroecologies, causing moderate losses. Some smuts are seed-borne, and pose significant challenges for the physical quality of seed in the local system. Most diseases pose the greatest problem in the highlands, because of greater moisture. Of these, anthracnose, leaf blight, bacterial stripe, and grain mould are the most damaging. Disease-resistance is a major target for formal breeding of highland sorghum.

Table 2.9 Main diseases and pathogens of sorghum in Ethiopia, sources and key as in Table 2.8.

Pathogen	Latin name	Reservoir of innoculum	Priority in Ethiopia*
Anthracnose	*Colleotrichum graminicola*	Crop residues; rain-splash infects plants	XXX
Leaf Blight	*Exserohilum turcicum*		XX
Zonate leaf spot	*Gloeocercospora sorghi*		X
Loose kernel smut	*Sporisorium cruentum*	Seed-borne, infects seedlings	XX
Head smut	*Sporisorium relianum*	Soil-borne, infects seedlings	X
Covered kernel smut	*Sporisorium sorghi*	Seed-borne, infects seedlings	XX
Long smut	*Sporisorium (syn: Tolyposporium) ehrenbergii*	Local, floral infecting through spore balls	X
Bacterial leaf stripe	*Pseudomonas andropogonis*	Crop residues	XX
Bacterial leaf spot	*Pseudomonas syringae*	Crop residues	X
Bacterial leaf streak	*Xanthomonas campestris*		XX
Downy mildew	*Peronosclerospora sorghi*	Soil-borne, some seed-borne: loose oospores can also infect seed-lots	XX
Charcoal rot	*Macrophomina phaseolina*	Mainly soil-borne	XX
Grain Mould	*Fusarium thapsinum, Curvularia lunata, Mycosphaerella spp. & others*	Air- and soil-borne; encouraged by late rain	XXX
Ergot	*Claviceps africana; Sphacelia sorghi*	Seed-borne and air-borne	XX
Striga	*Striga hermonthica*	Seed stored in soil	XXX

Weeds

In the lowlands, the most severe weed is *Parthenium hysterophorous*, also known as congress weed or feverfew. Oromo farmers call it *feremsis*, meaning 'sign off' (and leave your farm). *Parthenium* is strongly allergenic, toxic to livestock, and causes dermatitis and asthma in humans (Dhawan and Dhawan, 1995). Native to Central America, it arrived relatively recently in Ethiopia (Gebre-Medhin, 1992), and has spread rapidly across lowland Harerghe. Its introduction probably came via grain sent to Ethiopia as food-aid from North America 15 years ago, much as it spread to India and Australia in the 1950s (Aneja *et al.*, 1991).[18] Its dominance in the Miesso-Assebot Plain excludes other forage species and limits crop growth, as well as farmers' ability to expand cultivation (Frew Mekbib *et al.*, 1996).

Striga (*Striga hermonthica*) is a parasitic weed and a severe pest of sorghum and maize across much of Africa (Mbiele, 1989). Striga is a significant problem in northern Ethiopia (e.g. Debelo and Gutema, 1997), though it has started to appear in the Chercher Highlands of West Harerghe. I was present at one of the first recorded observations of striga in the

[18] An American citizen, working in plant protection for the Ethiopian Government in the mid-1980s, suggests this occurred rather frequently. Finding a high level of weed contamination in food-aid shipments from the USA, she criticised the donors level of phyto-sanitary care, suggesting that aid shipments essentially included floor-sweepings from grain traders. For her efforts, she was upbraided by US officials for showing a 'lack of patriotism'! (RK, *pers. comm.*, 1998)

lowlands of West Harerghe, on the edge of Melkaa Horaa FA in 1998. Yield losses can be high, and there are few effective management options, in part due to the long dormancy of striga seeds (Haussmann *et al.*, 2000a). Resistant sorghum varieties produced by international research projects show some promise, however (Ejeta, 2002).

2.6 Management and coping strategies

2.6.1 Land

Since the land reform of 1975, the Ethiopian state owns all land, but gives farming households usufruct rights, which can be passed to descendents. Despite the reform, across the Oromo region there are many households with no land of their own (Tefera *et al.*, 2002). Though rent or sale of land is officially forbidden (Rahmato, 1985), renting and sharecropping arrangements are common (ICRA, 1996; Wilbaux, 1986). These arrangements, despite their somewhat unclear legality, allow farmers some flexibility. For the poorest, sharecropping gives those without land a chance to cultivate, or those without labour or oxen a chance to rent to others. For more prosperous farmers, renting land offers one of the few opportunities for accumulation.

Households do not always have secure access to a specific plot of land, as FA administrations occasionally re-allocate land holdings among their members. Some argue that the insecurity arising from state control over land undermines farmers' interest in investing in the land to prevent land degradation (e.g. Bekele-Tessema, 1997; Lemma, 1999). However, studies suggest that security of land tenure has little relation with farmers' interest in soil conservation or productivity (Benin and Pender, 2002; Gavian and Ehui, 1999; Bewket and Sterk, 2002). Private ownership in itself may not significantly change resource management strategies. In any case, the government remains opposed to private land ownership, or legalising land sales, and policy changes seem unlikely in the near-team.

2.6.2 Labour

Gender roles

Between 6% and 10% of the households in the area are female-headed (Kefyalew *et al.*, 1996; ICRA, 1996), though estimates from other regions typically give higher figures of around 15% (Chiche, 1997). As ox-ploughs are traditionally considered a male domain;[19] women-headed households usually must wait for a male relative or neighbour to till their land for them, generally after he has prepared his own land first. This adds to the vulnerability of these households.

In most households, men are involved in much of the agricultural work, and often spend most of the day in the fields (which may be distant from their house, especially in Miesso). Across rural Ethiopia, women's regular tasks – grinding, preparing food, collecting water/fuelwood – demand enormous time and effort (Abegaz and Junge, 1990), but they also help with agricultural activities such as weeding, harvesting, and threshing. When crop production is poor, they also play a central role in income-generation. For instance, Miesso women spent up to eight hours a day in 1995 collecting fuelwood to sell, since the crop had failed that year (ICRA, 1996).

[19] Women do occasionally operate ploughs, though by all accounts, this remains very uncommon (McCann, 1995).

Women are typically in charge of post-harvest processing, as well as seed storage. Women's involvement in marketing of produce, and knowledge of cooking qualities, means that they have important inputs into a household's choice of crops and varieties. It is likely that other household decisions are also negotiated to some degree, such as a decision on whether to sell stored grain, though very little is still known about intra-household bargaining in Ethiopia (McCann, 1995).

Labour allocation

Household sizes average between seven and eight persons, with roughly half the population under 15. Hired labour is rarely used, so the family members do most farm work, with labour-pooling arrangements used during peak times. Households allocate very different levels of labour to farming, reflecting household resources and allocation strategies. For instance, the eight farms Wilbaux (1986) studied in the Chercher Highlands applied between 134 and 530 person days/ha labour in one season. In a good season, agriculture offers the best potential returns to labour (Storck *et al.*, 1997), particularly as wage rates remain low in West Harerghe (generally below Birr 5, or US$ 0.60 a day). However, these results are not guaranteed, and, as Table 2.5 showed, the most vulnerable households are also most involved in off-farm labour. This is probably a livelihood diversification strategy to minimise risk by complementing an insecure harvest with off-farm income. Elsewhere in Ethiopia, such diversification also seems most prevalent in the poorest households (Carswell, 1999; Rahmato, 1991b).

The more vulnerable households place considerable emphasis on off-farm labour, and minimise labour inputs on farm. For instance, a household with no oxen and little labour faces considerable transaction costs in obtaining oxen, and may only do so for essential activities such as sowing and the initial cultivation. Transaction costs comprise labour, time, and other costs involved in arranging a transaction, which may include searching costs (i.e. finding who has oxen to spare), and negotiation costs (i.e. arranging terms of exchange) (North and Thomas, 1973). Emphasising off-farm work from the middle of the season, these farmers are often not present to monitor the crop through the season, or participate in labour-sharing activities on other farms, as many of their neighbours do. Considering that their more prosperous neighbours tend to view such 'part-time farmers' pejoratively,[20] and that part-time farmers probably have less time to maintain social networks, they may have less access to local seed exchange. This is discussed in more detail in Chapter 5.

Mutual aid

In West Harerghe, mutual aid arrangements help share labour and oxen among households and manage risk. Farmers with only one ox will pair it with another to make a team, and work each farm in turn, an arrangement called *mekenajo*. Farmers with no oxen can work for a farmer who owns a team of oxen, exchanging several days' labour for every day with the ox team. These arrangements enable most farmers to continue ploughing, even as oxen ownership declines. However, the need for quick responses to rainfall means that not all farmers will be able to sow seed at the ideal time.

Labour pooling is particularly important for intense activities such as land preparation, weeding, and harvest. This may occur among a fixed group, linked by friendship or kinship ties, or can be a one-off arrangement based on seeking help from neighbours. In all cases, the

[20] For instance, prominent farmers, in individual interviews and in group discussions questioned the skills and dedication of 'part-time' farmers, blaming their problems in farming on a lack of commitment.

host is expected to provide food, *chat*, *hodja*, and drink for the workers. Such arrangements are not accessible to all farmers, as they may not be able to afford the costs of hosting, or have available labour to build up reciprocal ties (Adams, 1993; Wilbaux, 1986). Who is available for labour-pooling activities may have some bearing on who receives seed in farmer-to-farmer exchange, something discussed much more in Chapter 5.

2.7 Summary: agroecological and social variation

This chapter has sketched out some of the factors that shape farming systems within West Harerghe. Describing the broad conditions of the highland and lowland sites shows considerable variations between these two agroecologies, as well as within them. Sorghum remains an essential crop for all types of farmers. Farmers sow large amounts of seed to cope with uncertainty, and may re-sow several times a season. Consequently households need to store large quantities of seed. Households can run out of seed for many reasons: previous harvest failure, sale or consumption of the previous harvest, storage pest damage, failed *belg* rainfall, or poorly-timed sowing (e.g. a need to wait for someone else's oxen team). Seed security is a major issue in West Harerghe.

Changes to the environment (e.g. rainfall uncertainty, soil degradation) and emerging stresses (e.g. *Striga,* stem borers) place considerable demands on sorghum production. Besides production, farmers appreciate fuel and feed qualities of sorghum, as forage and fuelwood is growing more scarce, and sorghum's marketability is also highly important, as cash needs are paramount. Finally, lowland farmers in West Harerghe have a dual-track strategy with respect to sorghum, seeking fast-maturing varieties, often of MV origin, when early rains fail, but returning to long-maturing sorghum types (always FV) afterwards. Thus, farmers value a wide range of traits in sorghum, and generally seek a diverse set of sorghum varieties. Formal research can contribute, but must address a complex and varying set of needs.

Social variation among farmers is also significant, relating to different levels of assets. This affects livelihood strategies, particularly for the poorest, who allocate less labour to farm activities. The poorest farmers are doubly vulnerable: they have fewer material assets such as livestock to sell, but also less ability to engage in social exchange in order to build up claims to social resources. As I will show in Chapters 5 and 6, this ecological and social variation has important implications for seed exchange, as well as for other practices and processes of the local seed system, such as the introduction of diversity.

Chapter 3 Formal sorghum breeding in Ethiopia: a history of goals, practices, and impacts.

3.1 Introduction

3.1.1 Analysing 'conventional' breeding

Reforms to crop development tend to focus on changing specific practices, such as seed selection, in order to develop more effective MVs. These reform efforts – which usually involve farmer participation – assume that interventions will address the key shortcomings of a programme. Most of the discussion so far in this area focuses on appropriate methodology for reforms, such as how to learn about farmer criteria for a crop, number of participants to select, or the phase of breeding, or scale at which farmers should be involved. As Weltzien *et al.* noted (2000: xiv) two thirds of the Participatory Plant Breeding (PPB) cases reviewed "focused on identifying, verifying, and testing specific selection criteria." However useful such efforts may be, they rarely consider whether a focus on selection criteria, or communication with farmers, will address the main factors shaping the impact of breeding. Other starting points may be more effective, but most discussions of reform concentrate on the technical practices of breeding.[21] The broader history of a breeding programme, how it innovates around strategies, confronts practical challenges in crop development, and is guided by policy priorities, are not usually explored in designing reforms such as PPB (Biggs and Gauchan, 2001). Thus, it is difficult to assess how any reforms will fit into the complex institutional context of a large public-sector breeding programme.

Indeed, institutional change is becoming an increasingly important outcome for breeding reform efforts. This reflects an understandable desire – particularly from donors – for lasting changes in the practice of breeding that will be embedded in the everyday activities of National Agricultural Research Systems (NARSs). Impact assessment for these reforms seek "a change in institutional priorities" (Lilja and Ashby, 2002), suggesting a change in "research priorities" or in "the criteria for accepting/rejecting technologies" as indicators (Lilja and Ashby, 2000: 12-14). Despite this interest, an understanding of institutions remains a major gap, both in design and analysis of reforms (McGuire *et al.*, 1999). Without an analysis of the history of the breeding institution, and how it relates to wider practices and policies around agricultural science and development, it is difficult to appreciate how research priorities or criteria for accepting technologies were established, or the factors that might encourage or inhibit change. For reforms to be effective, and lasting, institutional analysis needs to move beyond indicators of change, and seek to understand the wider institutional context.

Thus a critical, trans-disciplinary, analysis of breeding programmes is important to understand how practices have been established and maintained. An appreciation of breeding as an institutional practice can offer insights into the technical and social factors that give legitimacy to breeding strategies, and help us to understand the scope for institutional change in formal breeding. As we shall see, path-dependency plays an important role in sorghum breeding in Ethiopia, enabling an impressive continuity amidst turbulent changes in staff and policies, but also constraining any dramatic shifts in practice.

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[21] Of the roughly 30 projects presented at a 2001 workshop on PPB in sub-Saharan Africa, nearly all concentrated on gaining farmer input into MV selection in formal breeding. My own presentation suggested that these activities may still miss addressing the main factors constraining impact in formal breeding; this seemed to cause some consternation.

3.1.2 Approach to analysing ESIP

This chapter develops a trans-disciplinary analysis of formal sorghum breeding in Ethiopia, as part of a critical assessment of its relevance for smallholders. It explores how breeding priorities and practices have become established, highlighting past innovations around strategies. I first give a brief historical account of agricultural research in Ethiopia, and the place of smallholders in agricultural policy, before focusing on the Ethiopian Sorghum Improvement Program (ESIP). I explore ESIP's structure and organisation, its establishment of priorities and goals, and how these lead to specific breeding practices. This leads to an analysis of both technical and social/institutional factors that shape impact, suggesting that breeding reforms need to focus on more than just technical methods or selection criteria.

An overly-critical stance of any breeding programme is unhelpful. As this chapter will show, ESIP practices often have their own internal validity, supported by conventional thinking in breeding, policy priorities, and empirical findings. While ESIP strategies can be criticised for having little connection to farming realities, resulting in low adoption rates for MVs, these strategies need to be viewed in a wider context, suggesting that policies need to be challenged . ESIP is technically and organisationally accomplished, and is conscientious in meeting the bureaucratic demands of the larger research institution to which it belongs. The continuity of programme strategies over 30 years is impressive, where complex activities have been maintained despite limited resources and infrastructure, and with dramatic changes in policy and personnel. But, as we shall see, some aspects of this continuity may work against any reforms to breeding strategies.

My purpose is not to single out Ethiopia or ESIP in the analysis, but rather to show how such a trans-disciplinary analysis can offer new insights into breeding reform. The most basic question for breeding reform is 'why is there little apparent impact?', but addressing this involves asking further questions. For instance, how has the policy environment shaped the context for agricultural science in Ethiopia? How do breeders understand their priorities, and how do they perceive impact? How are breeding strategies set, and what scope is there for changing agendas? Exploring such questions helps us to understand formal breeding in its institutional and professional context, better to identify priorities for breeding reform and challenges.

3.2 Agrarian development in Ethiopia: a brief historical overview

The policy environment provides an important context for understanding the pathways taken by agricultural research. Ethiopia has experienced dramatic social and political changes in recent decades, shifting from a feudal regime, to a Marxist military state, to the current government's support of economic liberalisation and ethnic federalism.[22] These policy developments affected not only how agricultural development was interpreted and promoted in different periods, but also shaped, more generally, the climate for agricultural science.

This section gives a brief historical overview of Ethiopia's changing policies around agricultural development, highlighting the implications for smallholder farmers who dominate the agricultural sector. For much of the past century the broad thrust of policy did little to help smallholder production, and at times undermined it. Ethiopian policy priorities continue to influence the overall goals of agrarian development, affecting the types of

[22] A brief overview of the Ethiopian Revolution is found in Appendix A.

technologies developed, and who has access to them. This provides a wider basis for understanding the impacts of sorghum research – which targets smallholders – than focusing only on the technical practices of breeding. Moreover, the dramatic changes over the last few decades in agricultural development policy can help us to understand better the path-dependency of research practice, and the challenges of institutional change.

3.2.1 Before 1974: feudalism and capitalist agrarian development

Social structure and land tenure

Until Emperor Haile Selassie was deposed in the 1974 Revolution the political system was largely feudal in nature, with authoritarianism, centralised command, and well-established class hierarchies guiding social interaction (Levine, 1965).[23] A small élite – aristocratic families, as well as officials appointed by them – formed the apex of politics, wealth, and political power. They derived their wealth from fiefdoms, which gave them the right to extract tribute from peasants (Marakakis and Ayele, 1986; Gilkes, 1975; Donham, 1999).

The Abyssinian empire centred on the Amhara and Tigrayan north of Ethiopia, but expanded southwards in the late nineteenth century, incorporating vast areas and diverse peoples into what is now Ethiopia (Donham and James, 2002). Emperors also created fiefdoms in the newly-conquered southern regions, granting control over large areas and populations to appointees (who were often northerners; Gilkes, 1975). As with their northern counterparts, the southern élite extracted labour and produce from smallholder farmers in the fiefs, but the burden on smallholders was more onerous in the south due to the nature of political conquest and the absence of countervailing social ties between peasant and nobility (Halliday and Molyneux, 1981). Most northern smallholders had traditional land rights which prevented them from being evicted, though they still owed tribute to élites. However, in the south, most smallholders lacked secure rights to land and effectively became tenants in the new fiefdoms (Ghose, 1985; Table 3.1). Landlords were often absent, pursuing politics or business in the cities (Table 3.2), using the land mainly to extract rents and tribute from peasants. These landlords could set high rents, charge fees to renew tenancy, or evict at will.[24] Given that the administrative, military, and judicial system was run by landowners, landlords, in many rural areas, effectively were the state.

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[23] The framework of feudalism is commonly used to describe the past regime (e.g. Gilkes, 1975; Cohen and Weintraub, 1975), particularly by Ethiopian intellectuals (Donham, 1999: 193-194n). Strictly-speaking, not all aspects of the land tenure system were feudal (Rahmato, 1985), but the term is still a convenient short-hand for describing the broad sweep of land and tenure relations, particularly in southern Ethiopia.

[24] For example, a government study in the late 1960s in Harerghe found that "Landlords are entitled to evict their tenants on any pretext at any time before the latter have sown their plots with seeds. They may also evict their tenants after the latter have farmed or even harrowed their plots. They may also evict them at any time after harvest." (Rahmato, 1970; cited in Gilkes, 1975: 165).

Table 3.1 Proportion of Ethiopia's rural population who were tenants before the 1974 Revolution, drawn from the Ethiopian Ministry of Land Reform *Reports on Land Tenure Surveys*, published between 1967 and 1972 (cited in Marakakis, 1973). **Bold** regions are "southern", incorporated into national system in late nineteenth century (*: parts of Shoa are considered 'northern' as well; †: case-study area located in Hareghe).

Administrative Region	Rural population	Total renting	% renting
Begemdir (Gondar)	1 087 200	160 080	14.7
Gojjam	1 344 500	267 809	19.9
Tigray	1 410 800	356 066	25.2
Wollo	2 061 800	834 766	40.5
Shoa*	3 585 000	2 401 950	**67.0**
Arssi	690 600	358 488	**51.9**
Gamo Goffa	583 300	271 045	**46.5**
Hareghe†	1 435 570	775 207	**54.0**
Illubabor	515 375	386 531	**75.0**
Kaffa	969 100	600 842	**62.0**
Sidamo	1 987 590	775 159	**39.0**
Wollega	1 064 100	624 453	**58.7**
Total	**16 734 935**	**7 812 396**	**46.7**

Table 3.2 Absentee ownership of land as a proportion of all land owners, and the proportion of all land area held by absentee landlords; source as in Table 3.1. Figures are probably underestimates, as they are reported by *Chika Shums*, local gentry (†: case-study area located in Hareghe).

Administrative Region	Absent Landlords (%)	Area held by absentee owners (%)
Arssi	28	28
Bale	15	12
Gamo Goffa	10	42
Hareghe†	23	48
Illubabor	42	42
Kaffa	18	34
Sidamo	25	42
Shoa	35	45
Wollega	26	28

Few factors encouraged agricultural development during the feudal period. In northern Ethiopia, if smallholders did have tenure to land, it was not to a specific plot, so there was little motivation to make long-term improvements, as they would not be passed on to direct descendants (Hoben, 1996). In southern Ethiopia, insecure tenure and high levels of extraction constrained smallholder ability to develop. More critically, the élite generally were indifferent to agricultural development, as their social advancement came through political or military achievement. Some landlords were actively hostile, fearing that any to improvements to peasant production would transform relations of production, and thus their power (Marakakis and Ayele, 1986). Indeed, peasant revolts did occur in several regions after the 1940s, though without changing production or tenure relations (Tareke, 1991). Finally, limited infrastructure and a small urban population meant that there was minimal market demand to drive intensification.

Government bureaucracy and agrarian development

From the 1930s, Emperor Haile Selassie started to build a civil administration to govern Ethiopia and promote development. Ministers were appointed from the aristocracy: for instance, 44 of the 63 Ministers appointed between 1941 and 1966 are to be found on the same genealogical table (Clapham, 1969). Haile Selassie also promoted the entry of young, educated Ethiopians (often of modest birth) into the civil service (Marakakis, 1973). While these civil servants were often talented and committed, their efforts were “frequently undercut by more traditional powers” (Gilkes, 1975:83; see also Levine, 1965) – in other words, by the interests of the élite at the head of the Ministries. Fearing the aristocracy, the Emperor barely devolved any real power to Ministers: they were required to remain in the capital for long periods awaiting an audience with him, and, in the 1960s, budget allocations only covered salaries, forcing Ministers into back-room negotiations for all other expenses (Clapham, 1969; Gilkes, 1975; Marcus, 1994).

Most government expenditure went to develop internal administration, finance, and the military, with agriculture receiving a relatively small budget (Marcus, 1994; Table 3.3). From the late 1950s, Ethiopia formulated Five Year Plans to organise development from a subsistence to an agro-industrial economy. Agriculture was targeted for investment, though the absolute amounts remained small in relation the size of the sector (Table 3.4). However, due to power struggles within the administration, and a lack of administrative capacity, only half the planned investment in agriculture actually occurred (Marcus, 1994). Local political opposition to rural development plans, a lack of appropriate agricultural technology, and poor co-operation among Ministries undermined rural development plans (ECA, 1966).

Table 3.3 Expenditure from main ministries in Ethiopia compared across four budgets, in millions of Ethiopian Dollars ($2.50 ETH ≅ $1 US), along with the percent of total ordinary expenditure, adapted from Gilkes (1975: 163). * Civil List includes the costs of the Imperial Court, Haile Selassie's private cabinet, the Ministry of the Pen (akin to the head of Cabinet), and, in 1944/5, the Senate and Deputy expenses; † by 1970 the Agriculture budget included the Ministry of Land Reform, the Awash Valley Authority, and the Wildlife Conservation Dept.

Ministries	1944/5	%	1957/8	%	1965/6	%	1970/1	%
Agriculture	**0.6**	**1.4**	**1.7**	**1.0**	**10.3**	**2.5**	**11.5†**	**2.3**
Civil List *	2.7	6.6	4.0	2.5	5.8	1.4	9.7	1.9
War/Defence	11.5	28.0	39.0	24.6	102.5	25.5	87.4	17.2
Interior	8.7	21.1	23.3	14.7	79.0	19.6	74.1	14.6
Justice	1.2	3.0	4.1	2.6	7.1	1.8	7.2	1.4
Information	-	-	1.3	0.8	6.1	1.5	7.2	1.4
Education	1.7	4.1	14.5	9.2	63.9	15.9	77.0	15.2
Health	-	-	4.6	2.9	25.4	6.3	23.4	4.6
Community Development	-	-	2.9	1.8	3.3	0.8	4.4	0.9
Commerce & Industry	0.2	0.5	0.6	0.4	1.4	0.3	2.2	0.5
Total, ordinary expenditure	41.1	100.0	158.5	100.0	402.2	100.0	507.1	100.0

Table 3.4 Estimates for investment by sector in the Five Year Plans, in millions of Ethiopian Dollars ($2.50 ETH ≅ $1 US), and the percent of total planned investments, adapted from Gilkes (1975: 164). *: these are possibly over-estimates. For instance, Lefort (1983) gives agriculture only 6% on the 2nd Plan.

Sector	1st Plan 1957-62		2nd Plan 1963-68		3rd Plan1968-73		Total
	Planned investment	%	Planned investment	%	Planned investment	%	%
Agriculture	**92.1**	**13.7***	**363.0**	**23.0***	**312.1**	**10.9**	**15.0**
Mining/Power/ Manufacturing	138.0	20.5	455.3	28.8	864.4	30.2	28.5
Transport/Building/ Communications	240.0	35.6	325.4	20.6	624.4	21.8	23.2
Social Services/Govt	57.0	8.5	120.8	7.6	173.1	6.0	6.9
Housing	122.5	18.2	250.0	15.8	524.6	18.3	17.5
Other	24.0	3.6	66.5	4.2	366.8	12.8	8.9
Total	673.6	100.0	1581.0	100.0	2865.4	100.0	100.0

Investment and growth in agriculture

From the 1940s-70s, most public or private investment in agriculture was in mechanised commercial farming, benefiting mainly the wealthy few who controlled land, transport, or marketing (Marcus, 1994; Marakakis and Ayele, 1986). For instance, the Awash Valley Authority (AVA) encouraged large irrigated cotton and sugar estates to develop along the Awash River. By 1974, the industrial sector occupied about 1% of all farmland. Smallholders had little interaction with large commercial schemes, though some were evicted to make way for them, and pastoral groups lost access to water and grazing land (Bondestam, 1974). Some individual landlords invested in mechanised commercial farming on a smaller scale, usually evicting tenant farmers to do so (Ståhl, 1973).

State policies promoted commercial farming (e.g. by exempting it from import duties or taxes on tractor fuel), but smallholders continued to face high taxes and import duties for their implements. Most public investment went to commercial farming; for the Third Five Year Plan (Table 3.4), 90% of the agricultural investment went to the commercial sector (Lefort, 1983).[25] The small amount that was directed to smallholder agriculture had minimal impact, as extension agents received insufficient support, and there were few available technologies, or channels for seed supply, marketing, inputs, or credit (Gebregzibher, 1975). Thus it is unsurprising that, while industrial farming grew by 10% a year prior to 1974 (Lefort, 1983), the smallholder sector only attained 2.4% growth in that period (Tareke, 1991).

Thinking of smallholders: the case of CADU

The Chilalo Agricultural Development Unit (CADU) was the first major development effort directed at smallholder agriculture in Ethiopia.[26] Initiated in 1967 by the Swedish International Development Agency (SIDA) at the government's invitation, CADU was an ambitious integrated rural development programme, modelled on the Ford Foundation's work in India (Cohen, 1974; ECA, 1966; Gebregzibher, 1975). Farmers received credit, inputs, MVs, and improved dairy cattle, but also education, health services, and support for marketing and co-operative development. Results were dramatic, and cereal yields nearly doubled (Cohen, 1986). These gains probably reflected the high potential of the fertile Arssi plateau where CADU worked, as well as the integrated nature of its activities. CADU's institutional culture was also crucial, where sustained funding supported a dedicated cadre of staff, while internal debate and organisational changes were encouraged (Gebregzibher, 1975).

CADU significantly influenced policy. For the first time, policy-makers came to see smallholders as a dynamic sector with a potential contribution to the national economy. CADU became a model for smallholder development, affecting breeding and especially extension (Beshaw, 1990). The Ministry of Agriculture (MoA) established the Extension and Program Implementation Development (EPID) in 1971 to develop smallholder agriculture. EPID managed projects such as the Wolayta Agricultural Development Unit (WADU) and the Ada District Development Project (ADDP), and set up the Minimum Package Program (MPP).

The Minimum Package Program is an apt title, as EPID projects – and subsequent ones – hoped to replicate CADU's impact more cheaply by focusing only on the technological package (MVs, inputs, extension), while leaving out education, infrastructure, or capacity development (Schultz, 1976). The shift from 'integrated' to more 'package-oriented' development projects reflected global trends in rural development practice in that period (Ellis and Biggs, 2001). However, the emphasis on technologies and yield gains obscured serious problems of equity, as wealthier households took advantage of cheap credit and inputs (Ståhl, 1974, 1973). As agricultural became more profitable, landlords raised rents and evicted tenants to increase their personal holdings (Cohen, 1975), and income inequality

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[25] It should be noted that these Plans were "to a great extent the work of international experts" (Ståhl, 1973: 9), mainly from the USA, Yugoslavia, and the FAO.

[26] Later Arssi Rural Development Unit (ARDU).

increased in the project areas (Cohen, 1974). The EPID projects encouraged the development of standardised technological packages, which have been the basis of agricultural development ever since. As I discuss later in this chapter, packages under-emphasise local-scale ecological or social variation, and can lead to breeding strategies with limited impact in high-risk areas.

In summary, smallholder agriculture received little policy attention until the late 1960s, as the landed élite mainly saw smallholders as a source of capital to invest elsewhere. The eventual (yet still small) government support in agricultural development mainly benefited investors in large estates, and wealthy individuals who took to mechanised or capital-intensive farming. Weak infrastructure and poor market integration left any smallholders with marketable surplus at the mercy of merchants, and most cash was consumed in paying taxes and rents. Smallholder-oriented projects reached a small proportion of the total population, and centred on technological packages. However, the extreme inequality of the land tenure and political systems constituted the greatest barrier to rural development.[27] Formal agricultural research was established during this period, and its early activities reflected the broad policy priorities of the feudal system.

3.2.2 1974 – 1991: Agrarian Socialism under the Dergue

The Ethiopian Revolution toppled Haile Selassie's government in 1974, replacing it with military regime known as the *Dergue*, led by Colonel Mengistu Halie Mariam. The *Dergue* came to embrace Marxism (see Appendix A), and promoted an authoritarian form of agrarian socialism, with significant impacts on smallholder development and on the climate for agricultural research.

The institutions of agrarian socialism

Land reform and Peasant Associations

In 1975, the *Dergue* enacted sweeping land reform, promising secure land rights to all who farmed the land. All land was nationalised, with private ownership and tenancy abolished (Provisional Military Administrative Council (PMAC), 1975). Over 20 000 Peasant Associations (PAs)[28] of roughly 800 ha each were formed, and their (smallholder) members given the task of redistributing land from landlords (or any household with more than 10 ha) to the poorest households. This occurred swiftly (mostly within three months; Alula Abate, 1983), and farmers took most decisions themselves. The removal of landlords and rents was welcome, but almost no new land was added to smallholder cultivation. In practice, reform often meant a smallholder family with moderate holdings transferring some land to a landless family, leaving them both poor (Ståhl, 1977).

Immediately following land reform, farmers increased their consumption, and, freed from rent obligations, marketed much smaller proportions of their harvests (Ghose, 1985). The result was increased food prices and urban unrest in the mid-1970s. The *Dergue's* policies around State Farms and collectivisation were in part a response to this. While ideology was a factor in the regime favouring collective and State Farms over individual smallholders, it also reflected a need to establish a 'reliable' sector for supplying food to urban consumers and the

[27] For instance, the World Bank warned in 1967 "Until a workable agrarian reform is implemented, no rapid improvement can occur in the economic well-being of the large majority of the people, nor can the full agricultural potential be realised" (IBRD, 1967: 6; cited in Marakakis and Ayele, 1986: 70n).
[28] These are now the Farmers' Associations.

military (Cohen and Isaakson, 1988). Agrarian institutions and policies supported an agenda of low urban food prices, despite the implications for smallholders.

State Farms

Large commercial estates were nationalised in 1975, and some became State Farms. They remained highly mechanised, and produced food crops, industrial and cash crops, and MV seed (through the Ethiopian Seed Corporation). By 1986, State Farms occupied 3.4% of cultivated area, and employed a few thousand labourers and technical managers (Belete *et al.*, 1991).

Producer Co-operatives

The *Dergue* encouraged the formation of Producer Co-operatives (PCs) within PAs, where individual households would pool land and other resources to farm collectively. Despite considerable pressure and incentives such as preferential access to technology and inputs, few farmers willingly pooled their land into a PC (Alula Abate, 1983), and in the first decade following land reform, they averaged less than 2% of all area (Table 3.5).

Table 3.5 The number of households and area cultivated in 1983, and the mean crop production for 1975/76-1985/86, according to production sector. Source: Cohen and Isaakson (1988), except †: Belete *et al*. (1991).

Measure	Production sector		
	State Farm	**Producer Cooperative**	**Smallholder**
Number of households	18 000	94 000	8 206 000
% of total	0.2	1.1	98.7
Cultivated area (ha)	222 000	114 000	5 987 000
Mean area per household (ha)	12.3	1.2	0.7
% of total area	3.5	1.8	94.7
% of national arable production, 1975/76 – 1985/86 †	3.0	1.2	95.8

Other institutions

The Agricultural Input Supply Corporation (AISCO) was established as the main organisation to obtain and distribute inputs. Its staff estimated demands for MV seed, fertiliser, and credit, and arranged delivery directly to State Farms, or via MoA field offices to PCs and individual farmers. Though State Farm and PCs represented only 4% of total area and production, they received a hugely disproportionate share of inputs from AISCO. For instance, State Farms received 91% of the agricultural credit, 79% of the MV seed, and 52% of fertiliser available nationally in 1980/81 (Belete *et al.*, 1991: 172-3). State Farms, or the controversial resettlement schemes[29] received most of the scarce MV seed (Table 3.6), while the amount directed to the smallholder sector, if spread evenly across all households, averaged around 300 g of seed per season.

[29] The World Bank first proposed resettlement in 1973, to relieve population pressure. The *Dergue* implemented a large-scale programme which peaked in the mid 1980s, moving 800 000 people from the northern highlands to less populated areas in the west and southwest (Pankhurst, 1992; Stroud and Mekuria, 1992). Widely seen as an attempt to dilute political opposition, the programme was unpopular. Migrants received poor support for farming in ecologies unfamiliar to them, and suffered high rates of mortality from disease; few now remain.

Table 3.6 Amount of MV seed supplied (in thousands of tonnes) for all crops, with the percentage of the total seed supplied to each sector. Source: Ethiopian Seed Corporation (1985). (*:Re-settlement activities peaked in the mid-1980s, and decreased considerably after 1985.)

Season	Total MV supplied	Production sector							
		State Farm		Re-settlement *		PCs		Smallholders	
		Amt.	%	Amt.	%	Amt.	%	Amt.	%
1977/78	5.9	2.0	34.9	0.4	7.3			3.4	57.8
1978/79	5.3	2.4	45.3	0.6	11.1			2.3	43.6
1979/80	9.8	6.4	64.7	0.8	8.0			2.7	27.3
1980/81	19.9	15.6	78.8	0.8	4.2	0.1	0.6	3.3	16.4
1981/82	22.0	17.6	79.9	0.9	4.1	0.4	1.6	3.2	14.4
1982/83	26.3	17.6	66.8	1.0	3.8	0.6	2.5	7.1	26.9
1983/84	7.8	5.8	74.6	1.8	23.2	0.0	0.0	0.2	2.2
1984/85	13.4	1.6	11.9	9.9	73.9	1.9	14.2	0.0	0.0
Total	**110.4**	**69.0**	**62.5**	**16.2**	**14.7**	**3.0**	**2.7**	**22.0**	**20.0**

The *Dergue* required smallholders to sell set quotas of grain to the parastatal Agricultural Marketing Corporation (AMC). Prices were fixed and low, in some cases 60% below local market prices, though PCs received higher prices (Franzel *et al.*, 1992). The AMC obtained its quotas even during the 1985 famine, forcing some farmers to sell livestock or buy grain on the market to do so (Clapham, 2002). Private grain trade between regions was highly restricted, and private traders also had to deliver much of their purchases to the AMC (Cohen and Isaakson, 1988). While these policies ensured cheap food supply to the cities and military, they prevented competition or market integration (Franzel *et al.*, 1992), effectively reducing smallholders' incomes, and undermining incentives for them to produce.

Despite incentives such as higher prices and preferential input access, State Farms and PCs often produced yields that were no better than those of smallholders (Table 3.7). Moreover, yields in these collectivised sectors actually decreased for most crops between 1975/76 and 1985/86 (Belete *et al.*, 1991). Challenges of labour management, inappropriate technologies, and over-mechanisation contributed to the poor performance of State Farms and PCs (Ståhl, 1977; Cohen and Isaakson, 1988). Agricultural output stagnated, with annual growth only 0.7% in the 1970s and 0.3% in the 1980s, well below other countries in the region (Weijenberg *et al.*, 1995).

Table 3.7 Yields of major cereals (kg/ha) by production sector, in the 1987 main crop season. (Source: CSA, 1989, cited in Stroud and Mekuria, 1992)

Crop	Production Sector		
	State Farm	PCs	Smallholder
Sorghum	973	939	1163
Maize	3302	1659	1923
Barley	1219	977	1234
Wheat	1429	1015	1170
Teff	172	738	795

A climate for critique?

By most measures, the *Dergue's* agrarian policies would appear to have comprehensively failed. Scarce inputs and credit were directed towards the most inefficient sectors, while smallholders, who comprised the vast majority of the rural population, faced serious disincentives to production. How did agricultural researchers respond to these policies, and how did it affect the climate for science?

There was much unease among Ethiopian agricultural researchers about the *Dergue's* agrarian development strategies. However, most policies were decreed by fiat, with little input from civil servants outside the Workers Party of Ethiopia (Rahmato, 1993), and the core agenda of agrarian socialism was subject to open debate (Wolde Giorgis, 1989; Cohen and Isaakson, 1988). The *Dergue* brutally eliminated opposition groups, and was highly authoritarian, with political cadres and informers ubiquitous (see Appendix A). Thus, it was a wise strategy for agricultural researchers to avoid expressing views that directly challenged policy, and focus on the technical aspects of their work. This is not to imply that scientists avoided empirical evaluations of the consequences of *Dergue* policies, but rather that framing these into a critique of policy was a risky prospect for most researchers. For instance, Ethiopian agricultural economists in the 1980s did document the egregious effect of AMC quotas on smallholders, but only in scattered reports (Franzel *et al.*, 1992). The institutional culture established during the *Dergue* rarely rewarded researchers who asked wider questions of impact, but rather those who kept their heads down: this may be one reason why most Ethiopian breeders, including sorghum breeders, do not ask about the actual adoption rates of their MVs. I return to this issue when discussing ESIP.

In 1990, the *Dergue* suddenly relaxed some of its agrarian policies, moving to a "mixed" economy. This was more a tactical response to rural hostility than any considered reaction to critiques, external or internal. Within weeks, the majority of PCs were disbanded and their assets divided among members (Rahmato, 1993). The *Dergue*, however, only lasted another year, and was toppled in May 1991 by the Ethiopian People's Revolutionary Democratic Front (EPRDF), which continues to govern the country.

Post-*Dergue* policies

The present government gives high priority to food security, and has liberalised most areas of the economy, including agriculture (Keeley and Scoones, 2000). Ethiopia is now a federal state, with new ethnically-defined regions organising many aspects of policy, particularly in agricultural development (James *et al.*, 2002). Land use policy, however, has not greatly changed: peasants retain usufruct rights, but may still not purchase or sell land. Also, PAs (now called FAs) remain the smallest unit for administration.

3.2.3 Summary: agrarian policy changes and agricultural research in Ethiopia

This overview has highlighted the changing policy environments to which agricultural research has had to adapt, and pointed to reasons other than technical failings in research for the poor record of development of smallholder farming. Both feudal and *Dergue* policies were, effectively, anti-smallholder, extracting surplus, directing scarce technology and inputs to inefficient collectivised sectors, and limiting, through local authoritarian controls, smallholders' scope for livelihood innovation.

Another point to highlight is the aspect of both change and continuity. Over the last 40 years, regimes and policies have shifted dramatically, though authoritarianism and hierarchy remain common elements (Keeley and Scoones, 2000), and certain discourses underlying agricultural development have endured. Most researchers avoided open discussion of political or socio-economic factors, as much for reasons of self-preservation as for any reasons of disciplinary rigidity. This is one factor in the endurance of some discourses, such as the high-input/high-output 'packages' of CADU and WADU, the MPP, and of contemporary initiatives such as the National Extension Improvement Program (NEIP). The continued enthusiasm for technology transfer approaches, and set packages, has exerted considerable influence on the development of agricultural research, particularly breeding. The impact of a (narrowly-interpreted) success like CADU, and the difficulty of mounting an empirically-based challenge to the message policy-makers have drawn from it, hint at the difficulty of shifting such established discourses, particularly in Ethiopia's political environment of the recent past (Hoben, 1996).[30] This path-dependency has important consequences for any agenda for breeding reform.

3.3 Agricultural research in Ethiopia

ESIP sprang from the Alemaya University of Agriculture (AUA) and the Institute of Agricultural Research (IAR), Ethiopia's two principle agricultural research institutions. I summarise key points of their history below, as an introduction to ESIP itself.

3.3.1 Alemaya University of Agriculture

Developing higher education in Ethiopia was a priority for Haile Selassie, and he secured funding from diverse donor sources for several educational institutes (Bentley, 1960). The Junior Colleges of Agriculture in Ambo (1947) and Jimma (1952) were the first agricultural training centres (Beshaw, 1990), involved in very local extension activities and a modest level of research (FAO, 1982; College of Agriculture, 1958). The College of Agriculture at Alemaya, which took its first students in 1956 (College of Agriculture, 1958) was more significant. Established in the eastern highlands near Harer, Alemaya College also had an experimental station in Debre Zeit in the centre of the country.

Alemaya College was modelled after US Land Grant Universities, where teaching, extension, and research were linked. Until 1966, the College was the leading source of agricultural research (Weijenberg *et al.*, 1995). The initial faculty were mainly expatriates from Oklahoma State University, whose teaching and research were US-oriented (Bentley, 1960). However, Ethiopian faculty increased over time (College of Agriculture, 1958; 1960; 1962), and research on Ethiopian problems started to emerge. Research output from Alemaya dropped in the late 1960s, as teaching duties grew (Anonymous, 1980). The government gave the MoA the lead role in agricultural research and extension in 1963, and linked the College to the newly-established Haile Selassie I University (later Addis Ababa University) (Beshaw, 1990). Alemaya now has its own charter as the Alemaya University of Agriculture (AUA), and has awarded post-graduate degrees since 1979 (FAO, 1982).

The USA's Point IV Program for technical development assistance was the main support for Alemaya until the 1970s, and the College reflected US models of agricultural research. The Point IV Program aimed to be a Marshall Plan for developing countries, albeit with less

[30] A fuller account of how policy discourses become established would include the key actor networks, and how they exploit opportunities to shape or change policy; see Keeley and Scoones (2000).

funding (Brown and Opie, 1953). Assistance emulated US institutional models, notably the Land Grant University for agricultural research and training (Kennedy and Ruttan, 1986). The founding director of the Technical Cooperation Administration, which administered the Point IV Program, was Henry G. Bennett. Bennett was then President of Oklahoma State University, the Land Grant University later contracted to develop Alemaya College, and he closely advised Haile Selassie about the College's formation (College of Agriculture, 1958). Thus, US practice exerted a strong influence on the early development of Ethiopian agricultural research.[31]

3.3.2 Institute of Agricultural Research

Structure

The Institute of Agricultural Research (IAR) was founded in 1966 and became Ethiopia's most important agricultural research institution.[32] IAR received significant support from the United Nations, through the Food and Agricultural Organisation (FAO) in its first two decades. Early work was organised at the research station level, with little central co-ordination. The large commercial estates were IAR's main clients in its early years, with research focusing on a few economic crops; crops important to smallholders, such as teff, sorghum, pulses, or oilseeds were not addressed (FAO, 1982, 1989). IAR generally reacted to the policy changes described above, though since its restructuring as the Ethiopian Agricultural Research Organization (EARO) in 1998, researchers have a greater role in defining policy (Getinet Gebeyehu and Gebremedhin, 1999). IAR became a fully autonomous institute in 1979, and started co-ordinating research nationally by discipline and commodity (Emana, 2001). Disciplines include breeding, agronomy, plant protection, agricultural engineering, and food science, among others, while commodities include individual crop and livestock species (e.g. sorghum, wheat, coffee, maize), as well as groups of species (pulses, oil crops, horticultural crops).

Spending and staff

In the 1980s, Ethiopia bucked the regional trend of shrinking research budgets for agriculture (Pardey *et al.*, 1997). Research spending increased from 0.3% of agricultural GDP in the early 1980s (ISNAR, 1987) to 0.75% by 1992/93 (Weijenberg *et al.*, 1995), giving Ethiopia one of the highest research intensities in East and Central Africa (Table 3.8).[33] While half Ethiopia's research budget came from donors in the 1980s (Bonte-Freidheim *et al.*, 1994), only 6% did by 1993, the lowest in East and Central Africa. By the 1990s, Ethiopia's high level of domestic financing meant that it could set and fund its own research agenda to a much greater degree than its neighbours.

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[31] Bennet, and most senior Technical Cooperation Administration managers died in a plane crash over Iran in 1951. According to Douglas Ensminger, a senior aide to Bennet who was to later to become a key player in the Green Revolution (as the Ford Foundation's representative in India in the 1960s; Biggs and Smith, 1998), US development policy shifted after Bennet's death. Bennett favoured capacity-building in the South via modest long-term support, but his successors, drawn from the Marshall Plan, moved US thinking towards more visible 'prestige' projects that involved large-scale financial (and military) support (Taylor, 1977).

[32] There were also the colleges, and several specialised research centres operated by the MoA.

[33] Only Burundi and Rwanda had higher intensities. Note that nation-wide estimates face challenges in determining what counts as agricultural research spending, and very limited data.

Table 3.8 Agricultural research intensity in Ethiopia for 1992/93, compared with mean intensities of different regions for that year, adapted from Weijenberg *et al.* (1995), except **†**, from Alston *et al.* (1998). (*****: This is the proportion of agricultural GDP spent on research. **§**: Least Developed Countries.)

Region	**Agriculture research intensity ***
Ethiopia	**0.75**
sub-Saharan Africa **†**	0.70
East and Central Africa	0.42
Low income LDCs **§**	0.32
Low middle income LDCs **§**	0.40
Upper middle income LDCs **§**	0.51
All developing countries	0.42
All developed countries	2.01

Staff numbers at IAR followed these spending increases, growing more rapidly than anywhere else in Africa in the late 1980s, albeit from a low starting base (Pardey *et al.*, 1997) (Figure 3.1). By 1992/93, IAR employed 3000 staff, with 300 researchers, including 22 PhD and 94 MSc holders. However, the most senior staff are concentrated in the three largest research stations in central Ethiopia (Holetta, Bako, and Melkassa). With a third of IAR's staff total, these three stations have 77% of the PhD's and 45% of the MSc's (IAR, 1994, 1992). According to an ISNAR review (1987), breeders have an 'overwhelming influence' over the research organised around commodities, and half of all experimental trials relate to cultivar screening or breeding. However, crop research is spread across many commodities, with only a few individual crops (coffee, maize, sorghum, wheat, teff, barley) receiving significant research attention (Table 3.9).

Figure 3.1 Number of research staff at IAR by year and level of training, (not including diploma holders), and annual budgets, in millions of $ETH or Birr (1 US$ ≅ 2.50 ETH$ or 2.07 Birr). Data adapted from Pardey and Roseboom (1989). (* Before 1970, only total number of researchers was available; not all are expatriates. 1965-69: specific data for 1966, 1968, and 1969).

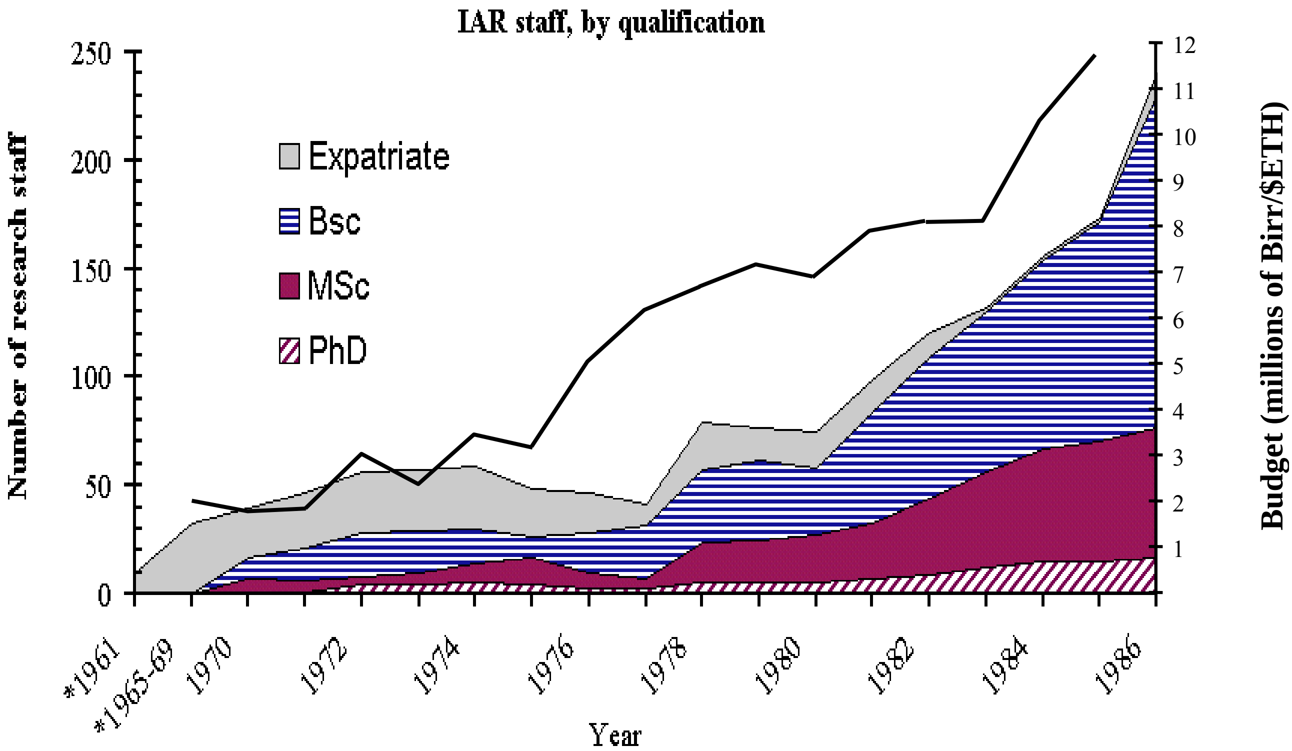

Table 3.9 Allocation of IAR research staff time by commodity in 1986, specifying the major crops, adapted from a survey in ISNAR (1987) that accounted for 169 of the 210 research staff then. (***** – other seeds include sesame, sunflower, groundnut, castor, safflower; **†** – other departments include livestock, research/extension, socio-economics, agricultural engineering, administration, and basic departments like soils or entomology).

Commodity	Person years	% total
Maize	6.6	3.9
Sorghum	**5.8**	**3.4**
Wheat	3.3	2.0
Teff	2.7	1.6
Barley	2.5	1.5
Oats	0.1	0.0
Other cereals	3.5	2.1
Oilseeds (mainly *noug*)	5.3	3.1
Other seeds *****	3.7	2.2
Faba bean	1.8	1.1
Soybean	1.2	0.7
Haricot bean	0.8	0.5
Field peas	0.7	0.4
Chick peas	0.5	0.3
Other pulses	4.7	2.8
Vegetables	3.8	2.2
Roots & tubers	3.7	2.2
Fruits & nuts	3.0	1.8
Spices	0.5	0.3
Other Horticulture	4.1	2.4
Coffee	8.1	4.8
Fibers	5.1	3.0
Other **†**	**96.8**	**57.3**
TOTAL	**169.0**	**100.0**

Both AUA and IAR have relatively recent histories, but have been exposed to diverse external influences and have experienced changes in their organisational structure during this time. Sorghum breeding, which moved from AUA to IAR, has also been affected by these influences and changes. The following sections explore sorghum breeding, and its impact, in some detail.

3.5 Sorghum Improvement in Ethiopia

3.5.1 Early efforts before ESIP

Sorghum improvement started in the late 1950s at both Alemaya and Jimma Colleges (Ketema B., *pers. comm.*, 1998). Small numbers of FVs collected locally were evaluated along with foreign introductions for local adaptation and agronomic performance (College of Agriculture, 1958; Damon, 1962). Details of early germplasm collections by Ethiopians are scarce, but records of Ethiopian sorghum accessions in the US genebank date from the 1940s

(Table 3.10).[34] The close ties with the USA at that time would suggest that most US collections were duplicated for their Ethiopian hosts. Table 3.10 indicates that most pre-1968 sorghum collections were opportunistic rather than systematic, gathering a small number of accessions from the vicinity of Jimma and Alemaya Colleges, or from markets or roadside communities, mostly in accessible parts of the country. US collectors also facilitated access to exotic sorghum accessions. For example, Kenneth O. Rachie, who was collecting sorghum from India and Africa for the Rockefeller Foundation at the time (House, 1985) brought sorghum lines from India to Alemaya in 1960 (College of Agriculture, 1960).

Table 3.10 All sorghum germplasm in the US collection collected from Ethiopia between 1940 and 1980, with the number of accessions, calculated from the US national plant germplasm system (Agricultural Research Service, 2001). (* US Department of Agriculture, Agricultural Research Service)

year	No. lines	Supplier and affiliation	Provenance and remarks
1944	29	E. Brandes, US Bureau of Plant Industry	Mainly sweet-stalked types from locations in East (near Harer) and centre (near Addis Abeba)
1944	21	Ethiopian government	Mostly from the East, near Harer
1945	2	A. Semple, USDA	Near Dessie in northern highlands
1951	55	J. Archer, USDA-ARS*	Mainly samples from markets or from near urban centres throughout central Ethiopia
1955	2	J.L Stephens, USDA-ARS	Market in Addis Abeba
1958	1	H. Murphy, Oklahoma State U	East Harerghe (near Harer)
1959	12	Alemaya College of Ag.	Mainly from Gambella in south-west
1959	1	Pioneer Hi-Bred	From city of Jimma
1960	51	K.O. Rachie, Rockefeller Foundation	Mostly from Alemaya's East Hareghe collection, with some market samples from Jimma
1961	20	J. Harlan	Mainly market collections near urban centres
1961	3	US Operations Mission	East Hareghe collections (near Harer)
1961	87	Texas A&M University	Dire Dawa nursery (Alemaya lowland collection?)
1962	77	K. Kofoid, Kansas State U.	Unknown
1964	3	Oklahoma State U.	Unknown
1965	40	New Mexico State U.	Unknown
1967	12	C. Smith, US Crop Research Division	Market samples, mostly from Addis Abeba in centre and Asmara in north
1968	1240	K.O. Rachie, L. Peters, B. Leese, and Alemaya College	Covered entire country, including Eritrea and Humera in north-west
1969	1	Q. Jones	On road near Jimma in south-west
1971	1	A. Taylor	South-east of country
1980	2414	Berhane Gebrekidian, via CIMMYT	Entire country; backup of ESIP collections numbered ETS 2000 and up

In 1968, Rachie was involved in probably the most extensive Ethiopian sorghum collection to date, with some coverage of most regions of the country. Along with what the Ethiopians had collected themselves, this helped Alemaya's collection of sorghum materials grow to 1800 Ethiopian and 700 exotic accessions by 1973, though this collection was neither systematic nor well-documented (Gebrekidan, 1973). However, this was norm in most

[34] In contrast, the CGIAR database, SINGER, only record material transfers from the mid-1970s.

countries before genetic resource activities became more formalised in the 1970s and 1980s (Pistorius, 1997).

Despite observations from the outset that local FVs usually out-performed exotic materials in the highlands (e.g. College of Agriculture, 1962), exotic sorghum accessions continued to be screened well into the 1970s. This reflected an underlying view that "all, or nearly all, of the [Ethiopian] sorghums are tall and very late in maturing…it has been demonstrated that short dwarf sorghums will out-yield the tall varieties" (College of Agriculture, 1960: 24). In 1962, Alemaya College released *Kulubi Dwarf*, a short MV for the surrounding highlands. However, farmers preferred tall varieties for stalk and leaf biomass, and *Kulubi Dwarf* "did not take long to disappear" (Gebrekidan, 1973: 444). Thus, by the 1960s, a 'dwarf narrative' was already well-established in Ethiopia, a view that breeding should focus on exotic, fast-maturing dwarf material with high potential grain yield. Experience in the US and the Green Revolution with dwarf wheat and rice reinforced this narrative (see Richards, 1997). A preference for dwarf sorghum persists in ESIP's lowland breeding, despite repeated evidence that farmers seek traits other than grain yield, and particularly value biomass. The persistence (in policy) of this fast-maturing dwarf 'ideotype' is a key instance of path-dependency in breeding, with relevance for breeding reform.

In 1966, the National Crop Improvement Committee (NCIC) designated Alemaya as the national headquarters for sorghum improvement. Throughout the 1960s, sorghum was evaluated mainly at Alemaya (Gebrekidan, 1982b). Brhane Gebrekidan, who joined Alemaya's faculty in the early 1960s (College of Agriculture, 1962), eventually became Ethiopia's principle sorghum breeder. By 1972, he directed Alemaya's Plant Science department (College of Agriculture, 1972). Brhane helped establish National Yield Trials (NYTs) for sorghum between 1969-71, expanding evaluation beyond the Alemaya area (Gebrekidan, 1974). The NYTs sent seed to eight locations nationally, both commercial farms and research stations. Only two sites besides Alemaya produced any data (one of them from irrigated plots on a commercial farm); all other sites failed due to pests, drought, or waterlogging (College of Agriculture, 1972). This underscores the difficulties of an essentially *ad hoc* crop improvement system: without guidelines and training support, many data were lost. The establishment of ESIP in 1973 eventually formalised trials, as well as freed Brhane (and others) from teaching duties to concentrate on sorghum improvement full-time.

Thus, early work in sorghum improvement concentrated on domestic collections, foreign introductions, and testing. However, the need for a more systemic approach was clear. International ties brought germplasm, but also influenced crop development objectives, as seen in the emphasis on dwarf sorghum types.

3.5.2 ESIP's development

Formation

Canada's International Development Research Centre (IDRC) wanted to support a fully-fledged sorghum breeding programme in Ethiopia as a means to improve food security in the country, and to co-ordinate sorghum development across East Africa. ESIP was established in 1973, in co-operation with both IAR and Alemaya College of Agriculture. IDRC spent nearly CDN$1m (US$750 000) supporting ESIP over three phases from 1973-82, funding personnel, equipment, training, and travel (Yemane and Lee-Smith, 1984). Alemaya (and later IAR) contributed facilities as well as some personnel (Gebrekidan, 1975).

In its early years, ESIP was based at Alemaya and focused mainly on highland sorghums. The first phase laid the foundations for expansion to a national scale, with staff training, more systematic collection and screening, and the start of a programme for making crosses. These activities intensified in ESIP's second phase, starting in 1976, and work expanded to include the lowlands. The programme started to develop parallel highland and lowland activities, and chose six research stations for help its expansion. ESIP headquarters moved to Melkassa, a newly-established IAR centre, located 100 km south-east of Addis Abeba near the city of Nazret. Melkassa's central location has far better transport and infrastructure links than the relatively remote Alemaya campus, the move was somewhat controversial since sorghum is not a very important crop in the Nazret area. Two small sub-stations – Kobo in North Wollo, and Miesso in West Harerghe – were established in ESIP's second phase to represent the dry lowlands along with Melkassa. A station at Arssi Negele was chosen to complement Alemaya in assessing sorghum in the 'high potential' highlands. Again, this site was selected more for accessibility (to Melkassa) than for its importance as a sorghum area. Finally, Melka Werer, an irrigated station in the arid Awash valley, became the main off-season nursery (Gebrekidan, 1982a). In the 1980s, ESIP defined a third macro-ecology for sorghum breeding, at intermediate elevations. Stations at Pawe and Bako, both in the west, were chosen for mid-altitude work. These eight centres remain ESIP's main breeding locations to this day (see Figure 3.3). The third and final phase of IDRC funding (1979-1982) smoothed the way for IAR to take over ESIP, and it has been co-ordinated and financed by IAR (now EARO) since then. Though IDRC had originally hoped that ESIP would co-ordinate sorghum breeding across East Africa, the focus remained national in the end, as Ethiopia was deemed to be challenge enough (Yemane and Lee-Smith, 1984).

Training

A key goal of IDRC support was to develop national capacity, training a cohort of skilled workers for the breeding programme. From its inception, Ethiopians carried out nearly all ESIP activities (Gebrekidan, 1975). Four outstanding Alemaya graduates were sent between 1974 and 1976 to North America for post-graduate training. Unfortunately, this period coincided with the Revolution, and only one (Yilma Kebede) returned to Ethiopia, constraining ESIP's expansion plans.[35]

ESIP staff recruited 18 high-school graduates as Technical Assistants (TAs), and developed an ambitious training programme for them in Ethiopia (Gebrekidan, 1982a). An early report (Gebrekidan and Kebede, 1977) highlights the scope of this training, listing 42 topics covered in a two-week course, ranging from the programme's purpose, centres of crop diversity, sorghum classification and genetics, and detailed aspects of breeding methods, experimental design, and data collection. The breadth of material was highly ambitious, particularly given the limited time and educational background of TAs. The TAs carry out tasks in remote field stations with infrequent visits from senior staff, and some of the training certainly helped here. However, TAs do not make major breeding decisions, so the purpose of giving all of them an overview of ESIP's breeding objectives, concepts, and techniques would seem to be in building a '*team identity*', forging a common sense of purpose among all staff. As McFeat (1974) argues, small 'task groups' functioning in complex environments need to structure the transfer of information among members in order to function effectively. Shared stories can help build a common sense of purpose. For the ESIP team, operating in complex (and

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[35] However, it should be noted that at least two of the non-returnees have made significant contributions to sorghum development in Africa, with good links to Ethiopian scientists.

politically turbulent) conditions, team identity and communication has been one of its great strengths. With this in mind, we now turn to ESIP's organisation and leadership.

Staff and organisation

By 1998, ESIP had approximately 30 staff, though another 20-30 work part-time on sorghum from technical departments (e.g. agronomy, pathology, entomology). Nine are researchers with BSc or higher (ESIP, 1997). However, there is considerable turnover among research staff: for instance, none of the six listed under breeding/agronomy in 1988 remains a decade later (Menkir and Kebede, 1988).

ESIP's centralised organisation was a response to its expansion in the 1970s. TAs are more or less permanently assigned to the various sub-stations, with senior breeding staff based in Melkassa (though there are efforts to post junior breeders to the sub-stations). Breeders in Melkassa plan all trials, nurseries, and crosses, and send TAs seed packets with detailed instructions on sowing, management, and data collection for each trial. A breeder comes to visit a sub-station usually once or twice a season to evaluate trials and select seed. The Melkassa centre analyses all data, writes reports, and maintains national and international contacts. All available staff, including TAs from some sub-stations, gather every year at the off-season station in Melka Werer to help in making crosses at the off-season nursery. A second annual gathering occurs during the research review process. In the past this may have lasted a month, and was used as an opportunity for training TAs. Presently, research is reviewed over several stages, and the national sorghum commodity research review gathers all sorghum researchers for two to three days in Addis Abeba. All the Melkassa-based breeders usually attend, as do staff from each sub-station (e.g. a senior TA, or, if present, a junior researcher), along with those form other departments and institutes who research sorghum.

This top-down organisation facilitated work on a national scale. A centralised team structure helped manage human resources, since ESIP "could cover the major sorghum growing zones only with two senior staff members and a good supply of technical assistants with high school education only" (Gebrekidan, 1982a: 10). Moreover, the central co-ordination avoided the sloppiness of the earlier *ad hoc* approach, when each testing site took its own approach in national trials. ESIP's organisation inspired praise as "an exemplary crop improvement program…probably one of the very few well-equipped and managed projects in the country" (Yemane and Lee-Smith, 1984: 63-64). Its set-up was the model for IAR teams for other crops, such as teff and durum wheat, and inspired the national crop team approach still in use in Ethiopia.

ESIP's hierarchical structure makes leadership particularly important. The influence of Brhane Gebrekidan, the founding director (1973-82) is still apparent in ESIP's design and activities. He was followed by Yilma Kebede (1983-90), Tadesse Mulatu (1991-92), Aberra Debelo (1993-98), and Erenso Degu, who took up the directorship in 1999.

3.5.3 ESIP's activities

There is no comprehensive list available of all sorghum MVs released in Ethiopia. Gurmu Dabi *et al.* (1998) state that 23 varieties have been released up to 1997, ESIP records lists 30 MVs as released or 'recommended', all produced by ESIP except for *Kulubi Dwarf* (Table 3.11). The section below discusses the main breeding activities of ESIP for developing these MVs, focusing on collection, hybridisation, selection, and testing environments.

Table 3.11 Summary information for sorghum varieties developed in Ethiopia. **Bold** names represent varieties recommended or under production by the ESE in 1998.

Ecology	Variety name	Release date	Days to flower	Height (cm)	Origins and remarks	References
Highlands (>1900 m)	Kulubi Dwarf	~1962			selection from local FV; quickly dropped	(Gebrekidan, 1973)
	Alemaya 70	1978	120-30	250-85	early (pre-ESIP?) collection; promoted near Alemaya by 1972	(Gebrekidan, 1982a)
	ETS 2752	by 1977	130-40	235-85	ESIP collection	(Gebrekidan and Kebede, 1977)
	ETS 601	by 1977			early collection; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	ETS 717	by 1977			early collection; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	ETS 2113	by 1977			ESIP collection; 'recommended' in 1977, quickly dropped	(Gebrekidan, 1975); (Gebrekidan and Kebede, 1977)
	Harerghe coll#4	1996			ESIP collection	Z. Guterma, *Pers. comm.*, 1998
	ETS 4946	by 1982	120-40	255-440?	ESIP collection	(Yemane and Lee-Smith, 1984); (IAR, 1997a)
Intermediate Elevation (1600-1900 m)	Awash 1050	by 1976			early (pre-ESIP?) collection; screened in 1973-75	(Gebrekidan, 1975); (Yemane and Lee-Smith, 1984)
	ETS 3235	by 1977			ESIP collection; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	ETS 2111	by 1977			ESIP collection; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	Bakomash 80	~1980	108-36	200-210	result from cross?	(Yemane and Lee-Smith, 1984)
	Dedesa 1057	by 1983			early (pre-ESIP?) collection	(Yemane and Lee-Smith, 1984)
	IS 9521	by 1983			international (ICRISAT) collection	(Yemane and Lee-Smith, 1984)
	IS 9323	by 1983			international (ICRISAT) collection	(Yemane and Lee-Smith, 1984)
	IS 9302	1983	87-120	130-180	international (ICRISAT) collection	(IAR, 1995)
	Birmash	~ 1989	84-121	130-235	cross and selection	(IAR, 1995)
	BaJi	1997			cross and selection at Bako and Jimma	Z. Guterma, *Pers. comm.*, 1998
Lowlands (<1600 m)	Kobomash 76	1978	77-88	109-140	from pedigree cross of NES-830 x 705	(Gebrekidan and Kebede, 1977);
	Gambella 1107	1976	80-95	120	early (pre-ESIP?) collection; screened in 1973-75	(Gebrekidan and Kebede, 1977);
	76 T1 #14	1977			from cross?; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	76 T1 #19	1977			from cross?; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	76 T4 #416	1977			from cross?; 'recommended' in 1977, quickly dropped	(Gebrekidan and Kebede, 1977)
	76 T1 #23	1979	60-70	110-140	from cross?; 'recommended' in 1977, still popular	(Gebrekidan and Kebede, 1977);
	Melkmash	1979	70-80	109-140	cross and selection	(Gebrekidan and Kebede, 1977);
	Dinkmash	1986	63-90	130-150	cross and selection	(Eshetu Mulatu and Belete, 2001)
	Seredo	1986	65-80	110-140	introduced MV from Tanzania & Kenya, brown-seeded	(Appa Rao *et al.*, 1989); (Eshetu Mulatu and Belete, 2001)
	M36-121	1996		120	origin unknown; widely-promoted	(Eshetu Mulatu and Belete, 2001)
	Aligodder Wodiferejja	1999			origin unknown; in final verification in 1998	Z. Guterma, *Pers. comm.*, 1998
	IS 777	1999			international (ICRISAT) collection; in verification trials	Z. Guterma, *Pers. comm.*, 1998

Increasing diversity: collection and introduction of germplasm

Collection of Ethiopian sorghum FVs was an early priority for ESIP. The 1740 Ethiopian accessions it possessed in 1973 were biased to roads and markets, and represented only a fraction of the diversity available in the country (Gebrekidan, 1973). TAs used local transport to collect throughout the country: "…the most appropriate and meaningful way of collecting Ethiopian sorghums could be only done by Ethiopians who understand and appreciate local traditions, customs, languages, and problems of sorghum growing peoples of Ethiopia…" (Gebrekidan, 1975: 5).

By 1982, the collection had grown to nearly 8000 Ethiopian accessions (Figure 3.2). ESIP's reports convey a sense of excitement over their collections, noting some of the most impressive FVs, and their local names: varieties with high lysine content (*Wotet be Gunchei*: 'milk in my cheeks'), heavy (450g) or long (60 cm) panicles (e.g. *Regim Gembo*: 'long sink'), extremely large seeds (*Bakulai*: 'big as a horse bean'), or with long glumes (*Bishinga Worabesa*: 'hyena sorghum') (Gebrekidan, 1975, 1976a). Initial evaluation was near Alemaya, though a significant proportion (e.g. 17% in 1976; Gebrekidan, 1976b) would not set seed in highland conditions. When ESIP expanded to work in the lowlands, a second evaluation site was added near the present sub-station in Miesso, for evaluation in 1977/78. Stresses (drought, birds, *Striga*) frequently wiped out the lowland evaluation sites, however (Appendix B).

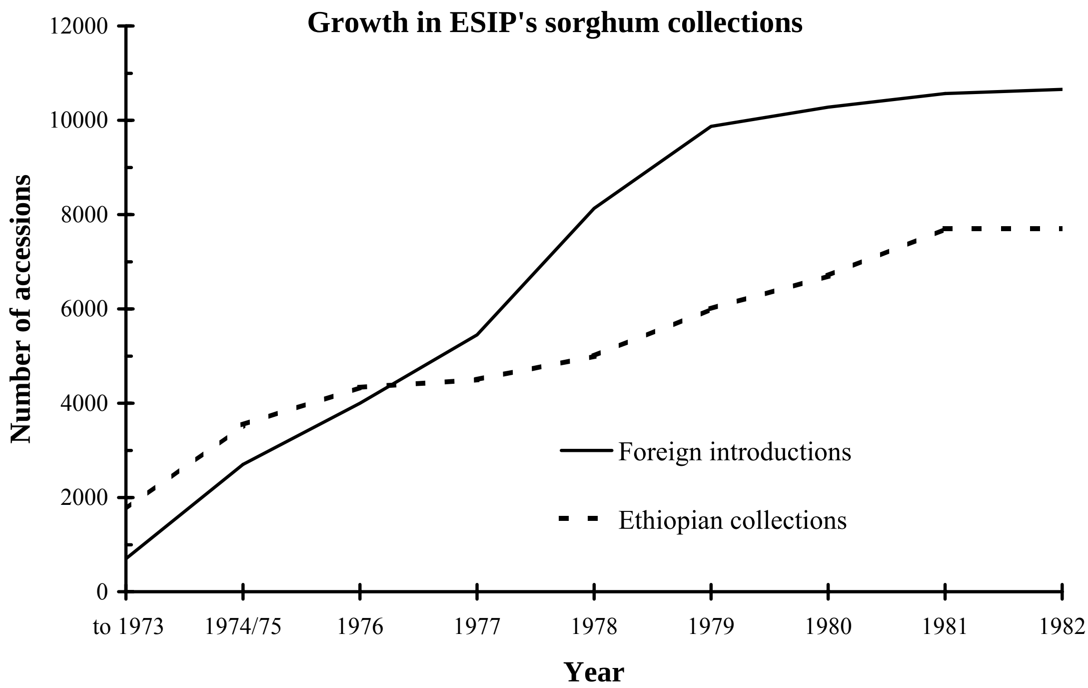

Figure 3.2 The cumulative number of sorghum accessions evaluated during the first ten years of the Ethiopian Sorghum Improvement Project, calculated from ESIP annual reports.

ESIP makes direct use of roughly 5-6% of the Ethiopian collection (Gebrekidan, 1982a; Kebede, 1991). These accessions typically enter either Crossing Blocks to develop new varieties, or Advanced Sorghum Selection nurseries (Appendix B). Selections from these nurseries may eventually be released as MVs: the seven MVs denoted by ETS numbers[36] in Table 3.11 are essentially pure-line selections of FVs. In 1978, the entire collection (then 5700) was transferred to the newly-established Plant Genetic Resources Center of Ethiopia (PGRC/E)[37], who now collect and maintain Ethiopian germplasm (Gebrekidan and Kebede, 1978), though ESIP still occasionally requests and evaluates accessions from the PGRC/E.

ESIP's collection work has had significant international value. Ethiopian sorghums are a valuable source of disease-resistance, food quality, and yield potential traits (Rosenow and Dahlberg, 2000). Many countries have received Ethiopian germplasm, either via bilateral transfers, or indirectly through FAO or CGIAR collections (Yemane and Lee-Smith, 1984). ICRISAT alone has recorded over 10 000 Ethiopian accessions going to other countries between 1976 and 1996 (Table 3.12), and the entire ESIP collection was duplicated in the late 1970s in the USA, as well as in ICRISAT. The USA has made considerable use of Ethiopian material through their 'conversion' programme. This programme started in 1963, and is considered an exemplary case of broadening the base of plant breeding (Simmonds, 1993). By crossing tall, tropical sorghums that are photoperiod-sensitive (i.e. mature normally only at a specific latitude) to a source of genes for earliness and dwarf stature, they can be converted to photoperiod-insensitive varieties that mature quickly, and are short enough for mechanised production. Backcrossing ensures all other original traits are retained. This enables tropical varieties to be readily used in any latitude. Over 10% of the 700 lines converted by this programme are of Ethiopian origin (Agricultural Research Service, 2001). Arguably, Ethiopian materials have been better-used abroad than within ESIP, a point not lost on ESIP's breeders (Geremew Gebeyehu, 1996). This partly reflects the fact that well-financed breeding programmes abroad can afford more careful evaluations, and presumably do not lose as many nurseries as ESIP did. But it also suggests that ESIP may be sometimes too hasty in rejecting Ethiopian materials, particularly if they miss traits of interest to farmers.

[36] The nomenclature used in collection to denote Ethiopian sorghum.
[37] Now called the Ethiopian Biodiversity Institute.

Table 3.12 The top ten donor and recipient countries in sorghum germplasm transfer with Ethiopia between 1976 and 1996, as recorded by the CGIAR (SINGER, 2001). (*****: Material supposedly of Ethiopian origin, requested from ICRISAT in 1978.)

Germplasm from Ethiopia		**Germplasm to Ethiopia**	
Country	**No.**	**Country**	**No.**
India	6405	Ethiopia *****	1049
USA	1670	South Africa	284
Kenya	983	USA	190
Burkina Faso	699	Lebanon	101
Mexico	294	India	79
Somalia	95	Sudan	38
Yemen	85	Uganda	27
Malawi	74	Cameroon	23
Zimbabwe	74	Turkey	17
Argentina	72	Nigeria	12

A great deal of exotic germplasm also came in. By 1982, ESIP had received and evaluated over 10 000 accessions from abroad (Figure 3.2). ESIP specifically requested some nurseries, but many simply arrived as part of regional co-operative trials (see Appendix B). Though Ethiopian breeders did not anticipate finding much useful material in the latter type of nursery, they accepted these in a spirit of collaboration (Yilma K., *pers. comm.*, 1998). While ESIP did seek out material that might be adapted to high and intermediate altitudes in Ethiopia, nearly all foreign material performed poorly in the Ethiopian highlands. They also sought duplicates of Ethiopian sorghum in other collections. In 1978, for instance, ESIP received over 1000 accessions of 'Ethiopian sorghum' from ICRISAT, all of which turned out to be early-maturing dwarf types. ESIP scientists wondered if these accessions had been mis-labelled, or contaminated during long storage. As Seboka *et al* argue (forthcoming), this poor 'traceability' of Ethiopian sorghum in foreign collections is hardly an isolated occurrence, but reflects poor genebank documentation and collection practices that ignored local contexts.

After screening many collections, ESIP eventually focused on Ethiopian sorghums for mid- and highland ecologies, using exotic material mainly as a source of disease-resistance. However, the lowland programme mainly uses exotic material. This strategy continues in more or less the same form today.

Hybridisation

Hybridisation – crossing between different individual plants – is useful for creating new combinations of traits, as all desirable characters may not be found in a single line or FV population. ESIP developed an elaborate and extensive hybridisation programme from its outset, which is quite exceptional for a low-income country, given the technical and organisational challenges involved. A former ESIP director considers the programme's greatest accomplishment to be the development of the skills and working routines to do large scale hybridisation (Yilma K., *pers. comm.*, 1998). Tanzania is one of the few other countries in the region with an extensive crossing programme for sorghum improvement to benefit subsistence farmers, and their work had colonial support when it started in 1948 (Appa Rao *et* *al.*, 1989).[38] ESIP's hybridisation efforts included pedigree breeding, population improvement, and F_1 hybrid production. This section highlights how routines have been established here, as well as some of the narratives that support them, and explores some of the implications for path-dependency in breeding practice.

Pedigree breeding

Pedigree breeding is a major part of ESIP's work. This involves selecting individual parent plants, and making controlled crosses between them. Usually, individual panicles are selected and sown the following season, repeating the process until a genetically uniform line is achieved. Sorghum is (predominantly) self-pollinating, so the variation within one line will decrease over several generations after a cross, and a line usually will be uniform enough to meet formal certification requirements by the 5^{th} or 6^{th} filial generation (F_5 or F_6).

Selection demands organisation and skilled labour. Both male and female organs are in the same floret, thus the seed-parent (i.e. female) plant in a cross must first be emasculated. This is done by hand, and is painstaking and slow; even experienced workers emasculate only 10 to 25 heads a day (House, 1985). ESIP seeks to re-employ the same temporary field assistants each season to minimise the amount of training needed. The timing of controlled fertilisation is crucial, and needs to be done with freshly collected pollen on newly-emerged stigmas. Thus, careful field monitoring and co-ordination are necessary for successful crosses. Detailed note-taking systems are needed to monitor the progress of many crosses, as well as to annotate decisions around the thousands of progeny lines that result.

Nearly all ESIP's breeders and TAs are needed to help in making crosses, working intensively for a fortnight or more each year. Irrigation at Melka Werer station enables this to occur in the off-season, and permits a second generation. The resulting F_2 progeny can then be sent to the stations according to their designated altitude zone, and sown in the following rain-fed season.

ESIP organises its pedigree breeding with Crossing Blocks, which gather lines with similar traits or origins. In ESIP's early years, a typical combination might be a block of mainly Ethiopian highland lines, all of which would be crossed with a block containing mainly exotic lowland lines (Gebrekidan, 1975). Such early combinations were not very successful, however, mainly because exotic sorghums performed poorly, even when crossed to local materials. However, ESIP adjusted its strategy through the early years, and felt that it was improving pedigree performance over time (Gebrekidan and Kebede, 1977).

In ESIP's early days, the scale of their Crossing Blocks reflected their ambition. In 1975, staff planned 1350 individual crosses, succeeding with 810 (60%) (Gebrekidan, 1975); by 1977, nearly 4000 crosses were planned, with 2643 (66%) made successfully (Gebrekidan and Kebede, 1977). Given that one or two scientists oversaw these crosses, along with another 1500 F_1 hybrid crosses, the level of organisation was truly impressive. For comparison, this approached the number of crosses undertaken by the CGIAR's international centres (Witcombe and Virk, 2001). House (1985:96) considers that 500 or more crosses constitutes a "large" developing country sorghum programme. Thus, ESIP was very large indeed in the late 1970s. Reflecting upon this period, a former ESIP director felt that the project "may have tried to do too much" (Y. Kebede, *pers. comm.*, 1998). Certainly, ESIP has

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[38] Two of the only other countries – Botswana and Zimbabwe – had support from commercial farmers. Tanzania's crossing work with sorghum stopped for nearly a decade when the expatriate director, High Doggett, left the region (Appa Rao *et al.*, 1989).

focused its efforts since then: for example, the 1996 Crossing Block planned for 130 pedigree crosses, and made 107 (82%) (Debelo and Gutema, 1997).

The number of crosses in a breeding programme is not necessarily linked to the scale of adaptation, nor to the likelihood of success (Witcombe and Virk, 2001), and ESIP's testing remained very centralised anyway. However, the breadth of ESIP's early activity reflects ESIP's experimental ethos when it was exploring many options (such as exotic highland sorghums, or 'broom' sorghums). Present-day ESIP staff are aware that their predecessors have tried and rejected many strategies, but there is a risk that the current strategy is seen as the best of many possible ones. While accumulated experience has clearly been valuable in informing current work, the assumption that "all has been tried before" can act as a brake on future attempts at reform, and prevent the exploration of different possible ways to organise breeding. In other words, a strategy, once established, can exhibit path-dependency.

Population improvement

Since its founding, ESIP has sought to establish and improve synthetic populations. This involves encouraging random outcrossing among plants to recombine traits, and keeping artificial selection pressure low, which allows stochastic and natural selection forces to shape the population's genetic evolution. This can increase local adaptation through the accumulation of favourable alleles in the population maintains diversity, while maintaining diversity, as long-term studies of synthetic barley populations have shown (Allard, 1990). Such populations can be used for both conservation and crop improvement strategies (Simmonds, 1962; Goldringer *et al.*, 2001; le Boulc'h *et al.*, 1994; Second and Iglesias, 2001), with particular value for stressed, low-input environments (e.g. Ibrahim and Barrett, 2001).

ESIP first developed population improvement for highland sorghums, using high-lysine types (e.g. *Wotet be Ginchei*) it had collected from northern Ethiopia. A single recessive gene, *hl*, controls this trait (Rooney, 2000), which is associated with dented or shrunken seeds, making it also useful as a marker (House, 1985). In 1977, for example, ESIP used 46 of their best highland lines as pollinators, mixing them with 60 high-lysine seed parents (Gebrekidan and Kebede, 1977). They select high-lysine plants with favourable characteristics and 5% plump seeds (indicating some receipt of pollen from other, non-*hl* plants)[39] for the subsequent generation, and the cycle continues. Lowland population improvement started in 1978 (Gebrekidan and Kebede, 1978). Here, male sterility from the ms_3 or ms_7 gene was crossed into lines to enhance their outcrossing rate.

Reports give little indication of concrete outputs from population improvement, though ESIP breeders suggest, in interviews and presentations, that the programme is starting to bear fruit. However, the value of any results depends upon the constituent lines used, and it has been suggested that multiple testing sites with low selection pressure may be the most effective to develop new cultivars (e.g. Veteläinen and Nissilä, 2001). ESIP uses few selection locations, and artificial selection pressure appears fairly intense, at least on occasion (for instance, only13 heads were selected from the highland population in 1996, which suggests a bottleneck; Debelo and Gutema, 1997). However, the potential value of this strategy for farmers is not easily assessed without knowing more about breeders' criteria for selecting 'favourable' plants.

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[39] Sorghum is roughly 5% outcrossing.

The use of high-lysine types for population improvement took advantage of the dented trait, but also reflected donor interest in technological solutions to nutrition. Many nutritionists in the 1960s and 1970s believed cereals with enriched amino-acid content was the best approach to protein deficiency. ESIP's sponsor, IDRC, dedicated an entire division to improving nutrition (IDRC, 1972). Improving protein quality was a key goal for cereal breeding programmes IDRC supported, and they promoted triticale (an artificial wheat-rye hybrid) for its nutritional qualities. IDRC also promoted technological developments in state food enterprises to increase their utilisation of these domestic cereals (e.g. IDRC, 1973a, b; Spurgeon, 1974; Hulse, 1978; Stanley, 1975). However, Waterlow and Payne's seminal review of nutritional research (1975) argued that poor quantity, rather than quality, of consumption is the primary factor in protein deficiency (i.e. malnutrition is linked to poverty and entitlement). Moreover, technological fixes may raise new challenges: for instance, high-lysine sorghum has poor processing quality (Hulse, 1978), and novel technologies still need to fit into complex farming systems and institutions (c.f. Biggs, 1982). Some large programmes for breeding enriched amino acids, such as CIMMYT's Quality Protein Maize (QPM) programme, have been scaled back because of these difficulties (CIMMYT, 1992). Discussions with ESIP breeders suggest that they still see improving the nutritional content of sorghum as an important goal for their population work. While this does not discount that other beneficial traits, such as disease-resistance, may build up, the influence of the 1970s-era narrative about enrichment still seems to linger. As with other dominant narratives (such as in soil conservation; Hoben, 1995), once straegies are established in the thinking and practice of institutions, they tend to be quite robust to change or critique. This shows a certain inertia common to many large bureaucratic institutions such as EARO (IAR), and challenges any reform efforts that seek rapid institutional change. As these goals also influence what germplasm and selection strategies are employed in population improvement efforts over the long term, they show how dominant narratives and institutional structure can lead to path-dependency in breeding itself; to the extent that it is technically difficult or time-sonsuming to switch to different goals, ESIP is 'locked in' to the current strategy (Hogg, 2001).

F_1 hybrid development

The development of F_1 hybrids is ESIP's third hybridisation strategy. A close examination of this strategy highlights how narratives in science, as well as in policy circles, interact with empirical experience from other countries to shape a programme and maintain a strategy, despite some serious questions raised by the local context. The enthusiasm for hybrids is based on specific results, as well as on policymakers' hope that they will induce inward investment into a commercial sector. These views are well-established, and F_1 breeding has become such a routine, that doubts over this part of the programme do not appear to be expressed openly. Meanwhile, the considerable challenges of hybrid seed production receive little mention, a clear instance of how breeding and seed supply are considered separately. This examination of the hybrid programme is intended to bring out how a confluence of factors, both 'technical' and 'socially constructed' can underpin a particular breeding strategy, and how these contribute to resistance to change.

F_1 hybrids are the first generation progeny from a cross. The aim is heterosis or hybrid vigour, where the F_1 out-performs either parent. To retain all traits, F_1 hybrid seed needs to be re-acquired every year from a formal seed source. Appendix C shows the complexity of producing F_1 hybrid seed for sorghum, involving three distinct types of specialised germplasm, careful planting and timing. Breeding these hybrids also involves many test crosses to identify useful combinations of parents. While pedigree breeding has always been ESIP's mainstay, the F_1 hybrid programme is also significant in Ethiopia, requiring time, intellectual effort, and field space. The point of this section is not to quantify the intellectual or material demands of the hybrid work, nor to estimate relative returns-to-effort. Rather, my aim is to consider justifications for the programme, and why these are so influential.

Though F_1 hybrids were first developed for maize in the early twentieth century (Kloppenburg, 1989; Fowler, 1994), sorghum's floral structure made it difficult to produce hybrid seed on a large scale. This changed in the mid-1950s with the identification of cytoplasmic-genetic male sterility in sorghum (Stephens and Holland, 1954). Hybrid sorghum varieties were first released in 1956 in the USA, and covered 90% of acreage within a few seasons, while sorghum yields doubled. However, hybrid sorghum's path to rapid adoption had been cleared by 20 years of previous experience with hybrid maize, which had established networks of seed companies, information channels, and farmers' expectations. Also, increased mechanisation and input-use in the USA in the 1950s accounted for two-thirds of sorghum's yield growth (C.W. Smith and Fredericksen, 2000). However, the idea of F_1 hybrid sorghum as a runaway success became established.

Besides the US experience, there was also some evidence that sorghum hybrids had higher grain yields than conventional varieties in African dryland conditions (Doggett, 1969), something supported in contemporary studies (e.g. Haussmann *et al.*, 2000b; Haussmann *et al.*, 1998). Finally, IDRC and ICRISAT – both key supporting institutions for ESIP – were very positive on hybrids (Hugh Doggett, incidentally, directed crop science at both). Thus, a narrative of success elsewhere, coupled with enthusiasm from supporting institutions, contributed to ESIP's own certainty around hybrids.

> "Advantages associated with hybrid sorghum production in several countries have been written up by so many commentators in so many technical and non-technical papers that it appears unnecessary to go into details of this issue…After careful consideration of the cumulative experiences of other sorghum workers in other countries, ESIP became convinced that hybrid sorghum appears to have great potential in the near future in increasing food production in lowland sorghum zones of the country." (Gebrekidan and Kebede, 1977: 59)

ESIP started a hybrid programme for the dry lowlands early on (Gebrekidan, 1975). By 1977, they had received many male-sterile (A), maintainer (B), and restorer (R) lines from ICRISAT, and from universities in the USA, and had made 1573 test-crosses (Gebrekidan and Kebede, 1977: 59). Many lines are discarded after test crosses, which assess the general combining ability, fertility, and desirability of different combinations of A/B and R lines (which are bred separately) (House, 1985). For example, ICRISAT sent 200 A and B lines in 1980-82, and another 75 in 1986, but none was retained after initial screening (Menkir and Kebede, 1988). By 1979, ESIP had begun replicated yield trials for Initial, Advanced, and Elite Screening of Hybrids. However, early yield results were disappointing, partly due to toxic levels of pesticide residue at the State Farms where these trials occurred (Gebrekidan and Menkir, 1979). More recent trials show high on-station yields (Debelo and Gutema, 1997). Though ESIP has invested in developing its own component lines, adapted to Ethiopian conditions, it is worth bearing in mind that US breeders spent two decades researching the best parental lines and best combinations before hybrid sorghum succeeded there (C.W. Smith and Fredericksen, 2000).

No hybrid variety has been released, to date, in Ethiopia. For whom were these hybrids intended? Mechanised State Farms were clearly important clients, though the assumption appears to be that smallholders in the lowlands would also be interested. However, hybrids have few, if any, advantages over FVs in stressed, low-input conditions, especially if additional seed costs are considered. More crucially, smallholders generally do not prefer semi-dwarf varieties, because they seek traits beyond grain yield alone. International efforts on developing lines for hybrid sorghum have focused on semi-dwarf morphologies for mechanised production. Given this established pathway, and the challenges in developing A, B, and R lines for hybrids, it would be extremely difficult for ESIP to shift to a different morphology for hybrids, even if it wanted to. If, for instance, ESIP were to develop taller, long-cycle hybrids, developing their own A/B/R lines with these traits, and identifying fruitful combinations through test crosses, would require many years' work. Sorghum hybrids are of necessity semi-dwarf hybrids.

Growers – State Farms or smallholders – must obtain fresh F_1 hybrid seed each season, which raises a critical question of seed production. If there were interest in sorghum hybrids, it is unclear who would produce the seed. The Ethiopian Seed Enterprise (ESE) has no lowland multiplication sites, and ESIP has limited space or labour to produce much hybrid seed itself. Ethiopia has recently opened the way for small enterprises to enter the seed industry, but it is difficult to produce F_1 hybrid seed profitably, due to inherent challenges, such as low yields of hybrid seed (Appendix C). Contracting out hybrid seed production would add additional organisational and communication challenges (Vellema, 2002). Despite these challenges, the hybrid breeding programme did not appear to be concerned with seed production, a clear instance of how the institutional separation of breeding and seed supply can obscure problems.

A former ESIP director conceded that he would have changed or scrapped the hybrid programme if he were still in charge, so why is the hybrid programme maintained given its complexity and lack of released MVs? The *Dergue's* State Farms policies provided an early justification, while post-*Dergue* policies for investment help justify hybrids now. One (non-ESIP) scientist suggested that Ethiopian policymakers want ESIP to maintain the hybrid programme to attract investment: "if any potential investor comes to inquire about seed supply, they will always first ask if there is a hybrid programme,". Another breeder noted that the government also seeks private investors to develop former State Farms as commercial enterprises, and some investors may wish to produce hybrid sorghum. A former State Farm, near Arba Minch in the south, has been suggested as a possible candidate, but the breeder thought the interest misplaced, as ESIP's sorghum hybrids performed poorly there. The potential marketability of hybrids (i.e. grain yield, and annual seed purchase) does not necessarily mean there is a ready-made market for them.

Thus the hybrid story shows how enthusiasm over a particular strategy can be based successes elsewhere, yet obscure significant challenges. It gives a clear example of how seed production is treated separately from breeding. The international narrative, reflected in Ethiopia's current policy environment, of hybrids as an investor-friendly, high-yielding strategy continues to support the programme's retention, and limits the space for researchers openly to question the strategy. These narratives, and ESIP's long-standing efforts with hybrids, help embed hybrid breeding within their annual routine, just as the limited specialised germplasm embeds semi-dwarfs as the primary hybrid strategy. Such established narratives, routines, and technologies all contribute to path-dependency in research, maintaining continuity against other forces for change.

Selection

Selection is a key activity when breeders seek the best genotypes by observing phenotypes, choosing which individual plants or lines to retain. As the most obvious point for breeders to determine the characters of an MV, selection receives great attention in breeding theory (e.g. Simmonds and Smartt, 1999; Falconer, 1981), as well as in discussions around breeding reform, particularly so that breeders' choices can better address farmers' needs (e.g. Atlin and Frey, 1989; Ceccarelli, 1994; Ceccarelli *et al.*, 1998; Atlin *et al.*, 2001). Some suggest that a greater general awareness of farmers' criteria is enough to orient selection to farmers' needs. This section considers how the practice of breeders' selection is guided by more than just a specific set of target traits, or selection theory.

Breeders often state that their work is art as well as a science. Though statistical or population genetic theory may inform trial design, the practice of selection is also guided by experience, and by what some call intuition or 'the breeder's eye' (Simmonds and Smartt, 1999; Squires, 1999; Maat, 2001; Duvick, 2002, 1996). There is thus an individual element to selection, something rarely analysed in formal accounts of breeding.

ESIP's stated selection goals for all environments are "better yields and acceptable grain quality" (Gebrekidan, 1982a: 2), with good stand establishment, and resistance to lodging and the major stresses. For the highlands, diseases are the main stress of concern, while birds, *Striga*, and stemborers are the main lowland ones, as well as drought (addressed by drought escape, i.e. rapid maturity) (Tadesse Mulatu and Debelo, 1995). These objectives are set within the context of a technology *package* for farmers, which includes recommendations for fertiliser, herbicide, and pesticide use, as well as management (particularly planting date and depth). Since CADU, such packages are at the heart of agricultural development policy in Ethiopia, as they are in most breeding programmes. Selecting varieties that respond best to optimal conditions can be seen as a way to encourage adoption of the whole input package, "Since improved varieties are usually better able to take advantage of this extra investment, they can thus be regarded as an incentive for farmers to raise their levels of inputs and to improve their management…" (Pham *et al.*, 1989: 205; cited in Cleveland, 2001: 262). Evidence from across semi-arid Africa suggests that improved management of water and nutrients will be necessary for any significant yield gains in sorghum (Ahmed *et al.*, 2000). These views lead to policy goals that emphasise input use for maximising grain production, which influence both selection goals, and the conditions under which selection occurs. However, the question remains whether farmers are interested in higher maximum yields (rather than, say, yield stability), and whether they can obtain or afford the extra labour and financial costs of inputs. The implications of these over-riding selection goals for low-input, low-potential environments are discussed in the next section.

Breeders select on-station, generally working very rapidly with visual assessment. Logistical demands drive the need for haste. Selection occurs late in the season, when all research departments need to go to sub-stations to evaluate trials. Vehicles and drivers are highly limited in EARO, so field trips are tightly planned and often include several researchers with their individual agendas. This means that breeders, who visit several sites, may have very little time for selection at each site. For instance, in 1998, an ESIP breeder had only one and a half working days to evaluate over 900 lines in 15 different replicated trials at the Miesso sub-station, before he moved on to his next station (Table 3.13). These included pedigree selection (F_2 and F_3), evaluation of germplasm for future use in breeding (e.g. lowland sorghum observation nurseries, early white sorghum variety), and trials initially to test combining ability in hybrids or assess hybrid candidate lines (advanced or elite sorghum hybrid trials). As a rule, TAs resident at the station assist the breeder, recording decisions, and offering background information when requested, such as a line's maturity time. Yield is only assessed for lines that reach advanced stages and are being considered for release.

Table 3.13 All trials at Miesso station visited by a sorghum breeder in 22-23 November 1998 for selection, with the number of individual lines in each trial. Trials had 3 or 4 replications, which were often viewed as well (*****: Separate from this, I invited farmers from Melkaa Horaa FA to come view these particular trials, and mark their own preferences.)

Name of trial	No. of lines
Advanced observation, long-maturing sorghum	15
Early White Sorghum variety *****	13
Early red and brown sorghum variety *****	7
Elite sorghum hybrid	6
Characterisation & delineation of sorghum test environments *****	15
Advanced sorghum hybrid	21
F_2 segregating lines	120
F_3 segregating lines	55
Initial screening of hybrids	80
Lowland sorghum observation nursery 1*****	40
Lowland sorghum observation nursery 2*****	32
Combining ability for hybrid grain yield	441
Sorghum variety trial	3
Pearl millet observation nurseries (2)	55
Finger millet variety trials	8

I was able to observe the ESIP breeder making selections in Miesso. The F_2/F_3 lines are still segregating, so rows were not uniform: he moved quickly through these rows, only selecting rows that showed robust, attractive plants, sometimes choosing an entire row to advance to the next generation, sometimes cutting off a few panicles. With the variety and hybrid trials, he again moved quickly to identify lines for retention, and did not always assess every replication. His criteria, based on my observations, and on later discussions with him, included head size, head compactness, seed size and seed colour (i.e. not brown and shrunken). He valued a medium-tall stature (roughly 1.6 - 2 m) with no evidence of lodging, earliness (based on records from TAs or his own observations), and ease of threshing, which he sometimes assessed by trying to rub the glumes off a handful of seeds. For hybrids, lines showing any sterility were rejected out of hand. For the large observation trials, he scanned them equally quickly, selecting roughly one in 20 lines for further assessment.

The breeder worked with a clear notion of how a good plant should appear, a sort of search pattern linked to desirable sets of characters. Most of the traits he sought were components of grain yield or suggested agronomic adaptability. However, this may not always include traits sought by farmers. I had invited groups of farmers to come the previous day and independently mark the lines they preferred for a subset of trials (marked with an asterisk in Table 3.13). From discussions afterwards, these farmers emphasised drought tolerance, and highlighted traits such as high tiller number, waxy bloom on the stovers, and the flag leaf close to the panicle. This suggests yield security is more important than yield potential for lowland farmers.

Testing locations and conditions

The conditions of trial sites, and range of environmental conditions they represent, also influence what materials eventually get selected and released, and affect how well they are adapted to on-farm environments. Breeding for specific adaptation to every possible environment is simply impractical. So ESIP organise and structure national work around three macro-ecologies based on altitude (lowland <1600 masl; intermediate 1600-1900 masl; highland >1900 masl), with separate germplasm pools, trials, and MV releases for these categories. There is a trade-off with number of categories between their fit with local environmental conditions, and the effort needed to have parallel breeding and testing programmes (Packwood *et al.*, 1998). Three macro-ecologies was seen as a manageable number, and their definition was regarded as an important innovation during ESIP's development (Yemane and Lee-Smith, 1984). The choice of stations reflected convenience of location, as well as how well they represented a particular macro-ecology: rainfall in Melkassa, for instance, tends to be more secure rainfall than for most lowland sorghum areas. For other trial sites, ESIP initially worked mainly with State Farms that were able to do so, but now has a set of more regular testing locations (Fig 3.3). These were also chosen for accessibility, as well as for how well they represented particular ecologies.

There is still significant variation within these altitude categories, some of it repeatable. For instance, the west or south-west tends to have more secure rainfall than elsewhere at the same altitude (Westphal, 1975). ESIP staff are well aware of such variation and readily admit to the somewhat rough and ready nature of altitude categories. However, they defend them on the basis of practicality. Recently, EARO has adopted a new and much more detailed agro-ecological classification, defining 18 zones on the basis of rainfall and temperature, and 49 sub-zones according to climate, elevation, topography, soil, land use, and agricultural constraints. My observations from the research planning process suggest that these new categories will be used mainly to describe trial locations more precisely, rather than to re-organise sorghum research. Regardless, whether three or 49 zones are used to organise sorghum breeding, they say nothing about social variation among farmers, which may influence how they benefit from a technology as much as environmental variation.

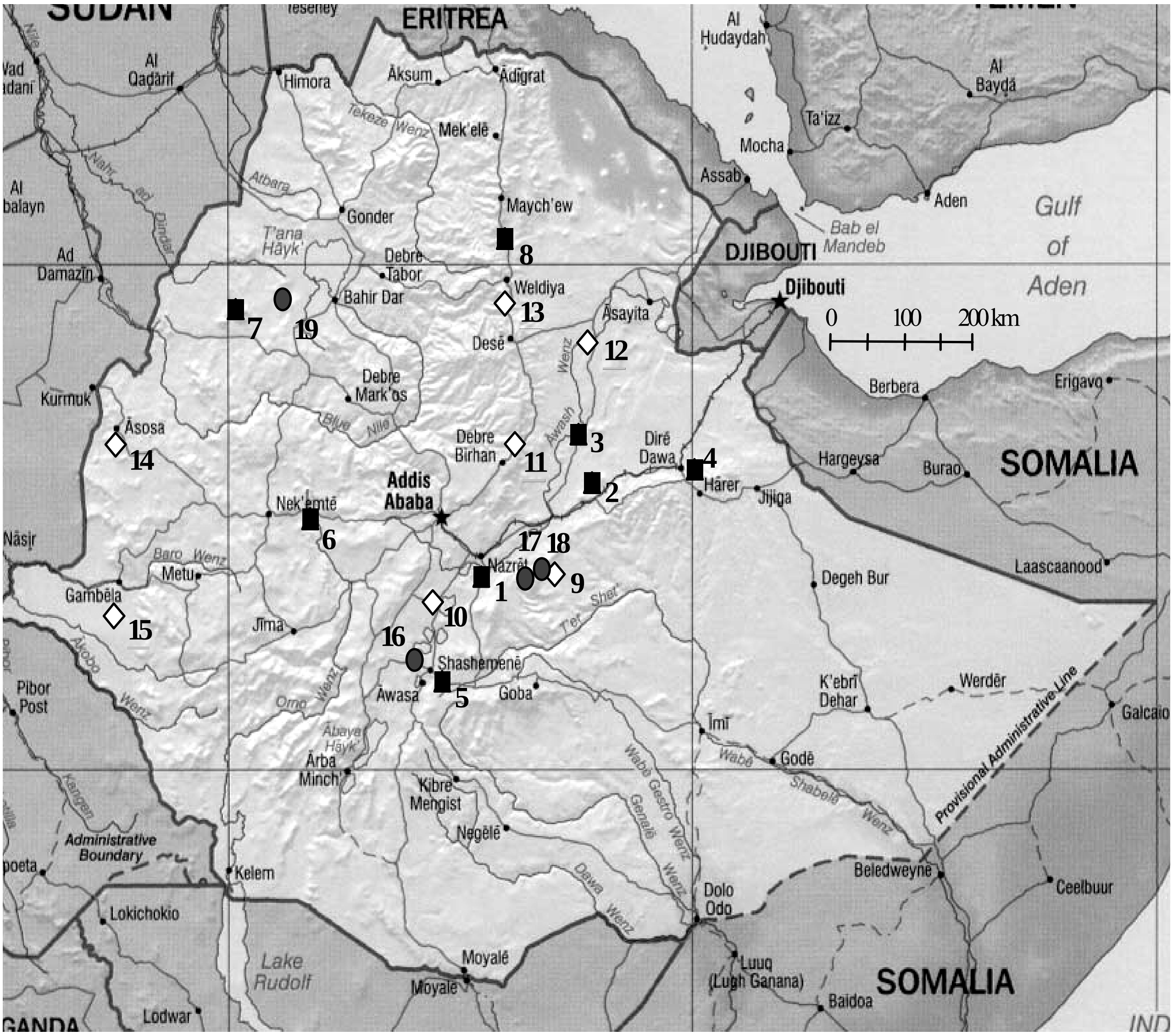

Figure 3.3 Breeding stations (■) and associated testing locations (◊) for sorghum in Ethiopia in 1998, according to data in ESIP (1997). Basic seed farms of the Ethiopian Seed Enterprise (●) based on the World Bank (1995) and Dabi *et al.*(1998). Breeding stations: 1 – Melkassa (Nazret); 2 – Miesso; 3 – Melka Werer; 4 – Alemaya University; 5 – Arsi Negele; 6 – Bako; 7 – Pawe; 8 – Kobo. Other testing locations: 9 – Mechara; 10 – Ziway; 11 – Shoa Robit; 12 – Tendaho; 13 – Sirinka; 14 – Assosa; 15 – Abobo (Gambella). ESE Basic Seed Farms: 16 – Shallo; 17 – Gonde; 18 – Iteya.; 19 – Kunzilla.

ESIP developed standard management conditions for its trials, since pre-ESIP results were neither reliable nor comparable. These management practices corresponded to the ideal management package promoted for sorghum. This specified seeding method (row planting), depth (4cm), inter-plant spacing, inter-row spacing, plant density, as well as timing and rates for weeding and other activities. Brhane Gebrekidan established the standard practices around 1980, and until now they remain the *sine qua non* for any trial: I have witnessed senior scientists in a research planning meeting directly citing Brhane in order to chastise a junior researcher's proposed trial that had incorrect plant spacing. Clearly a standard trial design is essential for generating reliable comparisons, but the point here is that standardised testing conditions have accumulated further meaning, as representative of the management package farmers should adopt, and as a legacy of ESIP's founder in its early years. As such, elements of testing conditions are not easily subjected to probing inquiry. For instance, the 4 cm sowing depth for trials is considerably less than the 10-15 cm planting depth found with farmers across Ethiopia (Goe, 1999). As soil crusting is also common on farms, but not in well-tilled testing sites, seedlings that emerge on-station may not do so on-farm. However, farmers are simply encouraged to follow trial practice and sow at 4 cm, something rather difficult to achieve when using a *maresha* plough.

Some spectacular trial results have emerged from these testing sites and management packages. Grain yields above 6 t ha^{-1} are common, and occasionally 10 t ha^{-1} (Gebrekidan, 1974), or even 11.6 t ha^{-1} (Menkir and Kebede, 1988). While extremely high figures may reflect measurement bias or errors (as an ESIP breeder conceded when shown these results), the less extreme on-station yields are still far above the on-farm average of 1t ha^{-1}. Eye-catching figures acquire an existence of their own, and become widely-cited, while concerns with the data receive less attention, in part because spectacular results offer a tantalising vision of a package's potential (examples in Box 3.1). A trial destroyed by birds or drought can simply be omitted when calculating mean yields, though farmers cannot afford to ignore such events. Formal institutions such as State Farms and the Ethiopian Seed Corporation (ESC) found it hard to reproduce 'optimal' station conditions, or yields approaching these trial results (Yemane and Lee-Smith, 1984). With much less control over inputs or labour, smallholders could not come close. The implications of selecting under optimal conditions is considered in more detail in the section on genotype-by-environment interactions below.

Box 3.1 Influential yield data

- One research report (Deressa, 1988) cited yield gains of 150% from using sorghum input packages, using 0.25 ha on-farm plots, with careful management and regular advice from extension. What the preliminary notes tell, and the final report does not, is that 15 of 20 sites were discarded due to poor results from no rain.
- The early years (1994-96) of the Sasakawa/Global 2000 (SG-2000) package programme produced dramatic yield increases for hybrid maize using input packages in central Ethiopia, seized upon by policy-makers to expand the programme dramatically (Keeley and Scoones, 2000). However, the region is high-potential, and rainfall in the period was exceptionally good. Moreover, these pilot farmers had far more support from extension than normal: close to one for every ten farmers, as opposed to one for several hundred, or thousand, normally.
- For SG-2000 maize packages in eastern Ethiopia (Seyoum *et al.*, 1998), the calculation of a 500% 'technological advantage' from the package does not factor in the use of tractors by participating farmers, even though extremely few smallholder farmers can access, or afford, tractors.

3.6 Enhancing the effectiveness of ESIP: lessons for breeding reform

ESIP is a large breeding programme that has accomplished a great deal in its 30 year history. Its breeders have assembled a large sorghum collection, developed technically demanding breeding strategies for Ethiopia's diverse environments, and promoted production packages for sorghum. Nearly 30 sorghum MVs have been released (Table 3.11), 10 of which are still recommended. Given the challenges of limited human resources, staff turnover, poor infrastructure, and a changing political environment, the fact that ESIP has maintained its working routines and technical capacity is a testament to its organisational structure. Any discussion of breeding reform needs to appreciate these strengths and accomplishments. With this in mind, how do we understand the apparent low impact?

3.6.1 Assessing impact

I found it surprising when I first discovered that ESIP breeders could not tell me the national adoption rate of their sorghum MVs – nobody would even venture an estimate. By comparison, this is essential knowledge for private-sector breeders, as it is a measure of market share (McGuire, 1996). However, researchers in IAR/EARO are not evaluated on the rate of adoption of their technologies. Rather, junior researchers are assessed on their production of research reports (signifying a successful trial) (IAR, 1997b). Promotion to senior research grades does require the researcher to release a technology (or peer-reviewed article), but the uptake or impact of the technology is not part of their appraisal. Uptake is beyond the remit of breeders, and is the task of extension, (what Squires (1999) terms "ordering of events"). Ethiopia's extension service has been weak in the past, and its links to research are poor, so there is little communication between breeders and rural-based agents about farmers' use or views of MVs. Thus, it is small wonder that ESIP has little detailed knowledge on adoption at a national scale.

Some estimates for national-level adoption rates exist, but these vary according to different methods and assumptions. At the high extreme, Hailu Gebremariam (1992) estimated that MVs cover 17% of sorghum area, based on a figure of 1490 t of MV, extrapolated to cover 149 000 ha. How he obtained the figure of 1490 t is unclear: formal production of sorghum MV fluctuates widely from year to year, averaging 630 t a year between 1979 and 1996 (see Fig. 4.2). The extrapolation assumes all available MV seed was sown, while the 10 kg/ha rate is low for smallholders. Field observations suggest 17% is far too high, but the figure has endured in some quarters. For instance, a CIMMYT seed system study cites this figure (Ensermu *et al.*, 1998), as did an FAO project researching sorghum seed supply and diversity. At the other extreme, one can reach a very low estimate using different aggregate data. Ethiopia's Agricultural Sample Survey uses a stratified sample of rural households to arrive at national statistics (CSA, 1997). The 1996 survey concluded that, nationally, only 1960 ha were sown to sorghum MVs, only 0.16% of total sorghum area. There are many problems with this figure as well. For instance, farmers may regard old MVs as 'local' after a few generations, as sometimes occurs with wheat MVs in Ethiopia (Hailye *et al.*, 1999; Beyene *et al.*, 1999). Farmers generally mix sorghum varieties in Ethiopia in the same field. Thus, enumerators would have difficulty identifying MVs in the field, let alone estimating area coverage: 0.16% is probably an underestimate. This nearly 100-fold variation of adoption estimates highlights the problems of extrapolating from patchy data.

Melkassa's socio-economists have produced some impact studies for specific locations, assessing the presence of sorghum MVs by asking farmers to list the varieties they grow. Studies of two areas in northern Ethiopia (Tadesse, 1997; Tillahun Mulatu, 1997), and two areas in central Ethiopia (Tillahun Mulatu *et al.*, 1992; Tillahun Mulatu *et al.*, 1996) found no farmers who were growing MVs. The latter study, in Minjar district, highlighted how poor seed supply contributes to this, finding only one recorded delivery of MV seed to the district, 160kg in 1988/89. By comparison, a survey in the Miesso area (Kefyalew *et al.*, 1996) found that a third of farmers were using MVs that season, covering 9% of the total area. The higher rate in Miesso is unsurprising, as the sub-station there means Miesso farmers have much better exposure than most other farmers to sorghum MVs, and access to seed multiplied at the station. However, these farmers generally only prefer MVs when early rains fail, and farmers in the adjacent highlands barely use MVs at all. Thus, when considering the entire region, and all seasons, 9% still seems an over-estimate. ICRISAT (cited in Maredia *et al.*, 1998) estimates that 30 000 ha (roughly 3% of total area) is sown to sorghum MVs in Ethiopia. Though the sources or basis for this estimate are not given, 3% seems a reasonable estimate for MV coverage, based on my own observations, information from location-specific studies, and the amount of MV seed actually produced (see section 4.3.2). While this figure is indeed low, it is similar to sorghum MV adoption rates in many other sub-Saharan African countries (see Chapter 4).

3.6.2 Understanding low impact – framing questions

Given ESIP's efforts, the obvious question is why is impact apparently so low? Initiatives to reform breeding generally assert – explicitly or implicitly – that poor adoption is directly related to breeders' lack of awareness of farmers' criteria. Following this logic, interventions to reform breeding, such as PPB, tend to focus on improving breeders' awareness of the criteria farmers seek, generally by organising discussion sessions or by inviting farmers to rank which MVs they prefer (e.g. Eshetu Mulatu and Belete, 2001). However, it is too simplistic to suggest that a few sessions with farmers will reorient crop development better to meet their needs, or that this is the best way to improve the effectiveness of crop development. To begin with, breeders are aware of farmers' criteria with sorghum, at least at a general level: for instance, the importance of non-grain traits was highlighted before ESIP started (Gebrekidan, 1973).[40] The fact that ESIP only really began to include such traits in 1998, as conceded by its then director, suggests that "breeders' awareness", and improved communication between them and farmers, may be only part of the issue.

A more fundamental question to ask is: why has the apparent low impact of breeding not precipitated a crisis in the system, leading to a major change in direction? As noted above, breeders are not necessarily aware of national adoption rates, as the 'ordering of events' between breeding and seed supply or extension means that they are not necessarily obsessed with adoption. This leads to further questions about breeding as an institutional practice, and how priorities become established, and sometimes fixed, early in the programme. There was clearly great certainty in the direction ESIP was taking in its first decade "…there was no involvement of the users or farmers in the formulation of the project at any time. There was no survey of farmer problems. [Though] researchers stated that…the principal people involved in the formulation of the project did represent the best interests of the farmer" (Yemane and Lee-Smith, 1984: 62). The reviewers found little assessment of farmers' opinion about sorghum MVs at that time. While Ethiopian agricultural researchers do consult much more with farmers now than they did during the command-and-control climate of the 1970s and 1980s, the overall programme priorities, and its institutional detachment from impact, have changed little since then. To better understand the scope for reforming breeding better to serve farmers, we need to consider breeding as an institutional practice, particularly the role of path-dependency in hindering fundamental changes.

The next section explores the implications of technical and institutional factors on ESIP's practice. Policy goals, stakeholder influences, and assumptions about adaptation all affect

[40] For instance, in Sierra Leone, Malcolm Jusu (1999) asked all research staff at a rice breeding institute to rank what they thought were the most important traits in rice for farmers. Among agronomists, farming systems researchers, and other professionals, the breeders' ranking were the only ones close to those actually given by farmers.

how farmers' needs are considered, and shape the type of MVs developed. ESIP's organisation also affects the way it works. These technical and institutional aspects of breeding contribute to path-dependency, mediating how and where change occurs, and posing challenges for simple interventions to improve breeding impact. This chapter concludes by exploring some of the implications of this for breeding reforms.

3.6.3 Issues from breeding practice

Biophysical challenges to breeding

Sorghum improvement is more difficult than for many other crops. The crop is most important in semi-arid areas which have variable climates and are far from the centre of Ethiopia. In general, remote and ecologically unfavourable regions have few factors to drive development (Wiggins and Proctor, 2001), so it is unsurprising that sorghum growers tend to take low-risk strategies. Across Africa, input use with sorghum is very low (Ahmed *et al.*, 2000), and is lower than for any other major cereals in Ethiopia (Table 3.14).[41] As sorghum breeding assumes the use of input packages, this presents a significant challenge for MV adaptation to low-input conditions, something discussed more below under yield stability.

Table 3.14 Total area sown to major cereal crops in Ethiopia in 1995/96, and proportions with chemical inputs applied, according to Agricultural Sample Survey (CSA, 1997). (*Di-ammonium phosphate fertiliser)

Crop	Total area (000 ha)	% of total area applying			
		Pesticide	DAP *	Urea	DAP + urea
Teff	2097	42.2	32.3	4.1	14.1
Barley	826	6.2	21.2	2.1	1.2
Wheat	882	19.4	31.8	4.3	12.9
Maize	1281	10.7	15.4	2.2	0.7
Sorghum	1252	8.6	1.5	0.7	0.1

The array of pests and diseases affecting sorghum (Tables 2.8 and 2.9) have received less study than those for other major crops (Leslie and Fredericksen, 1995), and wide knowledge gaps remain (Duncan and de Milliano, 1995). *Striga*, in particular, poses serious challenges for breeding resistance, as ESIP noted: "As usual, *Striga* counts showed tremendous plot-to-plot variability, that made visual comparisons extremely difficult" (Menkir and Kebede, 1988: 17). This complicates field assessments for *Striga* resistance, as does the strong interactions of resistance mechanisms with soil conditions and *Striga* biotypes (Haussmann *et al.*, 2001).

The challenges facing sorghum production, and low global investment in sorghum breeding, help explain why annual yield gains globally averaged only 0.4% between 1971 and 1996/97, lower than for wheat, rice, maize, roots and tubers, or even millets (Maredia *et al.*, 1998). For Africa, average yields have actually declined in the last two decades (Fredericksen *et al.*, 1995; Ahmed *et al.*, 2000). This situation should not cause despair for the potential of sorghum breeding, but it does provide some context for the relatively low success of sorghum breeding everywhere. Breeders assume that farmers will apply an input package, but limited

[41] Currently, the MoA is encouraging farmers to increase input use across many crops, but this remains relatively low in most sorghum areas in Ethiopia.

supply channels, and the vulnerability of most sorghum farmers, suggest that few will adopt inputs. Challenges from pests and diseases will require careful identification of stress-resistant materials, as well as improved management strategies.

Stakeholder influences

Whose views have the most influence on ESIP's priorities? ESIP's early years occurred under the *Dergue*, when an authoritarian policy environment made profound decisions on behalf of smallholder farmers, and gave them little real input into priorities. Arguably, large state institutions were ESIP's main clients before 1991: the ESC for seed multiplication, the State Farms for intensive, mechanised production, and the Relief and Rehabilitation Commission (RRC), who co-ordinated the resettlement schemes of the mid-1980s. These organisations used mechanised production, and their opinions on MVs and technologies differed sharply from farmers' perspectives: "One intermediate altitude variety grows 3 ½ - 4 m high, which may be liked by peasants for construction and fuel but is an *embarrassment* to the State Farms because it produces too much *undisposable biomass*." (Yemane and Lee-Smith, 1984: 66, emphasis mine). These large state institutions have long been the main recipients of ESIP MVs (see Fig 4.2). Also, at least during the *Dergue*, they were the main source of feedback to breeders about their varieties and input packages, though this was often *ad hoc*, via meetings and conferences: "Even these organisations [State Farms, ESC, RRC] are not too happy with the frequency and extent of contact of the (ESIP) researchers. The situation is much worse with the peasant farmers" (*ibid.*, 77). The development of ESIP's strategies and priorities may have been influenced by these formal sector stakeholders. At the very least, they reinforced an emphasis on grain yield, and preference for semi-dwarf varieties.

Though smallholder farmers are the stated target for sorghum breeding, they have few channels through which to give feedback to breeders. The Transfer of Technology approach for promoting technologies leaves little space for extension agents to note farmers' views (Dejene, 1989). This approach still dominates, and extension agents, working separately in the MoA, have weak institutional links with researchers (Deressa *et al.*, 1996). As a result breeders have few opportunities to learn of farmers' views from front-line workers, the Development Agents who live in farming communities. Field days on the research station, or on-farm verification trials, do give breeders direct contact with farmers, though these sessions generally provide little opportunity to explore farmers' opinions in detail, let alone explore how social variation among farmers, or their different livelihood strategies, might shape preferences. Some breeders I interviewed stated that they already understood farmers' needs, since they came from rural backgrounds.[42] This is a common enough view among IAR scientists, and has led to general scepticism around the value of researching farmers' opinions in detail. For instance, when Farming Systems Research (FSR) was first promoted in IAR in 1983, multi-disciplinary surveys into farmers' problems were greeted with hostility by some researchers who did not accept that they might need to learn some things from farmers (Mulugetta M., *pers. comm.*, June 1998). FSR efforts have given researchers insights into farming systems in specific locations, but most researchers still know little about how farmers' views of their technologies may vary according to season or social background. Recently, when Mulatu and Belete (2001) sought the views of a range of farmers on sorghum MVs, what they found surprised them.

The policy climate reinforces the influence of large institutional stakeholders. The historical review at the start of this chapter highlighted an enduring authoritarian trend of formal

[42] In Ethiopia, however, this sometimes means coming from a town in the provinces, rather than a farm.

institutions making decisions that affect farmers, and even representing their interests. As Keeley and Scoones argue (2000), only quite powerful stakeholders are able to influence policy, and individual researchers, let alone farmers, have little impact on policy priorities.

Thus, the ability of farmers to influence breeding goals is limited. State institutions for agricultural development are prominent users of ESIP technologies, and tend to emphasise grain yield and dwarf stature. Breeders still have limited interactions with farmers, which afford little space to learn about their varied and contingent needs. A field day can provide a brief farmer assessment of ESIP technologies, but this is not necessarily a representative view, nor one set in the context of farmers' varied livelihoods. As it is, breeders' job demands limit their time and inclination to dig deeper, and so breeding continues with what may be only a partial understanding of how its outputs are viewed by its main users.

Breeding goals and ideotypes

For ESIP, the main goal is grain yield, reflecting over-riding political priorities for production and self-sufficiency in Ethiopia, priorities particularly important for the current government. However, selecting directly for yield is inefficient, since it not very heritable in itself. Thus breeders emphasise components of yield, such as panicle size, head compactness, seed number and seed size. In the lowlands, semi-dwarf, erect plant types are associated with high grain yield. These traits, and others, can come to form a search image for breeders to use when they have to rapidly select among hundreds of candidate lines. Such search-images, linking particular crop appearances to broader breeding goals, have been termed *ideotypes*, following an influential paper by Donald (1968). While some breeders may define very specific traits for selection, specifying morphological, physiological, or phenological characters linked to their ideal plant (Rasmusson, 1991, 1987), most do not define their ideal plant so precisely. However, most breeders have a notion of how a promising variety should appear when they make selections. When asked, the ESIP director agreed that its breeders work with a 'loose ideotype' – a mental image of a desirable sorghum appearance – when they select. However, what is the rationalisation behind the ideal type, and is there scope for negotiation around what traits could be included (Squires, 1999)?

ESIP's emphasis on high grain yield – which farmers obviously also value – can lead to other traits farmers find less attractive. Semi-dwarf stature, part of the lowland ideotype, correlates with thinner stalks and smaller leaves, giving farmers much less valued biomass. Moreover, due to compensation in growth in plants, larger panicles may mean fewer tillers, another trait farmers value as a means to cope with stress.

As it is, social and agroecological variation mean that farmers generally do not seek a single ideal type of sorghum. Rather, farmers in high risk areas usually seek a bundle of traits from a portfolio of varieties, as seen with the on-farm diversity of sorghum on Ethiopian farms (Chapter 6; Teshome *et al.*, 1999). The variability of farmer preferences was apparent when I invited two groups of farmers on separate days to Miesso sub-station to tag the varieties they liked from among 110 different (fixed) sorghum lines in the nurseries. Each group came from distinct villages within Melkaa Horaa FA, with slightly different soils and micro-climates, and numbered around ten farmers. There was considerable variation among individual farmer choices: 40 and 52 different varieties received at least one vote from an individual farmer in the two groups, respectively. Between-community variation was also apparent, as only six of the most popular twenty varieties in one community were found in the top twenty of the other community.

The emphasis policymakers place on grain yield as a goal makes the traits ESIP associates with yield less open to scrutiny. While breeders are aware of farmers' interests in non-grain traits, high grain-yield has persisted as the primary goal, leading to an almost exclusive focus on semi-dwarf, fast-maturing types in the lowlands. Seeking different traits for the lowlands would take time, as existing breeding stocks are semi-dwarf, and new types of materials would need to be screened. These aspects of path-dependency in ESIP's strategies do not completely inhibit change – ESIP has recently started screening long-maturing sorghums for the lowlands – but they do make it more difficult. The question remains about the extent to which ESIP's selection goals can incorporate different traits of interest to farmers, and whether these will prove acceptable to policymakers or other important stakeholders such as seed certification bodies.

Adaptation of MVs to farmers' environments

How well ESIP MVs perform on farmers' fields relates to how breeders approach environmental adaptation, and is an important factor in the programme's impact. ESIP seeks – along with most breeding programmes – stable performance across environments, in other words, yield stability (YS). The challenge for breeders is how to relate a variety's performance in the selection environment (generally a research station) to performance in target environments (the diverse conditions on farmers' fields). However, there is no single view in breeding on how to do this. In part, this is because there are different perspectives on YS, associated with different breeding methods to achieve YS (Lin *et al.*, 1986; Cleveland, 2001; Ceccarelli *et al.*, 1998). In this section, I argue that ESIP's focus on selecting varieties with maximum grain yield under station conditions does not necessarily identify varieties that perform the best in low-input on-farm environments. However, this does not simply reflect wilful ignorance of farmers' conditions, but is supported by a prominent strand of breeding theory on how best to achieve YS. Thus, ESIP's perspective around environmental adaptation has internal validity, with some support from empirical experience, as well as from policies emphasising maximum grain yield. However, there exists another theoretical perspective on YS, drawing on different empirical evidence, which gives more emphasis to the possibility of genotype-by-environment (GxE) crossovers in variety performance. This second perspective suggests that a more decentralised approach is needed to select MVs for farmers' environments, one emphasising the importance of adaptation to specific niches (Ceccarelli *et al.*, 1996; Almekinders and Elings, 2001).

This discussion on how ESIP addresses the logistical challenges of breeding for wide adaptation shows how their practices can be influenced by a particular perspective in breeding theory, one which draws upon certain empirical support, but also reflects policy priorities. Thus, ESIP practices for achieving YS are both socially-constructed, but also reflect (a particular set of) empirical evidence (Cleveland, 2001). This offers another instance of the path-dependency of breeding practice, showing that a few participatory sessions with farmers may not be enough to improve the impact of ESIP. Rather, for ESIP to produce MVs that are well-adapted to farmers' environments, breeders' and policymakers' perspectives on YS may need to be challenged, particularly their consideration of GxE interactions. Box 3.2 summarises the technical roots of the YS debate, showing how different sets of data (i.e. the range of environmental conditions considered) can lead to different perspectives on YS, and different breeding practices.

Box 3.2 Yield stability and GxE interactions: debates from breeding theory

There is more than one way to describe YS across different environments, and there is an active debate among breeders over which type of YS is preferable or achievable. Much of the debate centres on the relative importance of what is termed Type 1 and Type 2 yield stability. This distinction can be seen by a graph that plots the yields of individual varieties across a range of environments, where the x-axis represents the 'environmental mean yield' (the mean yield of all varieties at that location; Figure 3.4). Low values on the x-axis represent low-potential environments (e.g. farmers' fields), and higher values indicate favourable environments (such as research stations). Type 1 YS is defined as having a low rate of yield reduction under poorer environmental conditions. Thus, the most (Type 1) stable variety would have a slope of 0, or the same yield across all environments, one with a slope of 1.0 would have average stability, and a less stable variety would have a steep slope. In contrast, Type 2 YS is defined as having a response to environments that is similar to the average among all varieties being examined: thus, those with slopes nearest to 1.0 have the highest Type 2 YS. However, breeders disagree over which type of YS is preferable (Cleveland, 2001). While Type 1 YS is appreciated, most breeders prefer Type 2 YS, as this gives varieties with good response to inputs across a range of environments.

How does this relate to MVs' adaptation to on-farm conditions? Breeders generally select the best varieties for their target environments from on-station selection environments that are quite favourable (i.e. the higher x-axis values in Figure 3.4). Selecting varieties that perform best under favourable conditions tends to lead to varieties with Type 2 YS (Simmonds, 1991). Many breeders assume that a variety that yields the best in favourable conditions will also be better than average variety under good conditions; this yield gain is called the yield *spillover*. In Figure 3.4, Variety C has the most yield spillover, and could be considered the ideal variety, performing the best across all conditions. This assumption is reassuring, as it suggests that the best variety (Variety C) for all conditions can be readily identified as the highest yielding variety under favourable conditions. In other words, this view supports indirect selection for widely-adapted MVs (Type 2 YS) under favourable conditions on research stations. Widely-adapted cultivars have been developed, such as for wheat by CIMMYT (e.g. Rajaram *et al.*, 1996; H.-J. Braun *et al.*, 1996). However, some breeders argue that such ideal varieties are unusual, and that often the variety performing the best in a favourable environment is not the best in poor environments. This second view highlights GxE *crossovers* for yield, where the rank order among varieties changes with environments. This occurs with Varieties A and B in Figure 3.4; in environments with average yields below about 1.7 t/ha, variety A yields more. GxE crossovers have been described for a number of crops (e.g. Ceccarelli, 1987, 1994; Ceccarelli *et al.*, 2001a; Simmonds, 1984; Atlin and Frey, 1989; Wagoire *et al.*, 1999), including sorghum (e.g. Takele, 2000; Bakheit *et al.*, 1994; Haussmann *et al.*, 2001; Blum *et al.*, 1991). If crossovers are occurring, and target environments are below the crossover point, indirect selection will be less effective than decentralised selection in target environments.

A model for calculating the efficiency of indirect selection (Atlin *et al.*, 2001), shows how spillovers and GxE crossovers are both possible, under different circumstances:

$$CR_T \propto i_S \; r_G \; h_S$$

CR_T is the correlated response for a given trait between the selection and target environments, which is proportionate to i_S, selection intensity, r_G, the genetic correlation of this trait between selection and target environments, and h_S, the heritability of the trait in the selection environment (i.e. the degree that its genetic component can be selected among phenotypes in that environment).

Many breeders justify selection in highly-favourable environments with the assumption that that traits are more heritable under those conditions – i.e. that optimal conditions are best for identifying varieties with high 'yield potential'. A second assumption supporting indirect selection is that genetic correlation for desired traits will be high between environments: e.g. alleles conferring disease-resistance in one environment will do so in another. If both these conditions always applied, a cultivar like Variety C could be easily identified in high-potential environments like research stations, and spillovers would occur across all environments. However, these assumptions are rarely tested. The available evidence is mixed: Ceccarelli (1994) found little difference in the heritability of yield between favourable and unfavourable environments for a range of crops, with heritability sometimes *lower* in favourable environments, as with sorghum in one case (Chisi *et al.*, 1996). Genetic correlation between two environments can also sometimes be low: for instance, a physiological character, such as a rooting pattern, which is adaptive in favourable conditions may be much less adaptive in poor conditions, or may even be counter-adaptive (i.e. r_G is negative) (Ceccarelli *et al.*, 1994). In situations where these assumptions do not hold, the best variety for favourable conditions is unlikely to be the best variety for unfavourable environments, and GxE crossovers occur. This suggests that selection should occur in target environments (i.e. farmers' fields) to identify the best varieties for these conditions. If the patterns of abiotic stresses vary between different areas, selection may need to be decentralised to identify the best set of traits for each location (Ceccarelli *et al.*, 1991).

One reason why some breeders emphasise spillovers and others crossovers is that different ranges of environments are considered (Ceccarelli, 1989; Cleveland, 2001). Many claims from international breeders such as in CIMMYT for wide adaptation and yield spillovers are indeed supported by evidence, as long as 'low-potential' environments are not all that low (e.g. 2t/ha or above). Breeders who work with very low-potential environments (1t/ha and below) tend to find more crossovers, suggesting that part of the debate about spillovers, crossovers, and YS is rooted in what environments and what data are considered. The implication is that if breeding is to take low-potential target environments seriously, it needs to check for GxE crossovers, and consider the possibility of decentralised selection in target environments, to exploit GxE interactions, rather than avoiding them (Ceccarelli, 1996).

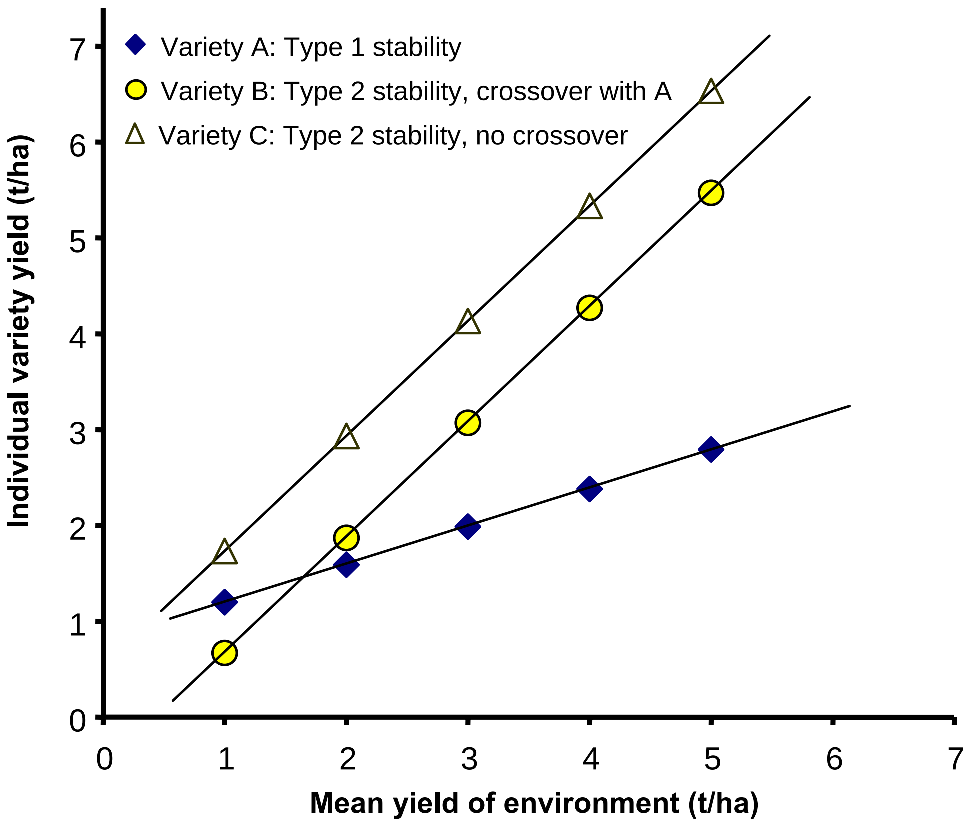

Figure 3.4 Type 1 and Type 2 Yield Stability for different varieties, as shown by regression across different environments, after Simmonds (1991), Ceccarelli *et al.*(1994), and Cleveland (2001)

Though explicit statements on the topic are hard to find, ESIP appears to emphasise Type 2 YS, and ignore the possibility of GxE crossovers. ESIP's stated aim is to select for high yield potential on research stations (>2.5 t/ha ; Tadesse Mulatu and Debelo, 1995: 71), which is well above average on-farm yields of 1 t/ha. Selecting the highest yielding lines under favourable conditions tends to implicitly bias selections to Type 2 YS, as argued by Simmonds (1991). ESIP selects from multiple stations (three for lowlands, two for other agro-ecologies). In many seasons, results from one station will be much worse than the others (due to pests or poor rainfall), but these results may simply be discounted, or decisions about which varieties to advance are made on the basis of mean yields across all stations. Either way, performance at the most favourable station (usually Melkassa), has a strong influence on decisions about which varieties to advance further. Again, this would tend to encourage Type 2 YS, and ignore GxE crossovers. For instance, ESIP reports often show considerable variation among stations in the rank order of varieties' yields, with the worst variety at one station sometimes performing the best at another (e.g. Debelo and Gutema, 1997; Menkir and Kebede, 1988). However, this is not commented upon. Equally, low MV yields in farmers' environments are also discounted, since they did not grow the variety "correctly", that is, by applying the input package. As one breeder said when we passed a field of MVs with poor stand establishment, "look at what the farmers are doing to our varieties!" This reiterates that MVs are developed with an input package in mind, with the assumption that farmers are able to reproduce the conditions under which the varieties were selected, and that it is profitable for them to do so.

As Box 3.2 shows, a school of theory and experience in breeding supports indirect selection, arguing that selection under favourable conditions will produce yield spillovers across all environments. However, very unfavourable environments (i.e. below the crossover point in Fig 3.4) are not often assessed. When low potential environments (typical of on-farm environments for a crop like sorghum) are considered, GxE crossovers are frequently observed. Thus, selecting the highest-yielding varieties under favourable on-station conditions may not arrive at Variety C in Figure 3.4, the 'ideal' variety that performs well in every environment, but at Variety B, which has below-average on-farm. A lack of good comparative data on GxE interactions that includes the lowest yielding environments also reinforces arguments for indirect selection (Cleveland, 2001).

Preferences for indirect selection and for Type 2 YS are also supported by normative policies in agricultural development. Ethiopian policy prioritises grain yield and aggregate national production, encouraging the use of inputs and management packages. However, livelihood security may be de-emphasised as a result. If there is an awareness of GxE crossovers with some MVs, the implicit view is that areas (and farmers) below the crossover point should increase inputs or management, or get out of production (*ibid.*). Yet, for many areas of Ethiopia, markets for inputs and produce remain weak, and farmers are risk-averse in the face of variable conditions and vulnerable livelihoods. Thus, the emphasis on maximum yield may not do much to help livelihood security for the most vulnerable farmers working the most unfavourable environments.

ESIP faces considerable logistical challenges in breeding for diverse environments, and the desire to make use of whatever station produces useable data in a given season is quite understandable. However, this may inadvertently tilt selections towards more fertiliser-responsive varieties with Type 2 YS. More decentralised selection may offer a way forward for low-input, low-potential environments, where farmers and on-farm conditions are used much more (Ceccarelli *et al.*, 2001b; Bänziger and Cooper, 2001). The question remains, how far to decentralise? Trade-offs between effort and coverage of specific environmental niches would always exist, but a different perspective on YS, recognising GxE crossovers and the validity of targeting low-potential environments, could help develop more appropriate MVs for sorghum farmers. A final organisational challenge comes from seed supply: while an ESIP director agreed that decentralised selection was technically possible for the programme, he felt that the formal seed system could not handle region-specific releases. This shows, once again, how other institutions as factors can interact with and influence the methods and design of a breeding programme.

Thus, ESIP's apparent emphasis on Type 2 YS and de-emphasis on low-input environments (and GxE crossovers) may undermine impact of MVs in low-input, high-stress environments. This approach is supported by several factors, including the theory and experience of some other breeders, policy emphasis on high yield, and the practical ease of indirect selection. These social and technical factors contribute to the path-dependency of ESIP's perspective on adaptation and approach to selection. If breeding reform is to explore different approaches, such as direct selection under farmers' conditions, both the technical and policy underpinnings of the current strategy need to be confronted. For instance, evidence on the actual correlation of response between selection and target locations, or on the importance of GxE crossovers, would shed useful light on the effectiveness of ESIP's selection strategies for low-potential environments. However, the value of policies that promote high grain yield and input packages as the only agricultural development strategy also need to be challenged, if selection strategies are to be re-oriented better to serve the low-input conditions of most sorghum farmers.

3.6.4 ESIP as an institution

Any effort to reform breeding needs to understand both why the impact of the existing breeding programme may be constrained, as well as the technical, historical, and social underpinnings of its practices. The foregoing sections analysed some technical reasons for ESIP's strategy, and the origins of its breeding practices. It showed how the choice of germplasm, environmental categories, ideotypes, selection strategies, and agricultural development goals are embedded in the routine practices of the programme, practices bolstered by both technical considerations, and by broader policy priorities. Technical factors, such as the location of a station, the type of germplasm available, and the interaction of genotypes and environments, as well as assumptions within breeding theory, and policy discourses in agricultural development and seed supply help embed these choices. This contributes to path-dependency in ESIP's theory and practice, making changes – such as those proposed by reform initiatives – more difficult to institute. Appreciation of a programme's history, and of how path-dependency shapes its current choices, is essential if any reforms are not to be short-term projects that simply wither and die when donor support ends.

There is an additional institutional dimension to path-dependency (Hogg, 2001). This relates to how decisions are made, and authority established, within a programme. The institutional context of breeding is very poorly understood in most efforts at reform, and barely figures in the PPB literature around re-orienting breeding (Biggs and Gauchan, 2001). Exploring institutional dynamics within breeding practice is a large topic in its own right. However, rather than become mired in ethnographic detail, this final section highlights a few salient institutional features of ESIP – its team structure, and its process for reviewing research activities – in order to identify key lessons and challenges for reform. This 'thin description' (Richards, 2000) emphasises how the breeding team's autonomy, and its hierarchical organisation, shape how decisions are made.

ESIP team structure

ESIP's team structure has already been cited as important in maintaining its complex and demanding suite of activities, spread across multiple locations. As its founding director stated upon his departure from ESIP: "In the interest of the crop at a national level, it is recommended that the existing set up not be disturbed (Gebrekidan, 1982b: 14). The centre of this team, housed in one location, comprised of the senior research staff, namely the breeder(s) and associated specialists. While the TAs were relatively stable in location and composition, the senior group of breeders shifted institutional home early in ESIP's history, from Alemaya College to Melkassa, within IAR, and had considerable turnover, as senior members left and were replaced, and new junior breeders eventually joined. The political context was at times turbulent, yet ESIP has held to its mission throughout. This is not always the case with other departments where I was told there is less of a culture of mentoring newcomers.

ESIP exists as a distinct unit within IAR/EARO, a commodity programme whose senior breeders are based in the same building in Melkassa. It does, of course, interact significantly with the national institution, and particularly with other Melkassa-based research departments. However, ESIP is autonomous when setting about its day-to-day tasks, particularly around breeding strategies, where the breeding team in Melkassa make all decisions to plan and implement breeding activities. This team also takes a leading role in the sorghum commodity programme more broadly. ESIP breeders co-ordinate the annual reports, and organise the various stages of the annual review process for all sorghum-related research (described below). This autonomy is reinforced by its team structure, which, as mentioned, meets annually to conduct crosses in Melka Werer, and organises regular training of all ESIP staff.

Because of its relative autonomy and team organisation, ESIP has its own institutional culture, embedded within the hierarchical culture of IAR/EARO. Mary Douglas and colleagues (e.g. M. Douglas and Wildavsky, 1982; Thompson *et al.*, 1990) argue that the way individuals understand the world is conditioned by institutional frameworks governing the way, for example, disputes are settled. In a hierarchy, for instance, people accept that decisions will come ‘from above’. Hierarchy, as an enduring part of Ethiopia’s bureaucratic culture (Levine, 1965), clearly influences how issues are framed within organisational cultures in that country. ESIP is no exception, as illustrated by the ESIP team’s focus on report-writing (reflecting bureaucratic procedures and priorities of the national research organisation), rather than on adoption rates. But ESIP is also a small team that needs to accomplish a huge series of complex activities every year, under conditions that are challenging and variable (both ecologically and politically). McFeat (1974) analysed how small ‘task groups’ with shifting membership maintain a sense of mission, and solve problems that occur in a dynamic environment. He concluded that the small groups most able to maintain their mission under variable and uncertain conditions tend to remain distinct from larger groups, avoiding the burden of communicating through larger bureaucratic hierarchies, at least when it comes to working through and communicating about their immediate task. This is the case with ESIP breeding strategies: breeders regularly submit reports, and present broad programme goals to colleagues, but the breeding team is left to get on with the details of its day-to-day work. McFeat stresses the importance of central messages within these small groups, and the transmission of these messages (such as ESIP’s mission, its central assumptions and practices) to new generations who enter the group, as a way of maintaining the group’s purpose. He found, through study of native hunting groups, as well as work with experimental groups of volunteers, that small groups mainly innovate around their task early after their formation. Later on, even when no original members remain, a group’s sense of its own purpose tends to change much less, lest it displace tasks and routines established.

I suggest that ESIP’s team structure, and the way it helps it form a task group, is an important factor in ESIP’s path-dependency. While it was highly innovative in its early years, trying a range of strategies with germplasm and breeding approaches (taking advice and germplasm from international colleagues in the process), the programme has settled into a pattern in recent years. Core messages and practices since that period have been retained, despite the complete turnover of staff, offering another reason why elements such as population improvement and F_1 hybrid production go unchallenged. The ‘institutional memory’ that has allowed ESIP to stay its original course amid so much change may also slow course corrections later on. If reform programmes are to introduce new lines of practice in breeding, they will have to find ways to introduce and transmit new messages within these small groups.

Research review process: the team thinking

All research in EARO, including ESIP’s breeding activities, goes through a lengthy review process, where proposals are presented and vetted at several stages before they are approved, and reports of completed work are delivered. The first stage is among a cluster of departments in one station, followed by a review across the station, then a national commodity review, and finally a review across all of EARO. I participated in the departmental review at Melkassa, and the national sorghum commodity review in Addis Abeba.

The first stage, the departmental review at Melkassa, gathered all Melkassa-based staff working on sorghum, lowland pulses, maize, and agronomy for two days in December for detailed presentations and peer review. The most detailed scrutiny comes at this stage of the review process, where specific questions are posed on the project outputs. The commodity stage gathered all breeders, senior TAs from the various stations, and staff from other departments working on sorghum, and lasted three days in February.

This process, though lengthy and time-demanding, does allow different departments to question each other's work (mainly in the earlier stages of the review process), and facilitates exchange between ESIP staff at different stations (at the national commodity stage). As stated above, the core breeding activities of ESIP (germplasm screening, different breeding programmes, yield trials, etc.) did not receive much comment from colleagues outside the ESIP breeding team. However, these meetings did offer insights into the complex interplay between individual researchers of different status within the system, and the centralised, bureaucratic tendencies in the vetting process. Projects from established researchers, and those that were modifications of established practices (e.g. a standardised fertiliser trial, but in a new location) tended to be probed far less than others. Those proposing a new project, especially junior researchers from outside the breeding team, were vetted very carefully. There was considerable attention to proper protocol (e.g. appropriate plot size for the level of trial, number of replications) and correct terminology in the naming a trial (e.g. "Your objective statement, 'to develop superior varieties for testing *on-farm*' implies that this should be a National Yield Trial. If we don't re-word it, this will provoke mockery at the centre review."). The relevance to farmers of a particular research question was less commonly called into question (though it occasionally was). Thus, the presentations, especially by young staff, tended to follow standard procedure, replicate the previous year's report, and employ the usual justifications. There was more than just fear of mockery if procedures were not followed: fines are levied on researchers if their projects are not completed on time. Again, an excellent example of how the institution (in this case, EARO bureaucratic controls) shape thinking and practice.

The exchange between different groups is useful, and can bring in constructive criticisms and new ideas, as was undoubtedly the intention. However, the existence of standard recommendations, set formats for proposals, and rivalries among different researchers can make it risky to suggest new directions, especially for junior staff. The tone of questioning can be robust, verging on aggressive, and the attention to procedure is forensic (reminding me of tedious assemblies in student politics). This can make it uncomfortable for all but the most confident or established researchers to propose a totally new line of work. Most staff thus tend to opt for proposals that fit within established narratives and practices, rather than face challenge at every stage. A few junior staff have expressed frustration to me about how senior researchers manage the process. Moreover, proposals can become almost self-referential, since they are vetted on their ability to deliver an output – a report in the appropriate format – rather than a concrete livelihood benefit for farmers. The nature of the review process, and its capacity to close down new lines of work, suggest that it is also a component of path-dependency in breeding practice.

3.7 Conclusions

This account has attempted to outline some of the accomplishments and challenges that ESIP has faced, placing the programme in an historical context of agricultural development policies and institutions. The chapter shows that, while the programme has had limited apparent impact on smallholders, the reasons for this are complex, relating not just to breeders' practices, but also to assumptions underlying these practices, to established conventions and practices in the international sorghum breeding community, and to the Ethiopian policy context, all of which affect how ESIP works. These factors, as well as the institutional culture of ESIP itself, contribute to path-dependency in its activities and its views. There are good reasons for path-dependency, such as the long-term duration of breeding work, and the need to retain the integrity and mission of a research a group amidst dramatic changes in personnel and policy. Given the challenges faced by ESIP, maintaining an active and complex programme counts as one of its greatest accomplishments. While path-dependency brings continuity, however, it also hinders change.

Often the first recommendation of breeding reform efforts is to increase breeders' awareness of which traits farmers desire, on the assumption that a better knowledge of farmers' criteria is the missing ingredient in effective plant breeding for poor smallholders. However, while well-organised farmer feedback on MVs would be enlightening (Eshetu Mulatu and Belete, 2001), this would, on its own, do little to shift the way ESIP works, or to improve its effectiveness. The above account suggests that the main priority (and challenge) for reform relates to the institutional and policy context in which breeding operates. To bring about lasting change (rather than donor-funded 'modular reforms'), efforts need to consider the role of other stakeholders, confront policy narratives about development goals (especially those emphasising grain yield and input packages above other strategies), and explore how ESIP and EARO, as scientific institutions, can return to a culture of innovation, encouraging different, innovative approaches. The logistical and technical challenges remain real: for instance, decentralised selection would require significant reorganisation of work, while new traits in MVs require long-term investment in developing germplasm. As this chapter argues, complex institutions such as ESIP have well-established pathways of theory and practice, often bolstered by factors beyond the individual breeder. The lasting institutional change that reform advocates are seeking will require more than a few on-station PVS exercises. It will require skilful management by agents who understand the complex and rich institutional culture within which Ethiopian plant breeding is embedded.

Chapter 4 Formal seed supply in Ethiopia: issues and challenges arising from reforms

4.1 Introduction

The previous chapter analysed sorghum breeding in Ethiopia, arguing that both technical and social factors strongly shape its practice, as well as its impacts. This chapter considers what happens after breeding produces a modern variety (MV), examining the processes and institutions that govern how an MV is released, multiplied, and supplied to farmers. These aspects of seed supply, along with extension information, are also an essential aspect of the formal seed system, as important as breeding itself in determining the ultimate impact of crop improvement work. If a breeder develops a promising MV for farmers, this technology may still have little benefit to livelihoods if the variety release committee rejects its release, if there is no effective multiplication of its seed, if the seed delivered to farmers is of poor physical or genetic quality, or if farmers lack the appropriate extension advice and support for that MV. Thus, we cannot fully interpret the activities or the impact of crop improvement by considering either breeding or seed supply on their own.

Seed supply features prominently in agricultural development strategies in the South. Donor emphasis also reflects this: for instance, USAID has supported 50 countries' seed programmes, the FAO has funded seed projects in 60 countries, while the World Bank has financed seed systems in 40 countries in sub-Saharan Africa along (including Ethiopia), spending US $80m in all (Scowcroft and Polack Scowcroft, 1999). However, the view emerging in the last decade is that these formal seed systems have had poor impact, raising questions about the effectiveness, efficiency, or equity of these systems (e.g. Srivastava and Jaffee, 1993; Cromwell *et al.*, 1993).

Reform is, thus, an issue for seed supply for similar reasons that it is for breeding. Like breeding reform, many efforts to reform seed supply also seem to lack a broad analysis of the existing system, and instead build their reforms upon assumptions about system failings. For instance, many reforms emphasise markets and competition, usually assuming that the efficiency of the seed system is the major problem, and that competition can improve this and make the system more responsive to users' needs.

This chapter draws from the critical literature on seed supply, which I use to analyse Ethiopia's formal system, and critique current efforts to reform. The reforms prioritise efficiency, strict regulation, and market forces as key drivers of a responsive seed supply system. Key areas, such as farmers' actual seed demand, or the appropriateness of regulation, seem to be overlooked. In this chapter I argue that a broad enough analysis of the existing farmer and formal seed systems can point to different forms of collaboration between formal and farmer seed systems, and thus suggest new approaches to reform.

Seed supply and extension activities usually occur in separate institutions from breeding, with distinct modes of working. Though some literature explores both issues in parallel (e.g. Almekinders and Louwaars, 1999; Witcombe *et al.*, 1998; Tripp, 1997a), in practice, most projects for reforming breeding give relatively little emphasis to seed dissemination, or leave this for 'scaling up' in a later project phase (Weltzien *et al.*, 2000; McGuire *et al.*, 1999). Treating seed supply as an add-on to breeding reform can miss how these two activities interact in seed systems, and can lower the potential impact of breeding reforms. For instance, a new breeding approach – such as PPB – may produce materials that are unacceptable to variety regulation if they are not sufficiently uniform or high-yielding under specified conditions (Louwaars, 1996b), or a centralised seed supply structure may be unable to supply (or certify) material produced through decentralised approaches. Reform projects that focus first on the breeder-farmer interaction, with little regard for variety release authorities, seed production enterprises, or extension agencies, risk undermining their local achievements, as these latter groups are also important stakeholders that influence breeding goals and strategies. Another reason why it is useful to consider the reform of breeding and seed supply together is that common policy narratives for agricultural development, and similar institutional aspects of path-dependency, can influence both activities, and their scope for reform, in similar ways.[43]

4.1.1 Main questions and chapter structure

In Ethiopia, as in many NARS, breeders point to failings in seed supply and extension as a reason for the low impact of their MV technological packages. This chapter explores this issue, considering how MV technologies are made unavailable to Ethiopian farmers. The focus, though, will move beyond only considering bottlenecks in supply and extension, and will also explore how formal seed supply determines seed demand, and how it regulates and involves stakeholders in this process. This broad framework is used to diagnose how the formal supply and extension system functioned in the past for sorghum in Ethiopia, and to analyse some of the current efforts at reform that aim to make seed and information more available and accessible to smallholders in Ethiopia. These post-*Dergue* reforms are wide-ranging, addressing extension and input supply (Habtemariam Abate, 1997; Ministry of Agriculture, 1998), and seed supply in particular (Medhin and Gebeyehu, 2000). This chapter explores key reform initiatives in seed multiplication, extension, and in seed policy.

Will these reforms effectively address constraints to Ethiopian seed systems? Analyses of seed systems typically emphasise production, and the efficiency of supply. Indicators of system-level performance and efficiency are of interest to donors, and can suggest areas for infrastructure or policy reform. However, while quantitative summaries of seed production, sales, or gross margins (e.g. Kugbei and Turner, 2000) are useful, they say little about actual use by farmers, or the benefits they gain. I argue that the reforms in Ethiopia are based on a more or less market-oriented approach, reflecting the experiences of maize and wheat, crops in the most favourable agro-ecologies. Social and institutional factors also underpin these reforms, resonating with policy narratives about aggregate grain yields, market efficiency, and technological packages, thus reinforcing the path taken by reforms. Farmers grow sorghum in less favourable agro-ecologies, and have their own particular demands for seed and for seed quality. Seed supply reforms that address sorghum, and consider equity as well as efficiency, may need to be different than for more market-oriented seed systems, and require different institutional structures. Thus, the broad approach I take to diagnosing Ethiopia's formal seed supply and extension system raises new questions about seed system reforms. As mentioned earlier, these issues also link in important ways to breeding, and to reform efforts such as PPB.

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[43] The "local participation first, wider dissemination later" approach, common to much farmer participatory research, is increasingly being questioned. For instance, a current research programme co-ordinated by TAO and supported by the Rockefeller Foundation explores (among other aspects of participation) how building plans and provisions for the scaling up of project impacts into the initial design of participatory work may be a better strategy to achieve wide impact.

4.2 Formal seed supply and regulation – elements of a critique

Some historical background to the development of seed supply and regulation internationally is helpful in understanding how these systems have developed in Ethiopia. The section below gives a brief historical context to seed supply regulation, and to how governments tend to view the relation between farmer and formal systems of seed supply.

4.2.1 Origins of seed supply regulations

Regulation of formal seed supply arose in industrialised countries at the end of the nineteenth century, as a means of guaranteeing the physical quality and genetic identity of seeds sold to farmers. Crop improvement was starting to develop as a scientific practice in these countries, and a wide range of the varieties developed by breeders – as well as those selected by farmers or introduced from elsewhere – were being marketed to growers through an emergent group of seed merchants. Concerns about inaccurate labelling of seed packets, copying of others' varieties, or poor seed quality increased pressure for the regulation of the industry. Farmers sought regulation to be sure of the identity and quality of the seed they purchased, as did breeders and (some) seed merchants, so that others could not simply pirate their innovations. Germany was one of the first countries to regulate seed sales, establishing a register of varieties in 1905, which listed the names, morphological characters, and performance results of tested varieties (Tripp and Louwaars, 1997b). Other European countries followed suit in requiring seed of agricultural varieties to be registered or certified, for example Switzerland (1913; Schneider, 2002), and the Netherlands (federal regulations in 1924; Maat, 2001).[44] While the UK did not pass seed legislation until 1964, a public institute began assessing variety performance in 1918, and tried to prevent copies of established varieties from being marketed (Palladino, 1990). In the USA, state seed laws began to appear in 1897 (Fowler, 1994), and Federal laws from 1939 (Kloppenburg, 1989).[45] This regulation generally resulted in certification of the identity, quality, and physical purity of seed. Regulation was driven by two main goals: giving farmers assurance of seed physical and genetic integrity, and the orderly development of a commercial seed industry.

Similar goals to protect farmers have also influenced seed regulation in the South, and many countries in sub-Saharan Africa (SSA) have invested in developing a seed sector, assuming that it would become a driving force in rural development (Bay, 1999). Public sector and parastatal enterprises have dominated formal seed supply in SSA until quite recently (Tripp, 1997b), though NGOs are sometimes involved at smaller scales (Cromwell *et al.*, 1993). However, changes in the financing of agricultural research and development since the 1980s (Alston *et al.*, 1998) have reduced funding for many seed parastatals. A number of public seed enterprises have been privatised in SSA, or encouraged to permit the involvement of private input suppliers as well (Cromwell, 1996). Farmers' seed systems still supply the vast majority of seed to SSA farmers, and the private seed sector is much smaller there than in countries such as India (e.g. Pray *et al.*, 1991; Tripp and Pal, 2001), but governments and donors alike seek to increase private sector involvement in SSA seed supply.

The idea that farmers' seed systems will be completely supplanted by formal ones is central to Green Revolution notions of modernisation. Pray and Ramaswami (1991) made this idea explicit by outlining four 'evolutionary' stages of seed systems, starting with farmer selection

[44] Interest in seed quality in these countries started well before legislation: both Swiss federal government and Dutch farmer groups were organising seed fairs from the 1880s to identify and promote 'quality seed', and Dutch provincial agricultural societies organised seed inspection committees from 1903 (Friesland) (Schneider, 2002; Maat, 2001).
[45] However, Kloppenburg (1989: 135-151) points out that US seed merchants blocked efforts in the 1960s to make the registration of varieties compulsory.

and seed supply, and ending with a final 'mature' stage when the private sector breeds and supplies most MV seed (which is widely adopted), leaving the public sector to concentrate on minor crops. Indeed, some donors and bureaucrats place entire national seed systems at a particular evolutionary stage, and many emphasise policies and initiatives to move the system along the continuum towards the "modern, mature" end. However, as Tripp (1996a) points out, complex national seed systems can rarely be characterised in such a straightforward manner, as the presence of breeding and input supply (public or private) varies enormously between crops and agro-ecologies. As I show for sorghum in Ethiopia, such variation can lead to a disjunction between the goals for national reform, and the realities of a specific crop and region.

This historical overview is too brief to explore complexities such as the variation among SSA countries (FAO, 1999), or the ways in which 'public' and 'private' categories can become blurred in Southern seed systems (e.g. through joint ventures) (Tripp, 1997b). Rather, the point here is to highlight how seed supply in the South is rooted in the desire of state to protect farmers and foster development and modernisation. Such desires and narratives – particularly that of an 'evolved' (i.e. modern) seed system – continue to exert strong influence on seed supply systems and reform efforts.

4.2.2 Challenges for formal seed supply

This section outlines a framework for understanding some of the difficulties formal seed supply and regulation faces in the South, drawing upon a number of crops and locations. A general overview is helpful to set the problems and issues faced by Ethiopia in a wider context, and shows that the country is hardly unique in having these difficulties. This framework draws upon recent critical literature, and considers challenges in producing and supplying seed to farmers, in predicting and meeting their seed demand, and in regulation.

Production and supply

A major challenge for formal seed supply is to produce sufficient seed of all varieties needed, and deliver it to farmers in a timely manner. This requires considerable organisation, time, and space, and incurs risks due to costs and production. To start with, significant area and effort is involved in seed production, though this varies by crop according to its multiplication rate (i.e. how much usable seed is produced per seed sown). For instance, beans multiply more slowly than maize (Table 4.1), and farmers require more bean seed per hectare, due to its high sowing rate. To illustrate for sorghum, to sow 100 000 ha to MV sorghum, at least 1000 t of seed is required (using a conservative seeding rate of 10kg/ha, well below farmers' typical rates; see Chapters 7 and 8). To produce that much seed, between 10 and 20 t of seed would need to be planted the previous season, after accounting for losses to cleaning and other quality control measures. In turn, several hundred kg of seed would need to be sown the season before that, to multiply this 10-20 t. These projections all depend on the stability of yield on the seed production farms. Since it takes several seasons to multiply enough seed for large-scale release, a poor season can throw off projections considerably.

Table 4.1 Biological features of some crop seed with respect to their rates of production and purchase, based on Cromwell's (1996) framework, modified with data from Louwaars and Marrewijk (1996) and the author. (§: Seeding rates as commonly recommended; * multiplication rate in seed production is the net seed yield per seed planted, after cleaning and quality-control, representing the range of figures provided by the above two published sources).

	F_1 Maize	**OP maize**	**Wheat**	**Beans**	**Teff**	**Sorghum**
Breeding system	Controlled cross	Cross pollination	Self-pollination	Self-pollination	Self-pollination	Intermediate
Sowing rate (kg/ha) §	15-25	15-25	70-100	100	35	5-10
Multiplication factor *	100-200	70-150	12-60	8-50	High	47-100
Genetic deterioration	Very rapid	Rapid	Slow	Very slow	Slow	Medium
Recommended replacement frequency	Annual	2-3 years	5 years	Variable	5 years	5 years
Justification for purchase	Essential	Good	Poor	Poor	Poor	Variable

In formal seed production, seed multiplication occurs through several generations rather than continually recycling the seed of one generation, to avoid building up physical or genetic contamination over time in the same lot of seed. Most systems use a recognised nomenclature for each generation, starting from Breeders' Seed (Box 4.1). The progeny is multiplied over several generations, producing ever greater quantities, to arrive at Certified Seed, the seed class supplied to growers. Controls aim to maintain quality for each generation of seed, with weeds (e.g. wild sorghum) carefully rogued along with diseased plants and off-types, the harvest dried, cleaned, and sometimes dressed (treatment of the seed-coat for storage), which adds to the costs and lowers the amount finally available. The supply of Breeders' Seed is a common supply bottleneck – this is typically maintained by breeders, and must be of the highest quality and purity. Though relatively small amounts are needed at this stage, breeders have little incentive to maintain this seed, often seeing it as a 'routine' task, and supply for further multiplication can be limiting (Louwaars and Marrewijk, 1996). Also, unlike for Certified Seed, Breeders' Seed is usually not tested for quality or purity.

Box 4.1 Classes of seed, and nomenclature used in generation control of seed production, with official names of the Organisation for Economic Co-operation and Development (OECD), after Cromwell (1996) and Chopra (1982). (* not officially mandated in Ethiopia)

Generation	Class Name	Comments
1	Breeder	Produced and maintained by breeders, should be to highest standard of physical and genetic purity, though details of this usually no specified.
2	Pre-Basic	Also usually produced by research centres in Ethiopia.
3	Basic	Produced at ESE-managed Basic seed farms. Called "Foundation" seed in US nomenclature. May be regulated for purity standards in future (for example, India specifies Basic seed must be at least 99.5 % pure ; Chopra, 1982).
4	Certified	The class sold to farmers, produced from contract farms.
5	Certified 2 *	Sometimes used to refer to subsequent multiplication (e.g. by farmers in a decentralised supply system).

The purpose of such seed classes is to maintain purity and quality by ensuring the purity of early generation material, particularly Breeders' Seed, which is usually maintained in smaller amounts. All Certified Seed is produced from Breeders' Seed, though this takes several seasons to multiply any significant amount of material, and a request for a specific variety may face delays if that variety is not already in the multiplication pipeline.

The costs and risks associated with this seed production pipeline can be high. Kugbei (2000) highlights environmental risks (yield variation, rejection in certification, storage loss), market risks (fluctuations of price and demand), and human risks (relationships with contract growers, poor management decisions), among others. Co-ordination of contract farmers add considerable organisational challenges, as well as costs, especially if seed-producing farms are highly dispersed. As Vellema found (2002), such combined technical and social challenges give rise to significant uncertainties in contract seed production. Moreover, seed enterprises frequently misjudge demand for specific seed varieties in a given year, leaving them with insufficient stock on hand, or a surplus to carry over to the next season, which can lose quality after storage. Estimating actual demand is not helped by typically poor communication links with organisations working directly with farmers (Cromwell, 1996). These costs and risks are compounded by the difficulties of supplying this seed to remote locations, via limited infrastructure.

Public-sector seed systems often are mandated to supply a wide range of crops and varieties to an entire country. Therefore, while public-sector seed supply organisations are commonly labelled inefficient, this needs to be understood in context. Up until a few years ago, this sector dominated formal seed supply in most African countries, and decades of donor support and regular government subsidies, have meant that public seed enterprises rarely needed to confront their considerable costs, and establish cost-effective approaches. It also does not help that the CGIAR has closed or has sharply scaled back the work of its Seed Units, restricting one avenue for NARS to gain training on less expensive protocols for seed multiplication (Scowcroft and Polack Scowcroft, 1999).

Even with this context, the failure of conventional public-sector seed supply is dramatic. Tripp and Rorhbach (2001) found no examples of full cost recovery in Africa, and point out that there is little to show for the decades of public investment: "Trained staff move on to more remunerative positions, laboratories are not maintained, seed production estimates are grossly inaccurate, seed production costs are higher than sales revenues, and farmers remain largely unaware of most new varieties." (150) However, as Cromwell (1996) found, improving financial *efficiency* in African seed enterprises, whether public or private, can come at the cost of lower *equity*. Important crops for the poor, such as beans or pumpkins, were dropped entirely, since they have low multiplication rates, and farmers do not need to purchase seed annually (Table 4.1). If profitability is the main concern of seed enterprises, she found, they would do best to concentrate on hybrid maize, which multiplies quickly and needs annual repurchase. Thus, formal seed supply faces challenges in securing sufficient seed production, limiting costs and risks, and ensuring distribution, challenges whose origins are both environmental and social. In particular, the certification system, while aiming to protect purity and quality, is expensive and lengthy. Reforms can offer trade-offs between economic efficiency and equity (or diversity), but some reform efforts try to address these challenges through different institutional organisation and relationships in seed supply, as we shall see later.

Farmer demand for seed

The nature of farmers' actual demand for MV seed poses perhaps a greater challenge to formal seed supply systems than any difficulties associated with supply or distribution. To begin with, farmers' actual demand for seed from formal supply channels is often poorly understood. Whether for FV or MV seed, farmer demand from formal channels can be quite low, since:

- formal supply may not offer crops or varieties that farmers desire (particularly low-input farmers)
- farmers can also obtain seed from other sources, including their own harvest, neighbours, or informal markets,
- farmers cannot easily assess the physical quality or genetic value of seed just by looking at it: its value is only proven long after purchase, and may disappoint in the end
- the package size for formally-supplied seed is often too large for use by small farmers.

Understanding the costs to farmers helps explain the nature of their seed demand: even if MV seed were proven valuable, farmers may only want it if the cost were below that of seed from other sources. Along with high supply-side transaction costs (e.g. for transport and storage), demand-side transaction costs are also high, including the costs of learning about the performance of an MV, and the risks to farmers of poor quality material. This lowers actual farmer demand even more. Thus, formal seed supply for many crops in Africa shows signs of market failure (Cromwell and Tripp, 1994; Cromwell, 1996).

Surprisingly, there has been relatively little study of farmers' actual demand for seed from formal supply channels, despite the plethora of research on farmers' *adoption* of MVs (e.g. Feder *et al.*, 1985; Brush, 1986; Brush *et al.*, 1992; Brush, 1995; Pingali and Feldmann, 2001; Heisey *et al.*, 2002; Morris, 2002). Even studies taking an economic perspective (e.g. Bellon and Taylor, 1993; Bellon, 1996; Schaefer, 1992; Herath *et al.*, 1982) generally focus on the degree of farmer MV adoption, rather than on preferences for seed sources. The assumption appears to be that, once adopted, farmers would return to formal seed sources every few years to renew their seed stocks, due to genetic deterioration (see Table 4.1). However, at least until the 1990s, there has been little detailed investigation of how frequently farmers actually returned to formal seed sources (Heisey and Brennan, 1991). Since then, there have been some assessments of the rates of turnover for MVs on farmers' fields, stemming from a concern for maintaining disease-resistance, and avoiding genetic break-down through occasional out-crossing. Brennan and Byerlee (1991) proposed a simple weighted average calculation to measure the average 'age', WA_t, of varieties in farmers' fields:

$$WA_t = \sum_i p_{it} R_{it}$$

where, for a given year, *t*, p_{it} is the proportion of total area sown to variety *i*, and R_{it} the number of years since variety *i*'s release. Though the recommended frequency of varietal replacement is five years for wheat, farmers in some locations retain their wheat varieties much longer (Table 4.2). In places like Mexico's Yaquí valley, or countries such as the UK, intensive production systems, good service delivery, and good communication about new MVs make varietal turnover rapid. In Ethiopia, poor seed supply, weak extension, and low demand for new MVs meant that the MVs farmers had were released 11-13 years ago (Ensermu *et al.*, 1998).

Table 4.2 Weighted average age (WA_t) of wheat MVs in farmers fields in selected regions. Data calculated by Brennan and Byerlee (1991), except for 1 (McGuire, 1996); 2 (Ensermu *et al.*, 1998); 3 (Hailye *et al.*, 1999), and 4 (Beyene *et al.*, 1999).

Region/Country	Period	Average age (years)
Punjab, Pakistan	1978-86	11.1
Punjab, India	1970-86	5.3
Yaquí, Mexico	1972-86	3.1
North Argentina	1970-80	6.8
Kansas, USA	1970-86	6.7
Paraná, Brazil	1979-85	9.9
New Zealand	1970-86	10.3
the Netherlands	1970-86	6.6
the UK[1]	1971-94	5.3
Chilalo, Ethiopia[2]	1995	13
Enebssie, Ethiopia[3]	1997	11
Holetta, Ethiopia[4]	1995	13

The figures in Table 4.2 estimate only one component of farmers' demand for formal seed – the replacement of one MV by another – but show that this can be very low in countries such as Ethiopia. When we consider that MV wheat adoption is not total in Ethiopia, that many farmers first acquired the MVs from informal sources, and that the renewal rate of MVs with the same MV from formal sources is also low (Beyene *et al.*, 1999; Ensermu *et al.*, 1999; Hailye *et al.*, 1999; Hundie Kotu *et al.*, 1999), we come to appreciate how irregular farmer demand can be for MV seed from formal sources. For crops such as sorghum, with much less MV adoption in general, farmers' seed demand from formal sources can be even lower.

Though farmers' demand may not always be steady enough to support expensive, formal supply programmes, this does not mean that farmers are unwilling, or unable to purchase seed. Bay (1999) suggests that seed demand in SSA is growing, though it remains difficult to calculate for subsistence farmers in low-potential areas. A common view is that subsistence farmers' demand for formally-supplied seed is "counter-cyclical" (Janssen *et al.*, 1992), occurring mainly after poor years, when farmers have consumed or lost their own seed, and other local seed sources are gone. The view that poor farmers mainly desire MV seeds after a disaster has long served to justify distributing seeds (and tools) for free as part of disaster relief, or as an opportunity to introduce MV seeds. These have rarely proven successful, or even necessary (Sperling and Cooper, 2003; Sperling and Longley, 2002), and can actually undermine the development of an independent seed industry in Africa. Emergency seed programmes generally use bulk supply channels to achieve the large quantities they need, often obtaining material on short notice from a few large suppliers, which all too often turns out to be of poor quality (Chemonics, 1996)[46]. This does little to stimulate the development of supplier networks that are demand-driven and sensitive to seed quality (Tripp and Rohrbach, 2001).

Counter to the assumptions underlying free seed distribution, studies of bean supply in East Africa (David and Sperling, 1999; Sperling, 1994) show that farmers can and do purchase seed from markets in small quantities. Studies elsewhere in Africa showed farmers very keen to purchase MV seed (of sorghum, millet, cowpeas, pigoenpeas, etc.) from rural stockists when they had vouchers to increase their purchasing power, or when seed could be sold in small amounts (Rohrbach and Malusalila, 1999; Milimo and Tripp, 1999; Mazvimavi and Rohrbach, 1999; Omanga *et al.*, 1999). These experiences suggest that, given the right approach and institutions, there may be able to tap an unmet demand for MV seed. Farmers' interest in obtaining seed from formal sources is higher when new varieties offer advantageous new traits. For example, some of the bean examples above were disease-resistant or climbing MVs, and there appears to be demand for the supply of disease-free potatoes or true potato seed (cf. Thiele, 1999). Farmers' interest may also be high when formal sources provide a new crop to the area (e.g. Grisley and Shamambo, 1993). The other examples given above are generally from areas where MVs already predominate, and where there are developed grain markets (e.g. breweries that purchase MV sorghum in Zimbabwe; Rohrbach and Malusalila, 1999).

Despite evidence of untapped demand, developments in supply and marketing institutions, particularly those that lower farmers' transaction costs (e.g. by providing seed in appropriately-sized packets, with credit and trustworthy information), still remain rudimentary in SSA (Tripp and Rohrbach, 2001). Even with more appropriate supply and marketing strategies, farmers may still have low demand for seed from formal sources. There still needs to be a demonstrable advantage over local supply, in terms of opportunity costs, prices, and benefits to the farmer, for there to be an appreciable demand for formally-supplied seed. When formal systems supply seed of no better health or field performance than that from local systems, farmers' demand for its seed will probably remain low.

[46] Despite its own role in leading the critique of inappropriate emergency seed supply (FAO, 1998b), FAO's Seed and Plant Genetic Resources Division was dismayed to learn that its emergency project for Afghanistan in 2002 was gearing up to dump poorly adapted and untested seed on the country, showing that inertia of stakeholders and supply channels can still foil efforts for a more 'sensitive' approach (W. Fiebig, *pers. comm.*, 2002).

Seed regulation

The third broad challenge for formal seed supply in the South lies in the regulatory process for formal seed release. Seed regulation involves a range of activities around deciding which MVs should be released, testing for purity in seed certification, regulating seed marketing, and protecting intellectual property rights.[47] Such regimes aim to ensure the physical and genetic quality of formally supplied seed, and to build farmers' confidence in such seed, through certification tags or other means. Tripp, Louwaars and colleagues (Tripp and van den Burg, 1997; Tripp and Louwaars, 1997a, b; Louwaars, 1996b) argue that seed regulatory regimes can hinder the emergence of new, more integrated approaches to formal seed supply, such as those involving private commercial firms, or decentralisation to more locally-based supply. In this way, the structure and function of seed regulatory regimes can exert path-dependency and lead to only certain options for reform being considered, as I argue occurs in breeding institutions. The section below outlines some of these aspects of seed regulation, using Tripp *et al.*'s categories of efficiency, standards, participation, and transparency. These rules and processes – common to most seed regulation – greatly affect the possible directions that reforms to seed supply, as well as to breeding, will be able to take.

Efficiency

The approval process for formal release of an MV is often long and complex, meaning long delays before farmers gain access to a new variety. In addition to breeders' evaluation trial data, submitted along with the candidate variety, variety release committees usually run their own evaluation trials over several seasons. Co-ordinating committee meetings to observe trials and decide on variety release can also bring delays, as members are drawn from diverse institutions. After approval for release, the need for certification and quality control inspectors to travel to distant seed production sites can also slow timely seed supply. All these procedures can be costly, with state agencies charging breeders or seed producers for their inspection and approval activities. By transferring cost (and risk) to seed producers, this may restrict participation to state actors, or to enterprises that concentrate on the most profitable seed for market-oriented farmers, such as F_1 hybrid maize. Small, localised seed enterprises or breeders may find this process less accessible. Poor communication links with extension agencies also limit extension agents' access to relevant and timely information on variety performance, which could be used to better promote these varieties to farmers. This not only slows the process, but further restricts the possibilities for a demand-led system (Tripp and van den Burg, 1997; Tripp and Louwaars, 1997a).

Standards

The standards used to determine which varieties to release, or what is acceptable seed quality are often needlessly restrictive (Tripp, 1997a; Witcombe *et al.*, 1998). Chapter 3 showed that breeding with a particular ideotype, wide geographical adaptation, or with high-input packages in mind can mean that material suited to local or to low-input conditions can be disregarded. Variety release standards reinforce this, since many breeders will not even propose a variety that might fall foul of such sweeping standards. For instance, breeders might balk at testing a variety for weed tolerance (a trait labour-restricted households would value), as the variety release committee would look unkindly on data from weed-infested trials.

[47] Intellectual property rights on seed have spawned an enormous literature of their own. I do not discuss this issue in detail, in part because Plant Variety Protection legislation has yet to be enacted in Ethiopia (Olembo, 2003).

To approve variety release, most countries specify that the variety be distinct from others released, uniform within the variety, and identifying traits stable across seasons (DUS). This concern with DUS reflects a desire to protect farmers (and intellectual property), by guaranteeing uniformity for commercial markets. However, strict uniformity is less crucial for subsistence crops, and DUS can prevent more diverse releases (such as population mixtures or multilines) that could offer better stability in the face of variable stresses (e.g. Haussmann *et al.*, 2000b; Smithson and Lenné, 1996). There are many examples of varieties that were never approved for release, but which were enthusiastically adopted and informally spread by farmers, suggesting that such standards frequently ignore varieties of value to farmers. With seed quality control, strict standards also add cost to seed production, due to frequent and stringent testing. Formally-supplied seed can have poor quality anyway, due to poor monitoring, or to deterioration after seed production fields have been inspected. Though blatantly poor quality seed hurts farmers, seed produced in farmer seed systems is often of comparable quality to formally-produced seed, as a recent study has found for wheat (Bishaw, 2004). Some countries, such as India, now recognise this by applying an intermediate 'farmer-produced seed' certification to good quality seed produced by small, local enterprises, designating an appropriate and accessible standard for decentralised seed production.

Participation

What stakeholders are involved in setting standards and protocols, overseeing regulation, and in carrying it out? Typically, national variety release committees mainly draw their members from government agencies, breeding, and research institutions. Such authorities "are subject to professional biases and jealousies, interpersonal rivalries and ideological stances" (Tripp and Louwaars, 1997b: 102). Other stakeholders, such as foreign private firms or NGOs, often have very limited involvement. Farmers are even more marginal to this process and may have no involvement at all, though a few may get to offer their views on candidate varieties during pre-release evaluations. Those that do, tend to be 'progressive' farmers, and not necessarily representative of their poorer neighbours. Participation may be similarly limited in defining standards for seed inspection, or overseeing seed certification protocols. Confining participation in seed regulation mainly to state actors can thus shut out other stakeholders, such as local level seed producers or farmers.

Transparency

National policies may retain state control in some aspects of regulation by defining certain crops as strategic, or certain public institutions as paramount. While this reflects understandable concern for food security and sovereignty, such protectionist instincts may further constrain involvement of non-state actors in the regulatory process, and can ultimately serve to restrict farmers' options (Tripp and Louwaars, 1997b). The status and authority of different agencies, and the standards for different crops may also be unclear. Where seed certification is required, this lack of transparency can offer opportunities for rent-seeking by agents involved in seed quality control, and result in greatly varying quality in seed supplied to farmers (Tripp and van den Burg, 1997).

In summary, seed regulation is often slow, expensive, and unsatisfactory in carrying out its tasks. There are concerns that regulatory regimes set standards too narrowly for subsistence crops, blocking varieties and seed delivery options that might otherwise have benefited farmers. Contemporary proposals for seed systems reform tend to encourage greater involvement of private enterprises and regional harmonisation of release approvals (Tripp and Rohrbach, 2001), as well as approaches that are better integrated with farmers' seed systems (Almekinders *et al*., 1994). However, the organisation and institutional path-dependencies of many regulatory regimes limit the scope for including new actors, standards, and strategies. While reforms have re-shaped regulatory processes to some degree, institutional change can still remain superficial and slow (Tripp and Rohrbach, 2001).

Seed regulation can influence breeders' activities and choices, and the standards and stakeholders involved represent a form of institutional selection, deciding which MVs get released, and shaping possible pathways to be followed by formal breeding. This confirms that any reform efforts improving effectiveness of breeding should also consider the functioning of seed regulatory regimes.

4.3 Ethiopia's formal system for seed supply and promotion

4.3.1 Promotion of varieties and production technologies

Formal extension in Ethiopia

The earliest efforts at agricultural extension in Ethiopia started in the 1930s, and a formal service was established in 1954. Until the late 1960s, however, extension activities were very local, with the entire national service comprising less than 200 staff working within walking distance of stations (Schultz, 1976). As mentioned last chapter, rural development projects started with CADU in Arssi in 1967, followed in a few other districts by similar schemes that shared its integrated, multi-sector development approach.[48] These schemes greatly influenced the Extension Projects Implementation Department (EPID), established in 1971 in the Ministry of Agriculture (MoA) (Schultz, 1976; Ståhl, 1974; Cohen, 1986). However, the EPID found a comprehensive approach too costly and labour-intensive to apply more widely. Thus, the Minimum Package Program (MPP) was developed as a simpler approach, using Development Agents (DAs) to focus on promoting MVs and fertiliser to farmers who lived near all-weather roads (Schultz, 1976; Beshaw, 1990).

The DAs continue to be the front-line extension workers, promoting technologies directly to farmers. They live in the farming communities, and generally have some post-secondary training. In the mid-1980s, the average DA tended covered 2500 to 3000 households, often with no transportation, and received little training or technical support (Stroud and Mekuria, 1992). It was recognised that communication links were weak, and that there was little support for DAs working at the village level. From 1983, a Training and Visit (T&V) pilot scheme sought to improve both the support for DAs, and their contact with farmers. Subject Matter Specialists (SMSs) gave DAs regular technical training, and a strongly hierarchical administration was established, with a single line of command from local to national levels. As with CADU, DAs worked through model 'contact farmers' in the T&V scheme. However, Dejene (1989) found poor support for DAs, as SMSs usually were young junior college graduates themselves with little specialist training, and poor links to research institutions. The time of DAs was mainly consumed by travelling to find contact farmers and writing reports to meet the demands of an hierarchical system. Moreover, the assumption that contact farmers would spread seed and knowledge to their neighbours did not seem to occur in practice. Interestingly, it was for this reason of poor technology transfer that the EPID had

[48] These integrated programmes of the early 1970s included projects in Wollamo and Awassa in the south, Ada (near Debre Zeit), and Adiabo, Hedekti and Humera in the north (Beshaw, 1990).

earlier abandoned the contact farmer approach in the MPP, in 1975 (Schultz, 1976).[49] The T&V scheme marked a return to working through 'model' individuals, an approach continued in current extension schemes, discussed below. Despite the problems highlighted by Dejene, the T&V pilot was regarded as a success, and its example has influenced policy-makers' views as to what is a 'well-managed' extension system.

Extension in Ethiopia has followed practices in many developing countries, focusing on the transfer of technological packages, often via 'model farmers'. The institutions remain hierarchical, and rarely see farmers as sources of knowledge or innovation in their own right. The technical recommendations have remained fairly rigid, and there has been little support – in policy or in the field – for farmers 'unpacking the package' and allocating components to different parts of a farm, in accordance with individual situations.

The subordinate position of DAs also constrains the nature of their contact with farmers. Several DAs assisted me on my field research in West Harerghe, and some were genuinely interested in exploring appropriate solutions to local problems. However, ambitious quotas set from above for adoption of local technology packages (for cereal production, improved poultry, soil conservation practices, seedlings, etc.) demanded almost all DA time. There was every incentive to meet these quotas, and complete the extensive reports demanded by their superiors, as diligence was the main path for an eventual promotion out of the village. Thus, though the DAs I met were sincerely interested in more open interactions with a wide range of farmers, their job demanded they focus on technology packages, mainly with the wealthier farmers most likely to adopt them. The demands on these front-line extension workers almost certainly affected the quality of interaction with farmers about new MVs.

ESIP's sorghum promotion

As founding director of the Ethiopian Sorghum Improvement Program (ESIP) put it "in many cases, the bottleneck to improvement is the inadequacy of the extension services (Gebrekidan, 1974: 91)." Thus, in ESIP's early years, most promotion of sorghum MVs came directly from ESIP itself. This started modestly, with roughly 10 demonstrations a year of MVs on farms in the Alemaya in the first phase of ESIP (1973-76) (Gebrekidan, 1982b, 1975). As ESIP grew in geographical scope, so did the on-farm demonstrations, though direct breeder interaction with farmers was always a minor aspect, since ESIP breeders considered their main task to be generating technologies, not promoting them (Yemane and Lee-Smith, 1984). Though breeders did get some feedback from staff on integrated rural development projects about what farmers thought of ESIP's sorghum MVs (e.g. from ARDU; Gebrekidan and Menkir, 1979), this was limited and *ad hoc*, and communication with these projects was generally poor. Consequently, ESIP breeders had a rather patchy awareness of farmers' opinions of their MVs, as outlined in the last chapter.

In the mid-1980s, the World Bank supported an initiative aimed at strengthening the links between research and extension, which formed the Research/Extension Division in the Institute of Agricultural Research (IAR) in 1985, and the Research-Extension Linkage Committee (RELC) in 1986. The RELC was meant to facilitate interactions at between IAR researchers IAR and MoA extension staff, at both national and local levels. However, irregular RELC meetings, and frequent staff and organisational changes in both institutions

[49] For instance , the EPID notes (in report 21, p. 20, cited in Schultz, 1976: 38): "[farmers] say that their role as model farmers is interfering with their farm work, and they have no obligation to make that kind of personal sacrifice in a job that does not have any personal rewards."

gave little momentum to the initiative, and research-extension linkages remained weak, especially at the district and local levels (Stroud and Mekuria, 1992).

The establishment of Research/Extension departments at IAR centres, though, did involve researchers more directly in technology promotion. The department at Melkassa communicated with district-level MoA staff, organising sessions for SMSs and extension agents, and open days at Melkassa (Deressa *et al.*, 1996). These links are naturally strongest with district offices nearest to Melkassa, though there is less contact with staff working in the more distant districts where sorghum predominates. With the aid of UNDP funding, the department produced booklets in English and Amharic describing sorghum MVs (IAR, n.d., 1995). Though they convey some essential technical information for field-level DAs (such as the maturity times of different MVs), such booklets are one-off donor-funded documents, and are soon out of date. Research/Extension staff also promote IAR technologies directly to farmers. For example, from 1988-97, Melkassa's department organised 333 different demonstrations to farmers of technologies developed at that station (Reda and Deressa, 1997). The staple of this promotional work remains on-farm demonstration plots, where different MVs are sown alongside with FV checks, following all management recommendations (e.g. row-seeding, fertiliser and weeding). Following the approach of the extension service, these demonstrations work with contact farmers, on the assumption that the technology package will then spread to their neighbours (as evidenced by such farmers being termed "change agents" by one commentator (Molla, 1996:2)). The tendency is to select 'progressive' farmers for on-farm trials, who are inclined to try these new technologies. However, these farmers, who are willing to apply the extra labour the input package demands, tend to be better off than most of their neighbours, with good natural and human capital assets (see Box 4.2). Whether these technologies are appreciated and adopted by other farmers, who may be less well-endowed, has not been investigated. Nevertheless, the Research-Extension department has made significant contributions to farmers' (and extension agents') awareness of sorghum MVs, and played an important role in promoting ESIP's varieties and technologies.

Box 4.2 Organising sorghum demonstrations, a case from Harerghe

I accompanied a Research/Extension mission as it was organising on-farm demonstration plots in the West Harerghe, and observed their activities there and elsewhere through the season. Given limited vehicle availability, and the narrow window for sowing, the work to select farmers and organise plots on their farms was rushed. We arrived at the MoA office for Chiro *Woreda* (District), and requisitioned an SMS who was in charge of DAs for Chiro. He suggested a suitable DA, and joined us in searching him out. The SMS supervisor explained our requirements to the DA, discussing with him who might be appropriate farmers for a demonstration plot in that village, based on proximity to the road, ability to adopt the recommended practices (e.g. available labour and oxen), and social standing in the community. In other words, the DA and SMS effectively sought out 'progressive' farmers that they knew well. We then approached two farmers, both of whom were already familiar with such trials. Both farmers were enthusiastic to participate, not least for the free inputs of seed and chemicals (and labour, in the case of one farmer, who managed to get our help in planting his field in rows, aware of researchers' enthusiasm for row-planting). The demonstrations sowed five varieties (one a local FV check) in a block, 10x10 m each, using recommended management and inputs.

The location – adjacent to an all-weather road, in a high-potential area – attracted many other researchers to work in this small area. During this visit I encountered Alemaya University researchers organising a maize trial down the road. I had accompanied this trip to give small (50g) packets of MV seed to randomly-selected farmers, to see small introductions of seed become disseminated. I gave no instructions on how they should sow these, assuming normal management would prevail (i.e. broadcast sowing, no inputs). However, in the areas near where these demonstration trials were located, several farmers were concerned if they needed row plant the seed as a condition of receiving it. I gave out over 120 such packets, over a wide area of West Harerghe, and only the farmers in this 'demonstration zone' asked this question. These observations left the impression that, because of the rushed nature of organising trial participants, and the need to work hierarchically through institutions and through personal contacts, a few highly-accessible localities were emphasised for demonstration trials. This approach tended to return to the same 'trial farmers', whose environmental and economic conditions were more favourable than average, and who were familiar with researchers' management expectations.

4.3.2 Variety release and seed supply: the Ethiopian Seed Enterprise

Establishment and development

How was MV seed multiplied and supplied to farmers in Ethiopia? Up to the late 1970s, seed supply was seen as the main bottleneck for crop improvement's impact, as noted by ESIP staff: "The perennial problem of lack of an effective national scheme for the production, processing, quality controlling, and distribution of good quality seed is still with us (Gebrekidan and Kebede, 1977: 96)." Until 1979, ESIP was the sole channel for MV sorghum. Then, as now, ESIP multiplied MV on its stations, if any extra space were available. This seed was passed on to other government agencies (regional authorities, State Farms, etc.), as well as to integrated development projects such as CADU (Gebrekidan and Kebede, 1977). The available reports suggest that these amounts were modest: for instance, 9.4 t of sorghum seed was passed on to government agencies in 1979, who generally passed it directly to users, without further multiplication (Gebrekidan and Menkir, 1979). Probably very little of this seed reached smallholders who were not part of the major integrated development projects.

In 1978, the Ethiopian government convened a National Seed Council to consider the issue of seed supply. From their recommendations the Ethiopian Seed Corporation was founded in 1979 as a state enterprise, run through the Ministry of State Farms, Coffee, and Tea Development (Dabi *et al.*, 1998). It was renamed the Ethiopian Seed Enterprise in 1993, and restructured to answer directly to the Prime Minister's Office, according to a Regulation of the Council of Ministers (No. 154/1993; World Bank, 1995). For simplicity, this account uses ESE to refer to both Corporation and Enterprise.

After 1979, ESIP greatly reduced the amount of seed produced, and left most multiplication to ESE. Melkassa, ESIP's headquarters, produced less than 2t of seed in the 1986-94 period, mostly Basic/Breeders' seed for further multiplication in the ESE. While direct seed distribution from ESIP to government and NGO agencies for direct distribution to farmers did continue, this was in very small amounts and remained *ad hoc*. However, ESIP was the only source of lowland sorghum MV seed, an issue I return to below. From 1979 until 1991, the ESE was the main seed producer in the formal sector, though it operated without much policy guidance in this period. Box 4.3 presents the general relationships between agencies in seed supply, for multiplication, information-exchange, and quality control, discussed in the following section.

Variety evaluation

At ESE's founding in 1979, there were no clear procedures for evaluating which MVs breeders had developed would be approved for multiplication and release. The National Crop Improvement Committee (NCIC), instrumental in founding the ESE, was also important in establishing the National Variety Release Committees (NVRCs) in 1982 (Getinet Gebeyehu and Gebremedhin, 1999). Each major crop has its own committee, though their statutory role was not legally defined until recently (Federal Democratic Republic of Ethiopia, 2000). An NVRC is usually chaired by a breeder, and includes agronomists, crop protection specialists and social scientists, representing different institutions (e.g. IAR/EARO; the Ethiopian Biodiversity Institute[50]; ESE; and the Ministry of State Farms, Coffee, and Tea Development) (Agrawal and Wolde Mariam, 1995).

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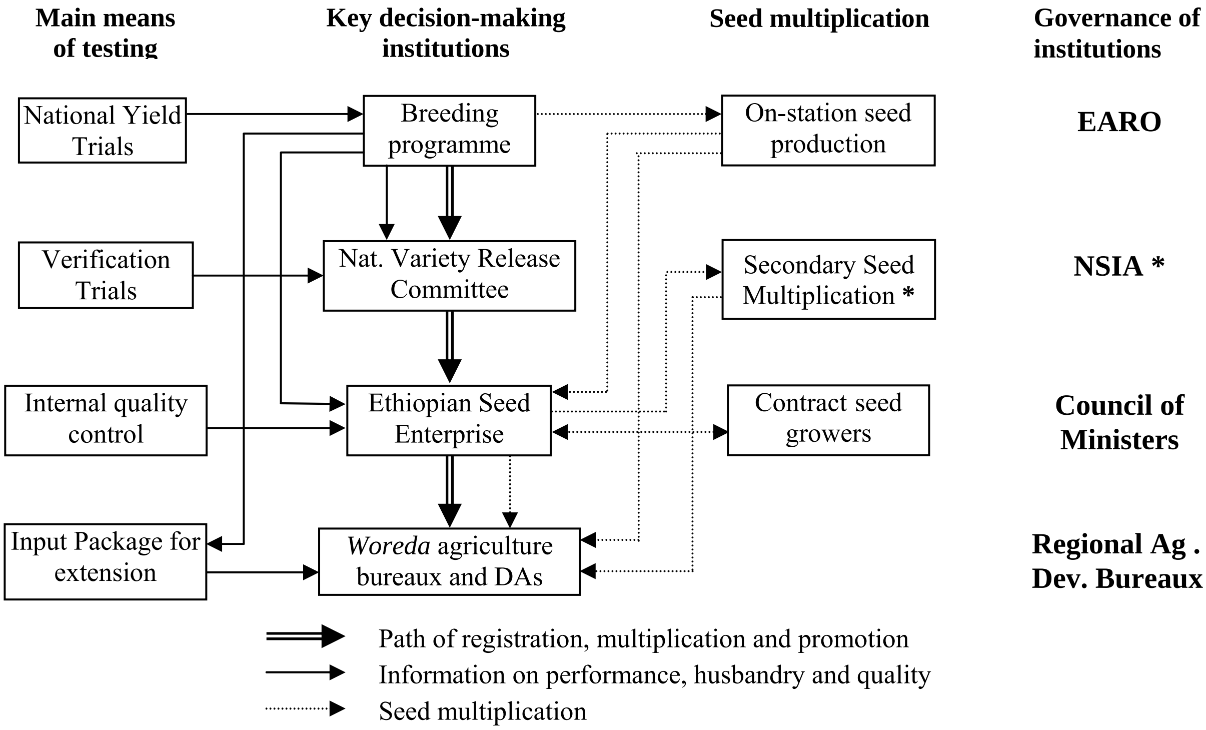
[50] Formerly called the Plant Genetic Resources Center of Ethiopia, PGRC/E.

Box 4.3 A simplified model of the main institutions and interactions in Ethiopia's public-sector seed supply (*: these elements only since mid-1990s).



Breeders' varieties are submitted to a National Variety Release Committee (NVRC), which uses data submitted by breeders, and its own on-farm verification trials, to decide upon release. For approved MVs, the Ethiopian Seed Enterprise (ESE) takes Breeders' Seed (produced on research stations), multiplies this via their own contract growers, and passes on the Certified Seed to the *Woreda* (District) offices for agriculture. This material then passes to DAs, and thence to farmers. In theory, the specific varieties and amounts supplied reflect assessments of local demand, transferred up the hierarchy from *Woredas*, to Regional administrations, to the ESE. In practice, allocations of seed to a given locality usually reflect top-down administrative decisions. The breeding programmes pass on husbandry information (i.e. the recommended input/management packages), adaptation zones, flowering times, etc. to the ESE and the Regional administrations, to guide their seed production and extension. These communication links are sometimes unsatisfactory. Extension services also use the on-farm demonstration plots to shape more local-specific recommendations. Since there was no independent seed assessment agency for certification until very recently, any testing of physical and genetic quality of ESE's seed occurred internally.

Some of the seed multiplied on research stations passes directly to NGOs and to Regional Agricultural Bureaux, usually at *Woreda* level, for distribution (not shown on this schema). Recently, the NSIA has organised "Secondary Seed Multiplication" on smallholder farms. Much of the seed produced here goes directly to the Regional Agricultural Bureaux, who supply it to farmers as part of high-input package programmes.

Before a candidate variety is submitted to the NVRC, it must have had at least two years of regional or national trials on-station at three to five locations, and a one year 'verification trial' on-farm, to demonstrate yield, disease-resistance, or "other important characteristics" (Dabi *et al.*, 1998: 2). Once the NVRC has received this data, it elects a technical subcommittee to oversee a further verification trial, evaluating performance on a 10x10m plot on-station, with a second one on-farm, assessing if height, days to maturity, and other performance data match that given by breeders. This is to ensure that the variety meets DUS criteria for stability, as well as for uniformity. The subcommittee also interviews the breeder in detail, particularly on agronomy, and solicits the farmer's views on performance relative to both a standard (MV) and a local (FV) check, usually grown on adjacent plots.

On the basis of these assessments, the sub-committee submits a report to the NVRC with their recommendation or otherwise for release. There are no apparent formal guidelines for how the farmer's evaluation would be integrated into the overall assessment. According to one informant who was involved in seed policy and had chaired NVRCs in the past, a 'negative farmer evaluation' (in comparison with standard MV and local FV checks) would usually assure no recommendation. Since interviews occur near harvest time, the farmer would not give post-harvest assessment (e.g. for weevil resistance, taste, grinding, general marketing qualities).[51] When asked about trial management, the same informant noted that the farmer is told when to sow and weed, "always" planting in rows, and presumably also following package recommendations for fertiliser. He found my question about management surprising; this again shows how the idea of an 'optimal' growing environment via a technology package is well-established throughout the entire variety development process. In practice, few farmers apply such management to sorghum, whether due to limited availability of inputs, or to other livelihood decisions. Others familiar with the NVRC complain of its "autocratic" nature, and its preoccupation with high yield in deciding which varieties to release. For instance, one international researcher complained that the NVRC rejected eight "very good" wheat cultivars in 1997 on the basis of yield alone (HV, interview, June 1998). This again shows how such 'institutional selection' can supersede breeders' selections, and reject potentially useful materials.

The NVRC is the final arbiter of a variety's quality, with the process designed to 'protect' farmers from unapproved varieties. On-farm verification trials show only one aspect of farmers' conditions, not how MVs might perform under the low-input conditions on most farms. Moreover, NVRC verification trials occur on only one farm per candidate MV, generally located near standard testing sites such as Miesso or Melkassa. Approval thus reflects policy-driven goals of maximising production, with the tacit assumption that socio-economic or agro-ecological variation is an unimportant factor in farmers' opinions about a variety. Soliciting only one farmer's opinion at the verification stage risks approving an MV that many other farmers might not appreciate, or, more worryingly, prematurely rejecting an MV that some others might find useful. However, Ethiopian researchers are reluctant to involve more farmers in testing candidate varieties before they are officially approved, since they are afraid that 'unapproved' varieties might spread via spontaneous farmer-farmer exchange (interview, DT, June 1998). I have been informed that some researchers take care to collect the entire harvest in on-farm trials of varieties not yet released, lest the farmer decide to re-sow the seed. While some caution is justified (e.g. if a variety had a defect that farmers could not immediately notice, such as disease-susceptibility), this protectiveness has contributed to the release process being rigid and slow. For example, Tsedeke Abate, a senior bean scientist developed a multiline bean MV in the late 1990s, with the variation in different genes for disease-resistance.[52] The NVRC initially opposed its release, as it did not meet strict DUS standards. Tsedeke had to present several years' data showing that the

[51] Post-harvest qualities may get attention earlier, via farmer evaluations during breeding, however.
[52] This makes the MV in effect a population of several lines, each line varying in the resistance gene it has, but identical in other traits. This increases diversity for resistance, and helps ensure the MV's yield stability, as it is harder for a single strain of the disease to overcome the entire variety (see Allard, 1990; Ibrahim and Barrett, 2001).

multiline had greater yield and yield stability compared to individual lines, and argued that the DUS standards were unhelpful in this case, as the MV was for local consumption, not export. Tsedeke is held in high regard in Ethiopia, and he eventually did convince the NVRC to approve the MV (interview, C. Farley, March 1998). While this augurs for greater flexibility in the future around DUS criteria remains to be seen, and it is less likely that junior scientists would be willing to challenge an NVRC in the near future.

Between 1982 and 1995, the NVRCs approved 67 MVs for release. Of these, 29 were from cereal crops, 17 from legumes, and 7 each from oil seeds, vegetables, and fibre crops (World Bank, 1995). Not all of these are supplied by the ESE (Table 4.3): except for maize and wheat, the ESE multiplies only a few MVs of most crops, and none of vegetables or fibre crops (Table 4.3).[53]

Table 4.3 The number of crop varieties released in Ethiopia between 1953-97, and the number multiplied by ESE in 1997, calculated from data in Dabi *et al.* (1998). Totals include: * 8 bread wheat and 6 durum wheat varieties; † 3 food barley and 2 malting barley varieties.

Crop		**Releases 1953-97**	**Multiplied by ESE in 1997**
Cereals	Wheat	48	14 *
	Maize	36	9
	Barley	32	5 †
	Teff	11	6
	Sorghum	23	5
	Total	***150***	***39***
Legumes	Faba bean		1
	Field pea		4
	Chickpea		2
	Lentil		3
	Haricot bean		4
	Soybean		4
	Total	***66***	
Oil seeds	Noug		3
	Linseed		2
	Mustard		1
	Total	***24***	***6***
Vegetables	***Total***	***21***	***0***
Fibres	***Total***	***3***	***0***

Seed production

Since ESE's establishment, Ethiopia uses a four-generation system for seed classes, with Breeder, pre-Basic, Basic, and Certified Seed classes (see Box 4.1). However, until the draft Seed Law (Federal Democratic Republic of Ethiopia, 2000) is enacted, there remains no external agency to certify seed (Dabi *et al.*, 1998). Despite these official classes, up until 1989, only 20% of the seed ESE traded was multiplied from Basic seed, due to the absence of

[53] This table shows a much larger number of approved MVs in the 1953-97 period. Most of these pre-date the NVRC, and are discontinued varieties.

seed production facilities. "Inevitably, the quality of output was disappointing on two counts: a) genetic quality was below the potential of what research had achieved; and b) physical quality and purity was below the potential attainable through superior husbandry and post-harvest processing" (World Bank, 1995: 8). In 1989, the ESE established two Basic Seed farms in Arssi, the former Administrative Region where the CADU integrated rural development programme had originated in the late 1960s. The farms, Gonde and Iteya, are both 250 ha and in the high-potential highlands. By 1995, a third farm was established with EU support in Shallo, near Awassa, in the Central Rift Valley, on 400 ha, in a mid-altitude (1600 masl) agroecology (Agrawal and Wolde Mariam, 1995; World Bank, 1995), while a fourth has recently been established in Kunzilla, 70 km north of Durbete in Gojjam in the north-west, also at mid-altitude (Alemseged Aregai, ESE, *pers. comm.*, 1998). These sites are all shown in Figure 3.3.

As a rule, the main research centres and AUA produce and maintain Breeders' Seed. This they supply to the ESE for further multiplication each year. The purity of this Breeders' Seed is sometimes questioned (World Bank, 1995). For instance, I observed researchers complaining at a national sorghum meeting that the traits of a mid-altitude MV, *Birmash*, had changed over the years because breeders had not given enough attention to avoiding contamination of Breeders' Seed for that variety.

The ESE produces Pre-Basic and Basic seed on their Basic seed farms. Finally, this is multiplied into Certified Seed at a number of locations. In the past, Certified Seed was produced on State Farms, but now the ESE generally uses private farms, under contract (Agrawal and Wolde Mariam, 1995). Because of the large area needed for Certified Seed production (e.g. in 1994, about 7750 ha), these contracts go to a few large farms. To simplify administration, these are generally concentrated in the south and west of the country (World Bank, 1995).

In some cases, breeders also supply Basic seed to the ESE, to supplement the what the ESE is able to multiply itself. For example, in the first half of the 1990s, a significant proportion (at least a fifth) of Basic Seed for chickpea, field pea, wheat, teff, and barley came directly from breeding programmes, though absolute quantities were only large for the latter three crops, with annual production around 300t, 50t and 30t, respectively. Some of this Basic Seed was sold directly, rather than multiplied into another generation, suggesting that demand for larger amounts than this remained uncertain in the early 1990s. For some important crops, including lowland varieties of sorghum, as well as sesame and groundnut, the ESE does not produce Basic seed at all, due to its lack of lowland multiplication facilities. Research centres must produce all Basic Seed for these crops. Vegetables, fruits, and forage crops, despite their importance, are not multiplied at all by the ESE (Table 4.3), and research centres generally produce only enough for their own needs, and sometimes for state enterprises (Dabi *et al.*, 1998). Most seed for horticultural crops is imported, mostly reaching farmers through local traders and markets (Eshetu Mulatu, DRAFT).

Table 4.4 shows ESE's production and sales figures for the main cereal crops in the early 1990s. The period falls neatly between the end of fixed seed prices and regulated demand in 1991, when the *Dergue* fell, and the sudden increased demand for MV seed in the late 1990s, due to the aggressive promotion of input packages through programmes such as Sasakawa-Global 2000 (SG2000) and the National Extension Improvement Program (NEIP). Thus, seed production and demand were comparatively unaffected by outside programmes during this period. The table shows that wheat and maize dominate Ethiopian formal seed supply, with 88% of cereal seed production between them, while other cereals are produced in much smaller amounts. For non-cereal crops (e.g. oil seeds and pulses), very small amounts are produced. Given the diversity of seed classes and sources, it is unsurprising that figures from different sources can contradict – for instance ESIP claims (1997) that the *total* amount of sorghum seed produced by it and the ESE between 1986 and 1997 was 2750 t, the same as Table 4.4 claims for 1992 alone. Regardless of some uncertainty around specific figures, all evidence shows that sorghum occupies a small proportion of total formal seed production.

Table 4.4 Tonnes of Certified Seed produced and sold by the ESE for the main cereals in Ethiopia between 1991 and 1996 (% of that season in parentheses), calculated from ESE data cited in Dabi *et al.* (1998) (* mean of 1991-95 for production, 1992-96 for sales).

Season	Wheat		Maize		Barley		Teff		Sorghum	
	Prod.	**Sold**	**Prod.**	**Sold**	**Prod.**	**Sold**	**Prod.**	**Sold**	**Prod.**	**Sold**
1991	8116 (83)		715 (7)		800 (8)		199 (2)		-	
1992	16111 (68)	6961 (59)	2401 (10)	1529 (13)	375 (2)	1230 (10)	2215 (9)	1894 (16)	2745 (12)	193 (2)
1993	11013 (69)	11085 (64)	4334 (27)	2384 (14)	160 (10)	316 (2)	123 (1)	1425 (8)	308 (2)	2059 (12)
1994	8737 (58)	12062 (57)	5348 (35)	3610 (17)	167 (1)	169 (1)	436 (3)	2424 (11)	483 (3)	2994 (14)
1995	13815 (68)	10135 (73)	4042 (20)	2632 (19)	1274 (6)	153 (1)	367 (2)	434 (3)	730 (4)	588 (4)
1996		9375 (72)		2819 (22)		273 (2)		357 (3)		163 (1)
Mean*	**11558 (68)**	**9924 (64)**	**3368 (20)**	**2595 (17)**	**555 (3)**	**428 (3)**	**668 (4)**	**1307 (8)**	**853 (5)**	**1199 (8)**

Another point from Table 4.4 is the annual variability of production and sales for each crop (crops not listed here are more variable still). In part, this reflects the difficulties of predicting demand year-to-year, but it also reflects fluctuations in the seed production chain. An important bottleneck for this is the supply of Breeders' Seed from research centres to ESE Basic Seed farms. Breeders do not usually get credit for maintaining their varieties, and multiplying seed for formal seed supply. Seed production from research centres can vary considerably. ESE staff have complained about receiving limited information from breeders about appropriate husbandry for MV production, or about MV morphological details, which limits their ability to obtain optimal production of Basic and Certified Seed, or properly rogue materials in the field (Getinet Gebeyehu, 2000; Yemane and Lee-Smith, 1984). However, poor infrastructure, seed quality, or management on the part of ESE has also contributed to poor seed yields. Moreover, the concentration of Basic Seed farms (and Certified Seed contractors) in a few locations risks greater variability in production due to climate or pests. All these factors contribute to making seed production highly variable from year to year, and difficult fully to predict.

Besides the variability in seed production, ESE lack of Basic seed farms in the arid lowlands limits its ability to supply important dryland crops such as sorghum and groundnuts. In part, this reflects past policy priorities in Ethiopia, which emphasised mostly high-potential, highland areas. Over 70% of ESE's sales are for highland crops (World Bank, 1995), and the dominance of wheat is a legacy of CADU's work from the 1960s on promoting packages of wheat. The lack of lowland capacity is particularly an issue for sorghum in the lowlands, as this is the only agroecology where there is an appreciable demand for MV sorghum. This demand, however, is impossible to predict accurately in advance, as it is strongest in seasons with poor early (*Belg*) rains, when farmers cannot sow their FV sorghum. Though storage is possible, seed deteriorates over time, as discussed below. So, even though MV seed provision for lowland sorghum could fill an important gap for farmers, this is challenged by a lack of multiplication capacity in the lowlands, and by the additional organisational requirement of supplying seed to a niche with cyclical, but irregular, demand.

Another important aspect of ESE's seed production, which is only partly a result of having no lowland facilities, is that not all released varieties are multiplied. Table 4.3 shows that a range of MVs are multiplied, but why are some recommended varieties not multiplied? The IAR recommended list contained ten sorghum MVs in 1997 (IAR, 1997a), but only five were multiplied. Moreover, among the varieties that do get multiplied, certain varieties get particular emphasis. In the case of sorghum, *Birmash*, an MV released in the late 1980s for intermediate altitudes, is emphasised, as it is promoted in recent input package programmes (Alemseged Aregai, ESE, *pers. comm*., 1998). This is an institutional choice, rather than an assessment of farmers' actual demand. Even highly-developed NARSs, such as in India, routinely reject MVs that are potentially valuable to farmers (Witcombe *et al*., 1998). In Ethiopia, the understanding of farmers' opinions of different MVs is still quite limited (Mulatu and Belete (2001) having done one of the first studies for sorghum). This suggests that decisions about which approved sorghum MVs to multiply in Ethiopia are not so much based user demands, but reflect institutional choices (including the location of Basic Seed farms). This rather radical form of 'institutional selection' occurs after breeding, and further determines the effectiveness of breeding practice.

Table 4.4 also points to the difficulty of aligning seed production with seed sales. For most crops, supply was either well above or below demand for at least one year in this period. According to an ESE informant, poor communication leads to weak links between supply and demand; ESE is supposed to base its multiplication decisions on 'timely requests' from the various regional MoA offices (since 1992, the Regional Agricultural Development Bureaux, or RADBs). Ideally, these requests should come before harvest in December, but sometimes arrive with only two weeks' notice, he said. Also, because multiplication adds a year between request and supply, the expected demand may not remain valid. The informant recounted a recent case where a large amount of seed had been multiplied in anticipation of high MV demand, but this demand turned out to be low the following season, due to good early (*belg*) rains. ESE ended up with nearly 500 tonnes of seed that it could not sell. Such problems are common in most formal seed supply systems in the South, and increase financial risk for institutions attempting to recover costs. In the case cited above "Luckily, we [ESE] had not treated that batch (we usually don't), and were able to sell it as grain." However, sometimes they do treat the seed, or decide to store it for another season, in the hope that it can be used the following year.

Processing, storage, and quality control

Seed processing involves drying, shelling, cleaning, grading, treating, packaging, and storage. What organisational arrangements did the ESE design for this? ESE dries its seed in the sun after harvest (Agrawal and Wolde Mariam, 1995) as it has no capacity for mechanical drying, though this would be difficult to do in any case with dispersed Certified Seed farms. Relying on the weather to dry their seed exposes the ESE to the same risks Ethiopian farmers face, where late rainfall can lead to seed spoilage and low germination. For instance, late rains during harvest in December 1997 reduced the viability of formal sector seed (Alemseged Aregai, ESE, *pers. comm.*, 1998).

ESE processing plants clean all seed, including that supplied from IAR or Alemaya University of Agriculture (AUA). Three of the five cleaning plants (in Awassa, Asela, and Koffele) are near the Basic Seed farms in the south-eastern highlands or Central Rift Valley, with another plant near Nekemt in the west, and one recently completed at Bahir Dar in the north-west. With mobile cleaners, they have a capacity to clean up to 30 000t of seed a year, though production has rarely exceeded 20 000t. There are storage facilities at these five plants, as well as at four other locations, three in the south-eastern highlands (Assassa, Dodolla, and Robe), as well as at Kombolcha, on the edge of the northern highlands (Dabi *et al.*, 1998). The concentration of these facilities in Arssi and Bale, in the south-eastern highlands, again highlights the emphasis on high-potential (particularly wheat-growing) regions. Large areas of the north, west, and east (including the study area in Harerghe) remain rather distant from these distribution points, adding additional challenges for transport and supply.

The previous section indicates that the ESE may sometimes need to store Certified Seed for more than a year. Moreover, Basic Seed may also require 2-3 years' storage. Though this is technically possible, storage conditions need to be carefully maintained, particularly keeping temperature and moisture low. ESE's director of production notes that seed viability can drop quickly in its stores, especially when it is decided to store material for an additional season. Loss of viability is a particular problem with maize, he said, as well as with sorghum: germination rates after 18 months storage are often below 50% (in some cases, below 30%). The World Bank review (1995) also notes that seed quality from ESE was not always high, in part because none of the storage sites has testing facilities for quality control. This increases farmers' uncertainty about the quality seed from the formal sector.

ESE Headquarters in Addis Abeba does internal quality control, but, until the draft Seed Law is enacted, there is no independent agency assessing MV seed in any kind of systematic fashion, following established standards. As such, the seed ESE sells is not (yet) certified, despite its class name (Agrawal and Wolde Mariam, 1995; Seboka and Deressa, 2000). Seed quality can be quite poor as a result, sometimes lowering yield potential of MVs to below what farmers can obtain with farm-saved FVs (Dabi *et al.*, 1998; Bishaw, 2004). Seed packaging and labelling is "another area of weakness" (World Bank, 1995: 9), as bags are only in 50 and 100 kg sizes, irrespective of farm size or seed rate. The bags are also unlabelled, with no indication of physical quality or germination rate. Contemporary ideas on seed supply emphasise labelling as a way to build farmers' confidence in formal seed, and to help them identify which types of Certified Seed are likely to have physical and genetic value.

The concern with quality control and seed labelling fits with a view of farmers as rational agents, who will make use of information and quality guarantees to decide if it is worth paying a premium for Certified Seed, and (if there is competition), from which seed source they will buy. The command economy of the *Dergue* gave little consideration to competition, and seed allocation reflected top-down decisions in any case. However, the entry of the Pioneer Hi-Bred corporation into the seed market in 1990, the market liberalisation since 1991, and the establishment of the National Agriculture Input Authority

(NAIA)[54] all herald policymakers' interest in a more market-oriented, demand-driven seed sector. Section 4.4.3 below returns to this issue, discussing the recent draft of the Seed Law (Federal Democratic Republic of Ethiopia, 2000) as a policy framework for such a market-driven sector.

Seed distribution

When discussing the impact of formal seed supply, Ethiopian commentators are fond of estimating the total national seed requirements. However, estimates vary wildly for this, depending on the assumptions made on the rate of sowing or seed replacement. For instance, ESE's production manager, Alemseged Aregai (*pers. comm.*, 1998) estimates that 4.5 million tonnes of seed are needed each year in Ethiopian agriculture, while NAIA staff (Dabi *et al.*, 1998) estimate 420 000 t, less than a tenth of this. Getinet Gebeyehu, NAIA's Director (pers. comm., 1998; 2000) arrives at a still lower estimate, 190 000 t, by using recommended rates for sowing (often well below farmers' actual sowing rates), and assuming that seed lots only need to be renewed every few years (see Table 4.1). Using these figures, formal seed production, which averages 20 000 t a year, met between 0.4 and 10% of farmers' requirements for seed for all cereals, pulses and oilseed crops. However, when we consider specific crops, the picture varies considerably.

How does ESE's production of sorghum seed relate to the national crop area, or seed requirements? Sorghum coverage in 1996 was estimated at 1.25 million ha, which would require between 12 500 t (using the recommended sowing rate of 10kg ha^{-1}) and 37 500t (using farmers' typical rate of 30 kg ha^{-1}). From 1992-96, ESE's average sorghum seed production (853 t; Table 4.4) thus met between 2 and 7% of national seed needs, though this fluctuated from year to year. Such an estimate is comparable with coverage in other African countries. However, this coverage is strongly affected by the patterns of seed distribution: where does this seed actually go?

The overall patterns of seed distribution in ESE reflect the high-potential areas and consequent siting of facilities: wheat seed is mainly distributed to Arssi and Bale in the south-eastern highlands, maize to Sidamo and Wollega in the south and west, and teff to Gojjam in the north-west highlands (Dabi *et al.*, 1998). This is unsurprising, given the logistical challenges, but it is the institutional distribution patterns that are most revealing.

The ESE was established during the *Dergue*, and its seed distribution mirrored changing policy priorities during this period. As with many NARS seed systems in the 1980s, there was little development of institutions for farmers to express their actual seed demands, such as through market purchase. Rather, the ESE supplied seed to a few large stakeholder institutions, in accordance with top-down policy decisions, and these institutions decided on the relative allocation of seed. Until 1990, roughly half of ESE's output went to State Farms, with the remainder split between NGOs and the MoA/AISCO (World Bank, 1995; Dabi *et al.*, 1998); smallholders' access to seed via the latter two channels has been indirect at best. From the ESE's founding until 1984/85, the vast majority of MV seed went to State Farms (Figure 4.1). This reflected the *Dergue's* agricultural development strategy in this period, when State Farms were to meet national food security needs, as well as serves as models for large-scale mechanised production to be adopted by Producer Co-operatives (Belete *et al.*, 1991; Cohen and Isaakson, 1988). In the mid-1980s, seed allocations shifted somewhat,

[54] In July 2002, this Authority was established to regroup three separate National Agencies, those for Fertilizer and Pesticide along with the National Seed Industry Agency (NSIA) (Raymakers, 2002). My work mainly addresses the latter agency, though its current name, NAIA will be used throughout.

reflecting the emphasis on famine relief and resettlement schemes in this period. For instance, the peak sales to the MoA in the mid-1980s was largely due to its re-settlement programmes. The Agricultural Input Supply Corporation (AISCO), which controlled all input supply from 1984 to 1991, distributed most of its allocation to Service Co-operatives (SCs), rather than to individual farmers.[55] With the surge in emergency relief from the mid 1980s, NGOs also became significant clients for ESE, with the Christian Relief and Development Association in Addis Abeba co-ordinating all seed purchase (World Bank, 1995). The majority of smallholders were in Service Co-operatives or resettlement programmes, or receiving disaster relief; these received very little formally-produced seed.

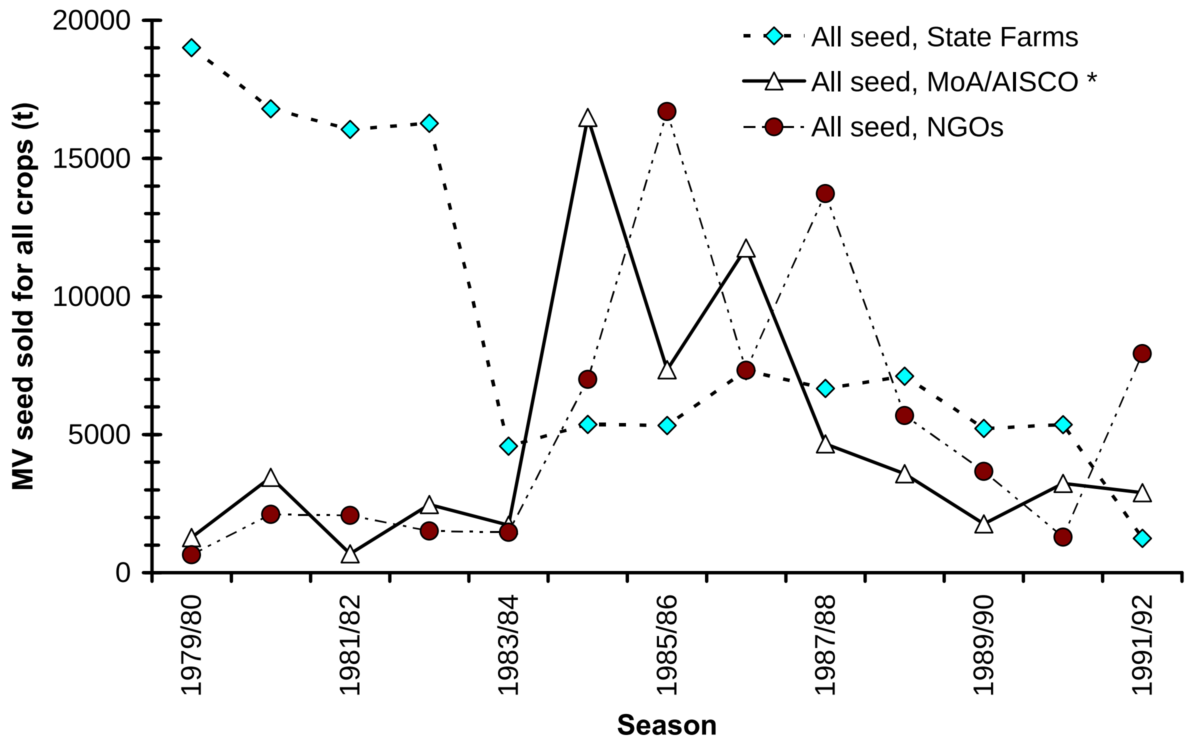


Figure 4.1 Sales by ESE of MV seed for all crops during its fixed-price period (1979/80 to 1991/92) to State Farms, AISCO/MoA, and NGOs, adapted from ESE data cited in Agrawal and Wolde Mariam (1995) (*MOA includes resettlement programmes; AISCO began trading in 1984, with much of its efforts directed at SCs rather than individual farmers).

In 1991, AISCO stopped being the sole dealer of inputs, and fixed price controls were lifted. In the early 1990s, a transitional period to new governance and political structures, most seed supply continued to go to disaster relief. For example, NGOs distributed 65% of ESE seed in 1994, with the emergency relief from the MoA taking another 30%. Direct sales to farmers, however, remained very small, less than 1% (World Bank, 1995). This suggests that there was little attention to developing farmer demand for MV seed, or institutional capacity to serve this demand. By the mid-1990s, the RADBs were taking over the Federal MoA's role in extension, and were setting ambitious quotas for the numbers of farmers they would reach by aggressively promoting input packages through programmes such as SG2000 and NEIP.

[55] Table 3.6 uses quite different figures, though it suggests that, in 1984/85, re-settlement received five times the seed that SCs did, while individual peasants received almost nothing.

Their demand for seed increased considerably; for instance, the RADBs received 18% of ESE seed in 1995, but 56% in 1996 (Dabi *et al.*, 1998). By the end of the decade, package programmes had expanded to the extent that they now consume nearly all formally-produced seed, from the ESE, as well as from other sources. The package programmes are discussed in section 4.4.2 below.

In 1990, the ESE signed a joint venture (30:70) with Pioneer Hi-Bred International, incorporated as Pioneer Hi-Bred Seeds Ethiopia (PHSE) (Seboka and Deressa, 2000). To date, only the ESE and the PHSE venture are permitted to produce and to market seed commercially in Ethiopia. Unsurprisingly, PHSE activity in Ethiopia has up to now concentrated mainly on imported varieties of F_1 hybrid maize, though there is some testing of hybrid sunflower or alfalfa, and, reportedly, sorghum (FAO, 1999). The venture uses their own agents, as well as DAs, to sell directly to farmers. Though the PHSE has an annual production capacity of 6000t in Ethiopian, annual sales only reached 1000 t in 1999, with total sales between 1992-2002 roughly 7350 t (Raymakers, 2002).

Returning to the specific case of sorghum, Figure 4.2 shows that, at least until the mid-1990s, State Farms continued to receive the vast majority of MV seed, a trend more obvious than for other crops. The amount supplied to smallholders is relatively constant, and small, with State Farms taking up any additional seed produced. This reiterates the relative importance of State Farms as stakeholders for ESIP. The low proportion of sorghum seed that is directed to smallholder farmers may be a reflection of the continued weakness of seed marketing and distribution institutions, as well as farmers' low and sporadic demand for ESE's seed. The average amount allocated to smallholders, about 150 t a year, is far below their estimated seed needs of 12 500 – 37 500 t. This would cover between 1 and 3% of Ethiopia's sorghum area. Interestingly, this is roughly the same as the estimate in Chapter 3 of sorghum MV adoption.

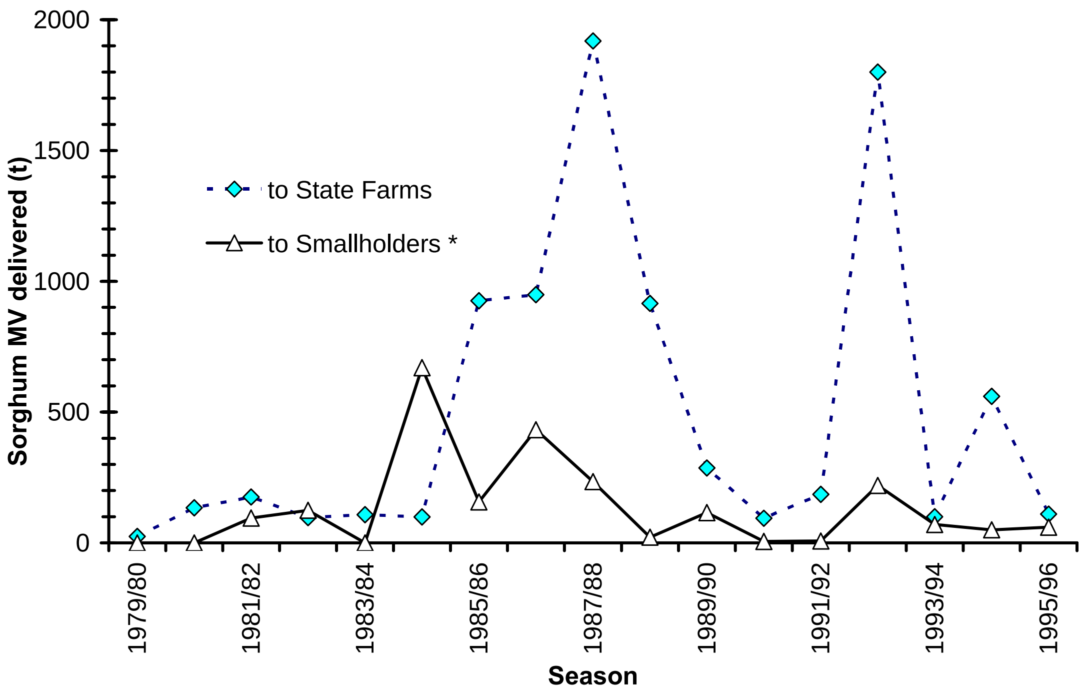


Figure 4.2 Deliveries from the ESE of Certified Seed of MV sorghum to State Farms and smallholders, from 1979/80 to 1995/96, calculated from data in Emana (2001: Table 1 and Figure 1 in Appendix B) (* Delivery to smallholders was via MoA).

A number of conclusions can be drawn from the seed distribution figures. The first is that distribution was mainly through a few large institutions, with the overall allocations largely determined by national-level policy choices and disaster relief needs. Secondly, these allocation decisions meant that smallholder farmers only had access to a small proportion of MV seed produced – sorghum is a particularly notable case here. Thirdly, the top-down approach to distribution, largely through administrative decisions, worked against any development of institutions that could respond to actual smallholder demand, and meet this through supply channels. Fig. 4.2 shows the consequences of this; with little development of demand-led channels, the actual supply to smallholders remains small and constant. Any extra seed is sent to State Farms. However, it is not clear whether the development of marketing institutions, better information about seed quality, and competitive seed prices in formal supply channels would actually result in higher smallholder demand for MV sorghum seed, as so little is known about seed supply preferences. The current emphasis on package programmes appears simply to continue the pattern of large-scale allocation to a few clients, who then distribute what they have; it is by no means certain that these programmes will stimulate the development of a more demand-driven seed distribution.

Seed prices

During the *Dergue* period, government policy fixed seed prices. These were liberalised in 1992, as part of wide-ranging free-market reforms that lifted price controls and sold off many State enterprises (Agrawal and Wolde Mariam, 1995). As a result, seed prices rose considerably (Amha, 2002). Sorghum seed MV prices for 100kg were 236 and 223 Birr in 1996 and 1997, respectively (about US$29) (Dabi *et al.*, 1998), though this is not much above market prices for 100 kg of grain, which range from roughly 120 to180 Birr. Table 4.5 gives an example of how seed price is currently broken down in ESE, with reference to wheat.

From Table 4.5, profits to the ESE, wholesalers, or retailers seem small. Margins are tight, and are presumably sensitive to fluctuations of yield, or of prices elsewhere. For instance, seed growers' margin in practice may be well below the 20% quoted here, since quality control requirements mean more labour from growers, and lower yields. Also, grain prices can approach those quoted for seed, as they did in 1997. Thus, the costs of meeting seed quality standards can lower margins for seed growers, and may restrict wider farmer participation in any schemes for seed production. Also, the low margins envisaged for wholesalers and retailers may prevent investors from entering this area, especially if farmer demand is so difficult to predict.

Table 4.5 Projected seed procurement and sale costs for 100 kg of MV wheat seed through the Ethiopian Seed Enterprise, 1996/97 projections, adapted from data cited by Kugbei and Turner (2000) († in Ethiopian Birr, 1US$ ≈ 8 Birr).

Stage	Costs †	Cost elements	Margin	Margin %
Seed grower costs (estimate)	131.25	Seed, labour, cleaning and roguing	N.A.	N.A.
Price paid to seed growers	157.50	Estimate cost, plus growers' margin	26.25	20
ESE enterprise costs	197.26	Transport, processing, packing, tagging, overheads	39.76	25
ESE price	217.00	ESE profit margin	19.74	10
Wholesale price	234.36	Transport, storage, wholesaler profits	17.36	8
Retail price	246.00	Transport, storage, retailer profits	11.64	5

Political economists (e.g. Chossudovsky, 2000) have decried such liberalising reforms, suggesting that donor coercion has been the impetus, and highlighting fears that the poorest will lose access to public services because of them.[56] However, the seed sector, at least, was clearly unsustainable before these reforms; for instance, the State Farms and AISCO paid roughly 10-30% below ESE's production costs, while NGOs paid 5-10% above. Only after the price liberalisation did ESE start to make profit. Moreover, these price distortions did nothing to help the MoA and AISCO estimate seed demand. Consequently, their estimates of seed needs, based on estimates from SCs, was more of "a wish list, rather than an effective demand estimation" (World Bank, 1995:10). Though structural adjustment has not been totally benign, arguably it has helped the ESE become financially viable, with (so far) little apparent abandonment of non-hybrid crops, such as has occurred in other African countries (Cromwell, 1996; Zerbe, 2001). However, it is not clear whether a more demand-sensitive system has emerged due to these price increases, only that the ESE is now more financially viable, and thus potentially more able to fulfil its role of supplying seed to farmers.

[56] Chossudovsky states that the Ethiopian government signed a Policy Framework Paper, outlining these changes, under pressure from the World Bank and the IMF, while USAID provided large supplies of fertiliser 'in exchange for free market reforms'.

4.3.3 Summary: outstanding issues for Ethiopian seed supply and extension

Like ESIP, the development of the ESE and formal seed supply in Ethiopia is an impressive accomplishment, given the institutional and logistical difficulties. Up until the mid-1990s, the ESE, like many African seed systems, was beset with problems relating to insufficient investment and infrastructure, low levels of management experience, and no independent system of quality control. This affected its capacity, and the quality of its output. Another consequence was a delayed process for approving a variety for release; the time from breeders making a cross, to the MV being released and multiplied as Certified Seed could take as long as 14 years (R. Kirkby, *pers. comm.*, 1998). A World Bank review (1995) found that participation of some institutions in the NVRC was inadequate, and that late reporting of evaluations (and poor attendance by committee members) delayed variety release. The current official goal is to streamline the process, and drastically reduce delays in variety testing and release (Getinet Gebeyehu, *pers. comm*., 1998). The variety testing process is opaque, with restrictive DUS criteria. Moreover, some MVs that do get approved may not be multiplied, particularly those for lowland ecologies, as there is little infrastructure for seed multiplication, storage, or distribution in this region. Finally, what seed does get multiplied is largely distributed through institutional channels according to administrative decisions, rather than through a distribution network in response to farmers' expressions of seed needs.

Until the 1990s, there was little legislative support to seed supply, and institutional roles were unclear. As such, the institutions to promote MVs, estimate supply, distribute seed to address demand, and maintain quality were weak or non-existent. All of these factors can undermine the efforts of breeders. Smallholders were not well-served by formal seed supply, with only maize and wheat featuring to any great extent, while regions outside of the highland areas where ESE facilities are concentrated have received far less attention.

These issues have driven seed supply reforms in the 1990s. The World Bank has been particularly important in promoting reforms to Ethiopia's seed sector, contributing $22m of a $31.8m project on improving seed supply (World Bank, 1995). These have focused on improving capacity and efficiency of the ESE, and encouraging more private-sector investment. These market-driven reforms, along with policy development and support from a relatively new agency, the NAIA (whose establishment as the NSIA in 1992 was also supported by the World Bank) are meant to improve the links between supply and demand, and enhance efficiency and quality.

However, the effectiveness of these reforms, particularly in addressing sorghum, remains to be seen. The following section explores three major elements of formal seed sector reforms in the late-1990s: supply (the 'Farmer-Based Seed Production' scheme); demand (SG2000 and NEIP); and policy changes (the NAIA and the draft Seed Law).

4.4 Seed system reforms in Ethiopia

The above discussion of Ethiopia's formal seed supply and extension mainly refers to the *Dergue* period, and immediately thereafter. Since the mid-1990s, Ethiopia has dramatically liberalised its economy, removing price controls and establishing policies to encourage – and regulate – private enterprise in agricultural input supply and marketing. These reforms have also addressed the seed sector, seeking to create a more dynamic, market-oriented, and well-regulated seed supply system that can better address farmer needs. Linked to this have been sweeping reforms to extension and promotion of input packages, in an attempt to lower barriers to MV adoption. I describe reforms to supply, demand, and regulation, exploring their effectiveness in meeting farmers' needs, considering the challenges outlined above.

4.4.1 Reforms to seed supply – farmer seed multiplication

In the late 1990s, the World Bank financed the Seed Systems Development Project in Ethiopia, implemented by the NAIA. As part of this project, the NAIA received US$5 million to implement the Farmer-Based Seed Production and Marketing Scheme (FBSPMS), starting in 1997 (World Bank, 1995). Recognising the limited capacity of the ESE and PHSE to produce enough seed to meet Ethiopia's needs, this scheme sought to organise large numbers of smallholder farmers in producing Certified Seed. The intention was that this scheme would double the total national production of Certified Seed, while making this seed more available to farmers by virtue of the decentralised approach, as the seed could be sold directly to district MoA offices, or reach neighbouring farmers through informal exchange. With this widely-dispersed approach, the FBSPMS sought to be more effective in meeting local demand, and supply seed in a timely and affordable manner. A further goal of the scheme is to organise the most successful seed-producing farmers into producer groups, and support these groups in becoming small independent enterprises specialising in seed production. The scheme's ultimate aim was to create a new production and marketing sector to run in parallel to the ESE, one offering seed from a wide array of crops, in response to local demand. Thus, a main component of the FBSPMS was training and capacity development for farmers and for regional government officials in seed production, marketing, and quality control (Medhin and Gebeyehu, 2000).

Starting in 1997, the scheme trained farmers and DAs in seed production and quality control, supplied input and credit to farmers, and collected seed from participating farmers for cleaning and dressing, returning treated seed to the producers for subsequent sale. The FBSPMS started with 1452 farmers growing seed on 740 ha, but planned to expand rapidly to 15 000 farmers by the final year, producing 39 000t of Certified Seed over the five year life of the scheme (Table 4.6)[57]. Projections anticipated that a wide range of crops (22 species) would be offered, and not follow ESE's emphasis on wheat and maize. In contrast with the projections, however, records for the first two seasons show that wheat still dominates actual seed production, along with maize and teff (Table 4.7), while barley and sorghum received far less attention than suggested in the plan (Table 4.6).[58] Detailed annual production data are unavailable, but roughly 34 000 t of Certified Seed were produced 1997/98-2001/02, with 9200 t produced in the final year, most of this being maize (Raymakers, 2002).

[57] Medhin and Gebeyehu (2000) cite 40 000 as the expected number of participants. As with some of the NEIP literature, they use the cumulative number of participants across years, and do not clearly state that the number of different farmers should be much less than 40 000.

[58] Seed production figures for other crops (e.g. oilseeds, forages) were probably not included in Medhin and Gebeyehu's account. Nevertheless, the relative emphasis on a few cereals is still high.

Table 4.6 Projected numbers of farmers producing seed for the FBSPMS, by crop and season, adapted from the plan at the outset of the scheme (Medhin and Gebeyehu, 2000) (* specific crops listed only for cereals: projections for other crop types include several species).

Crop type		Year					Total	% total
		97/98	98/99	99/00	00/01	01/02		
Cereals	Teff	560	800	1320	1989	2640	7309	18.3%
	Wheat	510	710	1195	1802	2392	6609	16.5%
	Barley	230	355	620	932	1238	3375	8.4%
	Maize	160	390	660	995	1320	3525	8.8%
	Sorghum	0	240	330	497	660	1727	4.3%
	Total cereals	*1460*	*2495*	*4125*	*6215*	*8250*	*22545*	*56.4%*
Pulses *		0	770	1275	1920	2550	6515	16.3%
Oil Crops		0	445	750	1130	1500	3825	9.6%
Vegetables		160	460	825	1245	1650	4340	10.9%
Forages		80	330	525	790	1050	2775	6.9%
Total		**1700**	**4500**	**7500**	**11300**	**15000**	**40000**	**100.0%**

Table 4.7 Actual (1997/98) and projected (1998/99) FBSPMS seed production, by crop, taken from Medhin and Gebeyehu (2000).

Crop	1997/98		1998/99	
	Seed (t)	% total	Seed (t)	% total
Wheat	562	51.7%	8290	75.0%
Teff	288	26.5%	2215	20.1%
Barley	73	6.7%	175	1.6%
Maize	155	14.3%	340	3.1%
Sorghum	0	0.0%	27	0.2%
Potato	8	0.7%	0	0.0%
Total	**1086**	**100.0%**	**11047**	**100.0%**

Is the FBSPMS more effective at estimating and meeting local seed needs than the national ESE programme? Though the plan is for the selection of which crops will be grown for seed to be based on a local assessment of needs, the choices are made at the level of the Regional States, through the RADBs, who consult Zonal- and *Woreda*-level officials, as well as local DAs (Medhin and Gebeyehu, 2000). Though the FBSPMS reads as it were rather participatory, there are a number of institutional reasons for questioning the level of actual farmer – or even DA – input into the scheme. As the same RADBs administer the NEIP, with its emphasis on maximising grain production, official choices in the FBSPMS may reflect such top-down policy concerns more than they reflect farmers' interests for diversity or for livelihood stability. The DAs are the only officials to live in farming communities, and know the most about local conditions, but their subordinate position in the bureaucratic hierarchy means they are unlikely to question decisions made at higher levels. Promotion to the electrified world of the *Woreda* office is more likely for DAs who diligently meet their quotas of NEIP participants and complete reports, than for those who challenge superiors' decisions. Finally, DAs generally work with the minority of farmers who have adopted input packages via NEIP; one study in the central Ethiopia estimated that DAs only have contact with 10% of farmers in their area (ICRA, 1999), while another, in the west, found that female-headed households (which tend to be poorer) had almost no contact with the local DA (ICRA, 1998).[59] When selecting participants in the FBSPMS, DAs tend to select "good farmers" (interview, AB). While there is no available information about the decision-making process in the FBSPMS, it would appear to be closely linked to centrally-driven policy concerns, mainly around the extension packages. Thus, it is perhaps unsurprising that the FBSPMS produced mainly maize in its final year, as that crop is prominent in extension packages.

A number of my informants have commented on how the focus of the FBSPMS has shifted from its original direction, from supporting local seed security, to developing a sector of seed production co-operatives. Though the FBSPMS increased availability of some types of seeds, it is unclear whether the scheme was able to develop sustainable farmer producer groups, or helps build up institutions for seed marketing. The RADBs were paying a premium price on FBSPMS seed, as an incentive, but this was only a short-term arrangement (interview, AB). The arrangements for seed cleaning are cumbersome, as it must be collected from dispersed locations, cleaned, and then returned to marketing groups. This adds costs and delays, and limits the flexibility of sellers to respond to quick changes in demand. As Cromwell (1997) points out, farmer-based seed supply reforms tend to replicate all the unwieldy elements of the formal system, without asking if they all are necessary. For instance, cleaning and roguing to meet certification standards, with the delays involved, add to the cost of producing seed; for instance, in the ESE, certification of wheat adds 47% to its cost as grain (Kugbei and Turner, 2000). The FBSPMS and similar seed multiplication projects (e.g. Kugbei and Fikru, 1997; Seboka and Deressa, 2000; Alemaw and Persson, 2000) all have government agencies paying a premium for the farmer-produced seed. Without this subsidy, it is unclear if local demand is sufficient to repay added costs of meeting quality standards, especially as FV from local markets can cost less. Though farmer-producers are potentially more flexible in meeting seed demands, if they emphasise only a few crops, they can be even more vulnerable than the ESE if demand collapses, as it did in 2002, when seed purchases fell by 70% from the year before (Raymakers, 2002; Fig 6.3).

Given the general weakness of marketing institutions in Ethiopia (Amha, 2002), the FBSPMS will have a difficult time developing viable market-based seed enterprises with farmer groups. For seed enterprises to survive, they need strong and flexible institutional links for exchanging information about prices or local demand, and for accessing inputs and credit. As studies of seed micro-enterprises elsewhere have shown (Lyon, 1999), informal networks and relationships of trust are important in providing such links for small enterprises. FBSPMS, and other "farmer-based" seed multiplication efforts in Ethiopia tend to focus on seed production methods and formal organisational aspects. However, there appears to be little if any attention to building institutional capacity, or to fostering linkages with other stakeholders, so that decentralised seed enterprises can be flexible and respond to local demand. Rather, the FBSPMS remains oriented to producing seed to meet the extension packages of RADPs. The scheme is hardly a profound reform to the structure and relationships found in formal seed supply.

[59] As mentioned in the wealth-ranking section in Chapter 2, the DA list of 'every household' of the village missed one third of the households. Almost 80% of these omitted households ended up being ranked among the very poorest.

4.4.2 Reforms to seed demand – extension package programmes

From the mid-1990s, the Ethiopian agricultural policy has centred around aggressive promotion of technology packages. This now guides all extension work, and in the last few years has largely defined the demand for MV seed in Ethiopia. Sasakawa-Global 2000 (SG2000), a joint effort of Japan's Sasakawa Africa Association and the Carter Center in the USA, has programmes in a dozen African countries and started work in Ethiopia in 1993. SG2000 focuses on increasing production by promoting Green-Revolution style technology packages to maximise yield through a combination of MV seed, chemical inputs, and management practices. SG2000 works to strengthen national extension services and promote packages produced by national research institutions. The approach used is a modified T&V system, where extension agents convince a number of farmers to sow a 'demonstration plot' with MV seed, following the full package of input and management recommendations. Farmers must pay 25% of input costs at the start of the season, with the remainder paid at harvest, all in cash. To be eligible, farmers must dedicate a sizeable plot (0.5 ha) to the package (though individuals can combine their plots to make 0.5 ha), and be prepared to show it to others, in the hope of stimulating faster adoption (interviews, TE, AB, 1998; Howard *et al.*, 1999).

Ethiopian policy-makers proved very receptive to this initiative. Researchers had been frustrated that their technologies remained largely 'on the shelf' due to weak extension, and the new government is strongly committed to achieving food self-sufficiency. SG2000 started in high-potential areas (Wollega, South and West Shoa) using maize F_1 hybrid MVs produced in Bako, in the same region. The few farmers who participated were under close supervision by project staff throughout the season (interview, AB, March 1998), and they produced spectacular results during an unusually favourable season, described by one commentator as a "lotto year" (Keeley and Scoones, 2003: 79). There was also a high-profile SG2000 workshop in Ethiopia in 1994, including ex-US President Jimmy Carter and Nobel laureate Norman Borlaug. As Keeley and Scoones (2000), argue, this combination of dramatic early results and influential actors attracted senior Ethiopian policymakers, who quickly made this extension approach the core of national agricultural development policy. It also fit with the agendas of key actors, including the Extension Division of the Federal MoA, who would otherwise have had little role, since extension had by then come under Regional governments. The National Extension Improvement Program (NEIP) started in 1995, taking up SG2000's basic approach, and proceeded to grow exponentially, reaching 3.8 million demonstration plots by 1999 (Table 4.8). In 1998-99, I could clearly observe the political prominence of the package programme; the large number of farmers involved was itself featured regularly on national news, though most researcher colleagues I spoke with were reluctant to voice their concerns with the approach and rate of growth of this programme.

Table 4.8 Number of 0.5 ha plots for technology packages in Ethiopia since 1993 for Sasakawa-Global 2000 and the National Extension Improvement Program (from Mohamed and Terfa, 2001)

Year	SG2000	NEIP
1993	161	0
1994	1482	0
1995	3185	35000
1996	2127	350000
1997	1934	650000
1998	847	2405742
1999	936	3807658
2000	658	3793757

I briefly review the discussion of the package programme impact before considering impact on seed supply. Farmers adopting the packages needed to invest much more labour to follow all package management recommendations (80% more according to one study ; Seyoum *et al.*, 1998), and loans exposed them to risk if harvests failed. Results in early years of NEIP showed large yield gains, making the package highly profitable for farmers, even with the additional inputs (Howard *et al.*, 1999; Seyoum *et al.*, 1998). However, these results came largely from more high-potential areas, DAs had a relatively small number of farmers to advise, and the 1995 and 1996 seasons were very favourable (Ethiopia recorded record production in 1996).

With the rapid expansion of participation, there was concern that the quality of support would decline as DAs became over-stretched (Howard *et al.*, 1999), especially since they were required to fill centrally-defined quotas for participants. One study noted that DAs spent most of their time administering various package schemes and chasing payments (ICRA, 1998), something my own observations confirm. A detailed evaluation of similar SG2000 work in neighbouring Eritrea (Gebreyohanes, 2000) questioned the suitability of technology packages for low-potential environments, and criticised project assumptions that all farmers are similar, that the project addresses their main production constraints, and that markets for inputs and produce would function efficiently. The NEIP/SG2000 project in Ethiopia makes similar assumptions, though all can be questioned. Poorer farmers, and those in low-potential environments either do not adopt, or wish to unpack the package, though there is little scope for this; regardless of an individual household's livelihood constraints, MV seeds must receive inputs and recommended management. In dryland and unfavourable environments more generally, the available technology packages were less effective (Abesha *et al.*, 2000). Farmers whose crops failed needed to sell valuable assets, such as oxen, to pay their debt, or face fines or imprisonment (ICRA, 1998). Several EARO colleagues expressed concerns to me that their technological packages were being pushed too hard, stretched well beyond their original recommendation domains, but felt that the package programme was beyond the reach of criticism. The high degree of political commitment behind the package programmes made it difficult to raise such concerns openly (Keeley and Scoones, 2000). For instance, a researcher from EARO joined two MoA officials for a field evaluation of the package programme. He was shocked to encounter farmers who had lost their oxen and had been imprisoned because of debts to the NEIP after a failed harvest. However, his MoA colleagues prevented him from raising the issue in the trip report, as it was something nobody wanted to hear. Inter-institutional and regional politics further complicate any critical evaluation of the programme, and was portrayed as an unqualified success in the national media and to foreign donors.

The NEIP has a significant impact on seed supply, and largely defines seed demand. Its sheer scale consumes all available MV seed, and seed supply was often a limiting factor for demonstration plots to occur. The number of demonstration plots for a given region is determined centrally, with quotas fed down through the extension hierarchy to DAs to fill. Extension staff also decide which specific varieties to provide for a given area. As the extension manager for Miesso *Woreda* informed me (TE, interview, June 1998) "the farmers don't know the difference between MVs, so cannot choose if given a choice." He based his choice of the sorghum MV 76 T_1 #23 on a farmer survey in the past. However, these opinions reflect a specific season, and the survey coverage may have been small in any case. From a bureaucratic perspective, this approach creates a large and predictable seed demand, driven by quotas and central planning, and it was assumed that formal suppliers and the FBSPMS would meet this demand. However, the sheer volume of demand meant that MV seed could be in very short supply, and there have been complaints about the poor quality of seed received (e.g. ICRA, 1998; Piguet, 2003; Eshetu Mulatu, DRAFT). Moreover, those not participating in the programme had little or no access to MV seed or credit. As far as Miesso *Woreda* extension manager was concerned, the NEIP programme is "agitating the farmers to work, to give attention to their farm," and many farmers were simply "too lazy" to allocate extra labour and adopt package management requirements.

Even where the packages were successful, the profitability for farmers depended on efficiently functioning markets. However, Ethiopia's poor infrastructure, limited financial institutions, and lack of competition greatly restrict effective market development (Amha, 2002). The liberalisation of the fertiliser market has not brought about the expected drop in prices, in part because of limited actual competition (for several Regional States, the only firm supplying fertiliser to NEIP programme is a company tied to the governing party) (Raymakers, 2002). The high production in 2000 and 2001 led to a collapse in cereal prices between November 2000 and May 2002, as there was little storage capacity, and effective demand is weak in Ethiopia, depending in part on stabilisation purchases of local grain by aid agencies (IRIN, 2002). Cereal prices fell more than 80% below their peaks, and stayed less than half their long-run averages in some places, keeping as low as Birr 24/100 kg for maize (roughly US$ 3), far below input costs (Guinand, 2002). Farmers could not repay loans, and often had to deplete their assets to cope, leading to fears of increased long-term impoverishment in many parts of the country. Farmers with outstanding debts were prevented from continuing in package programmes, though most were in any case unwilling to expose themselves to such risk again. From the peak in 2000, participation dropped, as did demand for MV seed; between 2000 and 2002, MV seed sales (from ESE and PHSE) dropped 82%, from 21 000t to 3800t (Raymakers, 2002) (Figure 4.3). Figure 4.3 also suggests that the package programmes influenced the crops for which MV seed was multiplied. From the mid-1990s, the relative dominance of maize and wheat in seed sales has actually increased, with maize now taking a larger proportion of demand than wheat, a reversal of the situation in the early 1990s. Meanwhile, sales of seed for other crops, including sorghum, dwindled to around 2% of total MV seed sales by 2002.

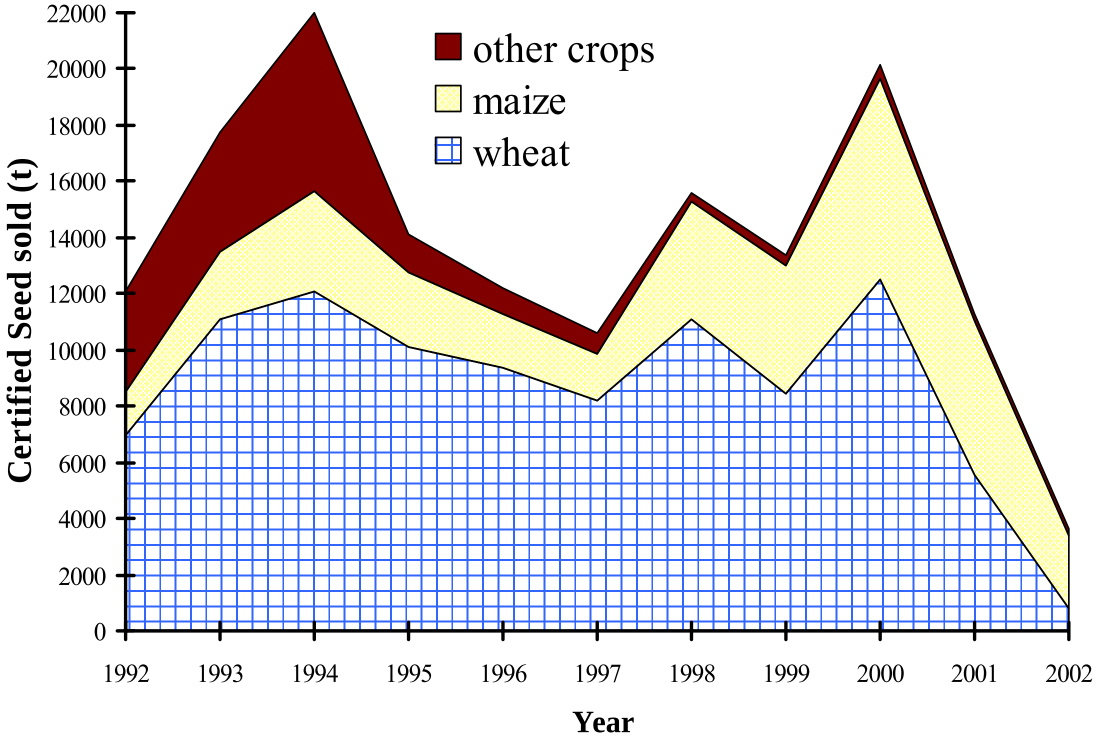


Figure 4.3 Total sales of Certified Seed from ESE, in tonnes 1992-2002, showing proportion of wheat and maize in total sales. "Other crops" includes, roughly in order of importance, teff, barley, sorghum, haricot bean, faba bean, chickpea, field pea, soybean, oilseed rape, sunflower, linseed, *noug* and mustard. Adapted from Dabi *et al.* (1998) for 1992-96, and Raymakers (2002) for 1996-2002.

Though some fear that the market collapse worsened the long-term prospects for many farmers caught in debt (Guinand, 2002), proponents of the programme argue that the collapse is a 'secondary problem' simply to be overcome (Sasakawa Africa Association, 2002). This underscores the over-riding optimism about the ease of developing market institutions, apparent in both the FBSPMS and NEIP cases. Policymakers' optimism was encouraged by IMF recommendations (Stiglitz, 2002), and fed by their desire to achieve surplus grain production at the national level, whatever the cost to local livelihoods. However, the economic and institutional challenges remain considerable, not least because weak markets do not (yet) provide effective demand for surplus grain production. While this is a questionable strategy for agricultural development, it is a disastrous one for reforming seed supply to be more responsive to demand. Seed producers sought to meet centrally-defined quotas, and were less able to develop information links necessary for an effective local seed market. Both the ESE and PHSE could not sell 80% of their seed stocks in 2002. While the figures for the FBSPMS are unknown, their sales were certainly very poor as well. This shows the limits of 'pump-priming' seed demand when the underlying conditions remain uncertain.

4.4.3 Reforms to seed policy – Ethiopia's Draft Seed Law

The programmes described above can be seen as reform initiatives, in the sense that they address the organisation of formal seed supply and demand, and attempt to establish new relationships. A third, and arguably more sweeping, area of reform for Ethiopia's formal seed sector has been in the area of policy. With the enactment of the National Seed Industry Policy in 1992, Ethiopian policymakers sought to establish a framework for subsequent legislation which would foster, and regulate, a dynamic seed sector. The 1992 policy led to the establishment of the National Seed Industry Agency (now NAIA), with a mandate to make processes for variety release, seed supply, and quality control more efficient and effective. Conservation of genetic resources, and farmer participation in the seed sector, were also objectives. Anticipating more decentralised approaches to seed supply, and the involvement of a more diverse array of actors in the seed sector, including private investors and NGOs, these policy reforms aimed to strengthen Ethiopia's seed regulation. This has culminated in the Seed Proclamation No 206/2000 (Federal Democratic Republic of Ethiopia, 2000).

The Seed Proclamation sets out rules to govern the development of a more market-oriented seed sector in Ethiopia. The Proclamation regulates the production, processing, and trade of 'prescribed seeds', that is, seeds designated by the NAIA.[60] Anyone producing, processing, distributing or marketing prescribed seeds falls within the scope of this regulation, and must obtain a Competence Assurance Certificate from the NAIA, with the exception of farmers who produce their own seed to sell to other farmers, unless that farmer advertised to sell seeds (Articles 2&3). To obtain a Competence Assurance Certificate, the holder must have 'qualified professional personnel' aware of technical aspects of seed quality and possess 'necessary equipment', including 'appropriate seed storage' (Art. 6(2)). Producers and processors also need to have a contractual arrangement with an approved laboratory for testing seed quality (Art 7(2)). The NAIA will formally establish quality standards for Certified Seed (i.e. variety purity, seed physical health) and appoint Seed Inspectors with the authority to appear at production, processing, storage, wholesale and retail sites to inspect seed for its conformity to these standards. Certificate holders must make records and samples from laboratory tests of seed quality available to Inspectors, and follow any advice the Inspector gives them for improving the quality, before they are allowed to sell their seed (Art. 13 & 15). Any prescribed seed on sale must have a label specifying it is Certified, the variety name, and the dates of production and testing (Art 16). Resale and exchange of prescribed seed by those without Competence Assurance Certificates is allowed, provided the variety is pure, in a sealed container, and has a Certification label attesting that its quality has been approved by an official testing station (Art 17). Finally, the Proclamation designates stiff penalties for violating these provisions, for example a minimum of 10 years' imprisonment and 50 000 Birr (US$ 6000) fine for selling unregistered or substandard seed.

These policy reforms apply to the entire seed production and distribution chain, and clearly show policymakers' desire to ensure that the seed sold to farmers is of the best possible standards. Reforms fill a clear policy vacuum, and clarify roles and relationships for a diverse range of actors in the seed sector. Policies for variety identity control (DUS) are perhaps most relevant for crops that are exported, or where there is an active seed market, such as for F_1 hybrid seeds. For the horticultural sector, where most seeds are imported, quality clearly needs to improve, since distributors sell impure or expired seed, which strongly impacts on the value of the harvest to farmers (Eshetu Mulatu, DRAFT). However, strict DUS purity is less an issue for crops marketed domestically, and local seed systems often maintain seed physical quality at comparable levels to formally regulated systems. The

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[60] These varieties will be listed on the annual variety register (Art 30(2)), which will most likely be MVs approved by the NVRC for formal release, though the scope for what falls under 'prescribed seeds' could be broader than this, and include FVs.

policy reforms are protective in nature, but could they actually restrict some types of developments in the seed sector, or make illegal existing informal seed supply channels that are of value to farmers?

The demands of obtaining a Certificate, the delays and costs of testing, and the risk of arbitrary (or rent-seeking) penalties from a Seed Inspector may prevent smaller enterprises from investing in the seed sector, and may concentrate efforts on the most profitable crops (such as F_1 hybrid maize), as has happened in other countries. For efforts at integrated seed supply (such as a farmers' co-operative or NGOs producing seed for local sale), the transaction costs involved to deal with the regulation may be prohibitive, and the risk of imprisonment too high. The scope of the Seed Proclamation provides further uncertainty, particularly in its definition of 'prescribed seed', and 'farmer'. If prescribed seed only includes MVs on a variety registry, there is the possibility that all trade in old MVs removed from the list by the NVRC would be illegal, or that trade in MVs that have undergone local selection and adaptation would be prohibited, even if farmers perceived an advantage in these materials.[61] Such exclusive variety lists have been criticised in Europe for restricting the exchange and use of useful diversity, while the standards and transparency of the NVRC have already been questioned above as being too focused on production. While the concern to only offer farmers MVs that are of proven value is admirable, the criteria for determining value are often quite narrow.

The delimitation of who may be involved in seed trade also appears restrictive. While the Proclamation does allow for farmer-farmer seed exchange, this is not the only source farmers have for seed. Petty traders, who are not always farmers themselves, play an important role in supplying seed, especially in more remote locations not reached by those possessing a Competence Assurance Certificate. Some of their wares may include prescribed seed, and, as the next chapter shows, they fill a gap in seed supply in seasons of seed shortage, often providing material of good quality. The Proclamation risks driving out of the seed sector a group operating at a larger scale than local farmer-farmer exchange, but whose members may find it too risky to become Certified traders. The requirement for anyone re-selling (or trading) Certified Seed to have Certification labels and sealed containers also risks squeezing out the smallest actors in informal seed markets. While the urge to protect farmers from sharp business practices is understandable, these provisions appear to reflect the generally poor image of local traders with Ethiopian policymakers, and an administrative urge to control. Moreover, these reforms fit with other policy goals for maximising production, based on the argument that only Certified MV Seed can provide this. However, we know very little about the actual risks and benefits to farmers' welfare of local seed supply systems. While these policy reforms aim to protect farmers, they may also restrict the development of new decentralised seed supply approaches, and stamp out local seed supply activities of real benefit to farmers.

4.5 Conclusions

This chapter has outlined some of the main challenges facing seed supply and variety promotion in Ethiopia, revealing difficulties in meeting supply, in estimating demand, and in ensuring seed quality. Formal seed supply and variety promotion has a strong impact on crop improvement, not just in determining the quantity and quality of MV seed that reaches farmers, but in deciding which varieties are approved and multiplied, and where the seed is

[61] There are many examples of farmers adapting MVs through hybridisation and selection (e.g. Bellon and Brush, 1994; Budelman, 1983), and even of their being formally released.

sent. Maize and wheat comprise the bulk of formal seed production, while sorghum receives much less attention, and lowland sorghum is in extremely short supply, due to the lack of seed farms. During the *Dergue*, the state controlled seed production and supply, and allocated much of the seed to the state sector; consequently farmers often had limited access to MV seed or extension advice. Post-*Dergue* reforms have aimed to make seed supply more efficient, strengthen extension services, and develop a more market-oriented, decentralised seed supply systems that would respond to local needs. These reforms have addressed supply, demand (through technology package programmes), and regulation.

However, these reforms do not seem very effective in the development of a more flexible and responsive seed supply system, largely because seed supply (through ESE, PHSE and FBSPMS) simply responds to the centrally-established variety demands of the package programmes. The reforms, as proposed, do not appear to spur institutional development in anticipating and meeting demand, as they mainly address gross supply and demand needs. Seed regulatory reform, while important, is potentially restrictive, especially if NVRC standards and definitions are too rigidly applied. Though there may be possibilities for small-scale enterprises to come in, the formality of the seed policy would seem to limit the scope for small operators. While there is attention in Ethiopia to supporting smaller actors in entering the seed sector, formal support has emphasised developing their financial skills and technical expertise. In supporting a more decentralised, responsive seed sector, there is still little apparent attention to capacity in accessing information, assessing demand, and building relationships and networks of trust with other actors – all aspects shown to be essential to the success of small seed enterprises (Lyon, 1999; Tripp and Pal, 2001).

For sorghum seed supply, the interlocking issues of supply/demand/information/regulation are more pronounced than for other crops; supply is limited, links are poor, demand appears low and sporadic, and local supply remains cheap and reliable. For these reasons, it is often assumed that farmer-farmer seed exchange meets farmers' seed supply needs for sorghum. This is not always the case, however. For seed supply systems to respond to local seed demand effectively, they need to understand the nature of farmers' demand for seed, including the diversity of choices and preferences. This chapter shows that Ethiopian formal-sector institutions are not well-attuned to assessing this demand, even after reforms. The next chapter explores farmer sorghum seed systems in detail in order better to understand local seed supply and demand, and to suggest different possible strategies for supporting these systems.

Chapter 5 Farmer seed systems for sorghum in West Harerghe: seed access and exchange.

5.1 Introduction

5.1.1 Why investigate farmers' seed systems?

The previous chapters addressed formal sector sorghum improvement in Ethiopia, highlighting some of the reasons why breeding and seed supply reach only a small proportion of smallholders. This chapter, and the following one, analyses the systems actually formed and used by farmers. The term 'farmers seed system' refers to all seed selection, management, storage, and dissemination activities occurring outside the formal sector (Almekinders and Louwaars, 1999; Sperling and Cooper, 2003).[62] As Chapters 3 and 4 showed, the principle activities of the formal seed system – germplasm conservation, breeding and variety testing, certification, multiplication, and extension – take place in separate institutions. However, farmers' practices are integrated (Almekinders, 2001). For instance, farmers' seed production is usually not separate from crop production, while their management shapes local the structure of genetic resources locally. Thinking of these practices in terms of a 'system' highlights such interactions, and also suggests that desirable outcomes such as resilience or equity can be analysed as emergent properties of this system (McGuire, 2001a). This point is explored more in the final chapter, in discussing 'seed system health'.

Globally, farmer seed systems remain important: a commonly-stated figure is that farmer systems supply around 80% of planting material each season in the world (Cooper and Cromwell, 1994; van Gasbeek *et al.*, 1994). Farmer seed supply remains overwhelmingly important for sorghum in Ethiopia: FVs dominate in the fields, and the vast majority of seed is either stored on farm, or obtained from local sources.

An understanding of farmer seed systems is crucial for any reform efforts in crop improvement. This is perhaps most obvious in the area of seed supply, especially when considering reforms to seed supply. In the past, many national seed programmes ignored farmer seed systems. The predominant modernising perspective assumed that formal seed supply should eventually replace farmer systems over time, due to the poor seed quality and inefficient seed delivery of the latter (e.g. J. Douglas, 1980; Pray and Ramaswami, 1991). However, the relatively recent perspective on "integrated seed supply" is becoming more popular in reform initiatives (e.g. DSE/ICARDA, 1996; ILCA/ICARDA, 1994; Rohrbach *et al.*, 1997). This perspective is pragmatic, avoiding the promotion of one system over the other, but rather seeking to combine the strengths of each system in order to arrive at a more effective, equitable, dynamic seed supply (Almekinders and Hardon, 2000; Almekinders and Louwaars, 1999; van Amstel *et al.*, 1995; David and Kasozi, 1999). Such integration can only occur on the basis of a critical analysis of both formal and farmer seed systems, their strong and weak elements, and the nature of their existing interactions. Integration could involve supplying germplasm, strengthening local seed production and storage skills, or

[62] Other terms have been used to denote non-formal seed systems, such as 'local' (Almekinders *et al.*, 1994) or 'informal' (Thiele, 1999) or 'traditional' (Aguirre *et al.*, 1999). However, these systems can combine 'local' and introduced elements, or display 'traditional' and 'modern' aspects. For similar reasons to using 'Farmer Variety', I will refer throughout to 'farmer seed systems' for any breeding and seed supply activities occurring outside the formal institutional boundaries.

facilitating communication linkages (McGuire *et al.*, 1999:23-25).[63] Choosing an appropriate course of action requires a good diagnosis of the farmer seed system.

Understanding farmers seed systems is also important for those promoting breeding reform. There has been a long-running interest in the ability of farmer seed systems to disseminate new technologies produced by breeding (e.g. Green, 1987; Cromwell, 1993; David and Sperling, 1999; Seboka and Deressa, 2000; Sthapit *et al.*, 1996; Witcombe *et al.*, 1999; Grisley and Shamambo, 1993). However, there is also growing interest in the role seed systems play in farmer experimentation and innovation, helping us understand how novel materials enter seed systems and spread between households (McGuire, 2002; Dhamotharan *et al.*, 1997; Richards, 1986; Weltzien and von Brocke, 2001). Seed systems are part of the local plant genetic resources management system, influencing geneflow and shaping how diversity is framed and managed as distinct farmer varieties (Louette, 1994), something explored in more detail in the following chapter. As with seed supply, there is also an interest in integrating the strengths and capacities of formal and farmer systems for breeding (e.g. Cleveland and Soleri, 2002a), driving an interest in analysis of local seed systems.

Thirdly, interest is also growing in the field of emergency seed relief. In the last 20 years, a common response to disasters, such as drought or conflict, has been supply of externally-produced seed as part of reconstruction efforts. Yet there is little evidence that these efforts are effective in most cases (e.g. Sperling, 1997; Sperling and Longley, 2002; de Barbentane Nagoda and Fowler, 2003; Haugen and Fowler, 2003). Emergency seed supplied in bulk can be of poor quality (Chemonics, 1996), and is often poorly-adapted to local needs. In Ethiopia, NGOs such as World Vision, organising seed relief after the 1984-85 famine, typically emphasised MV seed from wholly inappropriate crops, such as hybrid maize and wheat, when drought-tolerant crops such as millet or teff were probably more urgently needed (P. Richards, *pers. comm.*, 1997).[64] Ethiopia has experienced almost continuous seed relief programmes since then, yet with little apparent impact on seed security (Sperling and Cooper, 2003). The main reason for the poor impact of emergency seed supply is that interveners know virtually nothing about local seed needs in those situations, and are unaware of existing local capacity for meeting these needs. As Sperling and Cooper (*ibid.*: 3) attest “Seed relief activities should be built upon a solid understanding of seed systems”, which involves exploring their role in supporting local livelihoods. Seed continues to be scarce in West Harerghe for sorghum (Eshetu Mulatu, DRAFT; Piguet, 2003), making an analysis of farmer seed systems even more critical.

5.1.2 What to study in farmers’ seed systems?

Many seed studies have concentrated on estimations of aggregate seed needs for an area, but this tells us little about seed security at a household level, or how this varies by household (Cromwell and Tripp, 1994). A general description of seed sources also gives little indication of their relative importance or accessibility to farmers in different situations. Variation by season, environment, and household is also important. A useful analysis of seed systems needs to be detailed, grounded in its local context, and crop-specific (Thiele, 1999: 96). Of the more detailed studies, many have addressed potatoes (e.g. Prain and Scheidegger, 1988; Crissman and Uquillas, 1989; Thiele, 1999; Rhoades, 1985) or beans (e.g. Grisley, 1993; Grisley and Shamambo, 1993; Sperling, 1994; Sperling *et al.*, 1996; David and Sperling,

[63] Thiele (1999: 94-95), in his discussion of “linkage mechanisms” for seed system support, classes similar activities under the rubrics ‘injection’, ‘technological’, and ‘organizational’ linkage mechanisms, respectively.
[64] As Sperling (2002) points out, seed relief can be used to promote a particular modernisation agenda (i.e. by using it as an opportunity to promote only MVs).

1999; Janssen *et al.*, 1992), reflecting the interest of particular CGIAR centres. Other detailed system studies have also made important contributions (e.g. Teshome, 1996; Longley, 1997; Zimmerer, 1998; Bellon and Brush, 1994; Louette *et al.*, 1997; Richards *et al.*, 1997; ITDG/ODI, 2000; ITDG-Kenya/ODI, 2000; Dhamotharan *et al.*, 1997). These highlight how seed systems are specific to crop and location; this chapter follows in this tradition for sorghum in West Harerghe.

The chapter starts by asking how farmers obtain seed, as its starting point for analysis. Seed access is often seen as the central element in seed security (Sperling and Cooper, 2003). Exploring how households obtain off-farm seed uncovers valuable details about household seed security, and about different household approaches to seed access. This access could come via a household's own production, or off-farm sources, and a household's assets (its physical, financial, social capital, etc.) help determine what sources of seed are available to it. Besides accessibility, the timeliness, quantity, physical quality, and appropriateness (i.e. genetic quality) of the seed supplied are all important to farmers (Weltzien and von Brocke, 2001; McGuire, 2001a). The different possible seed supply channels (e.g. one's own farm, farmer-farmer exchange, local markets, NGOs, and government agencies) vary in all these aspects.

Chapter 4 highlighted the need for any seed supply effort to appreciate the nature of farmers' demand for off-farm seed, which can be variable and unpredictable, and to work with local definitions of quality (i.e. physical health or genetic purity). It is also important to understand that usage of different channels or mechanisms to obtain off-farm seed varies among farmers, as do preferences. This chapter traces actual seed exchanges, their amounts, terms and geographical scope, in order to analyse these different channels and their accessibility (and importance) to specific farmers in specific situations. A central hypothesis is that the importance of different seed channels varies between seasons, locations and farmers. The approach of this chapter, grounded as it is in analysis of actual exchanges of seed, aims to highlight variation among farmers, avoiding the more generalised approach of many studies of seed exchange (i.e. 'where do you usually go for seed?'), which may reflect norms, more than actual practice.[65]

Though 'social capital' is currently a popular concept, few studies analyse the social dimensions of seed exchange, and how they affect access to seed (though exceptions are Sperling *et al.*, 1996; Longley, 2000; Archibald and Richards, 2002). More technically-focused account sometimes assume that there are no barriers to seed exchange among farmers; in other words, all farmers have equal access to seed from their neighbours, and that useful varieties spread easily farmer-to-farmer. However, seed systems are social systems (Richards *et al.*, 1997; Richards, 1986), and exchanges are more than just simple transactions between individuals, but can reflect patron-client or gender relationships, norms and values. Identifying those marginal to seed exchange networks is just as important as identifying key actors in supplying seed to others. This chapter will explore how roles, opinions and preferences about seed exchange differ among farmers, particularly between those who frequently, and those who rarely, seek off-farm seed. Using the concept of moral economy, I also probe the broader social meanings behind seed exchanges, as cash-based transactions become more important in seed exchange and seed security.

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[65] Exchanges are in part a response to specific instances of seed need as they occur, which questions about general actions do not necessarily uncover. As the section on social relations argues, norms and social relations also influence how farmers approach exchanges.

This exploration of seed exchange aims to highlight both stronger and weaker aspects of farmer seed systems for sorghum in West Harerghe. By focusing on processes and relationships, we can start to assess important properties, such as stability over time, resilience in the face of environmental hazards, diversity, and equity. The field of ecosystem health claims to identify such emergent properties of environmental systems (Okey, 1996; Costanza, 1992; Costanza and Mageau, 1999; Rapport, 1998; Gallopín, 1995; Waltner-Toews and Wall, 1997). In a similar way, an attempt will be made to ascertain the 'health' of a farmer seed system (McGuire, 2001b). More to the point, such an analysis of relationships, and properties of a farmer seed system points to areas needing reform or external support.

5.1.3 Some conceptual distinctions

The boundaries of 'formal' and 'farmer' seed systems are not sharp. Seed can be part of both systems at a given point in time; FVs sometimes directly lead to MVs, through pure line selections, and FVs are the genetic raw material for most breeding. MVs adopted by farmers are often incorporated into existing mixtures of FVs (e.g. Scheidegger, 1993), and can come to be seen as a 'local' variety, especially when MVs hybridise with FV materials (Smale *et al.*, 1995; Budelman, 1983; Bellon and Brush, 1994). Though I continue to use 'farmer' and 'formal' to identify seed systems, this chapter shows that the systems farmers use to acquire seed, and the seed itself, blend elements of both .

This analysis distinguishes *variety introduction* (the arrival of a variety on a farm that was not present before) as a special case of *seed exchange* (any movement of seed). This is to stress the distinction between 'seed insecurity' (lack of planting material) and 'variety insecurity' (lack of desired or appropriate varieties). Both are important, but have different implications for local livelihoods (Sperling *et al.*, 1996). This chapter emphasises seed exchange and seed insecurity, while Chapter 6 considers variety introduction, and the available choice of diversity, as important facets of farmers' plant genetic resource management.

5.2 Sorghum seed exchange in West Harerghe

This account draws data from several nested samples, as described in Chapter 2. In the two selected Farmers' Associations (FAs), Funyaandiimo (highland, Chiro *woreda*) and Melkaa Horaa (lowland, Miesso *woreda*), I interviewed 141 farmers about seed supply during the planting period (May-June 1998). In the middle of the season (September), I administered a survey to 94 farmers over wider areas of Chiro, Miesso, and adjacent highland *woredas*, to confirm trends found within individual FAs. Within Funyaandiimo and Melkaa Horaa FAs, I regularly visited a subset of 21 contact farmers, selected as a rough cross-section of each community according to wealth, soil types, and levels of on-farm diversity. Germplasm collections, market collections, and focus group discussions also provided important information. For simplicity, I will refer to specific data by its source: individual interviews, survey, contact farmers, and focus group discussions, and to 'Chiro' and 'Miesso' for any samples in the highlands or lowlands, respectively. Most contact was with male household heads, as men carry out the bulk of early season cropping activities such as land preparation and sowing, and are thus very active in acquiring seed. Women and other family members also contribute to farm labour, and also can play a role in seed acquisition and exchange (particularly when this involves markets, where women are quite active). However, women or junior family members do not have separate plots for sorghum, and any seed management they do relates to the main family plot. Roughly 5-10% of households are female-headed, though my opportunistic sampling approach meant that only around 2% of my surveys and interviews were with women, though one contact farmer was as well. Thus, most of my information from 'farmers' comes from male household heads. While these are key informants on seed management for household sorghum plots, they are by no means the *only* informed household members; gendered aspects of knowledge and practice in managing sorghum seed systems constitutes a possibly important area for future investigation.

5.2.1 Seed insecurity: seed saving and germination risk

Most farmers are their own main source of seed each season. Designating a portion of their harvest as 'seed', they treat and store this separately from grain, to be used in the next sowing season a few months later.[66] The quantity of seed saved on-farm is an important – though not the only – factor affecting household seed security. They were asked in surveys about how much seed they intended to save from the 1998 harvest (Table 5.1). Though Miesso farmers planned to save significantly more seed, in absolute terms, than their highland counterparts, their field sizes are considerably larger in the lowlands, so farmers in both districts save roughly the same amount of seed in terms of area to sorghum, around 30 kg ha^{-1}. This is double the amount farmers in this area actually sow per hectare (Kefyalew *et al.*, 1996), and 2-4 times the sowing rate recommended by ESIP (IAR, 1995, n.d.).

Table 5.1 From surveys, means (with standard errors) of absolute amount of seed farmers planned to save at end of 1998/99 season, this amount relative to the area they sow to sorghum, and this amount as a percentage of what they consider a good or poor harvest on their farm.

	Chiro (n=53)	**Miesso (n=41)**
Total amount of seed planning to save (kg)	15.5 (2.7)*	27.7 (4.0)*
Amount seed planning to save relative to sorghum area (kg ha^{-1})	29.0 (3.9)	36.4 (6.1)
Seed to be saved as proportion of expected 'good' harvest	1.3% (0.2)*	2.5% (0.7)*
Seed to be saved as proportion of expected 'poor' harvest	7.1% (2.0)*	21.8% (4.5)*

(* Difference between districts significant at α<0.05)

There are a number of reasons for such high rates of seed saving. Firstly, not all seed may germinate, though the physical quality of local seed is often better than Ethiopian officials claim, and germination rates are likely to be respectable in most situations.[67] Secondly, germinated seedlings must emerge from deep (8-10 cm) planting, frequently through heavy or crusted soils, with erratic rainfall sometimes leading to unfavourable soil moisture. Thus, seedling emergence can be uneven under farmers' conditions. Finally, pest attack and drought can wipe out any seedlings that have emerged, further adding to the risk of poor stand establishment. As many farmers noted, high sowing rates are a form of insurance against these risks, increasing the chance of obtaining a well-established stand necessary for a good harvest. This is more than a simple blanket response. As Chapter 2 noted, farmers adjust their sowing rates to soil moisture conditions at planting time, suggesting that their

[66] The different local methods of seed storage are discussed in the next chapter.

[67] Studies comparing local and formal (certified) seed have often shown equal or superior germination rates for farm-saved seed, such as for rice in Sierra Leone (Richards, 1986) and Indonesia (J. Hardon, *pers. comm.*), and wheat in Ethiopia and Syria (Bishaw, 2004). This is not always the case, however (e.g. Kashyap and Duhan, 1994). The issue of physical quality is discussed more in the following chapter.

actions are calibrated to evolving conditions of rainfall and wind. However it is clear that those who can spare the seed tend to err on the high side. Farmers were aware that inter-plant competition could depress crop yield if that were too dense, but most thin out sorghum stands through the season by *shilshallo* (mid-season cultivation with oxen) or hand weeding (see Table 2.7). The young plants thinned out become an important source of livestock feed, a factors some farmers mentioned as contributing to their high sowing rates.[68] Finally, many farmers save enough seed for repeated sowing, further to increase their chance of successfully establishing their field. As one farmer reported "I save 100 kg, and plant 3-4 times, waiting two weeks after each sowing until it is established."[69] Similar to Watts's (1983) findings in northern Nigeria, repeated sowings are an important form of adaptation to drought and uncertainty.

Table 5.1 also presents the amount of seed farmers planned to save as a proportion of their expected harvest, giving a rough estimate of the 'cost' of seed security[70]. Two things become clear: this cost can become considerable in poorer years (even in Chiro, which is considered a 'surplus' area), and in the lowlands, seed can represent a significant proportion of the harvest. This reflects the lower and more uncertain harvests in the lowlands, and clearly indicates the greater general seed insecurity there. Mean figures mask considerable variation among farmers; while some farmers in both districts planned to save 100 kg as seed, others planned to save as little as 2 kg, presumably placing consumption first. Those saving smaller amounts are more likely to become seed insecure due to a storage mishap, consumption of their seed before planting, or a failed first planting (as there is insufficient seed to re-sow). On the other hand, those saving large amounts of seed usually have enough for multiple plantings, and can meet their own seed needs in most years. Some of these farmers state that they intend to give any unplanted seed to others.[71] Thus, it is unsurprising that, among my contact farmers, those who had supplied seed to other farmers in 1998 had saved significantly (2-3 times) more seed than those who had not supplied seed (Table 5.2). Household seed security is obviously a prerequisite for seed exchange, a point further explored below.[72]

Table 5.2 The mean amount (with standard errors) of sorghum seed contact farmers in Funyaandiimo (Chiro) and Melkaa Horaa (Miesso) stated they had saved at the end of the 1998/99 season, and how this amount compares between those who had given/sold seed in 1998, and those who had not.

	Chiro		**Miesso**	
	n	**kg ha^{-1}**	**n**	**kg ha^{-1}**
Seed saved, all contact farmers	11	55.3 (11.7)	10	48.6 (12.4)
Seed saved, those who gave seed in 1998	5	75.4 (21.2)*	3	78.9 (10.6)*
Seed saved, those who did not give seed in 1998	6	38.5 (10.9)*	6	24.9 (12.2)*

(* Difference between those giving and not giving seed significant at $\alpha<0.05$)

[68] For instance "I sow at a higher rate [16 kg ha^{-1}] for animal feed. Without animals, I sow at a lower rate [8 kg ha^{-1}]." AH, Cophii FA, Miesso, survey.
[69] DK, Madhicho FA, Miesso survey.
[70] Compared to some crops, sorghum is not 'expensive' in this regard: rice farmers in Sierra Leone use as much as 10% of their harvest, for seed, while wheat farmers in medieval Europe could use 25% (Richards, 1986).
[71] For instance "I save 100 kg, to have enough to distribute to others who need," JM, Lagalafto FA, Chiro survey..
[72] The amount of seed saved per area is considerably higher than in Table 5.1, possibly reflecting the specific location or small sample size reported in Table 5.2. However, the latter table cites actual amounts of seed these farmers had set aside, while the earlier table gives future intentions of farmers surveyed earlier in the season. Thus, the higher figures may be a more representative of the amount of seed farmers typically save.

Even with high seed saving rates, many farmers still need to seek off-farm seed in some years. For example, due to the unusually late rains during the 1997 harvest in Chiro, and the failure of the 1998 *Belg* rains in Miesso, 40% and 73% of those interviewed, respectively, had germination problems for their March-April plantings (Table 5.3). The majority of Miesso farmers were already planning to seek off-farm seed at that stage. The frequency of germination failure, particularly in the lowlands with its uncertain rainfall, reduces the capacity of the neighbouring farmers to meet seed needs after failed plantings. This contributes to more widespread seed insecurity.

Table 5.3 From individual interviews before main rains (May/June) 1998, the number of farmers (with percentages) reporting germination or emergence problems with sorghum, who had already received off-farm seed for that season, and who stated further plans to seek off-farm sorghum seed for planting with the late rains.

Situation in May/June 1998	Chiro (n=83)	Miesso (n=59)
Germination problems	33 (40.2%)	43 (72.8%)
Already received off-farm seed	14 (17.1%)	7 (17.5%)
Further plans to seek seed	2 (2.4%)	35 (59.3%)

To summarise, even though some farmers set aside large amounts of seed for the following year, seed insecurity remains a problem at the household level. Some farmers can be called chronically seed insecure (Cromwell, 1996), as their poor harvests, or competing demands for consumption grain mean that they save little or no seed, consequently needing off-farm seed most seasons. Other farmers are able to save large amounts of seed, allowing for high sowing rates, and repeated plantings. These farmers also appear to be important suppliers to neighbours in need. However, even those who save large amounts may run out of seed, particularly in the lowlands of Miesso, with its stresses on early crop development, though germination failure can be a problems in the highlands as well. The differences between those giving and not giving seed are important, and explored in the following section, as part of a more general discussion of seed exchange.

5.2.2 Seed exchange

Differences between those giving and receiving seed

Seed exchange between households is undoubtedly important, though different methods give varying levels of exchange. Of farmers surveyed in Chiro and Miesso, 35% and 22%, respectively (in interviews, more than a third from both locations) mentioned giving or selling seed in 1998. Slightly lower proportions admitted receiving off-farm seed, though this may be underreported.[73] With the contact farmers, followed through the season, more than half gave or sold seed in 1998 (Table 5.3), and most (82% in Chiro, 73% in Miesso) received at least some off-farm seed, even if only a small gift of a new variety to try. Though individual interviews and surveys may not capture all exchanges, they give a reasonable indication of the volume and nature of seed exchange. Smaller exchanges, important for the introduction and spread of new varieties, are explored more in Chapter 6.

[73] As suggested in several instances when cross-checked specific instances of seed-exchange, where some farmers I interviewed did not mention of receiving seed, even though they had been named by others as receiving their seed. While the recipients may simply have forgotten a small exchange, reluctance to admit needing to borrow seed may lead to its underreporting. This issue is discussed below.

The highland farmers of Chiro who stated in surveys that they had received off-farm seed in 1998 were not significantly different in most aspects from those who did not receive seed (Table 5.4). Those receiving seed had fewer oxen, on average, though this was significant only at p=0.08. This suggests that highland farmers who did receive seed in 1998 were not distinct from their neighbours in any straightforward manner, perhaps reflecting the widespread problems caused by the late rains in 1997. On the other hand, the lowland farmers of Miesso who received seed differed significantly (p<0.05) from their neighbours, expecting lower yields, and lower total production in a 'bad year'. On average this group owned more oxen, however, suggesting that their low yield expectations were due to poor land or to other livelihood constraints. In any case, the low yield expectations of seed recipients in Miesso underscores their vulnerability, and the likelihood that this group includes 'chronically seed insecure' households, who regularly need off-farm seed.

Table 5.4 Means of some characteristics of farmers in West Harerghe who stated in surveys that they had supplied or had received seed off-farm in 1998 (* *Timad* is a local unit of area, roughly 1/8 of a hectare).

Farmer characteristic	Chiro				Miesso			
	Received in 1998		Gave/sold in 1998		Received in 1998		Gave/sold in 1998	
	Yes	No	Yes	No	Yes	No	Yes	No
Number responding	6	47	19	34	9	32	9	32
Amount given / received (kg)	13.0	--	32.4	--	18.5	--	35.3	--
Number given to	--	--	5.8	--	--	--	4.7	--
Age of farmer	35.83	37.62	41.68**	35.03**	36.44	35.34	39.33	34.53
Family size	5.00	6.72	6.89	6.32	7.11	6.50	7.33	6.44
Number of oxen	0.83*	1.35*	1.39	1.24	1.89**	1.16**	2.33**	1.03**
Number of full-time additional workers	0.83	1.07	1.26	0.91	0.89	0.62	1.00	0.59
Area farmed (*Timad*)*	5.17	5.13	5.42	4.97	9.22	10.41	13.78**	9.12**
Area planted to sorghum (*Timad*)*	4.67	4.24	4.76	4.03	7.44	7.09	10.00**	6.38**
Seed saved/area to sorghum (kg/ha)	24.00	30.93	30.88	32.91	36.78	31.26	27.37	31.71
Expected production, good year (t)	1.27	1.28	1.71**	1.03**	1.30	1.93	2.86**	1.49**
Expected production, bad year (t)	0.41	0.39	0.53**	0.32**	0.17**	0.30**	0.44**	0.22**
Expected yield, good year (t/ha)	2.13	2.64	3.02**	2.33**	1.42**	2.36**	2.28	2.12
Expected yield, bad year (t/ha)	0.71	0.84	0.95	0.75	0.22*	0.38*	0.41	0.33
'Age' of seed stocks on-farm (yrs)	7.67**	12.98**	14.5**	10.9**	4.11**	11.30**	15.00**	8.23**

(Difference in means of 'yes' and 'no' responses significant at * $\alpha<0.1$ and ** $\alpha<0.05$).

Both the Chiro and Miesso farmers who gave or sold seed to others in 1998 expected significantly higher production, in both good and bad years (Table 5.4). Miesso farmers who supplied seed also had more land and oxen. This highlights the importance of households with relatively better assets, and harvest security, in supplying seed to their neighbours, particularly since these farmers supplied five or more other farmers, on average. Chiro donors were also significantly older than recipients. The issue of relative wealth, patron-client relationships, and seed exchange is revisited below in discussing social relations and seed supply. The sampling approach provided little time for identifying female-headed households, and only two of the respondents were female, which is below the general 15% proportion of female-headed households. Thus, the survey may miss gendered aspects of seed exchange. Such distinctions would likely reflect different levels of household assets, as there appear to be few clear differences between female- and male-headed households in crop emphasis or farming techniques (unlike in some countries), except for use of oxen.

The 'age' of seed stocks estimates the time stocks of each variety have been on a farm, based on the number of years since the farmer had to completely replace seed stock of that variety due to loss, or since its original introduction, if no new seed of that variety had since been taken in. This is averaged across all varieties presently on the farm. While a very rough indicator (it is based on farmer admission and recall of total replacement, rather than a partial 'refreshing' of a seed lot), it does give an estimate of the rate of turnover of seed stocks at the household level. Richards (1995; 1986) found very high turnover in the rice varieties grown by Sierra Leone farmers, reflecting a strong ethos of experimentation in trying new varieties, though also as replacements for lost varieties. West Harerghe sorghum farmers also adopt and abandon varieties as part of experimentation, though a few FVs dominate in each district (see section 6.3), and there is also a strong normative value placed on retaining one's seed stocks.[74]

Those receiving seed in 1998 have, on average, had their seed lots for a significantly smaller time, while those supplying seed have possessed their seed stocks for significantly longer, on average. This may reflect the fact that donor farmers tend to be older, and thus have had more time to hang on to a variety in the first place, but the magnitude of 'age differences' is somewhat greater with seed lots than with farmers (Table 5.4). This suggests that a lower age' of varieties represents a higher replacement rate of seed lots, mainly due to lost seed stocks. Some of this may also be due to farmer experimentation, but most of the varieties mentioned here were locally-established ones (i.e. were not novel varieties that farmers were 'trying out'; farmers do experiment, but this was usually not mentioned in the survey, but only uncovered in direct field visits – see next chapter). The average 'age' of seed lots thus gives a fairly clear indicator of a household's seed security, and is significantly different according to those who gave or received seed in 1998. The most dramatic difference was seen for Miesso, suggesting seed recipients lose their seed stocks much more frequently than their neighbours, requiring more frequent replacement. As Richards (1986) found, the poorest or most vulnerable farmers were often those who regularly lost their seed. The picture appears similar in West Harerghe.

Amounts and terms of seed exchange

Of the farmers who admitted receiving off-farm seed in 1998 in either surveys or interviews, those in Miesso received significantly more, on average (Table 5.5). This is unsurprising, given the higher environmental risk in the lowlands. The standard quantity used in seed exchanges in Miesso, particularly for purchases, is a '*tanika*' (=a tin can ; Leslau, 1976), which refers to a standard container that measures approximately 17 kg of seed. This

[74] For instance, when asked if they had ever replaced their seed stocks, a number of farmers announced with obvious pride that they had the stock of *Wogere/Muyra/Masugi* etc. given to them by their parents.

amount, generally enough to completely re-sow lowland plots, again highlights the high volume of seed exchange in the lowlands.

Table 5.5 Combining data from surveys and individual interviews, the mean quantity (with standard errors) of sorghum seed farmers reported receiving in 1998, according to district.

	Chiro (n=19)	**Miesso (n=9)**
Mean amount seed received in 1998 (kg)	8.8 (2.2)*	19.6 (6.3)*

(* Difference between districts significant at α<0.05)

Farmers seek off-farm seed from a number of sources, including relatives, other farmers, NGOs, government suppliers, and local markets. The terms of supply vary according to source: family members generally supply seed for free, while merchants nearly always demand cash payment. For other seed sources, terms vary. Government and NGO sources tend to supply on credit, with payment at harvest, as with the NEIP programme. Distributions of small amounts may be free, however. Terms from 'other farmers' (i.e. those not family members) tend to reflect the circumstances of the exchange, as well as relative wealth and relationship between donor and recipient. While small quantities (usually 2 kg or less) are generally given as gifts between farmers, larger amounts are sometimes (but not always) exchanged for cash, or the equivalent amount of grain. Loans for later repayment can also occur, though these were mentioned infrequently.

Some farmers – generally prominent individuals – do give large amounts of seed as gifts. Their presence is why the differences between the mean amounts of seed supplied as a gift, compared with amounts supplied on other terms, were not significant (Table 5.6). This table gives mean total amounts supplied by individual farmers in 1998, combining all exchanges mentioned by farmers. Again, these figures likely miss some smaller exchange, as suggested by the frequent exchanges and gifts of seed uncovered in more detailed discussions with the contact subset of farmers. As Table 5.7 shows, each farmer supplying seed in 1998 did so to over five other farmers, on average. There were no significant differences according to district or terms of supply. This table also shows that the most commonly reported form of non-gift supply was in exchange for grain.

Table 5.6 Combining data from surveys and individual interviews, the number of transactions and mean total amounts supplied (with standard errors) to others in 1998, by district and terms (* non-gift: cash sale, exchange for grain, exchange for other seed, or seed credit).

Terms of supply	**Chiro**		**Miesso**		**Both districts**	
	n	**Amount (kg)**	**n**	**Amount (kg)**	**n**	**Amount (kg)**
Gift	32	33.2 (7.2)	27	32.7 (6.6)	59	33.0 (4.9)
Non gift *	14	59.3 (15.1)	3	27.3 (11.3)	17	53.7 (12.8)
Total	**46**	**41.2 (6.9)**	**30**	**32.2 (6.0)**	**76**	**37.6 (4.8)**

Some farmers only become major suppliers, however, because their seed is the only available local source to meet the acute needs of neighbours. For example, one farmer in Chiro (AM) was the only one in his village in 1998 to have seed that germinated well, as his FV

('*Wogere*') had a relatively open panicle, and was less affected by spoilage from the late rains around the 1997 harvest. This was discovered by a neighbour of AM's, AAA, who is known in the village for his innovations (he is credited with introducing '*Hadhoo*' to the village). AAA took it upon himself to test the seed of every farmer in the village for germination, declaring AM's the best. Consequently, AM provided 200 kg of his *Wogere* to his neighbours to plant (some of it from storage), in exchange for grain.[75] In the lowlands, the *Belg* rain failure of 1998 required farmers to seek out fast-maturing seed to plant for the later rains. Even if farmers there had grown fast-maturing MVs the previous season, few set aside seed MV for the next season, in part because they consider its storage qualities poor (Kefyalew *et al.*, 1996). However, one individual in Melkaa Horaa FA (AAS) regularly does so. In 1998, AAS supplied over 100 kg to his neighbours for planting with the late rains, at 2 Birr/kg, comparable to the market prices at that time.[76] In both cases, the non-gift terms may have been related to the large quantities supplied.

Table 5.7 From surveys and individual interviews in West Harerghe, the number of transactions where farmers reported supplying seed to other farmers in 1998, with the mean number of other farmers supplied (with standard errors).

Terms of supply	n	Number of recipients
Gift	60	5.0 (0.7)
Sale	1	4.0
Exchange for grain	15	6.9 (1.4)
Exchange for seed	1	10.0
Seed credit	1	5.0
Total	**78**	**5.4 (0.6)**

One final point on terms of supply is that all reports of grain-for-seed exchange gave a 1:1 'exchange rate'. This is lower than exchange rates seen in other locations (e.g. 2:1 for maize in Honduras, C. Almekinders, *pers. comm.*). Farmers are acutely aware of physical quality differences between seed and grain, so it is unlikely that this grain-for-seed parity is due to unawareness of the advantages of material stored specifically as seed. Rather, I argue that this exchange rate is more a reflection of local norms of reciprocity among neighbours, where a higher exchange rate might be seen as profiting from the misfortune of others. I revisit norms in the section on social relations in seed exchange.

The different sources for farmers to obtain off-farm seed have different implications, besides the terms of supply. The quantity supplied, timing, physical quality, and genetic quality all interact with the terms of supply to some extent. Table 5.8 shows amounts exchanged according to source, as reported by recipients. Farmers obtained significantly more from markets than from other farmers, with family members intermediate. Markets appear important for supplying large amounts, while neighbours, though used more frequently, generally provide smaller quantities of seed. Interestingly, no Miesso farmer reported receiving seed from the wider family in 1998. The more recent and dispersed settlement patterns in the lowlands mean that neighbours are often more accessible than family members, and may face strong pressure to give what they can.

[75] Group discussion, Wasarbii Village, Funyaandiimo FA, 30 May 1998.
[76] Focus group discussion with poorer farmers in Hussee Village, Melkaa Horaa FA, 28 October, 1998.

Table 5.8 From surveys and individual interviews in West Harerghe, the number of events where farmer reported receiving off-farm sorghum seed in 1998, and the mean amount received (with standard errors) according to source and district.

Seed Source	Chiro		Miesso		Both districts	
	n	Amount (kg)	n	Amount (kg)	n	Amount (kg)
Family	3	15.7 (5.0)	0	0	3	15.7 ^{AB} (5.0)
Other farmers	14	4.7 (0.9)	6	14.5 (2.1)	20	7.6 ^{B} (1.4)
Market	2	27.0 (13.0)	3	29.7 (19.5)	5	28.6 ^{A} (11.5)

(Means followed by a different letter are significantly different at α<0.05)

No farmer in the interview or survey sample reported receiving seed from government or NGO sources in 1998. When their long-season sorghum plantings had failed, several Miesso farmers stated that they had registered with the *Woreda* MoA to receive fast-maturing MV seed via the NEIP package programme. The Melkaa Horaa farmers even assembled to ask the FA Chair to press their request with the MoA.[77] However, even with its links to the ESIP sub-station in Miesso, the *Woreda* received only a token 100 kg (it had requested 2600 kg), so very few farmers received seed from government channels, i.e. only those selected as 'best' farmers and required to implement the full input package.[78] NGO seed distribution efforts were equally patchy, and were potentially damaging. Local MoA workers spoke of poorly-adapted varieties being distributed; I encountered one area in the lowlands that had received a highland, late-maturing variety from the Lutheran World Federation, an NGO. This variety was completely inappropriate, and did not even set grain, so all harvests were lost.[79] These experiences explain why many farmers hold a negative view of government or NGOs as seed sources (see Table 5.14).

Where farmers have a choice among a range of market outlets of different scale and formality (e.g. local merchants, large shops), they often distinguish between them in terms of quality, availability, or ease of terms they provide. This has been noted with beans in East Africa (David and Sperling, 1999), as well as vegetable seed suppliers in East Harerghe (Eshetu Mulatu, DRAFT). However, market sales for sorghum seed in West Harerghe do not appear to be segmented in this way, and farmers make no mention of distinctions between different types of sellers. Farmer-sellers and small grain merchants are the source of nearly all marketed seed, travelling to weekly local produce markets. When farmers obtain seed from other farmers locally, they generally know its provenance, and 'neighbour certification' can vouch for genetic identity and quality (Cromwell and Tripp, 1994; Cromwell, 1993). If the material has poor physical quality and fails to germinate, there is at least some recourse to confronting the neighbour that supplied them. However, this is less possible for seed purchased from itinerant merchants. The sorghum seed they sell to farmers is generally sorghum grain. Physically mixed or impure seed can cause farmers problems, but can also be a means of 'unplanned' introduction of new diversity (see Chapter 6). More serious is the issue of poor physical quality, something Ethiopia's Draft Seed Law explicitly seeks to

[77] ASA, interview 3 June 1998.
[78] Interview with TE, director of extension for Miesso, 30 June 1998. He planned to hold back the seed of this MV until the appropriate sowing time, but expected all recipient farmers to be at the ready for land preparation when he gave the word. This underscores the argument last chapter that formal seed supply poorly responds to demand for lowland sorghum MV seed, and potentially undermines, rather than builds, real demand for MV seed.
[79] They distributed an FV, '*Demee Segel*' (=nine branches) to several farmers, according to one recipient (MUY, Bililoo FA, November 1998). This variety was extremely tall (>4m) and very obvious on farms in the area. None had set seed by late November.

address. Formal sector agencies often assume poor germination quality in local systems, but do not often test this. Evidence from elsewhere in Ethiopia and Africa indicates that farmer-saved seed could achieve germination rates equal to formally certified seed for a number of crops (Tsega, 1994; Wright *et al.*, 1995; cited in Wright and Turner, 1999).

I purchased sorghum seed from merchants in Miesso market on several occasions during the late planting season (June/July 1998). Seven seed lots were obtained from six different vendors, most being farmers from nearby communities.[80] Prices were above those of grain, varying between 2 and 3.5 Birr/kg, with higher prices prevailing in the final weeks as supplies were running out. I assessed germination rates after four days of these samples in the laboratory, using three replications of 100 seeds. Germination rates were high for four of the seven samples, and moderate for a fifth (sample 7). The poor germination of samples 3 and 4 indicates that at least some market seed may be of poor physical quality. Late rains in 1997 had widespread impact on seed quality, so these figures may be unusually low. Thus, farmers purchasing from the market do face some uncertainty, though it may still be preferable to alternatives. Price appears a larger concern (see Appendix D)

Table 5.9 Germination rates after four days for seven sorghum seed lots obtained from merchants in Miesso market in June/July 1998. Means of three replications (with standard errors) shown.

Sample	Germination (%)
1	89.0 (1.0) A
2	85.3 (6.9) AB
3	17.0 (6.1) C
4	9.0 (2.3) C
5	88.7 (1.2) A
6	87.3 (4.4) A
7	60.3 (10.1) B

(Means followed by a different letter are significantly different at $\alpha<0.05$)

Initial supply of seed for a variety

The introduction of new varieties to farms is a particularly important aspect of local seed systems, since this shapes diversity, particularly at the farm level. For each of their current varieties, farmers in the survey were asked about their initial source of seed for that variety, as well as the terms and amounts of this initial supply. Again, a household may obtain a new variety as a gift, via purchase, or exchange (Table 5.10), with gifts usually supplying smaller amounts[81]. Average amounts are higher in Miesso than in the highlands. Though not shown in Table 5.10, the average time period since gifted introductions was significantly greater (mean ≈19 years) than acquisitions by sale or grain exchange (9 and 8 years, respectively). This may suggest a decline in free gifts as a basis for exchanging new varieties, as some farmers claim (see next section). However, it may also simply reflect the fact that young farmers starting out typically receive their first seed as gifts from the family, while varieties obtained later in a household's history can come from a variety of sources besides family gifts. Varieties obtained long ago tend to be FVs such as '*Masugi*' in the lowlands, '*Wogere'*

[80] Five of the six stated they came from Assebot or Gorbo, both within 20 km of Miesso, with the other coming from near Metehara, more than 100 km to the west across the Central Rift Valley.

[81] Amounts received differed significantly according to supply terms (F= 3.23, df=2/66, p=0.046), though *post-hoc* multiple comparisons did not discriminate among these.

or '*Muyra*' in the highlands, which have been popular FVs for some time. Nevertheless, many popular varieties have been introduced relatively recently.

Table 5.10 From surveys, the mean amount of seed received (with standard errors) for the first supply of a given sorghum variety to a farm, by terms of supply and district.

Terms	Chiro		Miesso	
	n	Amount (kg)	n	Amount (kg)
Gift	15	5.4 (0.8)	18	10.0 (2.0)
Sale	10	11.2 (3.1)	10	11.1 (1.8)
Exchange for grain	17	7.2 (1.3)	2	24.0 (8.0)
Total	**42**	**7.5 (1.0)***	**30**	**11.0 (1.5)***

(* Significant difference by location at $\alpha < 0.05$)

Table 5.11 breaks down initial supply in terms of source and quantity. For Chiro, the market and Service Co-operative (SC), though less frequently used, supplied significantly larger quantities of seed than family or other farmers. Family members were actually the most common initial source for sorghum varieties, though quantities were not usually specified for supply from family; thus, other farmers are the most prominent source in Table 5.11. In Chiro, some farmers were members of the SC, and obtained FV seed through the SC, generally in exchange for cash. When the SCs were disbanded in 1990, their assets were dispersed, and some member families have retained varieties from the 1980s until this day. SCs were largely absent in the Miesso area, and hence played no role in input supply. Another difference between highland and lowland is that nine Miesso farmers stated that they first received seed of some fast-maturing varieties[82] from government, mostly as free gifts in the last few years, while the government played no role in the highlands. This reflects the greater potential role of MVs in the lowlands for drought escape, and the continuing efforts of the Miesso research sub-station to promote MVs through occasional farmer distributions. Past studies indicate that the majority of farmers in the Miesso area have been exposed to MVs, though most prefer FVs (Kefyalew *et al.*, 1996).

Table 5.11 From surveys, the number of times different sources were used for the first supply of a given sorghum variety to a farm, and the mean amount supplied (with standard errors). (*****As each variety introduction was counted individually, the number of transactions exceeds the number of farmers surveyed.)

Source	Chiro		Miesso	
	n*	Amount (kg)	n*	Amount (kg)
Family	36	5.4 (1.3) ^{B}	33	13.1 (4.4)
Neighbour	31	6.3 (0.9) ^{B}	10	13.9 (2.8)
Market	4	13.3 (6.5) ^{A}	4	12.5 (2.6)
Government			9	6.6 (1.1)
Service Co-op	5	14.7 (5.3) ^{A}	0	

(Means followed by a different letter are significantly different at $\alpha<0.05$)

[82] '*Sarude*', '*Harka Bas*', and '*Tayaqee*', all probably MVs or derived from MVs, as indicated by the names (see Table 6.3).

Other aspects of seed access

Farmer access to seed is of central concern is analysing seed systems. Table 5.4, and the above discussion, suggest a possible structural element to seed exchange, where better-off farmers are regular suppliers in a community, while regular recipients tend to be more vulnerable, and more likely to count among the chronic seed insecure. However, this social safety net may be insufficient to provide for all those in need, especially in a particularly poor season, as some of the better-off farmers suggested. Table 5.12 indicates the proportion of seed exchanges that involve another FA. In 1998, 29% of farmers obtaining seed sought it from a different FA, some because they had special ties in that location, or sought a particular variety from there, others because appropriate seed was not available locally. Particularly for Miesso, local unavailability of seed was a clear factor when farmers supplied seed to other FAs, accounting for nearly half of all cases. For instance, several farmers in Melkaa Horaa FA reported supplying seed to farmers who had travelled there from Madhicho FA, 15-20 km to the north, where lack of rain caused widespread germination failure. Highly localised rainfall variation, compounded by micro-topographic effects, makes such localised failures fairly common, particularly in the lowlands. This is highlighted by the fact that 80% of Miesso farmers who have had to replace their seed lot after a total loss (i.e. obtain new seed of the same variety) have had to go outside of their local communities.

Table 5.12 From surveys in West Harerghe in 1998, the proportion of reported sorghum seed exchange events that were non-local (**†:** non-local: to/from a different Farmers' Association than where the respondent lives).

Seed exchange event	**non-local exchanges† (%)**	
	Chiro	**Miesso**
Received in 1998	29	29
Gave/sold in 1998	17	45
First obtained a given variety on-farm	8	18
Replaced seed stock of variety after significant loss	11	80

Another dimension of seed access is the ease of obtaining seed of a specific variety from another farmer (i.e. to try a new type). Strong norms of reciprocity, and general politeness, make it difficult openly to refuse a request for a small amount of seed to try out. A number of farmers insisted everyone freely shares seed for such requests. However, a number of farmers did report difficulties obtaining a particular variety from others, particularly in Miesso (Table 5.13). Rather than being flatly refused, those who felt they had been denied access to new seed were dubious about neighbours' claims that there was no more seed to spare. The survey setting may have influenced under-reporting, since, in focus group discussions with poorer farmers, every person attending felt that such denials do occasionally happen, and that the generosity of neighbours with seed was somewhat less than publicly portrayed.

Table 5.13 From surveys in West Harerghe in 1998, frequency of responses to the question 'Have you ever wanted to try a certain type of seed, but were unable to obtain it?'

Ever have access problems?	Chiro		Miesso	
	count	%	count	%
Yes	2	3.8	14	34.1
No	51	96.2	27	65.9

One view of farmer seed systems, still widely-held, is that seed moves freely between farmers, a view supported by reports of rapid and spontaneous spread of new and interesting varieties among farmers (e.g. Green, 1987). This view carries the tacit assumption that there are few barriers to exchange between farmers, provided sufficient seed is available. As David and Sperling (1999) point out, this assumption is rarely tested. Referring to studies of beans in East Africa, they show that social barriers, as well as lack of seed, can limit exchanges between farmers and constrain the spread of varieties. There are a few reports of individuals, or lineages, restricting access to a cultivar they consider to be their own,[83] but such exclusive control over crop genetic resources appears to be rare in local seed systems, even among those who do recognise a form of individual or family 'ownership' over a cultivar (for a review of available evidence, see Cleveland and Murray, 1997). Certainly, there was no evidence of intellectual property playing a role in exchange of sorghum seed in West Harerghe. Where West Harerghe farmers do encounter barriers to accessing sorghum seed, these have to do with the transaction itself. The final section examines this social dimension in more detail, exploring seed exchange as one of many forms of mutual aid among farmers, and identifying issues that may arise in formal collaboration with local seed systems.

5.3 Social relations in seed supply

Some seed systems studies consider social relations, and how seed exchange reflects mutual aid and reciprocal support (e.g. Longley, 2001; Richards, 1986; Sperling, 1996; David and Sperling, 1999; Sperling and Loevinsohn, 1993; Dhamotharan *et al.*, 1997). However, these social support mechanisms usually do not have a prominent place in the analysis of seed exchange practices. In general, local coping strategies, and their wider social context, deserve more consideration, as agencies involved in agricultural development often overlook their possible benefits to farmers (Richards, 1990).

Besides the physical and genetic quality of seed, the quantities, terms, and timing of seed supply also matter to farmers. All of these factors influence the accessibility (and value) of seed for farmers. An important question is how do farmers' use of different channels interact with wider social relationships, and what are the implications for the quality of seed obtained, and for seed access more generally? As Table 5.4 suggests, farmer-farmer seed exchange is not entirely random, but rather better-off farmers tend to supply their poorer, more seed insecure neighbours. Do these exchanges constitute a form of patron-client relationship, and if so, what other exchange relationships are involved? Following this, how do more vulnerable farmers, or farmers with less access to potential patrons, obtain off-farm seed when they need it? Are social relationships changing? Farmer-farmer seed exchange is especially relevant for any seed system activities (whether in breeding or seed supply) that

[83] For instance, Chakanda (2000) encountered sorghum cultivars in Mali that were apparently a clan 'secret', and possibly off-types. See also Boster (1986b) for an example with cassava in Amazonia.

depends on local systems for dissemination (e.g. community seed banks). What insights might an analysis of seed exchange relationships offer for seed system interventions and reforms?

5.3.1 Moral economy

Different analytical frameworks exist to explore social relationships around seed exchange. Though the notion of 'social capital', as popularised by Putnam (1993), is one possible approach for analysing networks of support in a community, it tends to miss the cultural and ideological context of these relationships, and generally has little to say about the expression of agency and power (Harriss, 2002; Fine, 1999). In comparison, the notion of 'moral economy' is very much focused on how support relationships relate to power, as well as reflect a culture's values. For this reason, I use moral economy as a framework to analyse social relationships around seed exchange in West Harerghe's sorghum seed systems.

Moral economy is a term to describe the norms underpinning exchange relationships, particularly 'vertical' relationships between patrons and clients. This framework is especially useful for emphasising the consequences of changes in the nature of these relationships, when they shift from multi-faceted informal or 'traditional' ties that are often long-term, to more narrowly-defined ties based on short-term transactions, via contracts or the market (Ensminger, 1992). Does seed exchange form part of a moral economy in West Harerghe communities? Moreover, how has this moral economy been affected by Ethiopia's recent history, particularly by the (albeit modest) expansion of the cash economy in rural areas and the diversification of rural livelihoods towards more off-farm activities? Before considering whether it applies to seed exchange, I summarise some key points about the moral economy framework.

Gift-giving and mutual support has long been the subject of anthropological inquiry (e.g. Polyani, 1944; Evans-Pritchard, 1940). 'Moral economy' has frequently been used to denote the norms that underpin mutual aid in agrarian (e.g. Adams, 1993; Bailey, 1991; Richards, 1990; Watts, 1983) and pastoral societies (e.g. Henkdrickson *et al.*, 1998; Samatar, 1992). The concept is perhaps best known from James Scott's (1976) study of peasant rebellions in Southeast Asia. According to him, the moral economy of peasants relates to household-level survival strategies in variable and uncertain contexts, where the poorer households, close to the margins of survival, are risk-averse. Drawing from Chayanov's studies of peasant household economies (Chayanov, 1966 (1925); Kerblay, 1971), Scott shows that vulnerable households will enter into apparently unfavourable arrangements with patrons, such as with landlords, provided these offer guarantees of subsistence. Patronage from better-off individuals thus provides poorer households a degree of insurance against the uncertainty most of them expect to face. Wealthier households enter into such arrangements partly out of objective self-interest, as the abandoned poor could present a real danger to village society, and to the better-off in particular (Scott, 1976). Also, patrons of poorer farmers can build a network of clients, for labour, or as support for their social or political status. "Village egalitarianism in this sense is conservative not radical: it claims that all should have a place, a living, not that all should be equal." (*ibid.*: 40)

Scott's central point is that the norms underlying these patron-client relationships bring a political dimension into the discussion of peasant economic relations (Brass, 1991). Scott argues that norms of reciprocity lead the poor to expect, when they hit hard times, some degree of assistance from wealthier households, as part of a broader reciprocal relationship.

In a moral economy, the social status of better-off households is legitimised to the extent that they employ some resources for the good of others, and the appearance of selfishness would incur the "abrasive force of gossip and envy" from their neighbours (Scott, 1976: 5). However, the growing importance of the market in the last century, and increasing wealth disparities, mean that the wealthy are less dependent on material assistance from their neighbours, but can hire short-term labour when required. Thus, the commitment of wealthy peasants to reciprocal relationships has weakened, something which he argues was the origin of peasant revolts in Southeast Asia, as the poor sought to re-establish the security they had in the previous moral economy.

Critics of this thesis have questioned the historical methods Scott uses to build his case (Haggis *et al.*, 1986). More critically, Popkin (1979) questioned whether a moral economy underlies reciprocal relationships, arguing that rational interactions between individuals who calculate their costs and benefits can shape such relationships, rather than collectively-shared norms. In response, Scott's detailed study (1985) of a Malaysian rice-farming community showed an intense ideological struggle at the community level between landowners and their poorer neighbours over the degree and terms of reciprocal support. Recent developments in agricultural technology and markets enabled landowners to mechanise and hire short-term labour from outside the community, making them less dependant on their poorer neighbours as a reliable labour source. Consequentially, the poor received less paid work, charity, or favourable rents from their previous patrons. Scott detailed how the poor made morally-based appeals for a return to the previous terms of relationships, using gossip, passive resistance, and character assassination against wealthier neighbours who were seen to have strayed the furthest from the previous moral economy. Thus, a moral economy is not necessarily a fixed or universally-agreed set of norms, but rather a contested terrain, bound up with ideas about equity and social justice (Bailey, 1991).

5.3.2 Exploring the moral economy of seed exchange

The fieldwork in West Harerghe was not primarily ethnographic in nature, and the interest in social relationships only arose after a preliminary analysis of the seed exchange data. Much of the information I gained about norms is probably only the "partial transcript" available in public settings, and I had only a few opportunities to hear divergent "backstage" views, where disputes about a moral economy are more likely to be aired (Scott, 1985: 284-289). Thus, the following discussion does not claim to probe every aspect of social relations around seed exchange in West Harerghe. Rather, my aim is exploratory, to identify areas for future inquiry, and highlight important issues for consideration when supporting local seed systems. For comparative purposes, I also draw from the work of Watts (1983) in northern Nigeria and Richards (1986) in Sierra Leone, as both consider the links between patron-client relationships and coping mechanisms, though they draw rather different conclusions (Richards, 1990)

5.3.3 Evidence for a moral economy

Several reasons support the notion that seed exchange is part of a local moral economy. Firstly, as indicated by Table 5.3 and other exchange data, many farmers regularly need large amounts of off-farm seed to be able to continue farming.[84] Farmers recognise that having appropriate seed – and oxen for ploughing – at the right time strongly affects yields, and see

[84] This discussion focuses mainly on larger quantities required for planting, i.e. 10 or 20 kg, rather than small (<1 kg) exchanges of seed to try out a new variety.

the supply of seed and oxen to those in need as an essential support to their livelihoods. Public statements portray mutual aid in these areas as a moral imperative, for example citing Islamic requirements for charity to poorer neighbours. As one highland farmer stated when asked why he had given seed to so many of his neighbours "Our father said that seed and oxen should go to those who ask."[85]

Secondly, Oromo societies are characterised by strong horizontal ties of association. Clans (*gosa*) signifying common descent are scattered in a complex web across different communities (Baxter, 1994). For Oromo social or political organisation at the local level, friendship, neighbourliness, or voluntary ties are important, more so than networks based solely on kinship (Lewis, 1975; Hassen, 1994; Bulcha, 1996; Bassi, 1994). In the past, a complex age-grade system, *gada*, was the main form of local governance, presiding over the various clans in one location. Though *gada* has declined in most areas,[86] the sense of egalitarianism it symbolised remains important in Oromo societies (Pausewang, 1983; Bulcha, 1996). Some of my older, more prominent informants have been called to other communities for conflict resolution, much as their counterparts would have intervened under the *gada* system. Another central principle is *Nagaa* (Peace), which guides all interactions among Oromo: unacceptable behaviour is sanctioned by social, livelihood, or ritual isolation (Bassi, 1994). Oromo society is also known for its facility to incorporate outsiders (Blackhurst, 1996; Bulcha, 1996; Oba, 1996; Jalata, 1993; Hassen, 1994). As Million Tesfaye (1961) noted in Harerghe, even Orthodox Amhara families could become assimilated into Oromo social relations through a ceremony of adoption into a clan.

Thirdly, mutual-aid institutions are common. *Edir* is one widespread mutual-aid institution, particularly for sharing labour or oxen (Ta'a, 1996), found in many parts of Ethiopia (Rahmato, 1991a). In West Harerghe in the past, *edir* associations tended to be local, while *gosa* (clan) ties crossed village boundaries (Million Tesfaye, 1961: 71). *Gosas* were particularly important for organising mutual aid around funerals (Andargatchew Tesfaye, 1957). The *Dergue* restricted travel and discouraged traditional associations, and the geographical scale of *gosa* activity appears to be greatly reduced compared to the past. In West Harerghe at present, *gosa* appears to be much like *edir*, representing groupings of a small number of individuals in one village for sharing labour during peak periods (ICRA, 1996; F. Adam, pers. comm., 1998). However, such co-operative arrangements do not appear to be restricted to clan, but reflect friendship or other ties. Arrangements such as *gosa* are commonly organised as one-off arrangements for collective labour, with the host supplying *chat*, *hodja* (boiled maize), and food to the workers in exchange for a day's unpaid work. Similarly, a range of possible arrangements exist for farmers to borrow or loan out oxen in exchange for labour (e.g. *inyi*, or *wajjina* are arrangements that specify a certain number of days' labour for each day's use of an oxen team) (ICRA, 1996). Other arrangements can also be negotiated to acquire resources such as oxen or land in exchange for labour, or a proportion of the harvest.

A fourth reason that a moral economy may exist in West Harerghe is that patron-client relationships still exist between neighbours. The *Dergue's* land reform and abolition of tenancy in 1975 did remove the most extreme differences in the wealth of land households controlled, and rural society in West Harerghe is not stratified to nearly the same extent as in

[85] Interview with MDM, Funyaandiimo FA, 28 June 1998.
[86] Assimilation into new political and production relationships in past century contributed to the decline of *gada* as a system of organisation (Blackhurst, 1978; McCann, 1995), though it continues to be central to the Boorana Oromo of southern Ethiopia .

Watts's (1983) or Richards's (1986) studies, and money-lending appears to be less common. However, land ownership, wealth and livelihood vulnerability still vary considerably between farmers, and share-cropping and other patron-client relationships still exist, ranging from fairly informal arrangements to adoption. These ties are seen in other Oromo areas, and help secure livelihoods for the poorest (Bulcha, 1996; Blackhurst, 1996; Ensminger, 1992; Blackhurst, 1994). Richards (1986) found patrons with ambitions to be big men through local politics, or legal disputes, could benefit from the support of their clients. Some prominent farmers in West Harerghe seek office in the local Farmers Association (which controls the allocation of limited land, for instance), and these would presumably also benefit from a network of local clients and a reputation for generosity.

Finally, Table 5.4 suggests that seed exchange is related to wealth to some extent, and that the chronic seed insecure form an appreciable proportion of lowland farmers. A small number of farmers play a disproportionate role in supplying seed to others, and there may be normative expectations on their part for support, such as via *gosa* labour. The 'moral economy' relates to the idea of 'substantivism of embedded economies', where these expectations of reciprocal support, and the local sense of justice that supports them, finds expression in the material world of give-and-take. This is arguably the case with seed in West Harerghe.

5.3.4 Seed exchange and the moral economy

Taken together, social norms stipulating that nobody should be denied seed, traditions of mutual aid, patron-client relationships, and the links between seed insecurity and poverty suggest that seed exchange forms part of a moral economy. Reflecting upon seed exchange practices, I consider some of the possible implications for seed access and seed security for the poor.

Amount of seed exchanged

Farmers who run out of seed often need significant quantities. Miesso farmers requiring seed in 1998 received nearly 20 kg on average (Table 5.5). This is not a trivial amount for another farmer to supply, especially as this approaches the amount of seed many farmers plan to save for their own use (Table 5.1). If approached by someone in need, many farmers simply do not have much seed to spare; grain could be taken from storage, but this usually has poor physical quality, and unsealing storage pits re-exposes the grain to moisture and increases spoilage. Most farmers will wait until they are sure their fields are established before giving out the rest of their seed. This may be late for those in need, especially in the lowlands where the window for sowing can be small.

Table 5.4 shows that farmers supplying seed tend to be older and better-off than average, expecting higher yields per hectare (due to better land or management, rather than inputs), and having more oxen. This group is more able to spare seed, which they supplied to five others, on average. As mentioned above, some farmers regularly save large amounts of seed (> 100 kg), with the intention of supplying others in need, several telling me they 'always' do so as a gift. Farmers in this small group of 'major suppliers' are most able to give the larger amounts (>10 kg) required by the most needy farmers. They are generally prominent and respected individuals, and most closely fit the profile of patrons.

Terms of exchange

The terms of supply potentially influence the accessibility of seed. When widespread germination failure strikes the lowlands, very few farmers have seed to give others. Focus groups of mainly poor farmers indicated that they find it difficult to pay cash for seed from the market in such situations, and socially-disaggregated studies elsewhere (e.g. David and Kasozi, 1999; Sperling, 1996) suggest that market purchases may be a barrier to the most vulnerable. Exchanging grain for seed is another option, and the 1:1 grain-to-seed exchange rate is generous compared to many places. However, the chronic seed insecure, with no grain to exchange, would still rely on getting seed for free.

In public settings, farmers often pronounced that seed exchange between them was free and unconditional, a key element of mutual support. However, not every exchange meets the normative ideal. The level of generosity in the community is portrayed differently, depending on who you ask. For example, a focus group of wealthier farmers in Chiro insisted that older farmers still gave out seed for free, though they acknowledged that younger farmers generally did so only for cash now. However, their poorer neighbours, meeting in a separate focus group, disagreed with this. They insisted that most exchanges required cash, not only those from younger farmers: "if you want seed, it's never as a gift, but by exchange only. If we have no money, we do labour and get money to buy."[87] In this context, it is instructive to note that AAS, the Miesso farmer who sold 100 kg of his fast-maturing seed, at 2 Birr/kg, to his neighbours when their sorghum failed to germinate, was ranked in the wealthiest category in both wealth-ranking exercises I held there. Though he may have been able to afford giving the seed away, he asked the market rate. Finally, for some specific seed-exchange events, I was able to cross-check details with both the supplier and the recipient(s). In a few cases, seed recipients claimed they had received less seed, or had received it on less favourable terms, than claimed by the supplier; some recipients claimed to have not received seeds at all.

Regardless of the actual reality (which would be difficult to establish in any case) these disputes raise two interesting points. One is that there are competing *portrayals* of generosity, between public ('front-stage') and private ('back-stage') settings, and between wealthier and poorer farmers. Given the strong norms around mutual support, wealthier farmers may be tempted to over-state their generosity and play up their patron credentials. However, recipients may also be exaggerating, out of reluctance to admit needing seed, or for other strategic reasons of their own, such as pressing a claim that they are entitled to support. As Scott shows in his Malaysian study (1985), differences between how individuals represent their wealth and generosity and how others portray them lie at the heart of debates around a moral economy, where different portrayals are used strategically to press a norm-based claim for support (i.e. 'you can afford to give me seed', or 'you can afford to buy your own seed').

The second, related point is that norms for farmer-farmer exchange may be in transition, away from gift towards more transaction-based exchanges. The 'moral economy' as stated publicly may simply be the rhetoric of politeness, while underneath, the situation is changing. Watts (1983) argues that this has occurred in northern Nigeria as a result of merchant capital, and social relationships of support have become commoditised. Sperling and Loevinsohn (1993) have also found such a shift with bean seed exchange in Rwanda, away from gifts towards more commercial transactions, with possibly smaller amounts per transaction. In the highlands, both wealthier and poorer farmers agree that free gifts are declining to some

[87] Seed focus group of poorer farmers, Funyaandiimo FA, Chiro, October 1998. Quote from AAS.

degree: does this suggest that the moral economy is in decline? Or has environmental stress reduced farmers' capacity, rather than their willingness, to offer generous terms to their neighbours? Again, contrasting portrayals make it difficult to evaluate such shifts with this preliminary data, but this is clearly an issue deserving more attention.

Acute vs. chronic need

Analyses of seed systems, and interventions to support seed security need to distinguish acute seed shortages, due to a dramatic event, from chronic seed insecurity, due to long-standing vulnerability (Sperling and Cooper, 2003). This distinction may also have implications for seed exchange and reciprocity. An acute disaster, such as rain failure, has widespread effects, and people do what they can to ensure there is seed for the community, as the example of AM suggests. However, households that are chronically seed insecure tend to be always short of seed, even in 'normal' seasons without major stresses (Cromwell, 1996). These households, which frequently need seed from other farmers, may be hesitant to request a free loan, out of fear of being branded 'lazy' or 'poor farmers' for losing their seed again. I have heard one such chronically seed-insecure farmer claim he would simply not replant sorghum after his early sowings had failed, as he did not consider borrowing or purchase to be a possibility. A wealthier neighbour who was also present chided him for not selling his last goat to raise cash for seed purchase.[88] The hesitancy of the former to approach neighbours reflected the general unavailability of seed, but it may also reflect a fear of being labelled an incompetent farmer (especially given the admonishment he received), or worse, of being refused support outright. As Scott (1985) found, the poorest may avoid asking for charity, as a direct refusal amounts to a unilateral declaration that the relationship of support is now null and void. Studies in Rajasthan (Dhamotharan *et al.*, 1997) and Honduras (C. Almekinders, *pers. comm.*., 2001) have revealed that some poorer farmers prefer to seek seed from the market rather than ask neighbours, to avoid such moral stigmata.

In drought-prone areas such as the lowlands, repeated acute shocks can undermine households' capacity to cope and quickly recover, pushing them towards more chronic insecurity over time (Sperling and Cooper, 2003). Evidence suggests that the coping capacities of many in dryland Ethiopia have eroded due to the recent string of poor seasons. Social support may also be affected; Dirks (1980) argues that such support moves through different phases as stresses persist. Assistance and reciprocity increase during the initial 'alarm phase' of a crisis, but if the crisis continues the community may enter a 'resistance phase', support networks become smaller, and sharing strategies more short-term. If a crisis continues, eventually reciprocity reaches an 'exhaustion phase', when little capacity for social support remains. There may simply be less capacity to support a moral economy around seed exchange, especially as the coping strategies of the poorest involve off-farm labour, often to the detriment of the management of their own farms, and make them less 'worthy' recipients in the eyes of potential patrons.

Form vs. content

Another area of possible dispute in a moral economy is the distinction between form and content, where the outward appearance of support diverges from the support that is actually provided (Scott, 1985). Such disputes could arise around the expectations of appropriate amounts, quality, or even attitudes associated with seed exchange. Gifts of very small quantities of seed are quite common –for instance, three of the poorest contact farmers I

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[88] Interviews with MAS and JHA, Melkaa Horaa FA, 2 June 1998.

regularly visited had received small amounts of seed from at least six different sources each.[89] Donors may have been giving a token amount to maintain appearances, rather than refusing outright. Equally, the poorest farmers may be limiting requests to quantities they could receive as a free gift, as one of my poorest contact farmers in Miesso did, seeking out small gifts of 1-2 kg from six different sources. Seed is often in short supply, but the degree to which small exchanges reflect such strategic thinking on the part of either petitioners or donors highlights how seed exchange is also a social transaction.

Farmers are well aware that sorghum grain stored in an underground storage pit (*gurguad*) makes poor quality seed, as it rapidly loses its ability to germinate due to the moist storage conditions (though *gurguads* maintain quality for consumption purposes). Thus, they only seek planting material from their own *gurguads* as a last resort, and understandably consider it unfair dealing to receive 'seed' that actually came from a storage pit. I have heard a few complaints to this effect, though no open accusations. A focus group of wealthier highland farmers downplayed this possibility, stating that the difference between proper seed and grain from a *gurguad* should be obvious to all. Even if this is the case, it still raises the question of local power relations, and the ability of (poorer) farmers to directly challenge the supply of poor quality seed from a neighbour, especially if it is a gift. Richards (1986) noted that those lending rice seed to clients or other indebted people in Sierra Leone, often did not bother to rogue out an undesirable, semi-weedy rice FV, 'sanganyaa' , thus saddling these clients with a problematic contaminant. The fact that such disputes remain in the realm of gossip and rumour suggests that the poorest have difficulty in openly challenging transactions where form (exchange) has won out over content (viable seed). There may not always be scope for "neighbour certification". This suggests a somewhat less benign view of farmer-to-farmer exchange for vulnerable farmers who require free seed, but may not be in a position to query its quality. Again, behind the rhetoric of universal support, the moral economy may be changing, and the poorest may have less access to good quality seed in sufficient amounts from any channel, increasing their likelihood of seed insecurity the following year.

Finally, there is the question of attitude and behaviour. Discussions with poorer farmers suggest normative expectations of graciousness and lack of selfishness from donors. While all farmers publicly claim they do not place any conditions on who deserves to receive seed, wealthier farmers do talk privately of 'deserving' as opposed to 'lazy' poor. In this context, the 'deserving poor' seem to be expected to make every effort to obtain seed by their own means (such as selling their last goat), and to work hard on their farms. The latter view, which I have heard used in criticisms of supposedly incompetent farmers,[90] neatly parallels the NEIP requirement that beneficiaries of input packages be 'full-time farmers'. Those engaged in off-farm income-generating activities generally do so out of vulnerability, as the labour market is very uncertain, and wage rates are low. Yet these 'part-time' farmers were castigated as lazy by the Miesso director of the NEIP package programme, as they were unable to supply the extra labour required to meet the management demands of the package, and were thus ineligible for MV seed on credit. As the above section on acute vs. chronic needs suggests, normative expectations may affect whether a needy farmer asks for seed in the first place. All the above issues suggest that these norms may be contested and changing, ultimately affecting the accessibility of seed exchange, particularly for the poorest households.

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[89] IA, Funyaandiimo FA; ANA and MYE, Melkaa Horaa FA.
[90] As in, "those guys can quarry marble on their land. They are not interested in farming, and in fact don't even have time to farm!", interview with SS, perhaps the wealthiest and most prominent farmer in Miesso, October 1998.

5.3.5 Seed exchange and social relationships

The nature of the overall relationship between donor and recipient may influence the terms, amount, or quality of seed exchanged. What evidence is there that seed exchange is bound up with other social relations? In many cases, family members do not appear to be the most important seed source (Table 5.8). Yet needy farmers certainly choose whom they approach for seed. A number of farmers stated that they were most willing to give seed to their 'brothers', which implies close friends in this context as well as blood relations. Other forms of collaboration (such as labour- or oxen-sharing) can help cement such strong ties between farmers, as well as shared membership of a *gosa* or other mutual-aid institution. Similar local institutions have been used as a conduit for seed distribution in Northern Ethiopia (Pratten, 1997), and they probably play a role in exchange in farmer seed systems.

Interestingly, though the ethnic Amhara minority is well-accepted and integrated into Oromo life in the highlands, most of their seed exchanges seem to involve fellow Amharas. Four of the Amhara farmers interviewed in Funyaandiimo supplied seed to others in 1998, naming a total of nine recipients between them, all of whom were Amharas as well.[91] The four Amhara farmers who received seed in 1998 named six different donors, two of whom were Amhara. I should stress that relations between Amharas and Oromos in Funyaandiimo are very friendly and co-operative in general, and local Amhara farmers have no connection to the absentee landlords of the feudal era. However, the apparent bias in seed exchange does underscore the importance of networks and social ties, which remain strongest within this minority.

Some seed donors clearly have regular clients. For instance, one farmer gives 3-5 kg of seed every year to the same three chronically seed-insecure farmers.[92] Such regular arrangements may in fact be common, but I had not specifically inquired about them when in the field. I often interviewed farmers in their fields during work breaks, usually sitting in a makeshift shelter (*gojo*) where they were drinking *hodja*, and chewing *chat* if they had any available. Though nearly all farmers will chew *chat* if they can get it, not many can afford to buy their own, and happily will accept offers from others. Those who grow their own *chat* are almost always ranked among the wealthiest farmers. When visiting such farmers, I usually found others present chewing *chat* supplied by their host. Though local hospitality would lead a host to share his *chat* with whoever joined in, it seems unlikely that someone would help themselves to another's luxury good without having other links to them. Regularly sharing of *chat* with another farmer is thus a good indicator of close relationship ties. Supplying *chat* and *hodja* is an essential part of organising a labour party, such as *gosa*, something poorer farmers would find difficult to organise. Wealthy farmers who regularly supply *chat* may be doing so to cement patron-client ties, particularly to lower transaction costs in obtaining reliable labour.[93] In the same vein, supplying seed may help to build patron-client relationships, to secure labour or political support. In several cases, when asking seed donors to name the recipients, they simply gestured to visiting farmers sitting in their *gojo*, chewing their *chat*. Thus an analyse of exchange networks should consider more than the immediate

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[91] I used names to assign ethnic identity, which should be quite reliable in this location. Unlike urban or Orthodox Oromo from central Ethiopia, Oromo farmers in West Harerghe do not appear to have adopted Amharic names, and most Oromo names are obviously Muslim in any case.

[92] ZLJ, Funyaamdiimo FA, 26 June 1998.

[93] In some parts of West Africa, alcohol is used in the same way, to facilitate collective labour, as well as build up obligations for later support, such as palm wine and local gin (Richards, 1986), or beer (O'Laughlin, 1973).

transactions, but also explore how these relate to exchanges in other areas, and reflect wider social relationships.

Considering social relationships raises the question of exclusion. In central Mali, Adams (1993) found that those who did not participate in work crews and who lacked other ties were effectively shut out of the moral economy for support in times of need. Richards (1986) also found that, in work-parties, those whose labour contributions were below average eventually became excluded from mutual-aid networks. In West Harerghe, how important is participation in work-parties for accessing seed? Do the seed donors seek other kinds of support? As Wilbaux (1986) showed, Harerghe households vary dramatically in the amount of time they allocate to collective labour activities. Some households participate little in collective work activities, due to poverty, age, ill health, or simply inclination; this group tends to also include the 'part-time farmers' mentioned above. Are these farmers less likely to receive seed from a neighbour, or less likely to get favourable terms and suitable amounts? The views of some of my informants about laziness suggests this is a possibility. Farmers who are largely shut out of support networks may need particular support and attention. Similarly, if there are effectively parallel networks of seed exchange, among highland Amharas and Oromos, for example, this also carries implications for using social networks to supply seed and promote new varieties.

5.3.6 Seed source preferences

Finally, I consider farmers' differing opinions on seed channels. I asked farmers in the survey, if they lost their seed and had to seek seed for planting off-farm, what are the best and worst sources, and why. Their opinions on the advantages and disadvantages of different seed sources diverge between different agroecologies, highlighting the influence of practical and biological considerations, such as the amount of seed needed, its price, timing, diversity, and adaptability. However, opinions also diverge according to wealth, indicating that social interactions may also colour views about seed exchange. Such information adds to our understanding of the moral economy of seed exchange, while raising practical issues for seed system reforms or formal interventions about the relative accessibility of different channels for farmers.

Most preferred sources

Table 5.14 summarises the responses given. For preferred sources, the proportions differ significantly between the two locations. Lowland farmers are relatively more positive about merchants, while a greater proportion of highland farmers feel other farmers are the best seed source. Appendix D has frequency tables of the reasons given for each preference, which differed according to location. Favourable terms of exchange were emphasised, especially in Chiro, while Miesso farmers especially appreciated the assurance of local adaptation of seed from neighbours (Melkaa Horaa farmers complain that market seed, even if it came from Assebot 15 km away, often fared poorly in their drier micro-climate). A number of farmers, particularly in Chiro, highlighted social values related to reciprocity and trust (e.g. "we know them", "we give to each other"). A few emphasised that neighbour-supplied seed is nearby, timely, and can meet the need for small amounts (Appendix D, Table D.1).

Table 5.14 From surveys in West Hareghe, farmers' opinions of the best and worst sources for off-farm sorghum seed.

Seed source	Best source				Worst source			
	Chiro		Miesso		Chiro		Miesso	
	count	%	count	%	count	%	count	%
Other farmers	28	53.8	14	38.9	7	18.4	3	12.0
Merchants	8	15.4	14	38.9	19	50.0	6	24.0
Government	16	30.8	8	22.2	12	31.6	14	56.0
NGO							2	8.0

The majority of farmers who preferred merchants cited the ease and speed of obtaining seed (Table D.2), though several Miesso farmers noted that supply is only simple if they have money. The implication, made explicitly by some Miesso farmers, is that the social transaction involved in requesting seed from neighbours is complicated and leads to uncertainty around supply. Again, this suggests that there may be social transaction costs for some farmers to acquire seed from neighbours, though this may be as much practical as social in Miesso.

Some farmers preferring government-supplied seed (Table D.3) highlighted the germination quality of the seed, that it was usually MV, or that it came with advice and inputs (as part of a package). Interestingly, a few stressed that the government's role should be to supply.

Least preferred sources of seed

Farmers' least-preferred seed sources also differ significantly by location (Table 5.14).[94] A higher proportion of farmers in Miesso, compared to Chiro, viewed the government as their least-preferred source. In contrast, relatively more Chiro farmers were negative about merchants. Two Miesso farmers considered NGOs to be the worst source, though said this was because NGOs rarely gave out seed in their area. The two NGO responses are not included in the rest of the analysis.

For those who least preferred seed from other farmers, the most commonly stated reason related to trust: despite promises, they do not actually deliver (Table D.4). This calls to mind the above discussion of form vs. content: norms of reciprocity make it difficult openly to refuse a request, but that does not guarantee supply. Some Chiro farmers cited practical issues around timeliness or the adaptedness of farmer-supplied seed.

Unsurprisingly, some farmers who disliked merchants as a seed source cited the high market price as a reason why (Table D.5). Tellingly, five Chiro farmers explicitly highlighted the morality and trustworthiness of merchants selling for profit, distinct from price, an issue not raised by Miesso farmers. Other answers related to the value of market-supplied seed, particularly questioning its local adaptation.

Finally, the most common reason given for government being the worst source of off-farm seed was lateness of seed delivery (Table D.6): "The probability of getting [seed] from the

[94] The government and NGO categories were pooled for a 3x2 contingency table, as the original (4x2) table had low expected values, which might bias chi-square estimates (Roscoe and Byars, 1971).

government is high, but time is inexact."[95] "We will be starving a year before getting seed."[96] This was in the highlands, where the ESE has seed multiplication capacity, as well as the lowlands. Some farmers, mainly from Miesso, complained that the requirement for requests and delivery to be channelled through local FAs added unnecessary hassle and delays. Some Miesso farmers felt the problem went beyond lateness, and questioned the government's ability to supply at all ("The Ministry does not have seed."[97] "They do not give us. It is useless to ask."[98]).

Patterns of preferences

Considered together, the reasons listed above start to outline a profile of farmer perspectives on the strengths and weaknesses for each major seed source, showing there exists a diversity of views around some issues. The topic is more complex than is often assumed, particularly as there is no clear consensus on what is a good or bad source, or the reasons for this. For instance, the accessibility and adaptability of farmer-supplied seed was highlighted by Chiro farmers, while the speed and ease of obtaining seed from merchants was emphasised by farmers in Miesso. These views on the capacities of neighbours and markets to some degree reflect the ecological context: for instance, localised rain failure in the lowland can mean that neighbours are unable to supply the large quantities needed. Besides practical concerns of amounts, timing, and quality (including getting fast-maturing seed when needed) some farmers did emphasise more 'social' reasons for their preferences. For instance, the social value of reciprocity, and the moral dubiousness of merchants was mentioned by some farmers, particularly in Chiro, to justify their preference for neighbour exchange. Chiro farmers' ambivalence about merchants in part reflects the less significant role markets play in meeting seed needs, compared to the lowlands, but moral statements about community solidarity are used to frame these views. Miesso farmers, on the other hand, do not emphasise the value of neighbour-neighbour seed exchange to the same degree. Rather, some emphasise the simplicity of cash-based transactions, complaining that seed from neighbours involves delays, or tedious social entanglements.

The mean characteristics of farmers stating each preference were compared to see if preferences correlated with other farmer characteristics. Chiro farmers who prefer the government appear to be among the more productive, and possibly also the wealthier farmers; they expect significantly higher harvests, save more seed, and have more oxen (Table 5.15). This group seems to reflect the 'progressive' farmers sought out by Development Agents for extension package promotion. In focus group discussions in Chiro, only the group of wealthier farmers felt it could approach the Ministry of Agriculture for seed. In contrast, poorer farmers stated that this was not possible for them, and they would do better to go to market; Table 5.15 supports this, as those in the highlands who prefer merchants appear more vulnerable. There may be no problem with progressive farmers having the best links with government supply, if, as diffusion-based theories assume (e.g. Rogers, 1962), seed and innovations eventually spread to their neighbours. However, the concern here is that some of the poor remain excluded from supply channels, and possibly excluded from later spread of new varieties. There are no significant differences between Chiro farmers according to their least preferred sources, though the trends again suggest that poorer farmers dislike government the most.

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[95] BK, Quni Segaria FA, Chiro, 3 October 1998.
[96] MD, near Baddesa, Chiro, 7 October 1998.
[97] AA, Cophii FA, Miesso, 4 October, 1998.
[98] SA, Hamarreesaa FA, Miesso, 5 October, 1998.

Table 5.15 Means of some characteristics of farmers in Chiro, according to their most preferred and least preferred seed source, based on a 1998 survey in Western Harerghe.

Farmer characteristic	Most preferred source in Chiro				Least preferred source in Chiro			
	Other farmer	Merchant	Govern-ment	p†	Other farmer	Merchant	Govern-ment	p†
Number responding	28	8	16		7	19	12	
Number of oxen	1.15 ^{AB}	0.50 ^{B}	1.38 ^{A}	*	1.43	1.28	0.67	NS
Amount of seed saved/ sorghum area (kg ha^{-1})	23.96 ^{AB}	21.50 ^{B}	46.44 ^{A}	**	45.86	21.67	18.67	NS
Expected production, 'good year' (t)	1.09 ^{B}	1.19 ^{AB}	1.63 ^{A}	**	1.46	1.39	1.12	NS

(† Means between the three sources different at * α<0.1 and ** α<0.05, with different letters indicating significant differences between individual sources).

In contrast to Chiro, Miesso farmers who prefer government seed appear to be among the poorest and most vulnerable farmers in the area; they have fewer oxen, cultivate less area to sorghum, and have the lowest production expectations in poor years (Table 5.16). Those who prefer merchants the least are also poorer than average, according to these measures (the higher yield per area may be partially related to their smaller area they cultivate). The reasons that Miesso's poorest farmers avoid merchants for seed, yet do not count on exchange from other farmers, possibly has to do with financial and social inaccessibility. Those who need large quantities of seed to completely replant their fields ask a lot of their neighbours, especially if this occurs regularly. They may consider it simpler (or more reliable) to seek seed from the state. For most lowland farmers, though, the government seems to be the supplier of last resort; those with more available resources consider the government to be their least-preferred source. This suggests that only those who have no other choice place their hopes on government-supplied seed, especially since its record of timely supply is poor in the lowlands. This may be wishful thinking on the part of the poorest.

Table 5.16 Means of some characteristics of farmers in Miesso, according to their most preferred and least preferred seed source, based on a 1998 survey in West Harerghe.

Farmer characteristic	Most preferred source in Miesso				Least preferred source in Miesso			
	Other farmer	Merchant	Govern-ment	p†	Other farmer	Merchant	Govern-ment	p†
Number responding	14	14	8		3	6	16	
Number of oxen	2.15 ^{A}	1.07 ^{B}	0.63 ^{B}	**	0.67	0.67	1.63	NS
Area planted to sorghum (*Timad*)	7.21 ^{AB}	8.43 ^{A}	4.50 ^{B}	**	6.00 ^{AB}	4.00 ^{B}	8.56 ^{A}	**
Expected production, bad year (t)	0.30 ^{AB}	0.34 ^{A}	0.12 ^{B}	*	0.27 ^{AB}	0.08 ^{B}	0.38 ^{A}	*
Expected yield, good year (t/ha)	1.93	2.00	3.10	NS	0.94 ^{B}	3.74 ^{A}	1.87 ^{B}	**

(† Means between the three sources different at * α<0.1 and ** α<0.05, with different letters denoting significant differences between individual sources).

Those who prefer farmers as source represent a higher average range of resource-levels. However, it is not the top choice of the poorest, while a third of Miesso farmers claim they have been unable to obtain seed at some point from other farmers (Table 5.13). The transaction of obtaining seed from a neighbour in Miesso involves practical, and possibly social, challenges. As with the highlands, some of the poorest may not enjoy the social relations necessary for securing access to seed, yet the market, which serves a more important role in the lowlands, is even less affordable to them. The nature of the vulnerability of the poorest, chronically seed insecure farmers merits further study.

5.3.7 Summary

The moral economy concept is useful for exploring seed supply, as the above discussion suggests it is a morally-invested area. Opinions about the accessibility of different supply options, and preferred seed sources, vary to some degree with wealth and agroecology. Farmer-farmer exchanges do reflect social ties, though it is difficult to know how much this is part of broader patron-client relationships (as the moral economy thesis would suggest), without more detailed information on other forms of material and non-material support, such as work-parties. Both Richards (1986) and Watts (1983) found strong associations between local forms of clientalism and assistance from the wealthy, in the form of loans of seed. Watts views this support as a rather exploitative form of distribution, and evidence that patrons are using the cash economy to further marginalise their poorest neighbours. Richards, however, takes a more benign view of patronage in seed in Sierra Leone, which he sees more in terms of production rather than distribution (1990). Seed-based patron-client relations do not necessarily lock the poorest into a poverty trap. My own, admittedly preliminary, investigation in West Harerghe tends to follow Richards's view, as blocks on land sales, and the variability of the climate, mean that social stratification among farmers is not that pronounced, and a run of bad luck could significantly reduce the circumstances of relatively well-off farmers. Compared to Watt's and Scott's studies, the cash economy still plays only a small role in relationships of production or exchange in farming areas of West Harerghe. Farm labour is generally acquired through social exchanges and local institutions, rather than hired labour, and very few wealthy farmers can afford to treat their neighbours with disdain on the level seen by Watts or Scott.

The social transaction cost for obtaining seed appears to be an important factor in how farmers obtain seed, affecting the nature of the seed they obtain. Considering seed exchange as a social transaction highlights the possibility of households being excluded from local networks of support, particularly the poorest households. Chronic seed insecurity may strain neighbours' charity; limited involvement in other activities (such as labour-sharing) may weaken reciprocal or patron-client ties, run the risk the farmer being branded 'lazy' or 'undeserving'. The tendency for the poorest to prefer seed sources other than their neighbours may be an indication of a sense of exclusion. In any case, cash purchases from neighbours, and from the market, appear to becoming increasingly important means for many farmers to access seed. The evidence suggests that the moral economy around seed exchange is weakening, particularly in Miesso. This is of greatest concern to the poorest, who may otherwise have limited access to seed. It also suggests that we need to look beyond public statements of norms of universal support, and consider whether the poorest (who are often involved in off-farm labour, and have weaker social ties) are marginalised from networks of seed exchange and/or other forms of support.

Though preliminary, this exploration of social relations shows that seed exchange is more than a simple material transaction, but also has a broader social representation and meaning. Future work should examine preferences in more detail, using different scenarios (e.g. chronic vs. acute seed shortages, or sources for new varieties) to see how preferences are contingent on different events and goals. Also, a deeper probing of the numerous disputes, around norms and terms of exchange, and around specific transactions, could shed more light on how the moral economy of seed exchange may be changing.

5.4 Conclusions

Though almost all West Harerghe farmers save sorghum seed, poverty and environmental unpredictability mean that they regularly require off-farm seed, and seed exchange is crucial for their livelihoods. The terms, timing, quality and quantity of seed matters, and access to seed varies considerably between farmers and between locations; both the ecological and the socio-economic contexts matter. One of the strong points of farmer seed systems is that they are flexible, with multiple possible seed sources supplying a range of different seeds at appropriate times. Local markets, in particular, are an important alternative source when local channels are unavailable. However, the system is also liable to stress, particularly if it leads to a widespread lack of suitable seed for supplying those in need. Repeated harvest failures in the lowlands may have reduced local coping capacities, and limited the amount of seed exchanged between farmers. The social transactions involved in obtaining seed from neighbours may be a barrier for some farmers, though other sources also offer challenges to access, particularly involving cost and timing. These issues highlight areas where formal sector support could help improve the functioning of the seed system, particularly around seed insecurity, and improving seed access.

Interventions to support seed security need to take these issues into account. While seed supply preferences may not indicate absolute opposition to a particular supply source, they carry implications for acceptance of government- or market-supplied seed. For formal-sector support, one size does not fit all, particularly where the poorest are concerned. Differences in resource-levels among households help shape these preferences, and affect their ability to maintain seed stocks or supply seed to others. The seed secure are obvious potential partners for seed and variety dissemination, thus understanding the factors that define this group, and the particular roles they fill locally, is important. These farmers are more likely to have a patron role locally. While this may be a valuable part of local coping strategies, care should be taken to ensure that some groups of farmers are not marginalised, with little access to good seed. Thus, the chronic seed insecure deserve special attention, so that their particular needs, and the channels they use for seed, are better understood. Programmes seeking to improve seed security need to be aware of these important variations among farmers and locations, as well as to understand that seed exchange is in part a social transaction, and may be strongly affected by local norms.

Finally, the market is becoming more important for seed supply, especially in the lowlands. Agro-ecology is an important factor here. If little seed is available from other farmers, or if farmers are seeking fast-maturing MV seed, merchants play an important role. Shifting norms may also play a role, as farmers move to more cash-based transactions for exchanging seed, even with neighbours. Despite the fairly negative view of local traders in the Draft Seed Law, local markets play an important role in bringing seed in, especially to the lowlands, when no other channel can. Working with local merchants may be one of the most effective intervention approaches to support seed security in areas like West Harerghe, particularly in the lowlands, by improving the supply and quality of seed during times of widespread need. Another priority for intervention is to lower transaction costs for obtaining seed, particularly for the poorest. This will prove more difficult, though efforts in working through local associations (Pratten, 1997) or vouchers enabling market seed purchase (Sperling and Cooper, 2003) suggest some possible ways forward. As this chapter shows, the farmer seed system is extremely important for seed access, in favourable (i.e. highland) as well as unfavourable agro-ecologies. Though these systems are complex, they show great resilience, and effective interventions to strengthen farmer seed systems could make an important contribution to livelihoods.

Chapter 6 Farmer management of sorghum genetic resources: knowledge, innovation, and opportunities for formal support.

6.1 Introduction: farmers' genetic resource management

Farmer seed systems involve more than seed access and exchange, but also include all practises that impact upon crop diversity and shape the genetic and physical quality of seed. In other words, farmer seed systems are involved in crop genetic resource management. This chapter explores farmers' knowledge and practices in managing sorghum genetic resources in West Harerghe. This is of interest for seed system reform for several reasons. Many breeding reform initiatives wish to know more about farmers' selection criteria, to help redirect formal breeding goals better to address poor farmers' needs (e.g. Eshetu Mulatu and Belete, 2001). However, some initiatives seek more than a listing of desirable selection criteria to bring back to formal breeders, but wish to see closer collaboration between farmers and formal breeders in crop development. To do this will require a much deeper understanding of farmers' own knowledge and practice in managing crop genetic resources, particularly around selection practices (Cleveland and Soleri, 2002b). Some see this collaboration coming via training and skills-development in seed selection, encouraging a set of 'best practices' for farmers to be able to choose and maintain good quality seed (e.g. Gómez and Smith, 1996; Rice *et al.*, 1998). A more general reason for interest in farmers' genetic resource management is better to understand how farmers innovate with crop diversity, as this is a central area of farmer experimentation (Richards, 1986; Sumberg and Okali, 1997). Finally, there is interest in how farmer management affects agricultural diversity; how does farmer management shape and maintain the genetic diversity in crops (Jarvis and Hodgkin, 2000)?

Studies of farmer genetic resource management have tended to focus on one aspect, such as seed selection, or farmer choices around biodiversity. However, these aspects cannot really be separated as discrete processes in farmer seed systems, as farmer management is dynamic and complex, where changes in diversity, or opportunities to innovate, may not necessarily be planned. Inadequate appreciation of practice, set in context of local knowledge, labour demands, and social relationships, risks a rather reductionist understanding of farmer management, based on tacit assumptions, particularly around the goals and intentions underlying farmer management. As Cleveland and Soleri (2002b) rightly assert, assumptions about farmers' intentions or understanding – for instance, that farmers are actually seeking to improve the genetic traits in a variety when doing seed selection, or to enhance 'biodiversity' – need to be tested. Moreover, studies on local genetic resource management tend to concentrate at the household level (Rice *et al.*, 1998), and emphasise individual farmers' consciously-theorised activities. Many of the features of local systems, such as diversity or local adaptation, may in fact be emergent properties of individual and collective activities, not all of which are planned (Nyerges, 1997).

In the discussion of breeding reform, including PPB, an example of this reductionism is the emphasis on seed selection practices, in particular on farmers' selection criteria, timing, intensity, and approaches to address environmental variation. Some interventions promote 'improved' seed selection practices to farmers (e.g. Blanco, 1996; cited in Rice *et al.*, 1998), using training tools such as Farmer Field Schools (Louette and Smale, 2000). Other efforts at farmer-scientist collaboration in breeding involve farmers who are considered to be the most skilled or articulate about seed selection as their main partners (e.g. Cleveland *et al.*, 2000; Sthapit *et al.*, 1996). However, as this chapter argues, the emphasis on seed selection, or on the practices of the most skilled farmers, may be misplaced. Seed selection is not the only process shaping local diversity and adaptation, while 'expert farmers' are not the only source of experimentation. The high turnover of seed lots, seed exchange between households, and seed physical health may be more important for the overall functioning of the farmer seed system. Not all farmers may be able to follow the elaborated practices of their expert farming neighbours, due to labour or other constraints. Not all diversity is an outcome of conscious individual practices; while Teshome *et al.* (1999) were able to correlate individual farmer selection criteria with on-farm sorghum diversity in northern Ethiopia, diversity is not always introduced via discrete and intentional actions. Other factors – e.g. accidents and unplanned events – also influence the diversity found on individual farms. In other words, we need to remain aware of the 'performance' element of farming livelihoods, where individuals respond to contingencies as they unfold, recognising that these form an important element of local innovation (Richards, 1993).

By taking a broad approach to analysing farmer genetic resource management this chapter seeks to identify important processes in the farmer seed system, and set them in a context of local knowledge and social relationships. I consider, in turn, how gene flow is affected by local systems of nomenclature, the introduction of novel diversity, pollen flow, hybridisation, seed selection, and storage. I also explore local views of heritability and variation. By considering the biological and social context of these processes, and their possible significance for crop development and innovation more generally, I suggest where there might be scope for change, highlighting possible interventions to support farmer management.

Before exploring the various aspects of sorghum genetic resource management in West Harerghe, I briefly review sorghum diversity and classification. A detailed exploration of current taxonomic and genetic research is beyond the scope of this thesis, so this is merely a short summary. However, a sense of how sorghum genetic resources are shaped and distributed is useful for highlighting the significance of gene-flow via seed exchange, hybridisation among cultivated sorghum and occasional crosses with wild types, and in understanding the possible influence of farmer selection for sorghum diversity within these levels of gene-flow. Studies of the distribution of diversity also show that considerable levels of diversity may be available in a single region. This has implications for how local genetic resources are used, both by farmers and by breeders.

6.2 Sorghum diversity and farmer management

6.2.1 Taxonomy[99]

Sorghum classification has been confounded in the past by its geographical and phenotypic diversity. For instance, Snowden (1936) classified the Sorghum section of the *Sorghum* genus by morphology, describing 48 species (31 cultivated, 17 wild) of grain sorghum, under the Arundinacea complex. However, de Wet (1978) applied the biological species concept[100]

[99] To avoid losing the focus on farmer seed systems (and losing less technical readers), this section is as brief as possible, and highlights more general points. I recognise, however, that many details, particularly around genetics, can be explored in much greater detail.
[100] For sexually-reproducing organisms, this defines a species as all taxa that can potentially interbreed and produce fertile progeny.

to show that Snowden's 48 species were in fact a single highly diverse species, *S. bicolor*. De Wet re-organised this into three subspecies: ssp. *bicolor* contains all cultivated forms, ssp. *arundinaceum* their wild progenitors, while ssp. *drumondii* contains weedy hybrids (Box 6.1).

Genus Sorghum

Section Stiposorghum 5 species

Section Parasorghum 10 species

Section Heterosorghum 1 species, *S. laxiflorum*

Section Chaetosorghum 1 species, *S. macrospermum*

Section Sorghum

Halapensia complex 2 species

Sorghum halapense (L.) Pers.
Sorghum propinquum (Kunth) Hitchcock

Arundinacea complex

Sorghum bicolor (L.) Moench

ssp. *bicolor*	- domesticated grain sorghums
ssp. *arundinaceum* (Desv.) de Wet et Harlan	- wild relatives
ssp. *drummondii* (Steud.) de Wet	- weedy hybrids between wild and cultivated sorghums

There are five botanical races of ssp. *bicolor* (cultivated sorghum), and four botanical races of ssp. *arundinaceum* (wild relatives).

Box 6.1 Simplified classification of grain sorghum and closely related taxa, classification based on de Wet (1978) and Sun *et al.* (1994).

This sort of 'over-classification' has been common in domesticated crops. More recent understanding of the importance of crop-weed complexes in shaping diversity has spurred re-consideration of how domesticated plants are classified (Hetterscheid and Brandenburg, 1995; van Raamsdonk and van der Maessen, 1996). The ease of gene-flow across all subspecies of *Sorghum bicolor* contributes to the phenotypic diversity and plasticity within the species. Farmer management, of cultivated sorghum as well as of the weeds, has been important in shaping and maintaining morphological types within the sorghum gene-pool, as discussed further in the next section.

Domestication

Sorghum was domesticated over 5000 years ago in northeast Africa (Doggett, 1988, 1991), and spread to India at least 4000 years ago (Harlan, 1989; Meadow, 1996). Recent investigation has confirmed that cultivated types arose from the wild *arundinaceum* subspecies (Renganayaki *et al.*, 2000). Patterson *et al.* (1998) showed that a limited number of quantitative trait loci (QTLs) account for most of the wild traits lost during domestication. For example, a single locus accounts for the loss of shattering, and a the loss of a few genes can increase height and synchrony of flowering. These are all key traits for domestication. Domestication could thus be rather rapid with disruptive selection[101], perhaps occurring within a few human generations (Patterson *et al.*, 1995). This suggests that sorghum was probably domesticated only once and dispersed widely thereafter, with 'founder effects' and human influence leading to the development of distinct types (Cox and Wood, 1999).

Some of the genetic diversity in wild sorghum did not survive into cultivated types (de Oliveira *et al.*, 1996; Morden *et al.*, 1990). However, domestication in sorghum was nevertheless a 'wide bottleneck', with only a modest reduction of diversity between the wild and cultivated gene-pools (Aldrich and Doebley, 1992; Deu *et al.*, 1995), in contrast to some other cereals, such as wheat (Cox and Wood, 1999). Sorghum's wide bottleneck has facilitated occasional gene-flow between cultivated and wild sorghum, and has influenced the development of distinct regional populations.

6.2.2 Genetic diversity

Races

Harlan and de Wet's (1972) classification of cultivated sorghum is widely used by breeders to classify their germplasm, dividing ssp. *bicolor* into botanical races on the basis of mature spikelets. Five basic races – bicolor, durra, guinea, caudatum, and kaffir – as well as ten hybrid races are recognised. In Africa, these races reflect particular eco-geographic regions and correlate with cultural-linguistic groups (Stemler *et al.*, 1977; Harlan, 1989). For example, race kaffir is associated with Bantu-speaking peoples in Southern Africa (de Wet, 1978).

Are these botanical races genetically-distinct groups of sorghum? Isozymes do not easily discriminate between races, due to low levels of polymorphism at most loci (Aldrich *et al.*, 1992; Ollitreault *et al.*, 1989b; Ollitreault *et al.*, 1989a; Morden *et al.*, 1989), but molecular techniques reveal more polymorphism, distinguishing among closely-related materials (Vierling *et al.*, 1994). Some molecular analyses have been able to group cultivated sorghum races to some extent (Aldrich and Doebley, 1992; Guo *et al.*, 1996), but other genetic markers have been unable to do this unambiguously (Cui *et al.*, 1995; Menkir *et al.*, 1997). The races can be categorised into more or less distinct groups on the basis of morphological characters (Chantereau *et al.*, 1989). However, these characters have relatively simple inheritance and are shaped by farmer selection. All of this evidence suggests that races are not completely distinct genetically or taxonomically, but are largely maintained by human selection for their defining morphological traits, all the while being affected by gene-flow.

Geography

In some cases, sorghum genetic variation is better described by geography than race (de Oliveira *et al.*, 1996). While a distinct regional gene-pool reflects environment to some degree, its distinctiveness also reflects genetic isolation. Human management can help maintain the distinctiveness of some types of sorghum, if a group and their sorghums remain socially isolated, or if farmer management allows asynchronous flowering, keeping some types from cross-pollinating with others. For example, Stemler *et al*. (1975) argues that the distinctive race caudatum is associated with the Chari-Nile linguistic groups, and its distribution follows the migration pattern of Chari-Nile speakers throughout East Africa. In

[101] Disruptive selection occurs when two or more phenotypes have high fitness, but intermediate phenotypes between them have low fitness (Futuyma, 1986). Natural and human selection in this situation leads to bimodal phenotypic distributions, e.g. individuals without the shattering trait are selected by people, while variants with full shattering capacity are more fit under natural conditions than variants with partial shattering. Thus the latter's frequency in a population declines.

Ethiopia, caudatum sorghums are mainly confined to Nilotic-speaking peoples in the lowlands of southwest Ethiopia, with little spread to the rest of the country due to ecological and cultural-political barriers around these groups in the past (Stemler *et al.*, 1977).[102] Accessions of guinea margaritiferum, a West African 'sub-race' of guinea, were shown to be distinct from other sorghum types on the basis of mitochondrial DNA. This distinctness is possibly due to early flowering and strong human selection, being grown in home-gardens separate from other sorghums, as the only sorghums boiled and eaten as 'rice' (Deu *et al.*, 1995). Thus, historical patterns of human migration, deliberate isolation, and distinctive patterns of use have shaped sorghum diversity at broad scales, and it is likely this also occurs at smaller scales as well.

Ethiopia

What do patterns of sorghum diversity for Ethiopia, a centre of diversity, suggest about the processes shaping diversity? In a study of (*ex situ*) accessions from Ethiopia and Eritrea, 415 accession were identified by geographical region and agro-ecology zone, using the former Administrative Regions[103] and ESIP altitude belts, respectively (Ayana and Bekele, 1998, 1999, 2000; Ayana *et al.*, 2000).

Considering qualitative morphological traits (which are highly heritable and in discrete states, such as colour), there was high diversity within both regions of origin and altitude zones, with weak differentiation by region or altitude (Ayana and Bekele, 1998). Analysis of genetic variation using RAPDs (Random Amplified Polymorphic DNA, indicating neutral loci, not genes) gave similar results: 77% of total variation was within regions, and 94% was within altitude belts, suggesting that gene-flow and genetic identities have not been confined to a specific region or ecology. Rather, they attribute the blurring of clear regional or ecological identity to hybridisation and seed movement by humans (Ayana *et al.*, 2000). However, using quantitative traits such as height, days to flowering, or leaf number, the sample could be weakly discriminated by altitude (Ayana and Bekele, 1999). A multivariate analysis suggested that some of the quantitative traits are linked with each other, and vary in a clinal manner along gradients of rainfall and season-length (Ayana and Bekele, 2000). Thus, the authors concluded that there is no strong ecological isolation between different altitude zones that would create distinct genetic populations of sorghum FVs. In a given region, differences between highland, mid-altitude, and lowland sorghums relate mainly to adaptive traits that reflect the different climates and lengths of the growing season, and the clustering of some traits suggests linkage or co-adaptive gene complexes (Ayana and Bekele, 1999: 281). In other words, climatic patterns matter most for quantitative traits, such as height or time to flowering. Some of the quantitative traits associated with adaptation, such as flowering time, are subject to both human and natural selection. Regional origin does have some bearing on more neutral qualitative traits or molecular markers, but these traits also tend to vary more according to climate, both within and between regions (Ayana and Bekele, 2000, 1998).

The majority of studies on crop diversity, including those cited on Ethiopia, rely upon accessions from *ex-situ* genebank collections. Samples from accessions tend to be extremely small (only a few seeds), giving a limited picture of the diversity *within* an accession. Keeping genebank accessions viable involves occasional regeneration by self-pollination, reducing intra-accession diversity even further. Working with *ex situ* samples tells us little

[102] Admittedly, without molecular studies, we cannot say exactly how *genetically* distinct these caudatum sorghums were, but clearly traits relating to the distinct caudatum seed shape and spikelet were maintained by Nilotic groups.
[103] The largest geographical unit used before 1991 (Wollo, Harerghe, Eritrea, Sidamo, etc).

about the diversity within FVs, or about the level of gene-flow in farmer-managed populations. One of the few studies of the population genetic structure of sorghum FVs *in situ* is from Djè *et al.* (1999). They measured sorghum population genetic diversity within farmers' fields across several regions of Morocco, finding most of the diversity (85%) was within individual fields, while the level of genetic diversity among populations and across regions was low.[104] This suggests a considerable degree of gene-flow between fields and regions, probably by movement of seed and pollen. It also suggests that possibility that farmers can differentiate many types at field level. In Ethiopian sorghum, the weak association of (neutral) genetic markers with either region or agro-ecology (Ayana *et al.*, 2000) also suggests that gene-flow across regions or ecologies is sufficient to prevent sharp regional differentiation. As this chapter shows for eastern Ethiopia, and Seboka *et al.* (forthcoming) for northern Ethiopia, farmers have been involved in long-distance movement of sorghum seed between regions and elevation zones, both recently, and in the past.

6.2.3 Outcrossing rates

Between cultivated sorghums

Though mainly self-pollinating, some sorghum flowers do cross-pollinate. Flowering initiates at the top of the panicle, and florets there tend to outcross more (Maunder and Sharp, 1963). The rate of outcrossing tends to be higher for sorghum types with loose panicles: for instance, rates of 5-7% have been measured in compact panicles of race durra (Doggett, 1988), compared to 10-30% in the more open panicles of race guinea (Ollitreault, 1987; cited in Deu *et al.*, 1994). With these factors in mind, a typical outcrossing rate is around 10%, both in FVs and MVs (Pedersen *et al.*, 1998; Ellstrand and Foster, 1983; Zongo, 1997; Djè *et al.*, 1999).

Between cultivated and wild sorghums

There is no reproductive barrier between cultivated and wild sorghums, and cross-pollination produces stable hybrids (de Wet, 1978). Wild and weedy sorghums occur in similar ecologies to cultivated types. They are widely found in fields and field margins in Ethiopia, especially in the mid-to-lower altitude zones, 1500-1700masl. For instance, in a transect through the Central Rift Valley, Doggett (1991) found wild sorghum in 97% of fields. Pollen flow from cultivated to weedy sorghums has been measured at distances up to 100 m (Ariola and Ellstrand, 1996), producing viable hybrids (Ariola and Ellstrand, 1997). Similarly, there is evidence that cross-pollination has transferred some genes from wild to cultivated sorghums (Cui *et al.*, 1995).

6.2.4 Implications of sorghum diversity analysis for farmers

Classification of sorghum's considerable genetic and phenotypic diversity reflects gene-flow. There are few barriers to pollination among cultivated and wild types, which are all part of one large species. Human management has spread sorghum across a very wide range of environments. Looking at sorghum genetics, there is evidence both of adaptation to climate (e.g. Ayana and Bekele, 2000), and of long-distance gene-flow that works to blur any simple local genetic identity (Ayana *et al.*, 2000; Djè *et al.*, 1999). Farmer management may play a role both in influencing the nature and level of gene-flow, through seed-exchange and the long-distance introduction of new varieties. Weeds and wild relatives also need to be managed by farmers for sorghum to retain its cultivated characteristics. By selecting particular morphological characters and adaptive traits, and occasionally by keeping certain

[104] Djè *et al*. calculated $G_{ST} \cong 0.1$ (a measure of inter-population diversity); by contrast, studies based on *ex situ* accessions give much higher results, such as G_{ST}=0.9 for a global collection, using isozymes (Morden *et al.*, 1989).

sorghum types physically or temporally separate, farmers maintain specific FVs (and, more broadly, races) in the midst of this gene-flow. Thus, farmers' actions, conscious and otherwise, are crucial to the plant's continuing evolution, a key argument for supporting *in situ* conservation (Maxted *et al.*, 1997; Brush, 2000).

Farmers' genetic resource management works with their own systems for naming and classifying varieties. I describe local approaches to classification before continuing with other aspects of sorghum management.

6.3 Folk taxonomy: local naming systems for sorghum varieties

Naming systems in crop genetic resource management define a particular variety, effectively establishing a category within which farmers select, exchange, and otherwise manage their crops. These categories, linked to distinct morphological types can direct selection and seed exchange, as Louette (1994) found in Mexico for maize, another out-crossing crop. Farmers' variety names are not always coterminous with diversity at the genetic level (Wood and Lenné, 1997), but this raises particularly interesting issues around farmer genetic resource management. Farmers' variety names help maintain FV identities by keeping a few traits (e.g. seed colour) relatively stable in the face of high levels of gene-flow. Investigating local naming systems also provides insights into the history, origins, and use of varieties. Understanding how farmers place novel material, or off-types, into existing categories, and when they establish new ones, shows an important aspect of innovation in the context of introductions and gene-flow. Finally, the names themselves can also indicate particularly important traits (Boster, 1986a), and give some indication of the morphological features farmers consider important during seed selection.

Farmers in West Harerghe have well-developed, and occasionally contradictory, approaches to classifying their sorghum varieties. Folk taxonomies can relate well to formal scientific classifications as Teshome *et al*. (1997) found for sorghum in northern Ethiopia: the FVs named by farmers could be discriminated very well as distinct types on the basis of formal taxonomic classification using morphological characters, such as seed shape, glume colour, etc.. My purpose here is different: rather than validating farmer sorghum classification in eastern Ethiopia,[105] I explore how knowledge and use of the naming system varies among farmers.

6.3.1 Structure of the local naming system

Tables 6.1 and 6. 2 list the range of varieties farmers in Funyaandiimo Farmers Association (FA) (Chiro) and Melkaa Horaa FA (Miesso) listed as growing on their farms. These lists come from interviews with 141 farmers at the start of the season, who named on between one and two varieties, on average, for their farm (see Table 6.4), with 22 distinct names in total. Direct observations and collections at the end of the season, and a survey of 94 different farmers across a slightly larger region, uncovered a much wider range of named varieties, with 83 in total (55 in the highlands, 40 in the lowlands, see Appendix E).[106] This was by no means an exhaustive survey, but it gives a sense of the richness and complexity of names in farming systems that at first appear to be dominated by a few varieties.

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[105] Over 80 accessions of FVs were collected for on-station characterisation of their traits, but unfortunately, poor rains in 1999 meant that these samples were lost.
[106] A few varieties were encountered in both agro-ecologies.

Table 6.1 Sorghum varieties on farms in Funyaandiimo FA (Chiro, highlands), according to interviews with 83 farmers during planting season, with the number of farmers mentioning each variety, and percentage of total. (* This was considered as a distinct sub-type by the farmers concerned.)

Variety	N	%
Wogere Diima	53	63.9
Cheferee	18	21.7
Wogere Adii	13	15.7
Tiquree	9	10.8
Hadhoo	7	8.4
Muyra Diima	6	7.2
Muyra Adii	3	3.6
Wogere Bullo	2	2.4
Wogere Diima 'ye duro' *	2	2.4
Daslee Adii	1	1.2
Daslee Diima	1	1.2
Fandisha	1	1.2
Masugi Diima	1	1.2
Murata	1	1.2
Sarude	1	1.2
Wararbi	1	1.2
Wogere Hadhoo	1	1.2

Table 6.2 Sorghum varieties on farms in Melkaa Horaa FA (Miesso, lowlands), according to interviews with 58 farmers during planting season, with the number of farmers mentioning each variety, and percentage of total.

Variety	n	%
Masugi Diima	51	87.9
Masugi Adii	16	27.6
Sarude	5	8.6
Masugi 'early'	3	5.2
Masugi Daalech	2	3.4
Wacheela	2	3.4
Qiilee	1	1.7

Farmers in West Harerghe generally use two, and sometimes three, names to identify their sorghum types. The primary lexeme in the name denotes the main variety group, which some farmers called the "family" name. Farmers assign a primary name to types using some of the same features breeders use: panicle shape and size, grain shape and size, height, growth-duration, leaf pattern. These groups may be covariant with other traits, such as pest-resistance, storability, or cooking quality; in this way, farmers do not have to remember a complete matrix of characteristics (for another example of this with sorghum in southwest Ethiopia, see Miyawaki, 1996). Primary names often have no obvious meaning (e.g. *Masugi, Muyra, Wararbi*), but sometimes these names suggest origins, or particular characteristics (see Table 6.3, below). Secondary names describe variants within primary groups, nearly always based on grain colour (*Adii, Diima, Daalech*). Colour is often associated with market price, cooking quality, and palatability; for instance, the higher tannins in brown-seeded types confer bird resistance, but adversely affect nutritional quality (FAO, 1995). The Ethiopia Sorghum Improvement Program (ESIP) sometimes makes similar distinctions around colour, for instance seen in their separate variety trials for white sorghums and red/brown sorghums (Table 3.13).

Some farmers occasionally also use tertiary names to distinguish a sub-type or variant. These names usually refer to specific traits of the variant, its source, or the person who introduced it. Tertiary names are often very local in use, in some cases a family or individual distinction, and are not universally accepted. Some farmers do not make much use of tertiary names, while others insist that such names represent clear and important distinctions among sub-groups of a given variety. Tertiary names appear to mark out a special variant or trait to maintain (or, occasionally, avoid). For instance, some farmers contend that there are no meaningful differences within the FV '*Masugi Diima*' (red *Masugi*). However, others insist that clear sub-types exist. For instance, when I put it to SS, perhaps the most skilled farmer I encountered in Miesso, that some of his neighbours said all '*Masugi Diima*' was the same, he reacted with considerable anger: "These people do not know anything about sorghum. They are not serious farmers!" SS then proceeded to show me '*Masugi Diima Balamilik'*, which he considered superior to 'standard *Masugi Diima'*. A few others were also aware of this sub-type, but certainly not all.

Some variety names evoke key traits, or suggest possible origins; Table 6.3 lists possible meanings and origins of some names, based on linguistic analysis and on group discussions. Names such as '*Sarude*', '*Harka Bas*', and '*Gababi*' all refer to short-stature MVs. Some names refer to the person who originally introduced it ('*Abdelota*', '*Ahmed Isee*', '*Boruu Odaa*'), other names to the location of origin. Whether or not such references are completely accurate, they show how variety names embody local history and identity. For example, the tertiary names "*Ittu*" and "*Goruu Gedduu*" refer to "…ancient times, when we settled here, we came from the Ittu [clan], though our ancestors were from Goruu Geddu [region, in East Harerghe]."[107] The Ittu are one of the main Oromo clans (Jalata, 1993), and there is evidence that plough agriculture spread from East Harerghe in the past few centuries to the study area (McCann, 1995). These tertiary names refer to types of '*Muyra*', itself generally seen as one of the FVs grown for the longest time in Chiro. '*Muyra*' is much more dominant in East Harerghe, where it is the most common variety grown around the city of Harer. This is further evidence of the strong historical links with the eastern highland plateau. However, the presence of some Amharic names, and of some FVs that are common in the centre of north of Ethiopia such as '*Zengada*' or '*Qirimindahi*' (Teshome *et al.*, 1997; Million T., pers. comm., 1998), indicate that important influence of Amhara migrants and transport links in recent decades. Beyene Seboka (2005) has also found evidence of long-distance introduction of sorghum FVs in northern Ethiopia, where farmers clearly distinguish between 'local' types and more recent arrivals.

[107] Funyaandiimo, January 1999, discussion with IMY and NEG-W. Note the latter is an ethnic Amhara, but also knew this story of Oromo clan origins.

Table 6.3 Some sorghum variety names, with their meanings and possible origins.

Order of name	Location of use	Name	Meaning of name and possible origins (Or: Oromo, Am: Amharic)
Primary	**Lowland**	*Sarude*	Generic term in Miesso area for all MVs. Possibly a variant of "Seredo", the name of a MV released in the 1980s
		Abdelota	According to some, refers to "Abdalla", the farmer who introduced the variety to the Miesso-Assebot region
		Demee Segel	Or: "nine branches". Tall, with many leaves and loose-panicle
		Ahmed Isee	Local name for the MV 'IS 2284', after Field Assistant who distributed it
		Yemeni	A reference to Yemen, the variety's origin according to some
		Tejjo	Brown-seeded type, possible reference to *Tej*, a locally brewed drink, as it has high tannin content used for brewing
		Torserawit	Or: "military force"; in reference to its vigour
	Highland	*Gababi*	Or: "the short one"; generic term for MVs, referring to short stature
		Harka Bas	Or: "hand up"; generic term for MVs, referring to erect habit
		Hadhoo	Or: "yellow"(*hadaa*); yellow-seeded type, also a secondary name
		Murata	According to some, named after a Farmer Association in Doba *Woreda*, where this variety is particularly common
		Tiquree	Am: "black" (*tiqur*); black-seeded type
	High- and lowland	*Cherekit*	Am: "moon" (*chereqa*); has milky-white globular grain
		Chalee	=*cherekit*. From Or. *challee*, bracelet made from cowry shells
		Qirimindahi	Am. "I don't need my salary" (as I have this); large panicle, globular-grained type
Second-ary	**High- and lowland**	*Adii*	Or: "white"
		Diima	Or: "red"
		Daalech	Or: "grey" (*daalecha*)
		Bulloo	In reference to compact types, also can be a primary name
Tertiary	**Lowland**	*Meta*	Sub-type of *Masugi*, according to some, refers to sub-clan that first introduced it to Chiro from Doba *Woreda*
		Qiiloo	Sub-type of *Masugi*: 'the foolish one'. Late-maturing, does not fill well, not completely sweet, lower value
		Balamilik	Sub-type of *Masugi*: '4 breasts', sweet, good food quality
		Boruu Odaa	Sub-type of *Abdelota Diima*, named after farmer who introduced it to Miesso area 25 years ago
	Highland	*Goruu Geddu*	Sub-type of *Muyra*, possible reference to Ejersa Goruu region, near Harer. Possibly also Or: "mountain" (*Guraa*), "down" (*Geddii*). Seen as 'older' variant from Harar in east.
		Ittu	Sub-type of *Muyra*, named after a founding Oromo clan. Seen as 'older' variant brought with original settlers from east
		Funyaan Mucha	Sub-type of *Muyra*, Or: "nose" (*funaayn*), "nipple" (*muchaa*); the panicle tip forms a pronounced bump
		Ye duro	Am: "of the past"; used by some to denote an "old type"

6.3.2 Probing the naming system: areas of contention

Focus discussions in each location explored farmers' ability to identify and classify varieties, and the degree of consensus on variety names. For these, I used a collection of panicles of different FVs I had collected from the study FAs (Appendix E, Table E.5 and E.6). I organised focus group discussions in each location, starting with triad tests, where they were shown three similar panicles, and asked to remove the one that did not fit and explain why. After this, they were asked to identify the varieties in the entire set. Additionally, I conducted five sessions in Funyaandiimo with individual farmers.

There was broad consensus around the primary and secondary names of the most common varieties, and of varieties with highly characteristic appearances (e.g. distinct colour or panicle shape). However, I encountered considerable variations in naming with almost all varieties. In general, older farmers knew more names than younger farmers, and the names they gave accessions more frequently matched donors' variety names.[108] Also, women knew more than men, especially for varieties with more distant origins. Both women and older men were quicker in identifying sub-types (tertiary names) and older types that have nearly disappeared. As studies elsewhere have found, experience, travel, and marketing can give some individuals a better overview of a local naming system (Boster, 1986b; Gay, 1989). In West Harerghe, women have a significant role in managing seed and grain within household stores, as well as marketing, and their knowledge reflects this. While men may play the major role in seed exchange and planting, as the previous chapter argued, it is important to remember that women's management and knowledge of sorghum diversity is also central.

Some varieties inspired varied responses or confusion, particularly if they were novel or uncommon. In the highlands, for instance, an accession named '*Wararbi*' by the donor farmer was variously called '*Masugi*', '*Abdelota*', '*Muyra*' or '*Wogere*' by his neighbours. Interestingly, even when farmers did not know the name, they were reasonably accurate in identifying the source agro-ecology. For instance, several highland farmers, mostly women, correctly identified varieties that originated from lower elevations, on the basis of panicle appearance.[109] Equally, several lowland farmers identified varieties from higher or wetter locations. However, this ability is neither universal nor foolproof; seed purchase and exchange almost always uses threshed grain, not panicles. Thus some do get taken in by unscrupulous traders, and inadvertently obtain material that is not adapted to their local elevation.

Interestingly, a few farmers stated that some variations, particularly sub-types of varieties, were due to environmental factors and did not reflect distinct types. For instance, a couple highland farmers argued that '*Masugi*', '*Wararbi*', or '*Murata*' were merely how '*Wogere*' appears when grown in low-, mid- or high-elevation locations, respectively. It would be interesting to know how the differences seen in varieties such as these reflect genes or environment, but detailed analysis would be needed. However, such comments emphasise how the movement of material is important. Typically, flows are from lowland-to-highland, as differences in season-length generally make highland sorghums unsuitable for the dry lowlands. Indeed, only the oldest Miesso farmers had heard of some highland variety names, as migration down from the highlands had in some cases occurred in their lifetimes.

[108] Since some names given by donors were also contested by most other farmers, it is not completely accurate to say that the name given by donors is always the 'correct' or accepted variety name in a given community.
[109] A typical response was "this comes from Wachuu", the adjacent FA that extends down to the mid-altitude zone and below.

A final area of contention is around stalk juiciness. The stalks of plants with this trait, called *tinkish* in Amharic and *Ala* in Oromo, can be consumed fresh at maturity, like sugar-cane. A mature plant with juicy stalk is easily identified by the leaf midrib colour (white, bordered by green), though less easily by observing only the panicle. Plants with juicy stalks are considered to provide higher quality fodder and to tolerate drought better than non-juicy plants; thus the trait is highly-prized. When farmers tried to identify an unknown variety in the taxonomy tests, establishing whether it had juicy stalks was often their first step, something Gay (1989) called a main branching point in the folk taxonomy. Stalk juiciness is also the major branching point in some formal classifications (Guo *et al.*, 1996; Teshome *et al.*, 1997), which treat dry and juicy types as separate groups of varieties. However, farmers' classifications in West Harerghe are actually more nuanced than this. For a given variety, farmers often assigned a probability of stalk juiciness (i.e. sometimes, never, or often juicy). Thus, in folk classifications, the presence of stalk juiciness may help rule out some possible names, but is insufficient on its own to identify a variety. Also, according to farmers, environmental conditions influence the presence of juicy stalks in a given variety. Furthermore, farmers disagree over how present juicy stalks are in a given variety. This adds yet another possible dimension for confusion in variety naming.

6.3.3 Knowledge, practice, and Implications for gene-flow

The point of the above account is not to establish what a 'correct' local classification of sorghum varieties might be (given the influence of environmental variation, this would require genetic studies in any case). Rather, the aim is to examine what local classifications tell us about diversity in sorghum varieties, about the history and movement of these varieties, and about difference in farmers' and practice in naming varieties. All of these aspects affect how farmers distinguish a 'variety', with important implications for their management practices, and for gene-flow.

Several specific issues are raised in considering these folk taxonomies. One is that individual farmers use names with different levels of precision. Tertiary names used for sub-types of a variety appear to be mainly used by those with more experience, and paying a greater level of attention to selection, in order to keep track of specific traits within a defined sub-type. This suggests that there may be valuable variation within a variety that only some farmers acknowledge and manage. SS, the farmer mentioned earlier in relation to '*Balamilik'* feared that this knowledge was becoming lost among his neighbours, and blamed the time they spent away from their farms, pursuing other income-generating activities.

Another issue is that sorghum diversity, and the associated knowledge, is not local but regional. Farmers are aware of some of the common varieties in other ecologies, and their local names (e.g. "You get '*Masugi*' in the lowlands," or "they grow '*Cheferee*' up the hill). Often, they associate a variety with another area, based on its morphology (e.g. "this looks like something from Wachuu, down the mountain", or "this must come from Hirna or Doba, east of here"). Materials commonly come in from other localities; even if farmers do not always give the materials the same name as in the source community, their general knowledge of regional diversity shows that the genetic resource system is by no means 'local'.

Thirdly, the diversity of MVs, and other novel or unfamiliar materials, can disappear in the local naming systems. Material that is obviously an MV (namely, semi-dwarf erect types) may get a collective name such as '*Harka Bas*' ('hand up'; Table 6.3), but otherwise very local names tend to be used for new material, both for obvious MVs ('*Ahmed Isee*') and for other novel materials that do not have established local names. Thus, on the basis of name alone, it is difficult to know which specific MVs have a presence in the lowlands, or if any intermediate altitude or highland sorghum originated from an MV. The history of variety introduction in a given area needs to be probed more deeply to uncover this.

A final issue relates to the variability of farmers' knowledge and practice around classification. Farmers use names to distinguish distinct varieties, which they often manage distinctly. Even though fields are often mixtures of several varieties, the decision to plant a variety, its evaluation in the field, seed selection, exchange, and even storage is done on the basis of individual varieties, their typical characteristics, and expectations of performance. Different levels of knowledge about classification, particularly in how farmers distinguish sub-types, off-types, or non-local varieties, suggests different management practices among farmers. In discussions with farmers, their reactions to an unfamiliar type (e.g. from introduction, or hybridisation) seem to divide roughly into those of 'lumpers' and 'splitters', much as among formal taxonomists. When encountering something unfamiliar, some farmers would tend to lump it in with a more common variety, while others, 'splitters', would tend to maintain it as a separate type. Different approaches to classification may affect gene-flow within and between these populations. This is a good example of the value of looking at farmer practice, as the very variability in classification knowledge, and the confusion about categories it creates, may itself be an important factor in gene-flow. Not many studies have emphasised differences among farmers in how they classify (exceptions are Boster, 1986a, b; Gay, 1989). This variation raises awkward questions about *ex-situ* collections based on the name supplied by an individual farmer. As Seboka *et al.* (forthcoming) found with sorghum collections from northern Ethiopia, genebanks may know next to nothing about the local identities, values, or uses of their collections, which greatly undermines the value of these collections.

With the possibility of variability within varieties, I use 'variety' and 'FV' as working categories, referring to these varieties as named by the farmers involved. This is in accordance with farmer management, though, as the above discussion makes clear, it does not necessarily entail sharp or unambiguous boundaries.

6.4 Introduction: Processes supplying novel diversity

6.4.1 Defining 'introduction'

In contrast to the previous chapter's focus on seed exchange, this section specifically considers introduction. I define introduction broadly, as any process that brings a variety on farm that was not there the previous season. While many instances of introduction result from conscious farmer choices to add a variety to their portfolio, new material can arrive through other means. New material can be introduced via seed exchange, either as a result of a specific request for a new variety, or because that was the only choice available. Finally, introduction can be 'unplanned', if new and unanticipated material is mixed in with off-farm seed (especially that purchased in markets), and the new variety only noticed as the crop matures. Thus, only asking questions such as "when did you ever bring a new variety to your farm?" would give only a partial understanding of introduction, as this may only uncover cases when farmers intended to add a variety to their mixtures. However, introduction occurs more frequently than this, as a result of farmer practice. The present analysis assesses the different processes through which new materials are introduced to a farm, the relative importance of these processes, and how farmers perceive and evaluate material introduced.

6.4.2 Historical processes

In the case of sorghum in West Hareerghe, an exploration of recent history shows that introduction has played a role even with the most dominant varieties. Farmers can recall the first arrival of some of the most widespread sorghum types in the region. For some FVs, there is broad agreement as to the times, source regions, and even the individuals involved in introduction. For other FVs, there may not be a well-known story of a specific introduction event, yet the names of some, as well as the language of the name, suggest possible origins, as discussed above and in Table 6.3.

Historical events can also shed light on variety introduction processes deep in the past. In most of Hareerghe, the Oromo have shifted from pastoral to cultivating livelihoods since the 16th Century (Hassen, 1994). Cereal cultivation was earliest established in the plateau surrounding the ancient city of Harar, in East Hareerghe. Cultivation, and ox-plough technology, then spread westward through the Chercher Highlands, reaching West Hareerghe as late as the 19th Century (McCann, 1995). Farmers in Chiro consider '*Muyra*' and '*Fandisha*' to be the longest-established FVs in the region, and state that they came from East Hareerghe, possibly during the initial spread of cultivation. The study area in West Hareerghe has long been linked to Harar and the coast to the east by established caravan routes, while the Ethio-Djibouti railroad early last century, and a road in the 1930s, connected the region to the rest of the country (Marcus, 1994). These transport links are especially important for connecting Miesso farmers with other significant lowland sorghum areas, which are far away, as lowland areas closer to the Miesso-Assebot plain are too arid for cultivation.

During the feudal period, before 1974, some landlords acted as patrons to their tenants, taking an active role in introducing new material to them. For example, farmers from Funyaandiimo FA all agree that '*Wogere*' was introduced to them 30 to 40 years ago by Metawerk, their landlord at the time, who brought it up from the lowlands. Similarly, for a popular variety in the lowlands:

> "in the past, there was a landlord in Assebot, who collected '*Abdelota*' seed from all his tenants. This he planted, some by tractor, some by ox plough, some by donkey plough. He threshed them separately, and took each lot to market to weigh and asked the price. He then announced to everybody which one had highest value, saying 'This is the best *Abdelota*. Plant this.'"[110]

At least some landlords were actively interested in improving their tenants' production, since tribute was usually a proportion of the harvest; strengthened patrimonial relationships reinforced their positions (Pausewang, 1983).

This brief historical exploration shows that the varieties that currently dominate may be relatively recent introductions. A high rate of variety turnover is hardly unique to West Hareerghe: for instance, Miyawaki (1996) found that most of the most popular sorghum varieties of the Hoor people of southwest Ethiopia were introduced only 40-50 years ago, and many other varieties have come since then. Similarly, Seboka (2005) has found that a large number of FVs have been introduced in the last 20 years to Wollo, in northern Ethiopia, sometimes from distant regions in the northwest. The historical account also suggests that

[110] SS, Rekete village, October 1998.

significant introductions can come via a few individuals, such as landlords. However, the spread of introductions still depends on countless subsequent events, such as seed exchange.

6.4.3 Current processes

Planned introduction

Generally, farmers are interested in trying new varieties. Constraints, particularly moisture in the lowlands and low soil fertility in the highlands, are prompting shifts in cropping patterns and changes in the types of varieties they need. The diversity of household goals, meeting consumption, marketing, feed, fuel, and construction needs under variable growing conditions, also stimulates farmers' desire to innovate with new varieties.

As mentioned in Chapter 5, the survey asked farmers to name the initial source of their varieties. The results highlighted the importance of family members and other farmers in introducing a variety to a farm for the first time, with government and market channels also playing a role (Table 5.11). For the majority of these recorded introduction events, the source was in the same FA, though 8% of the time in Chiro, and 18% in Miesso, farmers first obtained a variety from someone more distant (Table 5.12). When seeking new varieties, some farmers stated that they purposefully try to obtain them from other areas, particularly areas known for a particular variety. For instance, farmers said that someone seeking '*Murata*' should go to the Doba area, 70 km east of Chiro, where the variety is most common. As Cox and Wood note (1999: 42): "When farmers can determine origin, there is some evidence from seed flows that traditional farmers worldwide may be using geographical distance (in source of seed) as a proxy for genetic distance. Farmers often go to some trouble to obtain 'distant' varieties."

Important actors in introduction

Before the Revolution, some individuals, mainly landlords, were potentially important channels of introduction, as their wealth enabled them to travel, acquire new sorghum types, screen materials, and store enough seed to distribute widely. Since the landlord class disappeared in 1975, there are few actors who play such a prominent role in introducing new varieties. In the highlands, a Federal Member of Parliament, Sheikh Alliyee, appears to have taken up the patron's role formerly filled by some landlords. Though he resides in the Zone capital, he has a sizeable farm (>2 ha) in Shoola, near to Funyaandiimo.

> "He knows the area, and goes everywhere, and asks farmers for seed, and tries these on small plots [on his land]. He stores many seeds at storage time."[111]

He is said to select sorghum seeds for normal maturity time, and is credited for introducing '*Hadhoo*' to the region.

Melkaa Horaa farmers could not name an important actor in variety introduction quite so readily: "In this region, farmers are all the same."[112] Twenty km away, in Assebot, there is a group of farmers who systematically seek out and screen new varieties. Since they have large farms (3-4 ha) farms, and can afford to hire a tractor, they are relatively wealthy. However, though farmers in Melkaa Horaa FA were aware of this group, nobody in focus group discussions could name any individual in the group. There is one farmer in Melkaa Horaa wealthy enough to hire a tractor, who collects and screens new material obtained on his

[111] JAA, Funyaandiimo, 25 Oct., 1998.
[112] AUW, Hussee, 28 Oct., 1998.

travels, though only his immediate neighbours regularly receive new FV seed from him. Outside that village few lowland respondents could name an important individual in variety introduction.

These significant actors are obvious partners for collaboration with the formal seed system in any activities to supply new germplasm to farmers, either FV or MV. Their experience, experimental orientation, and abiding interest in novel germplasm mark them out as classic 'innovating farmers' with whom researchers commonly collaborate. However, there are rather few farmers able to do this to any great extent, in part because of limited land. Also, there is a great deal of less systematic introduction, involving a much wider range of farmers.

'Unplanned' introduction; a reflection on measurement methods

Table 6.4 compares different methods for assessing on-farm diversity. While surveys and interviews relied upon farmers' statements about what varieties they were growing that year, direct observations involved walking through the field with the farmer at harvest. Covering a wider area, the survey encountered a wider range of varieties than the interviews (compare Tables 6.1 and 6.2 with E.1 and E.2), but the number of varieties named by each farmer was the same using both methods, roughly 1.5 per farm. In contrast, direct observations of diversity identified many more varieties in total (see Tables E.3 and E.4), even though the farms I visited were in the same communities as the interviews. More strikingly, the average number of varieties per farm was significantly higher than that found by other assessment methods (a threefold increase). While no farmer mentioned having more than three varieties in either surveys or interviews, I observed as many as ten distinct varieties on a single plot among my contact subset of farmers.

Table 6.4 Levels of on-farm variety diversity in 1998, assessed by different methods: individual semi-structured interviews in focus FAs during planting season, a survey over wider areas in mid-season, and direct field observations at harvest of sub-sample farmers and some collection locations.

Method	Chiro Number of farmers	Chiro Number of different varieties	Chiro Number of varieties/ farm †	Miesso Number of farmers	Miesso Number of different varieties	Miesso Number of varieties/ farm †
Interview	84	17	1.6 (0.1) A	57	7	1.4 (0.1) A
Survey	53	29	1.4 (0.1) A	41	15	1.4 (0.1) A
Direct observation	15	23 *	4.9 (0.5) B	21	27 *	4.4 (0.5) B

(* Total does not include varieties whose name was unknown to the farmer being interviewed. † Means [with standard errors]: those followed by a different letter are significantly different from means assessed by other methods.)

This discrepancy may simply reflect the limitations of basing variety diversity on farmer recall, since they may only mention the most abundant varieties they possess, or only the larger introduction or exchange events. Indeed, many of the varieties noted in direct observations had small populations, sometimes a few individuals. However, discussions revealed that most of these varieties were in fact introductions since the start of the season. This suggests that the discrepancy between methods reflects more than just failed recollection, but that varieties are frequently introduced to a farm during the course of a season, albeit in small quantities. This underscores the importance of looking at practice, understanding it as a series of contingent responses to unfolding situations, rather than as an established plan (Richards, 1986). For example, a farmer may state that he plans to sow two varieties when interviewed at the season's start, yet as the season progresses, may add more through the season by re-sowing a patch, where germination failed, with off-farm seed, or by sowing a small amount of seed from a couple varieties received as a gift from a friend. Considering practice opens up to scrutiny the possibility of multiple introductions over the course of the season, not all of them planned, or necessarily recognised as introductions.

'Unplanned introduction'; Surprises

Table 6.5 shows details for seed introduction in 1998 for the contact farmers, based on discussions. Interestingly, nearly all contact farmers had varieties on their farm at the end of 1998 that they did not have in 1997, and the overriding impression is one of frequent introductions, generally of small amounts of seed from neighbours or family. A few individuals in both locations received introductions from more than one source

Table 6.5 The sources by which 10 farmers in Funyaandiimo FA, and 9 in Melkaa Horaa FA, acquired varieties in 1998 that they did not have on their farms the previous season, with the number of farmers using each source, the number of varieties introduced by each source, and the mean amount introduced. (***** 'Unknown' sources refer to occasions when farmer did not plan introduction, but rather discovered a new variety in the field mid-season.)

Location	Source for introduction	Used in 1998?		Varieties introduced		Amount (kg)	
		n	% (of farmers)	n	% (of vars.)	Mean	Std. Err.
Funyaandiimo (Chiro)	Family	1	10.0	2	7.7	0.4	--
	Neighbour	7	70.0	16	61.5	1.7	1.1
	Market	3	30.0	6	23.1	5.5	2.1
	Government	--	-	--		--	--
	'Unknown' *	2	20.0	2	7.7	--	--
Melkaa Horaa (Miesso)	Family	4	44.4	7	31.8	4.4	4.2
	Neighbour	4	44.4	9	40.9	5.6	4.0
	Market	3	33.3	3	13.6	16.3	1.0
	Government	1	11.1	1	4.5	1.0	--
	'Unknown' *	2	22.2	2	9.1	--	--

Of particular interest in Table 6.5 is when the source was 'unknown'. This occurred when a new type to the farm was only noticed mid-season, as plants reached maturity. In most cases, the farmer would recognise the plants as a distinct variety, but could not identify which variety it was. Of 48 accessions collected from the lowlands, the farmer was uncertain of either the name or the source in 13 cases. The Miesso-Assebot Plain is portrayed as having a relatively lower level of varietal diversity than other areas, like the Chercher Highlands (e.g. Kefyalew *et al.*, 1996). This degree of unknown or unplanned introduction belies this image, and deserves more attention.

Some of these new or unknown materials may be off-types resulting from hybridisation. Indeed one focus group considered some of the 'unknown' varieties that they were shown to be off-types ('*dikala*'; see 6.5.1). However, many of these unexpected and unknown varieties were clearly distinct from others in the field (e.g. much taller, different morphology, etc.), and were presumably different varieties. Farmers generally stated that they regarded unexpected and unknown varieties in their fields to be distinct varieties, and most planned to replant them the following year to assess performance. Thus unplanned introductions provided farmers an opportunity to experiment.

How might unknown, or unexpected materials be introduced? Seed markets are one source, since merchants can travel from distant areas. One merchant in 1998 claimed to have brought sorghum seed to the Miesso market from Humera, over 1000 km to the northwest, the same source as claimed for some of the recent sorghum FV introductions Seboka (2005) found in northern Ethiopia. Whether or not this was strictly true, the seed in question was distinct in appearance from locally-available types, and the many farmers who purchased this seed could not identify it. This raises the issue of the difficulty of identifying a variety from its seed alone. Through ignorance or malice, merchants occasionally sell seed with traits or identity differing sharply from the variety as described to purchasers. This is can be a particular problem when it involves maturity time, such as when long-season sorghum is sold to farmers for the late rains. For this reason, a number of farmers avoid merchants (as Chapter 5 noted). However, farmers are not the only ones caught by surprise. For an ESIP on-farm trial near Miesso, one of the station TAs was sent to purchase '*Masugi*' from the market to use as a local check. Though he had over 16 years' experience in the area, and knew the local varieties better than ESIP breeders in distant Nazret, or than his other colleagues at the Miesso station, the purchased seed grew into an unfamiliar variety quite different from '*Masugi*', to his great embarrassment. The trial was undermined. This episode highlights how difficult it is to be assured of variety identity in market purchases, especially when the seed may actually be a mixture of distinct types.

Unplanned introductions also arrive in farmers' fields via seed exchange, when plants of a different, unexpected variety appear growing amidst the type the farmer expected. Seed exchanged in farmers' seed systems is not always pure, and mechanical mixture may stir new varieties in, both familiar and unfamiliar. For instance, several lowland farmers who had purchased '*Sarude*' (probably an MV) from a merchant pointed out scattered individuals in their field that were 50cm taller and different in colour than other varieties grown in the area. They did not recognise the variety, and insisted that they did not expect it to appear (though some were pleased with its performance). Even formally-supplied seed can be mixed. As mentioned last chapter, some Melkaa Horaa farmers received small (1-3kg) packets of MV seed from the *Woreda* office. Visiting a couple of these farms, I noticed at least three distinctly different varieties growing among the MV they had received ('76 T_1#23'), all of which were completely unfamiliar to them or to me. The seed originated from ESIP's Miesso sub-station, so the unknown varieties were probably unreleased lines from station trials, accidentally mixed in with '76T_1#23' on the station threshing ground, where threshing and bagging is done, using casual labour.

Such 'unplanned' introductions expose farmers to risk, though they occasionally also supply useful new materials. Most farmers identifying distinct and unexpected varieties introduced to their fields stated they would deliberately re-sow it the following season, to observe performance. Such unplanned introductions appear to be more common in Miesso, where markets, and to some extent the research station, supply seed to farmers. Some of this material may be mixed, or have distant provenance. Ironically, the greater vulnerability and seed insecurity in the lowlands is one reason why introductions, both planned and unplanned, appear to be more frequent there, as lowland farmers need to seek off-farm seed more frequently. Richards (1986) found a similar situation with rice in Sierra Leone; the most vulnerable farmers get loaned impure seed, but occasionally some of them get lucky with this, and uncover useful new materials.

6.4.4 Summary - introduction

Introduction occurs frequently on farms in West Harerghe, as a planned activity, as an incidental outcome of seed exchange, and as an unexpected appearance. As Table 6.4 shows, the methods used to analyse farmers' genetic resource management can have a strong bearing on such aspects as levels of diversity or introduction. In part, this is due to the limitations of farmer recall, excluding minor varieties and very small exchanges, but this also relates to the way different methods frame the question and the time period, or reflect intentional actions. In-depth observations of a few farms at the end of the season highlighted the contingent nature of genetic resource management as a practice, and showed its dynamism, with frequent small introductions. Variety composition is constantly changing, both at regional and at farm scale, forcing us to question the real meaning of 'local' germplasm. The introduction of materials, both planned and accidental, is an important aspect of farmer innovation.

One interesting question is whether the removal of dramatic wealth differences (with the elimination of landlordism) has actually lowered the scope for introducing new varieties to farmers. Despite improvements to infrastructure, and increased trade and migration in recent decades, there are fewer potential patrons who have the means – and incentive - to search and screen germplasm systematically, and disseminate their findings to others. While not defending the gross inequalities of the feudal era, is it not possible that some inequality helped sustain innovation, and provided an important service to the wider community? The relative absence of patrons capable of operating at this scale, supplying materials and stimulating innovation, may mean that an important layer of social protection is now gone. Interventions that wish to promote a more dynamic and effective exploration of germplasm need a better understanding of the key actors involved, their roles, and of the barriers that currently exist for farmers to explore and introduce seed. If the state or market is to replace the patron-landlord, we need to know whether either mechanism will operate as efficiently in introducing new materials. Issues around supporting farmers' genetic resource management are discussed more in the final section.

6.5 Hybridisation: generating new combinations

Farmers' management of hybridisation is an important part of the seed system, as this affects how varieties incorporate new traits, and how well varietal purity is maintained. Hybridisation arises from cross-pollination between individual plants, and is a key source of gene-flow. Crosses between different sorghum types, and occasional introgression from wild sorghums, is considered to play an important role in the continued evolution of sorghum in Ethiopia (Doggett, 1991). How do farmers perceive hybridisation when it occurs in their fields? What factors influence the rate of hybridisation, and do farmer practices affect it?

Box 6.2 reviews examples elsewhere of farmer management of hybridisation in relation to the breeding system of the crop, which dictates the frequency of cross-pollination, and structures the genetic diversity. As the review shows, farmer management of hybridisation can be positive (encouraging crosses, or opportunistically including off-types) or negative (roguing out off-types). The section below argues that hybridisation occurs readily in sorghum under farmers' growing conditions, and that farmer management influences this gene-flow both positively and negatively.

Crops that are mainly **self-pollinated**, such as wheat, rice, and most grain legumes, generally breed true, with occasional outcrossing to other plants. Diversity is typically best seen between varieties or seed-lots. 'Off-types' resulting from occasional hybridisations can be quite distinct in comparison to relatively uniform parental populations. There is evidence from many cases that farmers will notice off-types, either to rogue them out in order to maintain a pure trait in their varieties (i.e. to fetch a higher market price), or to retain them as a new type to be evaluated. This opportunistic exploitation of hybridisation can be an important source of new combinations, as noted for example with beans in East Africa (Ferguson and Sprecher, 1987; G.B. Martin and Adams, 1987). Bulk seed selection can passively include off-types. Richards (1986) notes that rice farmers in Sierra Leone pay special attention to field margins (where outcrosses are most likely between different varieties), and harvest the crop one panicle at a time, to be able to note off-types. Jusu (1999) has documented what are likely inter-specific hybrids of African and Asian rice (*Oryza glaberrima* and *O. sativa*, respectively), which Sierra Leonean farmers have maintained and classified separately. Until recently, such crosses were deemed impossible. Now, the West African Rice Development Association (WARDA) has succeeded crossing the two species, promoting the progeny from such crosses through the "New Rices for Africa" programme (Jones *et al.*, 1997; WARDA, 2001). Interestingly, the *O. glaberrima* parents WARDA uses for their crosses came from farmers' fields, and had already exhibited '*sativa*-like' traits (M. Jones, H. Gridley, *pers. comm.*, May 2001). This suggests that the materials may have been partially introgressed with *O. sativa* while under farmer management.

With **open-pollinated** crops, such as maize and millet, variation is often greater *within* a population (variety or seed-lot) than between populations from the same area. Farmers may deliberate mix different types or varieties to encourage the transfer of useful traits between them, for example, for mixtures of *Brassica* (kale) in Ethiopia (Worede, 1993). However, cross-pollination can also bring unwanted traits from one population to another, and farmers sometimes organise spatial or temporal isolation to limit cross-pollination and thus maintain desired traits as Song (1998) observed in China with maize. In Mexico, there is some suggestion that farmers actively encourage introgression between wild and cultivated maize (*Zea diploperennis* and *Z. mays*, respectively), by taking wild-cultivated hybrids and repeatedly backcrossing them into their crop populations to 'refresh' them (Benz *et al.*, 1990).

Finally, **vegetatively propagated** crops, like potatoes, generally reproduce clonally, so most diversity is between lines. Occasional cross-pollination allows for recombination, and produces true (botanical) seed. Progeny from these outcrossing events may be unconsciously added into farmers' variety mixtures, as Johns and Keen (1986) found with potato farmers in Bolivia. Enset (*Ensete ventricosum*), a staple crop in southern Ethiopia, only flowers after several years, though most farmers harvest it before then (Admasu Tsegaye and Struik, 2000). Shigeta (1990) found that Ari farmers in Ethiopia carefully tend any chance seedlings of enset that they find, knowing that they might acquire new types in this manner.

Box 6.2 Some examples of farmer management of hybridisation across breeding systems

6.5.1 Farmers' management of hybridisation in sorghum

Flowering times

There is considerable opportunity for gene-flow arising from hybridisation between varieties, or populations (e.g. different seed lots) of the same variety. Farmers growing multiple varieties almost always sow them intermingled in the same field. Cross-pollination presents an opportunity for gene-flow between the different varieties found in one plot, as well as between plots, since different holdings are usually contiguous. For different varieties (or seed-lots) to have a chance of crossing, their flowering periods need to overlap to some degree. Flowering lasts for 4-5 days on an individual sorghum plant, though viable pollen may be available from a given variety in a field for 10-15 days, because of variation among individual plants in when they initiate flowering (House, 1985).

To assess the potential for crossing I recorded the mid-flowering date – when 50% of plants of that variety are in flower – for all varieties on plots of 15 of the contact farmers, and of immediately adjacent fields. On 6 of the 9 farms observed in Funyaandiimo, and on 5 of 6 farms in Melkaa Horaa, the mid-flowering of at least one variety came within five days of another variety nearby (same or adjacent field; Table 6.6). Distances between overlapping varieties in this sample range from less than a meter for varieties in the same field to a few tens of metres for different fields, as plots are frequently contiguous. The average gap between flowering times of different varieties within a field was less than between fields (Table 6.7). Also, flowering times both within and between fields were significantly closer together in Miesso than in Chiro. Whether this results from greater conformity in planting time or in the germplasm used is uncertain. While precise geneflow estimations between fields and varieties would require other measurements, the overlap of flowering means that pollen flow between different varieties or seed lots (i.e. same variety, different farm) is at least possible for a significant proportion of cases.

Table 6.6 For plots observed in August-September 1998, the number where at least one variety had overlapping flowering time with another variety in the same field, or in one immediately adjacent. (***** Overlapping is defined where mid-flowering of one variety is within 5 days of another's.)

Comparison	Funyaandiimo (Chiro)	Melkaa Horaa (Miesso)
N plots observed	9	6
N with overlapping flowering*	6 (66.6%)	5 (83.3%)

Table 6.7 Mean difference (with standard errors) in mid-flowering times of sorghum variety populations observed in August-September 1998.

Comparison	Funyaandiimo (Chiro)		Melkaa Horaa (Miesso)	
	N of observed comparisons	Days between 50% flowering	N of observed comparisons	Days between 50% flowering
Between different varieties in the same field	3	8.0 (5.1)	3	1.0 (1.2)
Between varieties in adjacent fields	13	12.1 (1.7)	25	3.2 (1.5)

Sorghum FVs are photoperiod-sensitive, so most farmer varieties initiate flowering only when the day-length shortens below a particular critical length (House, 1985). As a result, FVs in the same region tend to flower at nearly the same time. Farmers also aim to avoid having their sorghum mature at a very different time than their neighbours, to minimise the risk of bird damage. This is a particular issue in Miesso, since photoperiod-insensitive MVs are available there that will mature in a fixed period following sowing date, regardless of the season. In that case, the planting date does influence the flowering time, and a seed lot sown much earlier than others will thus also mature much earlier and be a prominent target for bird attack.

This is a good example of how farmer genetic resource management involves collective action, as well as individual decisions. Some farmers stated they would to sow faster MVs in March-April with the *Belg* rains, but cannot diverge from their neighbours' practice, as their plots would mature too early and be vulnerable to birds.

Farmers' perceptions of hybridisation among cultivated sorghum

Highlands

Farmers note variants of sorghum types in their fields, especially when differing in colour, and give these variants a range of names (Table 6.8). Many explain this variation with the term *dikala*, an Amharic term – also commonly used by Oromo farmers – for a cross between plant or animal breeds. Applied to humans, *dikala* also means 'bastard', in both the literal and pejorative sense (Leslau, 1976). The negative connotations of the term may be significant, implying as they do unknown paternity, and the difficulty of assigning an appropriate category (in society, or in a field environment) to the *dikala*.

Table 6.8 Common terms for hybrids in Chiro and Miesso (West Harerghe), with farmers' most common explanations for their origins. *Language of origin, Or: Oromo, and Am: Amharic, though local terms used by both language groups.

Location	Type of hybrid	Term	Comments and views on origins*
Both	Any	*dikala*	General term for mixture of types, or off-type. Am.: any cross-breed, but 'bastard' if used in reference to people
Chiro (highland)	Between varieties	*jengaa; kadir*	Brown seed and vigorous growth; seeded via 'ox urine'. Kadir is from Or. 'gift of God'
	With weedy sp.	*fechatee*	Brought up from lowlands by accident, or deliberately during feud. Or: 'shatter'
Miesso (lowland)	With weedy sp.	*qiilee*	Shatters before harvest; from droppings of birds that breed in nearby marsh lands. Variant of 'keelo', Am.: "the foolish one"?
	Different seed colour in clusters on the same panicle	*tafakuur*	No comments on origins from farmers.

In general, *dikala* is a descriptive term used to refer to any off-type, and is not a variety name *per se*. However, some use it in place of a name, suggesting that the plant in question no longer can be grouped under a known variety, e.g. "this is not really *Wogere*, but a *dikala*".

Though discussions revealed that almost all farmers were aware of *dikala* sorghum plants in their field, their reaction varied. Similar to the issue of 'lumping/splitting' discussed above, a few farmers claimed they avoided *dikala*, and carefully selected seed that stayed true-to-type to enable them to maintain 'old type' (*ye duro*) populations. However, it is likely that other farmers also select against off-types, but simply do not describe the process as clearly. As the taxonomy discussion suggests, notions of variety identity and purity probably vary considerably among farmers.

Apart from the general term *dikala*, highland farmers recognise some specific types of hybrids with particular names. These are more universally shunned. In the highlands, '*jengaa*' is the most obvious example, seen on every farm I visited in Funyaandiimo. Individual '*jengaa*' plants stands out in sorghum fields, due to their vigorous growth (they can reach 5m on fertile highland soils), large panicles, impressive production, and (especially) their characteristic dark brown seeds. These characteristics notwithstanding, highland farmers generally dislike '*jengaa*' for its bitter taste (due to tannins) and poor grain quality. Some impoverished farmers admit they will still consume '*jengaa*', as porridge (*nefro*), or in the staple flatbread, *lafiso* (a form of *injera*). However, most farmers stated the only use they had for '*jengaa*' was as animal feed, or for brewing beverages.

The negative associations are strong, and no farmer admitted to sowing '*jengaa*' deliberately. Every farmer I interviewed or observed carefully separated out and removed any individuals found on their fields at harvest. Despite this, a few '*jengaa*' plants appear in most fields each year (one farmer estimated about 10 plants a year appeared), and farmers thus wonder at the origins of this unusual sorghum type. The standard explanation is '*ye beré shint*' (Am: 'ox urine'!), referring to the oxen that graze post-harvest stubble, though many farmers told me they did not think this was literally true. When pressed, some farmers felt it had divine origins – some older farmers call it *kadir*, meaning 'gift of God'.[113] Others felt it emerged 'from within the other sorghum', with some suspecting the cause to be a type of *dikala* (hybridisation) between different varieties. To this end, some sub-divide, implicitly assigning at least one parental type, based on panicle shape (e.g. '*Wogere jengaa*'). Though '*jengaa*' could be volunteer plants, another likely explanation for their continued presence, given negative farmer selection, is that they are the progeny of crosses between red and white-seeded varieties, exhibiting hybrid vigour.

Lowlands

In lowland fields of Miesso, 45 km away, farmers did not report the regular and unplanned appearance of strikingly different brown-seeded plants. Most lowland farmers I interviewed had never heard of '*jengaa*'; those who did tended to link it with maize (which has a higher out-crossing rate), as well as with '*ye beré shint*'. In focus group discussions, a few farmers thought that "what they call '*jengaa*' in the highlands" was simply the same FV that lowland farmers called '*Tejjo*', which has similar brown-seeds (though not the same abundant growth). However, older farmers disagreed with this explanation, pointing out that '*jengaa*' is not deliberately sown by highland farmers (while '*Tejjo*' is). If it is a result of cross-pollination, it is nevertheless striking that '*jengaa*' only seems to occur in the highlands. This issue deserves more study, particularly to determine the degree to which the presence of '*jengaa*'-like off-types causes problems for farmers elsewhere.

[113] Some older farmers consider this sorghum type a gift, due to its abundant production; interview with SDM, Funyaandiimo, October 1998.

In the lowlands, I found several plants on one farm that had both red and white seed on the same panicle, usually with entire primary or secondary branches all one colour. ESIP's head sorghum breeder stated that he had never seen nor heard of such panicles before, but suggested that this might be due to partial sterility in the panicle. However, five out of nine lowland contact farmers recognised it as a type, and a similar proportion recognised the name '*tafakuur*'. I subsequently found that a number of farmers in both Miesso and Chiro were aware of this name. When asked if they would select such a plant from their field to use as seed, most farmers said no, as they wanted to maintain pure colours and variety identities. A few farmers, though, said they would sow '*tafakuur*' out of curiosity. Though interesting, this phenomenon is probably highly uncommon.

Crosses between cultivated and wild sorghum

In both highland and lowland areas, farmers recognise crop-weed hybrids, and generally view them as contamination. In early growth, weedy sorghum hybrids appear exactly like cultivated types, and are only detectable at flowering stage. Only then can farmers see the 'wild-type' characters in a wild-cultivated hybrid: smaller black/blue-coloured seeds, very open panicle, long hairy glumes, and, most crucially, shattering, with all grain falling from the spikelets at the slightest touch. Given that the shattering trait comes entirely from one dominant QTL, *Sh* (Patterson *et al.*, 1998), this would usually be transferred to any cultivar with which it crossed, making it dehisce before harvest.

Highlands

Highland farmers in Chiro call such hybrids '*fechatee*', meaning "shatter" in Oromo. Once detected during flowering, they try to remove and destroy all '*fechatee*' plants before harvest, taking care not to spill any seed. While its shattering trait, and seed and glume morphology, suggest '*fechatee*' is a hybrid with wild sorghum, wild sorghum is not commonly seen in the highlands. Interestingly, older farmers in Chiro say '*fechatee*' first appeared 50-60 years ago, brought up from the lowlands. Some say that it was accidentally included when the landlord Metawerk introduced '*Wogere'*. Others associate its arrival with a feud between two farmers over land, when one farmer brought '*fechatee*' up from the lowlands to secretly sow in his enemy's field and sabotage the harvest; it has persisted in the area ever since. '*fechatee*' is seen as a pest, and farmers say they only way to control it is to rotate crops.

Lowlands

Lowland farmers commonly find crop-weed hybrids in their field, which they call '*qillee*'. This name may be derived from '*keelo*' of '*qilo*' ('the foolish one' in Amharic), which, along with '*sepo*' is a common name in central and northern Ethiopia for crop-wild hybrids (Doggett, 1991; Seboka and van Hintum, forthcoming). Like their highland counterparts, farmers can only identify '*qillee*' after flowering, but will rogue and burn any individuals they find. Again, '*qillee*' is not consciously sown. Some explained its presence as coming from the droppings of birds nesting in nearby marshy areas. This seems a plausible explanation, since wild *S. bicolor arundinaceum* tends to grow in wetter areas (de Wet, 1978). However, hybridisation with wild sorghum in field margins is also quite likely. As in the highlands, farmers see such hybrids purely as a nuisance to be removed.

Implications of management and gene-flow

The range of possible hybrids is potentially enormous, so the limited number of names farmers use for them is striking (Table 6.8), where two or three terms exist in each location. Also striking is the idea of pollution or contamination associated with the explanations of the origins of '*jengaa*', '*fechatee*', or '*qillee*', and the use of *dikala* as a general term for hybrids.

This small set of names may thus be reserved for distinctly negative types, concerning which there are required patterns of response (i.e. immediate destruction, lest you contaminate your neighbours' fields). Some authors have suggested that farmers do occasionally encourage introgression from wild plants to bring useful new traits into cultivated ones (e.g. Bezançon *et al.*, 2001 argue that farmers' management has encouraged wild-cultivated hybrids of millet in southern Niger). However, the likely transfer of undesirable traits, such as shattering, casts doubt on the value of such hybrids to farmers (Wood and Lenné, 1997).

In summary, there are multiple opportunities for gene-flow to occur through hybridisation, both among cultivated varieties and seed-lots, and between cultivated and wild types. Farmer practices enable these crosses to occur relatively frequently, through close field arrangements, planting multiple varieties in the same field, and through seeking synchrony in flowering . Human actions may also have facilitated the arrival of '*fechatee*' sorghum to the highlands, through accidental introduction of wild types from the lowlands, or through deliberate acts of contamination. There is no evidence that farmers deliberately encourage crosses, and most seek to maintain variety purity in their seed selection, avoiding selecting from obvious hybrids or off-types. Moreover, they aggressively remove any '*jengaa*', '*fechatee*' or '*qillee*' they find. Thus, farmer management allows for crossing, but conscious actions tend to work towards maintaining 'pure' types in most instances. In other words, in reacting to morphological characters, farmers demonstrate a conscious concern to maintain a measure of FV identity, while other practices tend to contribute to maintaining gene-flow. FVs are dynamic outcomes a farmer management that includes both conscious activities and the unintended impact of farmer practice on gene flow.

6.6 Farmer seed selection

6.6.1 Practices

Farmers generally use mass selection, identifying the best plants or panicles in their fields, bulking the seed to sow the following season. The usual harvest practice is to cut all panicles from the standing stalks, gathering these in piles in the field, before threshing. Most selection occurs from such piles of panicles, either in the field, or later at home, with the mix of varieties roughly proportionate to planting intentions the following year. Some farmers begin selection earlier, evaluating the full standing plant (e.g. for signs of stalk sweetness or drought tolerance) before or during harvest. Additionally, it was observed that a few farmers will note or mark plants earlier during the growing season (e.g. for early maturity), so that their seed choices are based upon observations during the season. A few also reported selecting and multiplying distinct variants from an individual panicle if it showed interesting traits such as earliness. However, the most common practice is to select on the basis of panicles alone, after they have been cut from the sorghum stalks.

Contact farmers were asked in semi-structured interviews to describe their selection criteria. Nearly all responded that they sought panicles free of obvious disease that showed good grain production. Some informants specifically mentioned selecting varieties that were true-to-type, or that exhibited specific traits, such as stalk sweetness. However, the actual traits sought may differ from those explicitly described beforehand. Also, other traits (e.g. seed size, plant height) may be linked positively or negatively to traits selected on the basis of a panicle, such as panicle size.

Adapting the method of Soleri *et al.*, (2000) I organised a selection simulation with contact farmers in each location to explore how farmer selection on the basis of panicles might be correlated to other crop characteristics. Nineteen contact farmers (11 in Chiro, 8 in Miesso) were shown a group of panicles of a common FV from their area (19 '*Wogere Diima*' for Chiro, 15 '*Masugi Diima*' for Miesso). I had collected these panicles earlier from plots randomly placed in farmers' fields as part of another trial, and measured height and biomass of each individual entire plant. Unfortunately, it was not possible to present a larger sample to farmers, as I used only a single FV in this exercise, to avoid asking farmers to select among a variety mixture. Presented with this group of panicles, farmers were asked to select the panicles they would choose as seed. Chiro farmers were asked to select six panicles, Miesso farmers five, a selection intensity slightly above 30%.

The difference between the mean of the selections, and that of the population from which they selected, can be expressed as the selection differential (S), in terms of the standard deviation of the base population (Falconer, 1981). Table 6.9 lists the S values of farmers' selections for eight traits, as well as the number of individual farmer selections with significantly different means from the base population, at two levels of significance. Measurement details of the base populations, and mean values for selections of individual farmers, are listed in Appendix F. Table 6.9 suggests there was directional selection for panicle weight (i.e. farmer selected panicles were heavier than the population mean), as well as for threshed grain weight. Both of these trends are unsurprising given farmers' stated criteria for large panicles. Interestingly, the greater grain weight (1000 grain weight) in Chiro selections appears to reflect more larger grains than greater grain numbers per panicle, while the reverse is true in Miesso. Also, whole plants in the Miesso selections (which the farmers did not see) tended to be taller and heavier than the base population, while this was not apparent in the Chiro selections.

Table 6.9 The selection differentials for several characters when 11 Chiro and 8 Miesso farmers selected from a sample of sorghum panicles at 30% intensity, and the number of farmers' selections whose means differ from the mean of the original population at 0.05 and 0.10 probability levels.

Character	**Funyaandiimo (Chiro) n=11**				**Melkaa Horaa (Miesso) n=8**			
	Selection Differential (S)		# significant t-tests		Selection Differential (S)		# significant t-tests	
	Mean	Range	p<0.05	p<0.10	Mean	Range	p<0.05	p<0.10
Fresh plant biomass	0.06	-0.30 – 0.73	0	1	0.72	0.28 – 1.05	3	4
Plant height	0.07	-0.43 – 0.61	0	0	0.69	-0.10 – 1.10	3	5
Panicle weight	0.67	0.11 – 1.15	1	6	0.71	0.15 – 1.13	2	3
Panicle length	0.47	-0.12 – 1.06	1	1	0.53	-0.06 – 0.94	2	3
Panicle width	0.61	-0.02 – 1.06	1	1	0.43	0.06 – 0.79	0	2
Threshed grain wt.	0.72	0.16 – 1.16	2	6	0.79	0.30 – 1.22	2	4
Grain # / panicle	0.50	-0.04 – 0.89	0	1	0.71	0.35 – 1.13	2	3
1000 grain weight	0.43	0.22 – 0.73	2	4	0.24	-0.22 – 0.58	0	0

Overall, the S values averaged between 0.4 and 0.7 for the yield-related traits listed above, values slightly lower than those found by Soleri *et al.* (2000). Constrained sample sizes would be one cause of this, as a larger base population would tend to have smaller standard deviations, making selection differentials higher. Another possible factors is that Soleri *et al.* used farmers known for their selection expertise. The sample of contact farmers used here reflected a range of ages, wealth- and skill-levels, and the negative selection differentials of some farmers may reflect this (i.e. their selections were shorter, smaller, etc., than the base population).

This simulation suggests important differences between locations in selection criteria – e.g. grain weight vs. grain number. For breeding reform efforts aimed at reflecting farmer criteria, understanding such variation is crucial. A more important point to emphasise is the degree of variation in selection intensities, even direction, *among* farmers (Appendix Tables F.1 and F.2). This highlights varying practices, goals, and (possibly) levels of expertise among farmers, and suggests that this variation in practice may play a role in maintaining diversity. Given the small sample sizes, these results are suggestive at best, and far more extensive research would be needed to gain a thorough understanding of farmers' actual selection goals.

6.6.2 Farmers' understanding of heritability

Farmers select based on phenotype, but even if the practices of some are directional, this may not produce changes year-to-year, given the high environmental variation (V_E) under their conditions. Do farmers expect that selecting the largest panicles will necessarily produce larger panicles in the following season? Exploring farmers' views about the heritability of the traits they select can shed some light on what motivates their selection practices, and on what conscious theories might be involved. As Soleri *et al.* (2002) argue, understanding farmers' knowledge of the relationship between genetic and environmental diversity can form a basis for collaboration with formal breeders, leading, for instance, to a strengthening of farmers' own selection practices. Additionally, in the absence of *in situ* tests to estimate heritability, farmer perceptions of the relative influence of the environment are of interest, as a preliminary indication of the challenges formal breeders might face in selection work undertaken in these environments.

The heritability of a trait is degree to which genetic variation of a trait can be determined from the phenotype (broad sense), and the trait transferred to the next generation (narrow sense) (Bänziger and Cooper, 2001). The expression of a trait with high heritability, such as grain colour, is not strongly influenced by environment, and tends to be controlled by a small number of genes. Traits such as yield tend to have low heritability (i.e. strongly influenced by environment). If yield has poor heritability, a directional selection for yield will not necessarily lead to greater yield potential the following season, as the highest-yielding individual plants selected as seed parents would reflect mostly environmental factors.

Adapting the approach of Soleri and Cleveland (2001), contact farmers were presented with two scenarios, using the panicles they selected in the above simulation exercise. In the first scenario, they were asked if the progeny of their selections would all have the same height and panicle size if planted on their own fields. The great majority expected that their sorghum plots would still vary in height and panicle size, due to variation in soil conditions, topography, or management (Table 6.10). The second scenario asked them to imagine planting their selections on an absolutely uniform field, flat, with uniform, optimal management. In this situation, nearly two thirds of farmers expected variations. As with the selection simulation, these findings are very preliminary; the phrasing of the scenarios was not tested to the same extent as Soleri and colleagues have done, nor were more highly heritable traits included. Nevertheless, results suggest that farmers perceive variation in environment or management as having a large influence on total variation.

Table 6.10 From discussions of scenarios with contact farmers, the number who expected that the offspring of their selections would have equal height or panicle size when planted in their own field, or in a hypothetical uniform field.

Location	n	Plant height		Panicle size	
		Own field	Uniform field	Own field	Uniform field
Chiro	11	3 (27%)	7 (64%)	3 (27%)	7 (64%)
Miesso	8	1 (12%)	5 (62%)	0 (0%)	5 (62%)

This limited, preliminary evidence suggests little correlation between expectations of heritability, and selection practices. Several individual farmers expected progeny to vary regardless of environmental conditions, which might be taken to suggest some understanding of innate (i.e. genetic) variation.[114] At the same time, there were no discernable trends in selection practices among the members of this group; some had consistently high selection differentials in the simulation indicating directional selection, while others had low or negative selection differentials. Selection practice may thus have only a tenuous link to farmers' knowledge of heritability, and in all likelihood, would have little directional impact on outcomes. Farmers select, but apparently not on the basis of any 'pre-theoretical' intuitions concerning heritability.

6.6.3 Environmental scale

The extent to which farmers recognise and co-manage environmental (V_E) and genetic variation (V_G) in their crops is a key aspect of their management of diversity at the variety level. Farmer exploitation of genotype-by-environment (GxE) interactions is of considerable interest to breeding reform, with implications for farmer-breeder collaboration, and for decentralisation (Almekinders and Elings, 2001).

Farmers associate specific environments with particular varieties they consider perform best in those conditions, identified by soil, rainfall, topography, or temperature. While the scale of associations is much smaller than ESIP, which defines three sorghum environments for all of Ethiopia, it is generally not at the level of individual fields. Rather, farmers link varieties and environments at an intermediate scale (a few hundred metres in the highland mountains, a few km in the lowland plains). For instance, in Melkaa Horaa FA in Miesso, farmers speak of FVs that are most suited to the small hills at the base of the Chercher mountains, which have sandy soils, 5 km away, or to the slightly wetter microclimate of Assebot, 15 km away from Miesso. In Funyaandiimo FA in the highlands, the distinctions were between FVs best for the wet, clay soils of the valley bottom, for the better-drained hillsides, or for the exposed hill tops, 300m above the valley bottom. Though farmers noted spatial environmental variation within their fields, I saw no evidence that they address this variation by planting different varieties in specific locations; they tend simply to mix varieties within a field. High V_E within a field, irregular patterns of variation in V_E, and low heritabilities of desired traits could all limit their opportunities to exploit GxE interactions at the scale of individual fields (Soleri *et al.*, 2000). However farmers clearly recognise GxE interactions between FVs and different environments in the immediate area, defined mainly by soil and elevation.

[114] One farmer, when asked if uniform fields would produce uniform offspring initially said yes, then, upon reflection, said no, stating "If two babies are born into a rich family, one may grow fat, but the other not. So I think there is more than just good conditions." Interview with NME, January 1999.

6.6.4 Distinctions in seed lots between farmers

The survey asked farmers if they thought that some farmers could have 'better seed' than others who had the same FV. Roughly two thirds thought that 'better seed' could exist. Some of the reasons cited included careful and attentive selection, 'at the proper time', considering the entire plant. Others mentioned that farmers with 'better seed' selected for uniform colour, or for material free of diseases. A number of respondents emphasised the importance of careful storage for better seed. These statements highlight seed physical quality (e.g. from good storage) as well as genetic quality (from selection). However, only a few of those recognising differences between seed lots suggested that this might be due to intrinsic (i.e. genetic) differences, rather than differences in management.

Over a third of those surveyed disagreed that other farmers might have 'better seed'. Many claimed that they had never heard of such a notion, while a couple exclaimed 'we don't say such things!' This shocked reaction to any suggestion of someone's superiority was in itself interesting, though I could not follow it up in the survey. One insisted that performance was due only to soil type. A few stated that the seed would be similar among farmers because their storage practices were the same. Interestingly, a few lowland farmers mentioned frequent seed exchange, specifically implying that this blurred differences among farmers' seed lots: 'we all give to each other, so nobody's seed is different.' In theory, even small levels of gene flow between populations, from seed exchange or pollen flow, can blur distinctions between populations (Dobzhansky *et al.*, 1977). Louette (1994), quantifying the movement of maize seed between different farmer seed lots in Mexico, came to a similar conclusion.

In summary, farmer genetic resource management is a series of interlocking processes, from introduction and exchange, to field arrangements and selection, all of which shape how diversity moves, and is selected and used. A complex naming system helps farmers manage their extensive diversity, with names reflecting FV origins, but also occasionally leading to further mixing of specific types, as naming practices differ among farmers. Some farmers select out sub-types they consider to be superior, denoting these with specific tertiary names, not always recognised by their neighbours. The introduction, evaluation, and spread of novel diversity are important aspects of this management, shaped by the conscious practice of individuals, and the social relationships in seed exchange. Processes of introduction are a key part of farmers' innovation in sorghum. Also important are farmer practices to maintain seed quality, both in terms of physical health and genetic quality, through controlling off-types, seed selection, and storage. The question for breeding reform is, how could support from the formal sector help strengthen this system of genetic resource management, to the benefit of farmers? The concluding section explores this question.

6.7 Entry points for support from the formal system

Much of the farmer participatory activity in breeding reform has concentrated on seed selection. This reflects the main interests of breeders, and, as mentioned, better targeting of seed selection to farmer criteria has been seen as the most fruitful area of intervention to improve the effectiveness of formal breeding. In this light, the focus on selection is unsurprising. Also, the more populist interventions that seek to enhance farmers' own skills and improve the overall sustainability of their seed systems have also tended to be interested in improving farmer seed selection practices (e.g. Cleveland and Soleri, 2002a; Louette and Smale, 2000). However, the above analysis highlights other processes in farmer genetic resource management, such as introduction, seed exchange and storage, which may be more important in the functioning of the farmer seed system. Interventions around seed selection may in fact have little scope for assisting farmers in coping with environmental variability, and efforts here may contribute little to their welfare. In comparison, efforts that help farmers to maintain seed in storage, enhance seed physical quality, and access novel germplasm, may actually be more beneficial and cost-effective.

Moreover, breeding reform interventions – whether to improve breeders' selection practices or enhance farmers' skills – have tended to favour collaborations with a small number of individual farmers. Such farmers are usually not chosen at random, but on the basis of their exceptional interest and/or skill in seed selection (e.g. Sthapit *et al.*, 1996). Some projects collaborate with a small group of farmers to identify (or develop) 'best practice', in the hope collaborating farmers will pass on these skills to neighbours (e.g. Bueso, 1994; Berg, 1996a). However, there are some concerns about this approach. Firstly, it was shown above that many farmers are far less familiar with local diversity, and spend less time on seed selection, than the local expert farmers. In particular, the poorest and most vulnerable households tend to face labour constraints, or allocate labour to off-farm activities in the mid-season, and thus are less able to observe crop performance as the season progresses. Secondly, while local 'best practice' in seed selection may produce better results (e.g. for directional selection, or identifying and maintaining new traits), more study is needed to confirm how, and under what circumstances they offer improvements, and how accessible 'best practice' might be for other farmers. Thirdly, emphasising intentional practices and knowledge of individual farmers around seed selection in any interactions with breeders might miss (unintentional) aspects of practice or social interaction that have a greater aggregate impact on genetic resource management, whether negatively or to the benefit of farmers. For instance, in highly seed insecure areas, seed exchange may be more important to the effective functioning of farmer seed systems than seed selection (since seed lots on farm are often lost) (see Rice *et al.*, 1998 for an example with maize). Likewise, in difficult circumstances, 'unplanned' introduction may be crucially important as a channel for introducing useful new diversity. Fourthly, seed exchange, as a crucial aspect of the spread of new varieties, is affected by the state of social relationships between farmers (possibly, the spread of knowledge is also affected by this factor). Communities divided by, for example, a bitter land dispute may suspend neighbourly seed exchanges. Conflict resolution might do as much to restore useful gene flow as participatory breeding! For interventions to support farmers' knowledge and practice, it is essential to understand local practices and innovations in a broad social and ecological context, including gift exchange and barriers arising from conflict.

With these issues in mind, I explore possible immediate and mid-term courses of action in Ethiopia to support and enhance activities farmers are already doing. Seed selection, the maintenance of seed quality and health, and the introduction of novel germplasm will be addressed in turn. For each broad activity, I consider evidence concerning benefits from existing practices, and for improvement, including promoting the 'best practice' of some farmers to others, and possibilities for fostering an ethos of cooperative experimentation among farmers. The section closes with an examination of some cross-cutting social issues.

6.7.1 Improving practice affecting seed genetic quality

Existing practices

To what extent might farmer seed selection lead to improvements in the genetic quality of sorghum, so that varieties are better adapted to farmers' conditions and provide the functional attributes they desire? In terms of directional selection – the improvement of traits such as yield – farmer selection would not be expected to make much impact in most cases, as a number of factors moderate any changes to genotype. Under farmers' conditions, environmental variability (V_E) is very high, both over space and time. Selection based on phenotypic variability (V_P) for poorly-heritable traits would be expected to have little directional impact under these conditions – a standard argument for selection under controlled or multiple environments (Atlin, 1997; Atlin *et al.*, 2001). Thus, on-farm GxE interactions limit the impact of farmer selection.

Furthermore, selection intensity is not always very high, particularly in the lowlands where farmers may set aside over 20% of their harvest as seed for the next generation (Table 5.1). Also, since most select after the crop has been harvested, and panicles have been removed from the stalks, there is limited opportunity to select, based on traits visible in other parts of the plant, or at other stages of crop development. Thirdly, selection simulation has suggested that specific approaches vary among farmers, with some having high selection differentials, and others low or even negative differentials. With high levels of gene-flow between farms, the highly directional selection practiced by some farmers seems liable to be cancelled out by the practices of others.

Conscious seed selection at harvest is just one of several processes shaping sorghum genetic population structure. Natural selection, and less conscious selection activities, are also significant. During thinning and weeding, farmers eliminate seedlings with poor germination, infertility, or other signs of stress, and reduce plant populations by as much as 80% from sowing (Table 2.7).

However, all natural and artificial processes of selection are also affected by the likelihood of high rates of gene-flow within and among variety populations. Selection, whether natural or artificial, directional or stochastic, should be seen as only one of several forces at work. Novel diversity is introduced though multiple channels, both planned and unplanned, seed exchange is frequent and occasionally voluminous, and farmer preference for synchrony of flowering increases chances of cross-pollination. Some farmers may also lump different varieties together, managing – and selecting – them as one. All these processes contribute to gene-flow, which is probably the most significant force shaping crop population structure and diversity, as genetic studies suggest (Ayana *et al.*, 2000; Djè *et al.*, 1999). Farmers' conscious seed selection at the end of the season may have only a minor directional impact in the context of such gene-flow, particularly if heritability is low. In this context, it seems hardly surprising farmers place little stock on selection as such, and ascribe much variation to environment (Table 6.10).

Best practice

Nevertheless, there are some exceptional farmers who do carefully select seed, can describe the process and their reasoning behind it, and claim some degree of success in and benefits from improving traits or maintaining desired characteristics. They are proud of the care they take, and some are widely recognised for their ability to choose good seed and identify new types. Gene-flow and GxE interactions still challenge their impact, but their efforts appear to have some impact for highly-heritable traits such as early-maturity. For instance, I encountered two farmers in Miesso, SS and AAS, who undertake repeated single-panicle selections for the earliest-maturing FVs in their fields, and claim to have achieved faster-maturing FVs. This may be possible in photo-sensitive sorghum FVs that have introgressed fast-maturing traits from MVs, for instance. However, their selections turned out to have other undesirable traits, and were eventually abandoned. Farmer selection may also be effective in maintaining desired traits in 'pure' varieties (e.g. '*ye duro*'). Such 'purity' can add value to a variety (e.g. as in pure colour seed in teff; Kugbei and Fikru, 1997). Maintenance selection appears to be common in farmer practice, and fits well with local understandings of gene-flow. These activities certainly merit more investigation, though the benefits of this effort in terms of yield or other characters should also be established.

Even if the seed selected by the most skilled farmers has genetic advantages, the materials must still be disseminated to other farmers to spread the benefits. This largely depends on the social relationships between expert selectors and the rest of the population. While the examples here, and elsewhere in Ethiopia, suggest that expert selectors are generally happy to disseminate their seed to their neighbours, since this accords prestige for being seen to help the community,[115] some people may be shut out of seed exchange or access to novel varieties, as discussed in section 5.3. The materials also need to be maintained to some degree, or the supply refreshed, to keep these advantages over time.

A more difficult issue is 'visibility' of any genetic improvements; farmers need to recognise (and be able to reap) any benefits conferred by material selected under 'best practice'. Yet about a third of farmers in this sample do not believe other farmers might have 'better seed'. When farmers have poor access to information about improved varieties (FVs or MVs) few are able to take advantage of these varieties (Tripp, 2001). This is especially true if advantages are not immediately apparent (as with disease-resistance), or are only observed in certain environments. The issue of visibility of better germplasm, or of novel germplasm, is discussed further below.

Building an ethos of experimentation

A popular area for supporting farmer genetic resource management is through promoting more general skills-development in crop genetic improvement, particularly for maize (Gómez *et al.*, 1995). There is growing interest in developing approaches to help farmers learn critical and empirically-based approaches to management (Leeuwis and Pyburn, 2002; Loevinsohn *et al.*, 2002), such as the Farmer Field Schools developed for Integrated Pest Management (van de Fliert *et al.*, 1995; A. R. Braun *et al.*, 2000), or integrated nutrient management (Defoer, 2002; Wortmann and Ssali, 2001; Hagmann and Chuma, 2002). The content of such skills-development in breeding might include simple but improved selection methods, such as whole plant selection (Rice *et al.*, 1998), or methods to correct for environmental variation, such as stratified or 'grid' selection: (e.g. Roupakias *et al.*, 1997; Bletsos and Goulas, 1999). The latter approach has been promoted by an NGO, AS-PTA, with farmers in Brazil (Cordeiro and Mello, 1994).

While there may be potential to improve practice across a wide group of farmers, we need to question why most select their seed post-harvest. Most farmers in West Harerghe do not appear to work with a theory of innate (i.e. genetic) change within their sorghum varieties, but rather view most variation as a result of different varieties, or of variations in environment and management. However, discussing inheritance with farmers may not be enough. Given the high levels of gene-flow and environmental variation, it may often not be possible to achieve improvements that offer economically-recoverable yield gains to repay the extra labour involved. For instance, an on-farm selection programme with beans in East Africa improved seed quality and disease-resistance, but achieved only a 14% yield gain, which may not repay the considerable extra labour involved (Sperling *et al.*, 1996). The

[115] For example, one particularly knowledgeable and motivated farmer in the Nazret area, Ato Sissay, is renowned for his collecting activities and his pure selections of teff seed, which have higher market value. He happily shares these with his neighbours, and with researchers at the Nazret station (C. Farley, *pers. comm.*, 1998).

opportunity costs for additional labour in the fields are high, particularly for those pursuing income-generating activities off-farm. A recent study in the region (Adenew, 2001) found that similar considerations of limited labour availability and returns to effort hindered farmer investment in soil conservation structures. Thus, while farmer seed selection under local conditions could theoretically achieve improvements with qualitative traits (those affected by one or a few genes) in a few cycles, the potential to improve quantitative traits with more complex inheritances and strong environmental influence, such as yield, seems low under these conditions. Improving yield in variable environments may require multi-location trials and appropriate statistical analysis, to address this environmental variation; formal sector breeders could play an important role here, in collaboration with farmers managing on-farm trial plots in multiple locations (Atlin, 1997; Almekinders and Elings, 2001). Thus, formal selection could conceivably address such challenges over time, but doing so has significant implications for how formal breeding is organised, as discussed in the final chapter. There may be some benefit, however, in improving local skills in maintenance selection, provided that this offers clear benefits – for instance, where a more uniform-coloured teff variety fetches a premium price (Kugbei and Fikru, 1997). Added value is not so readily apparent in sorghum.

Remaining questions

Many questions remain about farmer agency in shaping the genetic identities of sorghum varieties in Ethiopia, particularly about the role of selection in this. Given the unlikelihood of strong directional impacts of farmer selection for many traits, why do some farmers put so much effort in it? When Soleri posed the same question to Mexican farmers, they replied that they feared if they did not carefully select seed, yields might steadily decline (*pers. comm.,* 1999). Farmer selection (as well as natural selection) is probably important in maintaining key morphological characteristics and functional attributes associated with a variety, when gene-flow and hybridisation might otherwise blur variety identities (c.f. Louette, 1994; Seboka and van Hintum, forthcoming; Seboka *et al.*, forthcoming). However, this needs further study for sorghum. Maintaining morphological traits may also have moral significance in these communities emphasising concepts of maintaining links with ancestors.

Selection is only one aspect of gene-flow, which farmers influence through both individual and collective practices. Beyond the introduction of novel varieties, high levels of gene-flow may also help maintain genetic diversity within variety populations, which may help these populations to adapt to variable biotic and abiotic stresses. Long-term studies of crop populations containing high genetic diversity show continual adaptation to variable stresses such as diseases, where there is no artificial selection (Ibrahim and Barrett, 2001; Goldringer *et al.*, 2001; Allard, 1990). Could farmer genetic resource management maintain the adaptability of FVs? To explore this, we need to examine more closely how farmer management influences genetic diversity, and over time may affect adaptation. One approach would be to compare MVs under farmer management for many seasons with Certified Seed of the same MVs, whose genotypes should be the same as when originally supplied to the farmers.[116] Another approach would be to compare FVs collected in the past and stored under static genebank conditions with the same FVs as managed on-farm. Tin *et al.* (2001) did such a test with rice FVs in Vietnam, finding considerable change in some traits over 11 years, which they associated with dramatic changes in the farming. However, very little, in general, is known about the biological outcomes of farmer genetic resource management, the most important actors or processes involved, or the implications for genetic diversity and

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[116] I had collected several varieties that farmers claimed were MVs to do such a trial, but the drought in 1999-2000 prevented it from happening.

adaptation. Recent interdisciplinary work on on-farm management (IPGRI, 1996; Jarvis and Hodgkin, 2000), has only started to shed light on these issues.[117]

Thus, attempts to improve farmer seed selection appear to be bound by the influences of gene-flow and GxE interactions on one hand, and on the other hand by relations between 'specialised selectors' and the rest of society. Improving farmer seed selection may not repay the effort, except perhaps in maintenance selection, and other possibilities should be explored first. Two such possibilities, improved seed quality, and variety dissemination, are discussed below.

6.7.2 Improving practice affecting seed physical quality and health

Existing practices

Seed physical and phytosanitary quality affects performance as much as genetic quality. When asked about 'good seed', most farmers surveyed spoke exclusively in physical or health terms, referring to storage conditions, freedom from disease, and the germination ability of seed. Their awareness of this reflects the immediacy and obviousness of poor physical quality of seed. In seed selection, farmers avoid obviously diseased grains, and tend to select larger grains, two factors that can help increase germination. Most are aware that the humid conditions in grain storage pits (*gurguads*) harms germination. Consequently, seed is usually stored separately, and kept dry. The most common storage methods involve hanging panicles from the roof, over the cooking fire, or in sacks (Table 6.11). Other locations include clay pots (*gotera*), and a few store seed in *gurguads*. In addition to moisture, seed predation from weevils or other insects is also a problem, as reported by the majority of farmers surveyed. If the seed is not being hung over the fire (where smoke affords some protection) farmers often treat seed in storage sacks or pots, commonly using salt, sorghum glumes, dust, or 'DDT', though the latter two may afford little protection, especially if the chemical has expired or the dosage is insufficient. Several farmers reported severe losses from insect predation, even a few using 'DDT', and some farmers lost their seed entirely. In general, the causality of crop diseases is not known to farmers (Trutmann *et al.*, 1996). This is also the case with West Harerghe farmers and sorghum (ICRA, 1996), and none were aware that some smuts are seed-borne.

Table 6.11 Sorghum seed storage locations and treatment practices, as reported by farmers in the survey in West Harerghe in 1998, with percentage of farmers responses (* individual farmers may use more than one strategy, so totals add up to more than 100%; †: DDT is a generic local term for insecticide, and can include a variety of chemicals).

		Survey location	
		Chiro (n=53)	**Miesso (n=41)**
Storage location	Hanging from roof	71.7 *	9.8
	Sack	35.9	61.0
	Clay pot (*gotera*)	7.6	12.2
	Storage pit (*gurguad*)	1.9	--
Storage treatment	None	69.8	22.0
	'DDT' †	20.8	61.0
	Dust or glumes	7.5	26.9
	Salt	1.9	9.8

[117] Edwin Nuijten's PhD research in the Gambia, on farmer management of gene-flow in rice and pearl millet, promises to be an important contribution here.

Best practice

As with seed selection, a small proportion of farmers have elaborated detailed and careful practices for maintaining seed physical quality. Some check periodically during the storage period for damage, adjusting treatments if necessary, such as an additional spray with chemicals. A few farmers store seed in multiple locations, as a 'belt and braces' approach in case seed in one storage location is damaged. Some farmer treatments (e.g. salt) may be more effective than others at preventing insect attack, though there appears to be little study comparing the different local storage practices or treatments used. Some farmers claim there is little difference among the different treatment and storage methods practised. Most cannot afford storage materials other than the salt, feed bags, and clay pots currently in use.

Disease control is another important aspect of maintaining seed quality. Covered smut (*Sporisorium sorghi*) is entirely seed-borne, and loose smut (*S. cruentum*) partly so. In northern Ethiopia I have met sorghum farmers who tried to limit contamination by carefully removing any plants infected with smut, and disposing of them far away, though I have no evidence that West Harerghe farmers practiced this. However, covered smut can produce spores when the plant is still healthy, so manual removal of affected individuals is not completely effective. Recent research at EARO has found that soaking seeds briefly in animal urine prior to storage is effective in killing spores of covered smut. Ironically, this treatment was already familiar to at least some Ethiopian farmers. When the researchers who had developed the urine soaking treatment presented their findings to an EARO National Research Review meeting in 1998, one participant informed them that Wollo farmers had practiced the very same treatment in the past (Girma T., *pers. comm.*, 1998). The researchers had apparently made an independent discovery, but this episode highlights another point. There is scope for finding, verifying, and disseminating many other equally useful innovations, but researchers need to consider and study farmer practices more seriously, rather than treat them anecdotally.[118]

It appeared that not all farmers were aware of what would be 'best local practice' in seed storage. Practices involving purchased inputs, like DDT, are not accessible to every farmer. Though practices common to most farmers, such as hanging seed over the fire, may maintain reasonable quality for the few months required, avoiding attacks by insects or rodents, and limiting disease and spoilage demand more care and attention than many farmers give. However, some treatments, such as urine-soaking, are widely accessible. Another low cost treatment, soaking seed in water for a few hours the day before sowing ('on-farm seed priming'), can enable faster and more even germination, and increase yields (Harris, 1996; Harris *et al.*, 2001a; Harris *et al.*, 2001b). In one sense, seed priming also serves to maintain seed physical quality, like other treatments mentioned above, yet it also has the potential to reduce farmers' risk of poor seedling emergence under variable and uncertain moisture conditions.

Building an ethos of experimentation

The link between different storage methods and their impact remains unclear, and there may be value in encouraging farmers to compare them, using institutions to organise trials and share information. The example of AAA (the farmer who tested every neighbour's seed for germination quality in 1998) shows that farmers can organise and test the germination

[118] In November 1998, this treatment was demonstrated to farmers in Miesso, as a media and public-relations event for EARO, with local dignitaries and national television invited.

potential of different seed lots. However, institutions, whether formal or informal, could help better co-ordinate such inquiries, and share information, as for the moment this experimentation rests on the initiative of motivated individuals like AAA.[119] Structured 'local certification' activities would help encourage farmers to explore the links between practice and seed physical quality. Since women are often in charge of storage within the household, knowledge and practice may be gender-specific here, so support to experimentation needs to be gender sensitive.

Remaining questions

Miesso farmers claim that the poor storage ability of MV seed is one reason they do not save MV seed for the following season, just in case they need to plant fast-maturing seed (Kefyalew *et al.*, 1996). This claim merits investigation, as it may constitute a major barrier to adoption. It would be useful to do a more detailed ranking of the different causes of seed loss, and loss of seed quality under farmer storage. More study is needed of farmer storage and treatment practices to identify the effectiveness of various practices, and where there may be scope for improvement. For instance, a more thorough investigation of the impact of different practices on seed moisture levels, and of the efficiency of anti-insect treatments is needed. Even if seed germinates well, it still needs to emerge through soils that are frequently difficult (variable moisture, low organic-matter content, surface crusting). The ability of different varieties to emerge under farmers' conditions deserves much more study, as on-station tests with shallow planting may not be representative. The same applies to farmer strategies to address poor emergence, including higher seeding rates, and selection of larger seeds.

6.7.3 Introduction of novel germplasm

Existing practice

Introducing novel germplasm is a key process in farmer plant genetic resource management, with clear potential benefits to farmers. Though many FVs and MVs were found in the two FAs studied, these reflect only a small proportion of the diversity in Ethiopia. The evidence on genetic diversity (Ayana *et al.*, 2000) suggests that a considerable amount can be found at the local level in Ethiopia, though the patchy distribution of varieties suggests much is encompassed by only a few farmers in a given area. Farmers' continuing interest in trying new varieties suggests the potential value of exposing them to novel germplasm, both FV and MV. But the distribution of varieties and *ad hoc* nature of introduction also suggests scope for more systematically exploring – and disseminating – diversity found in the immediate region. It makes sense thoroughly to explore the diversity already available, as farmers face significant transaction costs in searching for and screening useful new diversity (see Bellon, 2004). As some argue, in regard to breeding reforms, the available diversity should first be assessed, before embarking on a more elaborate breeding programme with crosses and selection (Witcombe *et al.*, 1996). As collection and taxonomy trials showed, farmers are often unaware of what varieties their neighbours have, or of the varieties available in other areas.

Most farmers encounter new varieties mainly through small gifts from family and neighbours, and occasionally from the market. Material new to the farmer sometimes also appears in their field as a result of contamination or hybridisation in the seed source. Farmers

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[119] AAA found that AM's seed germinated better than any others, as had managed to harvest early, before late rains could damage his crop. If Miesso farmers had organised similarly, they may have ended up taking seed from MAS, who, upon noticing the rain, collected his seed fast and dried it over the fire.

handle this novelty in a variety of ways, with some sowing a new variety in one place for better observation. Farmers generally make a conscious decision about whether to retain a new variety, or to exclude unfamiliar seed as an off-type. The rate of introduction to a given farm is driven to some extent by chance, but also by wealth, location, and other opportunities exposing farmers to new material. Social networks, ecology, and knowledge shape subsequent dissemination. In some cases, the names used for varieties are very local, particularly for sub-types. This makes it potentially more difficult for others to seek out a particular variety (and especially a particular sub-type) by name. The lack of regional consensus about variety names, as well as information gaps about variety performance, and the occasional arrival of material unfamiliar to everyone, means introduction still poses risks to farmers if a variety is not well-known. Sowing material with the wrong season length, or poor local adaptation makes farmers cautious about future novel materials.

Significant introduction channels

Some farmers are especially active in seeking out new types, and are more aware than others of locations in which to find material appropriate to their local conditions, and of 'core areas' where high quality materials for a given FV can be obtained. Such knowledge usually reflects an individual's travel or family contacts, and is particularly important in the Miesso-Assebot Plain, as there is no other lowland area growing sorghum in the vicinity. This knowledge, and the ability to obtain and multiply materials, resides mainly with wealthier and older farmers. However, introductions tend to be *ad hoc*; very few have the interest or capacity to systematically collect materials, and evaluate or disseminate them widely for others to use. While the MP in the highlands has been able to do this, and presumably has an interest in assisting constituents, he is an exception, and farmers say that most systematic efforts at variety screening and introduction stopped after the Revolution, when wealthy rural groups were eliminated.

Organised introduction: collective activities

One immediate possibility for collective action could be to improve the 'visibility' of varieties in the vicinity. Though farmers learn about varieties others possess through social interactions, they are generally unaware of the range of varieties in their area, or where they could find a given variety. Variations in naming systems can confound access, as new materials may change names from one community (or individual) to the next. But also the layout and physical location of farms limit awareness of what is locally present, since it is difficult immediately to appreciate a handful of individual plants of one variety when scattered through a field of other varieties, especially if this field is part of a continuous plain of different fields, or is remotely located.

Introduction, screening and dissemination of diversity could be more systematic and organised, with potentially significant benefits for farmers. Walking tours near harvest time might be one useful and cost-effective way to increase awareness of locally available diversity. Perhaps better still, community seed fairs seem an efficient and effective way to raise local awareness of diversity and encourage its exchange. Fairs could be organised on a more regional scale, and offer prizes or incentives for those with the most diversity (thus garnering popular interest and perhaps media exposure). They also provide an excellent opportunity for to raise awareness within formal research and extension institutions about locally available diversity. However, the multiplication and distribution of sufficient seed remains a challenge.

Organised collection and evaluation of materials (FV or MV) by community-based institutions, with assessment under different conditions, and multiplication by those interested, involves another level of organisation and co-ordination. However, in at least two communities where I distributed small packets of pre-release MV seed in 1998, community-level mobilization did occur to some degree. With no formal involvement, farmers compared performance in their fields for the different varieties I distributed, and decided themselves which variety they should multiply and distribute in their communities. Local mutual-aid institutions, such as *gosa*, could play a role in such initiatives, such has occurred elsewhere in Ethiopia with seed security work (Pratten, 1997). However, this depends upon a degree of organisational capacity and social solidarity in communities, and a sense that the effort will repay farmers' efforts. In other cases where communities have collected and evaluated germplasm, external organisational and financial support has usually been required.[120]

The degree of fit between newly-supplied materials and individual environments and livelihoods remains an issue; both can vary considerably in a small area, so what one farmer has may not necessarily be useful to her or his neighbour. Changing individual strategies through the season can complicate the picture further, for example when farmers (highland or lowland) seek fast-maturing varieties for late planting after an earlier crop has failed. Thus in searching for germplasm, farmers make use of more than the three environmental categories used by ESIP, and individuals also cross these categories, with highland farmers occasionally searching for lowland material. Finally, increasing land-use intensity, soil degradation and possible climate change are affecting growing conditions for sorghum, with varieties popular in the recent past, such as the lowland FV '*Gadineki*', now no longer appropriate, or even absent (ICRA, 1996). To meet such diverse and changing on-farm conditions, careful attention needs to be given to the provenance of introduced materials.

Remaining questions

How important are dynamic flows of diversity in maintaining the functioning or sustainability of farmers' seed systems? In other words, how important is the introduction of new varieties into a region, and variety turnover at the farm level, in maintaining the system's resilience and ability to adapt to new demands? Farming systems are changing; Seboka and van Hintum (forthcoming) note that a third of the sorghum FVs found in northern Ethiopia have been introduced in the past 20 years, partly in response to recurring drought and land degradation. Which processes and individuals are most important in maintaining rates of turnover, and driving innovation? Significant patrons, such as landlords, are largely no longer available as major channels of new varieties. However, the above evidence suggests that infrequent, even one-off introductions, still contribute to the diversity available locally, though onward dissemination is equally important. Different channels for bringing novel diversity onto a farm should be assessed in terms of their relative contributions to local-level gene-flow and innovation, but also on the opportunities and risks they bring farmers. For instance, markets occasionally introduce novel material with distant provenance, but farmers cannot observe performance under local conditions before purchase. Much more needs to be known about local markets as a potential channel of diversity, particularly the ways in which

[120] In SAVE, a CARE-supported project in Sierra Leone, farmer clubs were organised to screen novel crops and varieties (George *et al.*, 1992). CIAT organises CIALs (Community Committees for Agricultural Investigation) for this in Latin America, but considers that the costs of experimentation are a barrier to farmers' organising on this, and provides a small amount of money to defray costs (J.A. Ashby *et al.*, 1995; J.A. Ashby *et al.*, 1996). An exception is the *Beej Bachao Andolan* (Save the Seeds Movement) in Uttar Pradesh, northern India, which collects varieties over a wide area, stores, screens, and distributes them, all with little to no external support. However, this case depends greatly on the energy and connections of politically-active individuals, with the main catalyst being Vijay Jadhari, a long-time activist with the *Chipko* movement in India (A. Kothari, 1997, *pers. comm.*, 1997; L. Sperling, *pers. comm.*, 1997).

merchants assess market needs and choose varieties to supply, and their means for assessing environmental adaptation and variety provenance. Training seed merchants may be as important an area for institutional innovation as training farmers to contribute to selection or breeding. The highlands of Harerghe cover a large area, but are separated from other highland sorghum regions by the Rift Valley, while the Miesso-Assebot Plain in the lowlands is also somewhat isolated from other lowland sorghum growing regions, so finding material from other regions adapted to these areas presents some challenges. The impact of the Draft Seed Law on local traders remains uncertain, but requirements for formal certification and registration as traders may push the smaller operators out of the market, with unknown implications for the introduction of novel diversity. Finally, methods should be developed to estimate the value to farmers of finding and assessing new germplasm, in relation to the effort and costs of doing this. There are existing models for assigning value to germplasm on the basis of functional attributes that farmers appreciate (e.g. Smale *et al.*, 1999; Morris, 2002; Heisey *et al.*, 2002). These could be adapted to assess the value to farmers of their diversity.

6.7.4 Cross-cutting social issues

Just as seed exchange demonstrates that seed systems are social systems, social factors are threaded through other aspects of plant genetic resource management. Farmers who have more detailed selection strategies, know about better variety sources, or have more detailed variety taxonomies, are not scattered randomly through communities. An individual's experience, available time and labour, exposure to other locations, and thus to some degree, wealth, all matter in giving some individuals more opportunity than others to innovate with germplasm (though differences between farmers are not solely structural). Repeated stress may make the system less resilient, both in terms of the amount of seed available for exchange to those in need, as well as the levels of diversity available. As the last chapter argued, relationships between farmers are important in seed exchange more generally, and the transfer of material and information is fundamentally bound up in social interactions.

Innovation and social relationships

Much farmer experimentation is effectively adaptive, where an individual tries a new technology in an existing context, or makes small changes to an existing practice (Sumberg and Okali, 1997). Trying a new variety, or a different seed storage treatment, are good examples of this type of innovation. Most extension efforts have focused on spreading successful innovations from individual to individual, either through promoting a specific best practice (Rogers, 1962), or by encouraging an ethos of experimentation.

However, the nature of the seed system and its key processes is not solely based on individual actions, nor exclusively defined by actions that farmers consciously undertake on the basis of their indigenous technical knowledge. As this account shows, a range of processes beyond the scale of individual households shape genetic resources, and reflect a wider set of practices rather than discrete, planned management interventions. For instance, gene-flow occurs through seed exchange, planting arrangements, the presence of wild and weedy relatives, and flowering synchrony, and is mediated by farmer selection for trueness-to-type. Seed selection may occur at several stages, and may be the product of individual choices before harvest, or come only after a work-team of harvesters has cleared the field. This has important implications for interventions seeking to improve the functioning of the seed system, to enhance resilience or sustainability. How relevant is it to foster innovation as a separate activity (e.g. for selecting for specific traits), if other practices have a much greater influence on outcomes, such as seed quality or diversity? Important processes, such as the introduction of diversity, derive from social interactions between different individuals in the system. These interactions, and the social values that underpin them, need to be better understood.

One way to make some of these interactions more transparent is to promote collective activities or institutions to share genetic resource management approaches, as well as germplasm. Approaches such as seed fairs, or collective screening of the germination ability arising from different storage methods could make materials, knowledge, and practices more 'visible'. This may help farmers to identify useful material they otherwise could not hunt down, and judge for themselves which approaches work best (e.g. for seed storage). However, any discussion of collective activities in Ethiopia is challenged by the present limited scope of most informal institutions. This is partly due to the antipathy of formal state institutions towards self-help groups operating outside traditional or religious realms. Moreover, self-help work in general is constrained by limited labour-availability, by chronic stress to livelihoods, and by the legacy of food-for-work programmes, where labour for public goods such as anti-erosion structures or water tanks is typically supported with payments-in-kind (Hoben, 1995).[121]

The *Dergue* regime was hostile to independent civil society, and most local institutions were eliminated or subsumed into the state (Donham, 1999). Village-level groups organised by the state, such as Youth or Women's Associations, were generally used for monitoring and control, and farmers remain understandably wary about organised group activities. Though local administrations have more legitimacy now than in the *Dergue* era, their functions are still largely administrative, and bound up in local disputes over land and resource rights. However, even if collective activities could be initiated and sustained, they may reflect mainly the interests and perspectives of the handful of farmers identified as 'innovative', who are generally prominent individuals. The particular production practices of these farmers, or their normative concepts of 'good' and 'bad' farmers, may be promoted. For instance, an initiative of 'best selectors' to promote careful seed selection might imply that farmers who identify and mark individual plants for selection before the harvest are 'lazy', even if the poorest farmers are often constrained by lack of labour. Both local administrations and formal researchers tend to have weaker links with the poorest farmers, increasing the risk that these farmers may benefit little from any efforts to support farmer innovation in the seed system. Thus, there remain questions of how the poor could benefit from any collective activities to strengthen plant genetic resource management.

Other issues

Cultural views associated with plant genetic resource management bear consideration. Despite changing varietal demographics at household and regional levels, farmers value constancy and links to ancestors when discussing genetic resources. Farmers speak with pride if they have maintained their seed stock since receiving it from their parents (even if occasional topping-up of seed stocks and gene-flow mean that the seed lot may be very different genetically from the one they received). This complicates investigation, as some are hesitant to admit to needing off-farm seed, but it also points to the value farmers attach to seed security, and to germplasm that they know. The idea of a continuous link seems important: one farmer who lost his '*Masugi*' seed stock after many years declared "Now our link with *Masugi* is broken!". Another farmer, who gave me panicles of three unusual

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[121] In Funyaandiimo, farmers displayed little sense of ownership over anti-erosion structures they built with food-for-work support, but treated it as contract labour. This lack of ownership is seen more generally in such schemes, where farmers sometimes expect continued payments for maintaining conservation structures (Hoben, 1996).

varieties made sure that he first pinched seed from each, and scattered these on the ground (libation), to ensure that the variety continued on his farm the next year. This desire to maintain ancestral links to land and nature may make farmers hesitant completely to replace the seed stock of one variety with another, even if the seed of the first variety remains locally available.

The unease that some farmers manifest in identifying ‘better’ seed or practices, or at direct comparisons among farmers, was also striking. This is perhaps a reflection of social norms that prize egalitarianism, and discourage saying that one farmer’s practice is better than another’s, lest this imply that the individual is also superior. However, the legacy of the *Dergue* period, when it was rarely desirable to draw attention to oneself, may also still be a factor. In any case, the notion of difference among farmers is not openly espoused by some. Reform activities promoting local ‘best practice’ may need to navigate carefully around this issue.

All these may not be overriding issues, but are worthy of more consideration, and may become important in relation to some seed system reform activities. In any case, they reinforce the view that plant genetic resource management is a value-bound practice.

6.8 Conclusions

Farmer management of genetic resources can be understood as a series inter-linked processes that influence gene-flow. The introduction of new diversity, seed exchange, hybridisation between different genotypes, seed selection (both natural and artificial), and seed storage all shape the genetic and physical characteristics of sorghum seed. Farmers influence these processes, based on their perceptions of genetic and environmental diversity, their knowledge of specific varieties and variety characteristics, their awareness of where novel diversity can be found, and their exploitation of opportunities for innovation. Empirical observations, indigenous theories relating genetic and environmental diversity, and cultural values all inform practices, but as this account has shown, chance plays an important role as well, bringing new diversity via unexpected sources, or bringing other opportunities for innovation. The various routes through which diversity is introduced provide farmers with important opportunities for experimentation and adaptation. Farmer genetic resource management is dynamic, reflecting a range of individual and collective activities affecting how seed systems adapt to change.

Participatory approaches to support farmer seed systems often emphasise enhancing farmers’ seed selection skills. Yet, as the discussion on gene flow suggests, seed selection may not be the most influential process, particularly if the elaborated practices of (local) experts are not followed by many neighbours. This chapter suggests other processes may be more important for the overall sustainability of the seed system; these include continued opportunities to assess and exchange diversity, and seed storage practices that maintain household seed security. Seed system reforms that address farmer participation should pay more attention to helping farmers access and assess new germplasm. This is an area where links to the formal system could be valuable, though the limited information on many sorghum accessions (particularly socially-relevant information, such as local names or functional attributes of interest to farmers) complicate this task (Seboka *et al.*, forthcoming). However, formal research and local institutions could usefully collaborate to increase farmer access to diversity by organising activities for farmers to observe and assess a wide range of material, both MVs and FVs collected from other parts of Ethiopia, and to multiply seed for distribution to those interested. Finally, assessing and promoting appropriate seed storage methods, and other approaches to seed physical health, have important, untapped potential to improve seed security at the household level.

Farmers' agency, where they apply their knowledge to shape diversity, is clearly seen in the maintenance of sorghum races and FV functional attributes in the face of gene-flow, in variety naming, and in efforts to control against off-types. However, farmer practices also contribute to mixing of varieties, when planting arrangements encourage cross-pollination, or when divergent approaches to variety naming mean that seed lots mix different genotypes. These examples show the importance of focusing on practice for understanding farmer seed systems, rather than exclusively considering farmers' stated intentions. Participatory interventions to support local seed systems have tended to concentrate on a small number of specific actors and activities (e.g. 'expert selectors', or 'seed keepers'). While the knowledge and practices of the most innovative farmers are an interesting entry point for farmer-scientist collaboration, the activities of these individuals comprise only a part of the entire seed system. Ultimately, the seed system is a collective enterprise involving all farmer practices, whether consciously theorised (as can occur with seed selection) or otherwise, wherever they influence gene flow or adaptation. Thus many processes contribute to the emergent properties of a seed system (e.g. the diversity or environmental adaptation of varieties), and these processes are shaped both by individual actions, as well as social interactions.

Interventions to support the sustainability of farmers' seed systems ought probably to address social interactions, rather than focus exclusively on individuals. Social relations affect key issues such as seed access and exchange, introduction of new varieties, and the dissemination of knowledge and skills among farmers. This account suggests that wealth and patron-client relationships facilitated the exchange of diversity, and the knowledge of its use, in the past, but that such channels of introduction may be more *ad hoc* now. Community institutions could fill an important gap in this area, facilitating seed exchange and innovation, making local diversity or successful practices more 'visible' to local farmers, or lowering transaction costs for individual farmers to acquire new diversity and assess new practices. This might have a greater impact on welfare than consultations among a few farmers about criteria for selecting an MV for eventual release. For sorghum in West Harerghe, this study suggests that the most valuable interventions to support and sustain the health of farmer seed systems will be community-based, possibly building on existing local institutions to reach a wide range of farmers.

Chapter 7 Conclusions. Building a healthy seed system in Ethiopia: beyond 'modular' solutions.

This thesis has developed a trans-disciplinary approach to understanding formal and farmer seed systems for sorghum in Ethiopia. The broad aim was to identify different possible futures for breeding and seed supply, where the formal system could be better integrated, and more closely linked to farmers' seed systems, so that formal research might more effectively address farmers' needs. The ultimate goal is to improve the functioning of seed systems to support farmer livelihoods, respond to changing environmental and economic situations, and contribute to poverty alleviation. This concluding chapter summarises the main findings, and draws out implications for possible reforms. I use the empirical findings to comment upon the main strategies for reforming seed systems in the South. Revisiting PPB, market-based seed supply reforms, and local skills development, I show how these interventions tend to model single components of a seed system, often working from implicit and untested assumptions, therefore missing important interactions between different aspects of the larger seed system. This underscores the value of a broad trans-disciplinary research approach, and the importance of taking a systems focus. I then put forward the concept of 'system health', as applied to environmental systems, as one possible framework for assessing the functioning of a seed system, and highlight some key areas that might contribute to improving the 'health' of Ethiopia's sorghum seed systems. Finally, I conclude by considering possible linkages between formal and farmer systems, and ways in which individual modular interventions might better be aligned, highlighting logistical and institutional challenges.

7.1 Main findings

7.1.1 Ecological and social variation

Chapter 2 highlighted the environmental uncertainty and social variation among farming households in both the highland (Chiro) and lowland (Miesso) study areas in West Harerghe. As recognised in the ESIP macro-ecologies, highland and lowland farmers seek distinct sets of sorghum varieties due to broad differences between the locations in terms of climate and stresses. However, the variety traits farmers seek varies among households within each location, as topography and soils vary at smaller scales, while wealth and livelihood strategies differ among households. Moreover, seasonal variability means farmers seek different varieties from one season to the next, particularly when early sowings fail in the lowlands and long-maturing varieties are temporarily replaced by short-season sorghum. Similar links between environmental variation and sorghum diversity have been found elsewhere in Ethiopia (Teshome, 1996). Seed systems, farmer or formal, face considerable challenges in meeting this high demand for diversity. Differences in asset ownership among households, particularly of oxen, lead to different household strategies to deal with uncertainty. To some extent, local institutions help share inputs among households. However, social variation remains important, affecting household seed security and access to off-farm seed, and shaping overall ability to cope with environmental variation.

7.1.2 Formal seed system

Chapter 3 asked why there is so little apparent adoption of sorghum MVs in Ethiopia, despite the technical sophistication and organisational scope of the Ethiopian Sorghum Improvement Program (ESIP). Participatory reforms to breeding often seek to improve breeders' understanding of farmer criteria for varieties, but knowledge of what farmers seek is only part of the story. The chapter showed that ESIP's organisation, and the institutional and policy environments of its work also shape its impact profoundly.

Sorghum breeding targets smallholders, but the broad thrust of Imperial and *Dergue* policies hardly favoured these farmers, and exposure to sorghum MVs was limited. Subsequent policy environments were much more supportive of smallholders, but continued the previous emphasis on input packages as the main agricultural development strategy. Consequently, ESIP bred with optimal inputs and management in mind, a policy-driven orientation to some extent, but also one influenced by conventional views on breeding for wide adaptation. Downstream activities of seed supply and extension were left to other institutions. This modelling of environments, and 'ordering of events' (Squires, 1999) between breeders, extension agents, and farmers, kept smallholders' low-input reality from greatly influencing sorghum breeding.

The organisational structure of ESIP is not inevitable, but rather the outcome of conscious decisions made early in the programme. Dividing work into three macro-ecologies, with breeders performing selections on rapid visits to stations enables ESIP to organise a great deal of work over a large country. Also, a centralised breeding team structure and research review process plays an important role in maintaining a collective sense of mission despite political and personnel changes. However, institutional forces, such as the embedding of messages in ESIP's team culture, the organisation of IAR/EARO, or the long-term nature of breeding and germplasm work, contribute to the path-dependency of the programme. For instance, government policies encouraged the maintenance of the F_1 hybrid programme, in the absence of a clear market or seed supply strategy. Policy processes are not necessarily responsive to empirical realities such as seed demand (Keeley and Scoones, 2003), making it harder for a programme to change direction. Finally, the performance of breeders is not evaluated by adoption rates. Producing MVs and reports is considered evidence enough. This weakens any pressure for programme-level reflection on impacts, or for change.

Thus to improve the impact of breeding we need to look beyond the immediate knowledge and practice of individual breeders, and consider policies and institutional organisation. Policy and institutional narratives, and the technological path-dependency this engenders (e.g. in choice of germplasm, long-running breeding strategies, location of stations), means that institutional change in established programmes such as ESIP may be rather more difficult than the seed system reform literature implies. This change is unlikely to come about by PVS activities alone, where farmers meet breeders and look at and discuss MVs in a field day setting. Chapter 3 makes clear that the challenge for reform is to find ways of organising breeding, and the institutions supporting breeding, to maintain cohesiveness, technical sophistication, and peer-reviewed rigour, while allowing for flexible approaches to crop improvement reflecting the actual situations of farmers.

Chapter 4 shows the importance of seed supply institutions for understanding the impact of formal breeding. Formal seed supply and extension face significant challenges in anticipating farmers' demand for MV seed, and supplying appropriate varieties at the right time and quantity. Seed multiplication confronts significant risks in Ethiopia, not just of storage and quality control, but of logistics in multiplying seed over several seasons from a few large centralised (and mainly highland) farms to meet dispersed, and counter-cyclical, demand. Regulation determines variety release criteria and seed quality standards. The chapter shows that choices embedded within regulatory institutions constitute forms of 'institutional selection' imposed upon the results of breeding; the variety release committee decides which candidate MVs get released, while the choice and amount of MVs multiplied reflect estimates from Regional Agricultural Development Bureaux, as well as the location of seed multiplication farms. Farmers have limited scope to influence these decisions, especially because of weak bottom-up communication links in extension. Lack of choice over which sorghum MV might be supplied locally, as well as the limited quantities and frequent tardiness of supply, undermine farmers' potential interest in MV seed.

The seed system reforms in Ethiopia show the limitations of focusing on supply or regulation in isolation, and of ignoring the social actors in local seed systems. The Farmer-Based Seed Production and Marketing Scheme (FBSPMS) sought to augment supply through more decentralised on-farm seed multiplication, but decisions on what to multiply remain largely top-down, and not responsive to demand. Like many similar schemes, the approach retains the most cumbersome aspects of formal quality control and regulation, constraining its scope for improving seed accessibility for the poor (Cromwell, 1997). The National Extension Improvement Program (NEIP) sought to pump-prime demand for MV seed, and to add an element of predictability, with advance projections and quotas for specific seed varieties by region and *woreda*. However, centralised decision-making, and over-optimism about the functioning of grain markets, undermined its impact, which was largely confined to the more market-friendly crops (maize and wheat) in any case. Both areas of reform addressed the 'hardware' of seed systems, neglecting the 'software' of social networks of actors and information necessary for making seed supply sensitive to local demand (Tripp and Pal, 2000; Lyon, 1999). Reforms to seed regulation in Ethiopia are concerned mostly with increasing the efficiency of variety release, and strengthening formal standards, both laudable aims. Yet the protective tone of these reforms effectively excludes actors, such as small-scale seed merchants, who perhaps possess the best 'software' for meeting seed demand in rural areas.

The challenge for seed system reform is to be responsive to local seed demand, with appropriate timing and quality. This requires a better understanding of local demand, particularly of which farmers use formal or market seed channels, and why. Counter-cyclical demand for MV seed, particularly in the lowlands, implies more rapid responses, and a wider range of actors, than currently found in a lengthy and centralised multiplication chain. As the reforms above show, governments cannot simply organise supply and demand via quotas, or will markets to behave in predictable ways. Involving such actors as Development Agents, rural stockists, or travelling seed merchants could help develop a more diverse and responsive seed supply system, making use of local knowledge and social ties. However, this will require a significant shift away from the current centralised ethos of institutions and regulation, and still faces the economic and logistical challenges of meeting diverse and variable demand.

7.1.3 Farmer seed system

Chapters 5 and 6 highlighted key processes in the farmer seed system for sorghum in West Hararghe, focusing on farmer practices and how these influence the wider properties of the system. Seed security emerges as the primary seed-related concern of many households, and regular off-farm supply plays a crucial role. The quantities, timing, terms, and choice of varieties supplied are all important to farmers, and differ by source, and by the nature of social ties. Farmers exchange significant amounts, as do markets, the latter channel being the chief source of fast-maturing sorghum varieties when early sowings fail. Farmer-to-farmer exchange can reflect patron-client relationships, as suppliers tend to have more assets than recipients, and a few individuals regularly supply large quantities to their neighbours.

However, farmers' preferred sources for off-farm seed are not uniform, but differ among households, to some extent according to the level of assets a household possesses. This suggests that social variation shapes individual farmers' transaction costs in obtaining off-farm seed, with particular implications for the seed security of the most vulnerable. While there appears to be a 'moral economy' of seed exchange, where better-off farmers support their poorer neighbours, my analysis suggests these relationships are changing, or even breaking down, due to changing social and labour ties, and the high overall demand for seed. Chapter 5 shows that both agroecological and social aspects of the local seed system are important, and changing, with implications for seed access for the all but the least vulnerable farmers.

Chapter 6 focused on the dynamic aspects of farmer-based sorghum diversity management. Some farmers have a perspective on genetic components of variation, and describe practising deliberate selection for traits. But evidence suggests high environmental variation, generally low selection intensities, and gene-flow via seed exchange and cross-pollination between fields blur any directional impact of individual selection. Farmers' innovation and agency in genetic resource management comes more from introduction and screening of novel varieties, as evidenced by the considerable varietal turnover at the farm scale and beyond. This mirrors findings in Wollo, northern Ethiopia (Seboka and van Hintum, forthcoming), where farmers have introduced sorghum FVs from other regions in response to changing environmental conditions. Though patron-client relationships helped organise introductions in the past, current introductions are largely *ad hoc*, entering the local seed system as individual varieties encountered in travels, or as 'unplanned appearances' in mixed seed lots. Local naming systems highlight important traits, and show farmers' agency in managing off-types, but the complexity and local specificity of these naming systems may hamper farmers seeking out particular named varieties. As it is, farmers are often unaware of the local or regional availability of varieties whose name and appearance they would recognise, adding to the transaction cost of obtaining new material. It is concluded that interventions to foster innovation in screening of new varieties, and in promoting the best local practices in seed storage, offer more potential than seed selection practices in strengthening the health of the local seed system.

These chapters give a sense of the complexity of farmer seed systems, and show the value of focusing on practice. Important aspects of the West Harerghe sorghum system, such as gene-flow, variety introduction, seed security, or innovation, can be seen as emergent properties, i.e. outcomes of individual and collective practices across different scales. If we consider only the intentional actions of individuals, some properties of farmer seed systems do not come fully into focus. Besides reflecting ecological variation, seed systems are also social systems, as social relationships influence the ways individuals obtain seed and information. This suggests that social mobilisation, as well as technical intervention, is necessary to improve household access to seed of the appropriate genetic and physical quality. This mobilisation should underscore existing norms about everyone having the right to seed, and aim to facilitate access for the poorest. Local mutual-aid institutions, or local government (FA) councils, are possible fora for social mobilisation, in order to bring the issue of access to seed and new diversity more into the public sphere. This is discussed further below.

7.2 Reflections on current efforts for seed system reform

When we consider current initiatives to reform breeding or seed supply, the value of taking a systems perspective becomes clearer. Many reform strategies seek 'modular' solutions, changing one aspect of the formal seed system (e.g. breeders' selection, organisation of seed multiplication), usually with only a passing consideration of how this fits in the wider picture. This thesis has also taken a modular approach, in that I have considered formal breeding, seed supply, farmer seed exchange, and farmer genetic resource management separately. However, I have attempted to show throughout how these specific areas of activity are integrated into the seed system as a whole, and emphasised how policy processes and social relationships require us to understand these activities in a wider context than normally done.

'Modular' reforms can be very effective in achieving specific goals, such as improved farmer input into variety selection, or the transfer of specific skills to farmers. However, these goals risk being mis-located if they do not take account of how they fit into the seed system as a whole. For instance, reforms to seed selection will have little impact if seed supply remains weak. In this light, I briefly discuss the prevailing approaches to seed system reform: Participatory Plant Breeding (PPB), seed supply reform, and farmer skills-development for breeding.

7.2.1 PPB

In the PPB literature, a rich and diverse discussion highlights a range of possible goals (improving breeding, enhancing biodiversity, empowering farmers, or reorienting institutions), and debates methods for achieving farmer-scientist collaboration, and for evaluating impacts (e.g. McGuire *et al.*, 1999; Weltzien *et al.*, 2000; Farnworth and Jiggins, 2003; Sperling *et al.*, 2001; Anonymous, 1994; Smale *et al.*, 2003; Witcombe *et al.*, 2001; Eyzaguirre and Iwanaga, 1996a; Cleveland and Soleri, 2002a; Lilja and Ashby, 2002; Witcombe and Joshi, 1996; Gómez and Smith, 1996). The practice of PPB, however, is less diverse than the literature discussing it; as Weltzien *et al.* (2000) note, for many projects seeking reforms to breeding, Participatory Variety Selection (PVS) appears to be the default option. Two thirds of the PPB projects they reviewed used PVS, while nearly all projects represented in an Africa-wide workshop on PPB in 2001 worked solely with PVS.

PVS occurs near the end of the research cycle, seeking farmers' views on material proposed by breeders for MV release (Witcombe *et al.*, 1996). Much attention focuses on how best to gain farmer input (e.g. the choice of appropriate participants, testing locations, number of candidate lines, or ranking methods), and how to assess impacts (PRGA Program, 2002). These activities have been successful in identifying useful varieties for farmers, and in some cases, shifting institutional practice. However, most participatory reforms to breeding are 'modular' in practice, addressing the farmer-breeder interaction while leaving the rest of the seed system as a black box. Good methods are clearly important, but there is a risk that many practitioners will see having the right methodological 'toolbox' as the key to successful interventions, while neglecting a broader analysis of the reasons for low impact in the first place. Eliciting farmer views of candidate MVs may not be the best starting point for improving breeding, or the overall sustainability of the seed system.

PPB activities, particularly PVS, seem to start with the assumption that better targeting of MVs is the key intervention to improve the effectiveness of breeding, and that structured feedback from a few well-chosen farmers is enough to improve this targeting. However, this may not be the top priority for reforming sorghum seed systems in Ethiopia. ESIP breeders have a good general awareness of farmer needs (though inevitably less so for specific locations). However, impact is shaped by more than just identifying the right set of traits; the broader context of policies and institutions shape breeding goals, team organisation, testing conditions, and the nature of communication within and outside the breeding team. Moreover, PPB has tended to neglect seed supply (McGuire *et al.*, 1999; Weltzien *et al.*, 2000). Emphasising selection may identify a few cultivars that the needs of farmers (those consulted, at least), but these cultivars still need approval for release, and the seed still needs to reach farmers who need it. Even if seed were accessible, a few additional MVs, no matter how well-targeted, may only make a minor contribution to the sustainability of a highly diverse farmer seed system where social and ecological variation play such a large role.

7.2.2 Seed supply reforms

Seed supply reforms can also make valuable improvements to the availability and accessibility of seed for poor farmers. However, many reforms to formal seed supply also involve 'modular' changes to existing supply institutions, such as the FBSPMS and NEIP initiatives, which respectively address supply and demand. Again, assumptions underlying such reforms – that supply and demand are readily predictable, and that central design and strict regulation will lead to effective delivery mechanisms (including markets) – may not apply to sorghum in Ethiopia. As with PPB, relationships among formal institutions (particularly between breeding and supply institutions) receive less attention in reforms, despite the problems posed by communication among different actors and agencies in formal seed systems (Tripp, 1997b). Moreover, inter-personal ties for exchanging seed and information in farmer seed systems, so important for local seed access and responsive seed systems, are not emphasised in many formal reforms. As with emergency seed relief (Sperling and Cooper, 2003; Sperling, 2002), there is the concern that, unless formal seed supply reforms seek seriously to engage with local systems, they actually undermine the resilience of these systems.

7.2.3 Skills-development

Some very interesting initiatives seek to enhance farmers' own skills in seed selection (Gómez and Smith, 1996; Rice *et al.*, 1998), linked to a more general interest in relating farmer and breeder knowledge (Soleri and Cleveland, 2001; Soleri *et al.*, 2002). Some of the best efforts in this area are sincere in supporting farmers' own capacity for innovation, and make serious contributions to farmer empowerment. However, this work tends to emphasise seed selection, and work with a few expert farmers. As argued last chapter, farmers' conscious practices in seed selection may play only a minor role in shaping the performance of sorghum, particularly with frequent turnover in seed lots (cf. M.E. Smith *et al.*, 2001). Furthermore, not all farmers will be willing or able to follow the selection practices of their most skilled neighbours. Thus, developing farmer seed selection skills may do little to improve the functioning of sorghum seed systems in Ethiopia. However, efforts focusing on farmer selection do emphasise genotype-by-environment (GxE) interactions, an emphasis shared with recent developments in breeding theory and practice (e.g. Atlin *et al.*, 2001; Bänziger and Cooper, 2001; Ceccarelli, 1996; Ceccarelli *et al.*, 2001a; K.D. Joshi *et al.*, 2001; Toledo Machado and Fernandes, 2001; van Eeuwijk *et al.*, 2001). This opens up new possibilities for addressing variable, low-input environments, though significant changes in the organisation of breeding would be required (Ceccarelli *et al.*, 1996; Ceccarelli *et al.*, 2001b). These are further discussed below.

7.3 Discussion: Improving the functioning of seed systems

7.3.1 Modelling optimal solutions

For many formal seed system activities, as well as reforms, conceptual models appear to influence thinking and shape expectations of behaviour. Models – implicit or otherwise – suggest that farmers' demand for MV seed, the functioning of seed markets, or the value of input packages are predictable to some degree. Modelling can also occur when specific cases are used as the basis of much more general strategies, such as where early experiences with input packages, or the role of markets with wheat and maize seed, influenced national extension and seed supply strategy across a range of crops and environments. The attraction of models is that they suggest clear rules and goals in a system, and make it more amenable to intervention. Thus, an intervention that seeks farmers' views on MVs can be related to a complex goal such as improving rural livelihoods. Models reflect a 'hard systems' perspective (de Boef, 2000; Jiggins and Röling, 2000), which suggests that there are clear relationships between components (e.g. breeding practice, seed supply, farmers' use of MVs, regulation), and that optimal solutions can be sought.

However, the complexity of seed systems limits the scope for such an engineering approach. Agro-ecological and social variation makes it difficult to predict how all components of the seed system will behave (e.g. farmers' seed demand). Policies and institutions influence the seed system; these cannot be seen a simple executions of formal plans or policy statements, but are also influenced by key actor networks, and institutional cultures (cf. Biggs and Smith, 1995; Biggs and Smith, 2002; Thompson *et al.*, 1990). In general, where environments are variable and multiple institutions are involved, 'hard systems' approaches are inappropriate for developing management strategies (Jiggins and Röling, 2000). The broad trans-disciplinary analysis of this thesis shows that seed systems do not behave in mechanistic ways, and a single, optimal management strategy will remain elusive. However, co-ordination among a series of interventions in different areas of the seed system may offer a promising way forward for improving the function of the system as a whole. The closing sections discuss some possibilities here, as well as important challenges.

7.3.2 Understanding seed systems: stakeholders and scales

Co-ordination of activities among the range of stakeholders involved in the seed system is challenged by the fact that each stakeholder has its own perspective on the seed system, emphasising different priorities (de Boef *et al.*, 2000b). For example, national policymakers stress aggregate grain production, seed regulators are concerned with 'protecting' farmers from unreleased materials, while farmers prioritise access to seed on time and opportunities for innovation with novel varieties. Commonly-agreed problems may offer useful entry-points for involving different stakeholders in understanding and reforming the seed system (Jiggins and Ravnborg, 2000). For instance, the general concern with the apparent low impact of formal breeding could lead to joint learning around such areas as farmers' actual seed demand (FV and MV), their perceptions of 'better seed' (Almekinders and Thiele, 2003), or the accessibility/quality of seed obtained via different channels. The real issue here is that there needs to be more problem-centred interaction among different stakeholders in the seed system.

Any understanding of a seed system needs to take account of multiple geographical scales. While farmer seed systems reflect the agro-ecologies, livelihoods and social relationships of the immediate area, seed and information also come from further afield, via formal and informal channels. Policies and practices of the formal seed system may have a national mandate, but are also affected by institutions at the national, regional, and local scales, and by the logistics of organising breeding and seed supply for a vast country. Thus we should avoid conceiving the farmer system as simply local, and the formal system as only national, but consider how different scales of the seed system interact.

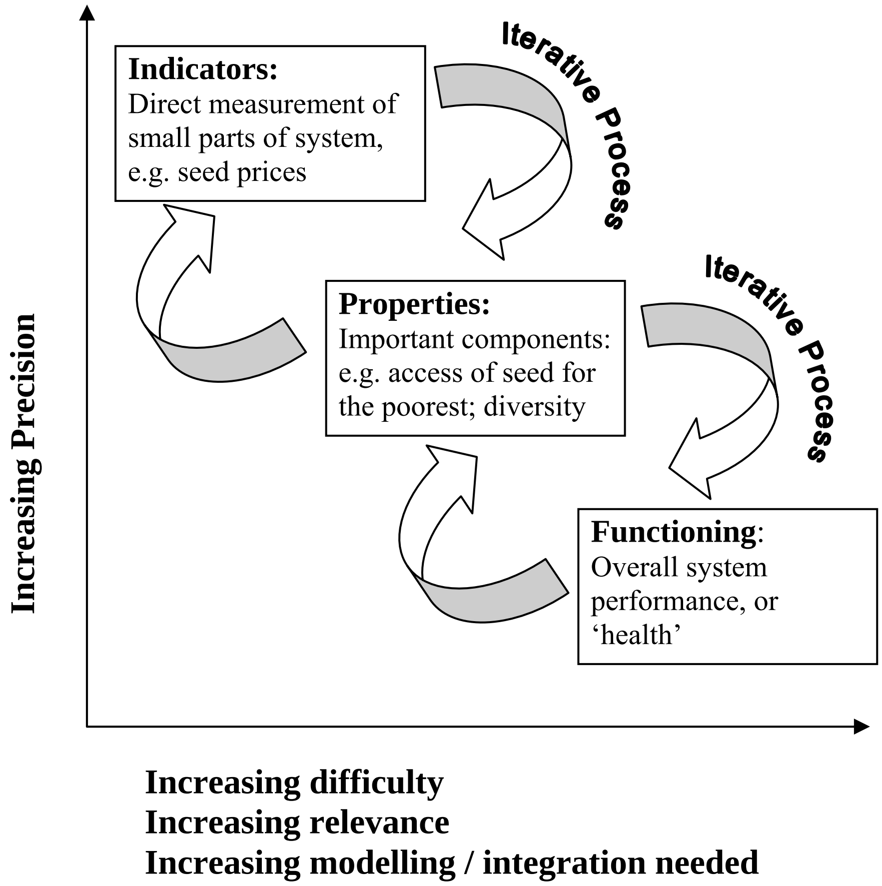
7.3.3 Assessing the functioning of the seed system: system 'health'

As chapters 2-6 demonstrated, specific practices – such as breeding and seed supply in formal research, or seed exchange and diversity management among farmers – do not exist in isolation. This is the why this research has emphasised seed systems, and explored practices and institutions related to crop development and seed supply at the systems level. It would be very useful if there were a workable approach to assess how well a seed system as a whole functions in supporting farmers' livelihoods. Among disaster relief agencies, there is growing interest in assessing the overall functioning of seed systems to help determine when emergency seed relief may be appropriate, and to evaluate the impacts of emergency interventions seed on the long-term sustainability of a seed system (Sperling and Longley, 2002; Sperling and Cooper, 2003). Equally, an assessment of how well the whole seed system functions could assist in evaluating seed system reforms, and help direct interventions better to integrate formal and farmer seed systems. One approach for making system-level assessments is in natural ecosystems, where some researchers are trying to make the notion of 'system health' operational. Could this approach help us identify key properties of a well-functioning seed system, and possibly even indicators?

In recent years, ecosystem health has emerged as a distinct field of study. Drawing upon classic works on the emergent properties of environmental systems (Holling, 1973; Kay, 1991) or agricultural systems (Conway, 1987), proponents argue that the 'health' of a complex system can be defined operationally through reference to emergent properties of the system such as its organisation, vigour, and complexity (Costanza and Mageau, 1999; Rapport *et al.*, 1998a). By studying how these properties change under stress or disturbance, and the implications for the overall functioning of a system, practitioners aim to develop a measure to assess the health of a system, and suggest possible management strategies (e.g. Bertollo, 1998; Costanza, 1992; Fairweather, 1999; Gallopín, 1994; Okey, 1996; Rapport *et al.*, 1998a; Rapport *et al.*, 1998b; Schaeffer *et al.*, 1988; Vora, 1997; Xu and Mage, 2001).

The challenge with ecosystem health – as with human health – is to identify appropriate indicators, and interpret their meaning for a broad value such as health. Practitioners choose indicators that tell them something about the state of key emergent properties of a system, which in turn can tell them something about the system's overall health. Selecting indicators, and integrating their meaning for system properties and for a broader determination of health, is an iterative process, requiring continued reflection and adaptation (Fig. 7.1).

Figure 7.1 Schematic representation showing how models can relate indicators with system properties and overall functioning (McGuire, 2001b; adapted from Costanza, 1992).



This approach works best in relatively closed natural ecosystems, such as a watershed or forest, where responses to stress are relatively predictable (Schaeffer *et al.*, 1988; Rapport *et al.*, 1998a). Seed systems, though, are part of agro-ecosystems, which have important social, economic, and cultural dimensions that make the choice and interpretation of indicators much more complicated (Waltner-Toews and Wall, 1997; Izac and Swift, 1994; Gallopín, 1995). For this reason, a seed system's 'health' is unlikely to be predictable from a set of indicators in the same way as for some natural ecosystems. However, the concept of health may have some value for seed systems if used more heuristically, i.e. as a framework for thinking broadly about important properties of a well-functioning seed system, and for identifying possible indicators.

Defining the 'health' of any system is inevitably a normative process, reflecting human values and desires of the system's purpose (Waltner-Toews *et al.*, 2000). For instance, a farmer might emphasise different properties for a well-functioning seed system than a breeder, government regulator, or conservationist. Arguably, livelihoods should drive any concept of seed system health for sorghum in Ethiopia, given the need for rural development and the continued dominance of farmer seed systems, though biodiversity is likely to contribute to this goal. From this perspective, I propose some properties of a healthy sorghum seed system in Ethiopia, and suggest possible indicators for assessing them. The intention is to stimulate reflection about what aspects are important for how the system as a whole functions. The properties I put forward – seed security, seed quality, diversity, low transaction costs, and an enabling environment for innovation – are preliminary suggestions, and further study and discussion with stakeholders would be needed to refine the choice of properties and indicators.

Seed security

Seed security for all types of farmers should be a defining property of a healthy seed system. This starts at the household level with sufficient farm-saved seed for replanting, but off-farm seed is also needed to replace lost seed lots, or to obtain new material. Thus seed supply should respond to demand, with farmers able to learn about and obtain good quality seed of the varieties that interest them, whether MV or FV, via accessible channels. Archibald and Richards (2002) argue that equitable access to such a key input is a fundamental right and an important element of social inclusion. This does not always occur; widespread shortages within the farmer system can restrict amounts available for farmer-to-farmer exchange, and some farmers, particularly the most vulnerable, may have limited access to networks of exchange. Local markets do respond to local seed demand, but supplies may also be limited, and the costs can also be inaccessible to some. As we have seen for formal seed channels, official decisions around variety release, and the organisation of multiplication and testing greatly influence which sorghum MVs are delivered to a given location. For sorghum, supplies of MV seed are often limited and arrive late. Moreover, socially-constructed categories such as ‘full-time farmer’, and the full adoption of input packages, determine who may access this seed. Seed security is therefore an outcome of both the availability of seed through various channels (household storage, local exchange, local markets, formal supply), and the accessibility of these channels for different types of farmers.

Seed quality

Healthy seed systems need to maintain appropriate levels of seed quality, both physical and genetic. The farmer system often maintains reasonable physical quality in farm-saved seed for cereals like sorghum (a study of two other cereals in Ethiopia, barley and wheat, found farm-saved seed of comparable physical quality to formal seed; Bishaw, 2004), though poor weather or seed-borne diseases can undermine this. Physical quality of off-farm seed can be less certain, particularly when grain is sold or exchanged as ‘seed’. High sowing rates act as an insurance against poor physical quality. The physical quality of seed from the formal system should be better, though regulatory systems to not always guarantee this (Tripp and van den Burg, 1997). Also, some farmers argue that MV seed does not always store well, or germinate from deep (>10 cm) sowing – questions which need further study. The genetic quality of seed is also crucial, though environmental variation, and differences between what breeders and farmer emphasise as ‘good’ traits (e.g. maximum grain yield versus reliable performance) make genetic quality difficult to assess in any simple fashion. However, a variety that is very susceptible to a common stress such as drought or disease is clearly seen as having poor genetic quality in that context, regardless of its other attributes. Formal regulation should ensure some level of physical and genetic quality in purchased seed, though strict uniformity and tight regulatory standards may offer little benefit. Rather, intermediate standards for certified seed may be preferable (e.g. ‘local quality seed’), protecting farmers from the worst quality seed while allowing a diverse range of actors to be involved in seed supply (Louwaars and Tripp, 2000).

Diversity

The genetic diversity available in FVs or MVs is another important property of seed system health. Farmers make use of a wide range of sorghum varieties to address variable environments over space and time, and meet diverse livelihood needs. Their demand for diversity may shift as the market comes to provide goods and services previously provided by diversity (Bellon, 1996), but this is unlikely to occur soon in rural Ethiopia. Studies in Ethiopia and elsewhere highlight the importance of diversity, particularly for poorer farmers (Richards, 1986; Brookfield *et al.*, 2002; de Boef *et al.*, 2000a; ITDG-Kenya/ODI, 2000; ITDG/ODI, 2000; Negash, 2001; Sperling and Loevinsohn, 1996; Teshome, 1996; Bayush Tsegaye, 1997). Maximising diversity is not usually the main goal of farmers, or of breeders, as the previous chapters have shown, but their practices influence the level of diversity that does occur. In other words, diversity is an emergent property of the seed system.

Transaction costs

Farmers in a healthy seed system should have low transaction costs for obtaining new varieties of interest. Transaction costs in this context reflect the resources farmers expend to learn about, acquire, and test novel varieties, costs which involve labour, or financial or social assets. Factors such as distance, poor infrastructure, lack of awareness of where particular varieties can be found, genotype-by-environment interactions, and local naming practices make it difficult for farmers to make informed choices in seeking out and adopting new diversity, whether FV or MV. The financial or social costs of acquiring the seed remains a barrier for some. Where transaction costs are significant, as they appear to be for sorghum in West Harerghe, they may constrain the amount of diversity found in farmer seed systems, as farmers find it harder to seek out diversity they value (Bellon, 2004).

Enabling innovation

Lastly, an important property of a healthy seed system is the degree it supports innovation among its main actors. Organising formal institutions and policy in such a manner that new approaches can be explored and evaluated is important, avoiding situations where the formal seed system is 'locked in' to particular strategies (Hogg, 2001), either in terms of germplasm or practice. Farmers' innovation around crop and seed management is also important, particularly for responding to local or unforeseen situations, but also for adapting material and techniques provided by the formal system. Providing farmers with technologies that are suitably flexible and robust to different growing conditions, rather than precisely-defined packages, may facilitate farmers' adaptive modification and allow for a better division of labour in agricultural innovation (Sumberg *et al.*, 2003). The effectiveness of linking farmers' innovation with that of scientists is also greatly affected by the level, timing, and modalities of farmers' participation in research. These issues are discussed more below.

Indicators of system health

Relating to these properties, I suggest possible indicators for shedding light on the functioning of farmer seed systems. As equity is often a major concern (indeed, some consider it a key system property; Okey, 1996; Conway, 1987), these measures should be disaggregated according to gender or wealth, or targeted to the most vulnerable households. This list is by no means exhaustive, particularly as it takes a farmer perspective; rather different indicators may be needed to assess some aspects of the formal seed system.

- Adoption rates of MVs
- Production and production stability – i.e. yields in ‘good’, ‘average’, and ‘bad’ years, and the frequency of such years
- Proportion seeking off-farm seed, quantities obtained, and terms of access
- Amount different types of farmers are willing to pay for seed under specific scenarios (e.g. lost seed lot, obtain new variety)
- Seed prices in local markets in relation to grain prices, and their change through the season
- Germination rates for seed from different channels, including on-farm storage and formal supply channels
- Varietal diversity at different scales (field, community, district)
- Farmers’ knowledge of this diversity: e.g. ability to identify varieties, awareness of presence of these varieties in vicinity
- Proportion of diversity considered recent introductions, at different scales
- Proportion of farmers who have ‘involuntarily’ abandoned a variety (i.e. lost seed lots)
- Time and effort farmers expend in re-obtaining specific varieties involuntarily lost
- Proportion of farmers who have experimented in past season (i.e. tried a different variety/management approach; Sumberg and Okali, 1997)

The value of indicators such as these would need to be assessed over time. Given the complexity of seed systems, such indicators may not predict the state of key system properties with the same precision or reliability as with natural ecosystems. For instance, when grain can be used as an alternate source of seed (albeit with lower physical quality), assessments of seed security become more difficult. Nevertheless, thinking about the functioning or ‘health’ of an entire seed system, and how to assess it, can have heuristic value if it stimulates reflection about how different actors and activities interact to affect the seed system, and how the various actors might function in different and more effective ways.

7.4 Integrating formal and farmer seed systems: strategies and challenges

Seed system reforms take the same starting point as this thesis, that a closer integration of formal and farmer seed systems has the potential to improve the functioning of seed systems, and consequently, farmer livelihoods. However, many different types of integration are possible; closer association might improve farmers’ access to information and MVs from the formal sector, collaboration in the development of MVs or of seed supply strategies might be pursued, or an aim might be policy integration, linking regulation with local realities. The challenge is not so much to foster closer farmer participation, but to define the character of this association. For instance, the depth and timing of farmer involvement in formal research is important (Johnson *et al.*, 2003; Sperling *et al.*, 2001). Highly decentralised formal sector activities are potentially responsive to local needs, but may be very restricted in geographical scope and lose the benefits of national peer-review. Thus bringing about more effective collaboration between farmer and formal seed systems involves not only identifying key areas for collaboration, but also addressing important logistical and institutional challenges. These issues are explored in the following sections.

7.4.1 Linking formal and farmer seed systems

Seed supply

This research shows that farmers have an enduring interest in trying new sorghum varieties to expand their options. However, individual access to potentially useful diversity is constrained by the high transaction costs of learning about and acquiring novel germplasm. Farmers are often unaware of all the diversity growing in their area, even in the same FA, while environmental variation and local nomenclatures make the search for appropriate germplasm time-consuming. Change in social relationships indicates that farmers are less likely to obtain useful germplasm via a patron than in the past, while some have limited access to seed in general. Facilitating information-exchange, and access to seed, might help address such supply-related barriers to the spread of sorghum diversity (FV and MV) in local seed systems. This could increase diversity found at the farm level, and potentially expand livelihood options for farmers (Bellon, 2004; Almekinders, 2002).

Collaboration between the formal and farmer seed system could help lower farmers' transaction costs in learning about and acquiring diversity, whether FV or MV. Seed fairs have had some success here, encouraging farmers to bring diverse seed types for display, raising awareness and appreciation of diversity, and facilitating the exchange of seed and associated knowledge (Actionaid-Kenya and ITDG-Kenya, 1999; Tapia and Rosas, 1993; Sperling and Cooper, 2003; Sperling and Loevinsohn, 1996). Additionally, the 8000 accessions of Ethiopian sorghum held at the Institute of Biodiversity Conservation and Research are a resource to be tapped by farmers, especially as this collection contains FVs collected over 25 years ago, many of which are no longer common *in situ*. However, the sheer size of the collection, and the general lack of farmer-relevant information (e.g. local names, uses; Seboka, 2005), pose major challenges. Here, a staged approach may help, similar to one used for maize in Oaxaca, Mexico (Bellon, 2004). There, several hundred accessions were grown at large demonstration sites (such as research stations), and farmers from different communities were invited to visit and vote for the accessions that most interested them. Based on their votes, smaller subsets of varieties were grown under local management at several community demonstration sites, and anyone interested could purchase a small amount of seed of any accession they wish. Oaxaca is an FV-based region with great maize diversity, yet farmers did not always encounter the diversity that interested them due to high transaction costs; they were enthusiastic to screen diversity, and the project led to increased on-farm varietal diversity. This approach could be useful in supplying new and valuable diversity to farmers in Ethiopia, though the final supply of seed still poses challenges.

Well-organised feedback sessions with farmers in germplasm screening work, or even seed fairs, could give researchers a great deal of information about the traits farmers seek, and how this varies socially or ecologically. While breeders do get farmer feedback via extension demonstration plots, open days, or, more recently, PVS (e.g. Eshetu Mulatu and Belete, 2001), these usually encompass a narrow range of MV material under optimised management. A systematic assessment of farmers' views of a wide range of diversity can improve conservation approaches (Smale *et al.*, 1999), lead to better-targeted germplasm interventions over time, fine-tune breeding goals, and even uncover new parental materials for breeding (e.g. vom Brocke *et al.*, 2002).[122]

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[122] *Ex-situ* collection is inevitably patchy, and much of it occurred over a generation ago in Ethiopia. My own modest attempts at collecting germplasm in the Miesso area uncovered highly productive FVs that were unfamiliar even to TAs living and working there for 16 years, let alone Melkassa-based breeders. Some of my collections were used for further

Seed security

Interventions that strengthen local seed security would also improve seed system functioning. In Ethiopia, both local seed enterprises (e.g. Alemaw and Persson, 2000; Kugbei and Fikru, 1997; Medhin and Gebeyehu, 2000) and community seed banks (e.g. Hailu Mekbib *et al.*, 1993; Berg, 1996a; Feyissa, 2002) have been used to address seed security. While these have been important interventions, they typically face problems of financial sustainability (Rohrbach *et al.*, 2001; Rohrbach *et al.*, 1997; Almekinders and Thiele, 2003; Louwaars and Marrewijk, 1996). The challenges facing local seed enterprises – low, sporadic demand for purchased sorghum seed, and the added expense of strict quality-control protocols – have been outlined earlier. Community seed banks also face significant costs for storage and administration, which are difficult to meet if they are truly working to ensure accessible seed for the poorest.[123] Identifying and promoting the best local practices for seed storage may be a better approach, as argued last chapter. However, the effectiveness of these practices still needs to be verified, and farmers must be able to realise clear improvements in seed storage (or performance in the field) to offset any increased time or effort on their part. As Almekinders and Thiele (2003) argue this is hardly assured. Approaches that rely exclusively on the market, or on ‘community’ institutions, may not reach the most seed insecure, who tend to be poor or socially marginalised. Seed vouchers, sometimes used in emergency relief, could help poorer groups to access off-farm seed, if properly targeted and designed (Sperling and Cooper, 2003). However, a voucher strategy would require funds, formal guarantees to local seed merchants, and more recognition of these merchants than currently given in seed policy. Better comparison is needed of the different approaches for supporting seed security in rural Ethiopia; this is one area where co-ordination among a range of different pilot interventions, and continuous exchange of experiences among them, could prove very helpful.

Improving seed security remains a key issue, both for households’ welfare, and for the wider impact of any other seed system intervention, particularly breeding. As Chapters 5 and 6 argued, social mobilisation could be a valuable strategy for strengthening seed security, by supporting the exchange of seed or novel germplasm or storage practices. Formal-farmer collaboration could do much to improve seed security, but this will be most effective if it involves all key stakeholders. For instance, most seed merchants are not certified seed dealers, yet play an important role in seed provision. Such merchants need to gain recognition as important stakeholders in their own right, and be involved in efforts to support seed security, rather than be ignored by formal-sector initiatives.

Breeding

Chapter 3 argued that there are many possible ways to organise a breeding programme – in the same vein, reforms to crop development can take many forms different from on-station PVS. For ESIP, a major challenge will be to enact reforms to its workings that do not disrupt its technically strong and scientifically-grounded work. Different divisions of labour among the different parties (farmers, breeders, technical support such as TAs or DAs) may be one way to make best use of different skills and knowledge, while allowing breeders to continue to focus on their strengths. For instance, having farmers select among segregating lines may

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screening. Involving farmers in more systematic collection/screening potentially would identify much more material for consideration by breeders.

[123] For instance, community seed banks run by the Relief Society of Tigray (Berg, 1996a) or the EBI (Feyissa, 2002) both required subsidies to continue.

not be effective or efficient in all situations,[124] but involving farmers in defining goals or assessing trials can help improve the speed, as well as the effectiveness, of breeding (Lilja and Ashby, 2002). Collaborating with distinct social groups of farmers, or working with farmers' own environments, should produce a more diverse set of MVs than where maximum grain yield, and optimal environments, drive breeding goals. However, this does not mean that collaborative breeding needs to set goals for every environmental niche or social circumstance. Developing varieties that are widely adapted to different management conditions and environments may represent a better division of labour, giving farmers scope in their adaptive experiments to fit new varieties into their farming systems (Sumberg *et al.*, 2003; Reece and Sumberg, 2003). Selecting across multiple environments (i.e. farmers' fields) could help develop such widely-adapted materials, and improve quantitative traits affected by GxE interactions (Atlin *et al.*, 2001; Bänziger and Cooper, 2001; van Eeuwijk *et al.*, 2001). Breeders and formal researchers would have a clear role in organisation, offering physiological insights into environmental effects, and in statistical analysis of performance, while farmers could help identify representative sites for important stresses (Almekinders and Elings, 2001). DAs could also assist in local organisation and data collection. Population improvement, to enhance FVs for instance, can also help improve adaptation, and provide a wider genetic base from which breeders and farmers can select (Ibrahim and Barrett, 2001; Veteläinen and Nissilä, 2001; Tessema and Bechere, 1998). There is no single ideal approach for breeding reform, but adaptive work in Ethiopia could over time identify appropriate modalities for farmer-breeder collaboration that use each parties' skills and knowledge to best effect. Critical examination of the reform strategies to date in Ethiopia, and pilot studies, could help in reflecting upon which reform approaches might be most appropriate.

Institutional challenges

A possible way forward for seed system reform is not to abandon 'modular' interventions, but rather to find ways to orchestrate among a range of different interventions, each focusing on a particular area of the seed system, so that all interventions work towards the same set of goals around seed system health. Convening a forum among a broad group of stakeholders in the formal and farmer seed system would be an important step here, to start to learn from past experience, and develop common perspectives and goals. As suggested above, there is unlikely to be immediate consensus among stakeholders as to what constitutes a healthy seed system; in any case, fixed blueprint plans, and singular optimising goals for the seed system are likely to be inappropriate. However, there may be scope for eventually agreeing upon common principles, such as seed accessibility for the poorest, or availability of diversity. Such a forum might best start by focusing on a single region and crop.

One significant challenge to co-ordinating among different stakeholders is that both horizontal (between different sectors) and vertical (between different levels of government) links are weak in Ethiopia. This makes 'joined-up' thinking and practice more difficult to bring about. For instance, there are sometimes fewer effective links between different government agencies or research departments at the regional or *woreda* levels, and the breakdown of federal-regional responsibilities remains unclear, and subject to debate (Deressa *et al.*, 1996; Debela, 1998). However difficult and time-consuming it may be to bridge different institutional cultures, this is a necessary task, and will probably involve building a constituency of support for a different way of working.

[124] However, this is poses less of a problem for vegetative crops such as potato, where selections are cloned. Also, there may be conditions where no existing FVs or MVs perform well, when crossing and selection *in situ* with farmers is the only option; see Sthapit *et al.* (1996) or Ceccarelli (1994).

Ethiopia's institutional orientation remains largely centralised, with senior researchers and policy-making capacity concentrated in a few institutes near Addis Ababa. The smaller research stations and regional bureaucracies have far less capacity, and focus mainly on adaptive research. Redeploying senior federal expertise to remote areas is not a realistic option, as the most able staff understandably wish to remain close to the capital's infrastructure and opportunities. However, the junior staff posted at remote sub-stations such as Miesso, and the Development Agents who live in farming communities, could be involved much more in initiating collaborative work with farmers. A possible entry point for reforms is in training and supporting this cadre of junior researchers to undertake collaborative work with farmers that is decentralised, and which reflects local conditions. Appropriate support and guidance from senior staff at the major centres could add needed expertise, and potentially expand the scope of very localised work. However, in the top-down systems found in Ethiopia, the recognition of junior contributions remains a serious issue. This needs to be addressed, not just so to support more innovative work in regional research centres, but also to support the morale and enthusiasm of junior staff.

The policies and organisation of seed supply also restrict possibilities for innovative approaches. Centralised multiplication and supply constrain any responsiveness to local level needs, and policies hamper the involvement of smaller merchants. Centralised organisation, and a strict regulatory approach may constrain the release of regional-specific MVs, or MVs that do not fit variety release committees' view of quality, such as DUS. Finally, seed supply needs effectively to convey information to farmers about varieties and their traits if it is to have real impact (Tripp, 2001). A more integrated approach to seed supply should challenge existing seed policies and institutional practices, and seek to improve communications with farmers and between agencies in order to enhance the effectiveness and diversity of seed supply.

The path-dependency of breeding and seed supply practices suggest that farmer participation is unlikely on its own to change the goals or organisation of formal institutions. As Johnson *et al.* (2003: 297) found, National Agricultural Research Systems (NARS) "tended to be less influenced by lessons of participation than international centres of NGOs". High staff turnover, poor incentives, and rigid policies all constrain any shifts in research agendas or institutional structures in NARS. Thus, reforming formal sector practice will necessarily involve strategic engagement with the national institutions, and winning influence over the direction of policies relating to seed regulation, variety release, extension, and agricultural development more generally.

Most seed system reforms avoid discussing policy. However, the policy environment in Ethiopia is a significant influence on all formal seed system activities. The centralised and protective approach to planning, the emphasis on maximising aggregate yield through high input/high output strategies, and the emphasis on input packages as the main development strategy all constrain the emergence of formal-sector activities that take a different, more flexible approach. As the SG2000/NEIP case showed, productivist discourses in Ethiopia gain much of their force from the support from a network of influential actors in the international community (Keeley and Scoones, 2000). Scientific critiques from researchers in EARO or elsewhere will have difficulty on their own to shift discourses supported by strong actor networks (see Hoben, 1996; or McCann, 1999: 79-107 for other examples of environmental narratives in Ethiopia that persist in the face of contradicting evidence). To open up space for different visions of agricultural development, and to build institutional support for reforms around seed system health, it is necessary to engage strategically with key actors in institutions and policy networks. An alternative constituency that seeks more collaborative reforms to the seed system could be built from those already engaged in participatory breeding or seed supply activities in EARO, the CGIAR, and NGOs, but the support and promotion from influential policymakers in Ethiopia is also needed. The grain price collapse after 2000 may open up 'policy space' (Keeley and Scoones, 2003:22) to allow different agricultural development strategies to be considered, and draw support from the participatory experiences that are now starting to emerge in Ethiopian agricultural research.

Thus, effective integration of farmer and formal seed needs to confront policy and institutional challenges, as well as technical and methodological ones. Co-ordination of efforts among different stakeholders offers a potentially fruitful way forward for this. If reforms are to have lasting impact on ongoing debates within policy and institutions, they also need to become part of the institutional culture. Working with farmers is gradually gaining recognition within institutions in Ethiopia's formal seed system as a valid approach which can generate useful results. However, building and maintaining a broad constituency of support for such work, both among senior management, and within the teams working directly with farmers seed systems, will be necessary to support this work. Developing the skills and perspectives for understanding seed systems and identifying appropriate reforms, and building relationships among different stakeholders to co-ordinate a range of seed system reforms, may prove to be the biggest challenges to effective integration of seed systems in Ethiopia.

I close by listing a brief summary of some of the reform suggestions from this closing chapter:

- Encouraging regular interaction between the key agencies in the formal seed system (breeding, seed supply, extension, and related policymakers), with an aim to develop a more shared analysis of problems and co-ordinate reform activities; farmer representatives should also be involved in agenda-setting
- Giving more emphasis to breeding for low-input growing environments; this involves working with GxE interactions, and using new breeding approaches, such as selection in target environments
- Organising events to facilitate the exchange of germplasm and information, such as regional seed fairs, or demonstration plots of collected material
- Consideration of approaches to decentralise formal seed supply, through collaboration with merchants and others in the informal sector, to increase the availability of MV seed
- Uncoupling the provision of MV seed in extension programmes from other management requirements
- Reconsidering seed policy for semi-subsistence crops like sorghum, so that the criteria for variety release and certification are not too restrictive; considering intermediate 'farmer-certified' category seed
- Stimulating more attention to seed physical and genetic quality in farmer seed systems, with a view to encouraging practices that are effective in maintaining quality

7.5 Conclusions

Access to seed of appropriate genetic and physical quality is a central issue in agricultural development. Whether from FVs or MVs, farmers need to "get genes" in order to respond to changing environmental and socio-economic conditions; this is particularly so with sorghum as a staple in low-potential areas. Growing interest in reforming formal breeding and seed supply reflects a widespread view that these activities could, in many situations, be more effective in supporting farmer livelihoods. Most reforms to date, however, generally focus on changing only one component of the system, and usually do not engage with social or institutional aspects. This thesis has sought to consider the entire seed system, both formal and farmer, and addressed five main areas: the farming system and its effect on sorghum seed needs, the practices of formal breeding, formal seed supply, farmers' seed exchange, and farmers' activities to maintain and improve seed quality. Within these activities, I considered how practices were shaped by agroecology and knowledge, as well as social relations, institutional factors, and policy. This broad approach reflected upon the main strategies for reform to date, and sought a wider, systems perspective on both formal and farmer activities in crop genetic resource management, with sorghum in Ethiopia as a case study.

Considering the entire seed system allows us to take account of some of its complexities. Agroecological conditions vary considerably in space and time, and interact with institutions and social relationships that can also be highly specific. Crucial aspects of the seed system, such as farmer access to seed and information, or the establishment of formal breeding goals and interpretation of trial results, provide examples of how biophysical and social factors interact. While the physical and genetic quality of seed for a given environment remains essential, social processes also influence access to seed, or the 'path dependant' nature of a research programme. This thesis has highlighted some of the limitations of trying to reform seed systems on the basis of simple conceptual models that take little account of policy or institutions. For instance, they may miss the main cause of low impact, and have little influence on wider institutional practices. Yet, to take account of the level of complexity in seed systems remains difficult. Though there is interest in trans-disciplinary analysis of seed systems, there are few empirical studies that have taken this approach. This thesis has contributed a grounded, empirically-based analysis of a seed system, but should be seen as a preliminary attempt to account for system complexity. Complexity on such a scale will always be hard to deal with, and universal or invariant system goals will remain elusive. System function or 'health' is one possible approach to considering the whole system, though other language from adaptive management and 'soft systems' thinking (Leeuwis and Pyburn, 2002; Jiggins and Röling, 2000) might be equally helpful in future analysis and discussion.

The thesis has shown that there are many different entry points for reforming or reorganising a formal seed system with the aim of better service delivery for marginal farmers, besides PVS or market-driven reforms. The practices of Ethiopia's formal seed system for sorghum are technically impressive, and the strengths of the formal system could help improve farmer access to diversity, seed security, and scope for innovation. The farmer seed system still dominates for this crop; supporting farmers' practices, and strengthening ties between farmers and with other stakeholders in the seed system, could also offer important ways of improving seed system function, and ultimately support farmer livelihoods. This study suggests that there is no single best way for integration to occur. Rather, a range of strategies will probably be needed, tailored to an analysis of the specific seed systems of a given crop and country. The complexity of seed systems is not a good reason to treat them mechanically, focusing on one components while leaving others areas in a black box. The growing interest in local genetic resource management, and in revitalising research and development systems hopefully will spur more research into formal and farmer seed systems, and into the properties and processes that make them function well. However, the real challenges to reforming seed systems go beyond any difficulties of analysis and interpretation: the complicated logistics and economics of seed supply, difficulties for scaling up locally-specific work, long-term stresses to farmer seed systems in Ethiopia, and trends in institutions and policy all represent significant hurdles. If reforms are to endure and be effective, they will need to engage with policy narratives around agricultural development, and with institutional cultures in the formal seed system. This remains a daunting task, but the poverty and chronic stress Ethiopian farmers face underscore the urgency of facing up to the challenge.

Appendices

Appendix A. Brief overview of the Ethiopian Revolution.

The crisis of agrarian underdevelopment, and the social structure, eventually weakened the imperial regime in rural areas. Though Haile Selassie's bureaucratic modernisation aimed to undermine the power of the traditional nobility and landed élite, they retained considerable influence in rural areas, as, with the growing dissatisfaction of peasants, and or urban-dwellers, the élite classes remained his main (and in the South, his only) source of political support in the rural areas (Marakakis and Ayele, 1986). Most landlords had little source of wealth other than extraction from smallholders, as few of this class invested capital in enterprise, concentrating on government (Halliday and Molyneux, 1981; Lefort, 1983). This left most landlords vulnerable, as they were economically dependant on their tenants. Absentee landlords, and notably those in the South (where few smallholders had secure tenure, or social ties with the noble classes) were especially vulnerable (Pausewang, 1983). As the authority of the State, and the power of the nobility waned, change was swift in the rural areas, particularly the South.

A failed *coup d'état* in 1960 marked the beginnings of more open opposition to the Imperial government. From January 1974, low-ranking soldiers organised a string of successful insurrections to protest their conditions. As this escalated towards a crisis, Prime Minister Aklilu Habtewold and his Cabinet voluntarily resigned in late February, in the hope that a show of reform would bring calm. On the contrary, this "hinted at panic and weakness in the palace which soldiers and civilians would fully exploit in the coming months" (Ottaway and Ottaway, 1978: 3). This touched off a "creeping revolution", and students, teachers, taxi drivers, Muslims, organised workers all took to the streets in general strikes and increasingly militant expressions of dissent (Marakakis and Ayele, 1986; Donham, 1999). Moving beyond particular demands, an increasingly politicised group of middle-ranking soldiers and NCOs formed the Co-ordinating Committee for the Armed Forces, which was eventually to develop a radical political agenda for the entire country; *Dergue*, an Amharic word for committee, came to refer both to this secretive committee as well as to the regime it created. In the ensuing months, the *Dergue* arrested Aklilu, his cabinet, senior generals, and others in the nobility and élite. The *Dergue* further weakened the Emperor by dismantling Imperial institutions and subverting his new Cabinet's attempts at reform. Finally, they took advantage of urban-dwellers' anger at runaway inflation (80% for food in 1974; Lefort, 1983), and at the official cover-up and half-hearted response to the horrific 1973/74 famine, which killed at least 200 000 in the North and the lowlands. The belated government response had little effect as "it could not overcome profiteering, corruption, and the refusal of local and provincial government to waive taxes, and it was unable to divert grain exports to relief agencies (Marcus, 1994: 182)." The anger in the cities was such that, when Haile Selassie was finally arrested and deposed on 12 September 1974, there was almost no protest (Marcus, 1994).

As the *Dergue* formally took power, it still faced power struggles both internally, and with civic groups. Its ideology was developed as it consolidated power, forming uneasy alliances with movements of politicised intellectuals. The most significant of such groups were students and intellectuals associated with Haile Selassie University in Addis Abeba, and those returning from study in Europe or North America. These groups generally pushed for a transition to a democratic, and socialist, republic, and were noted for their ideological zeal (Halliday and Molyneux, 1981; Marakakis and Ayele, 1986; Wolde Giorgis, 1989). The *Dergue* tried to subvert its increasingly left-wing critics by appropriating their rhetoric and policies, including land reform and socialism (e.g. Provisional Military Government (Ethiopia), 1976). This dialectic of opposing groups competing to be the most left (and thus, modern, since the activists viewed the former US-allied regime, and it traditions, as "backwards") effectively ratcheted the politics of both the *Dergue* and their critics to be far more radical than they likely would have been on their own (Donham, 1999).

To maintain control, the *Dergue* engineered the installation of loyal cadres as leaders of urban dwellers and peasant associations (*kebelles* and PAs, respectively), operating as informers, propagandists, and thugs. This struggle for hearts and minds was waged via propaganda, particularly against populist leftist organisations trying to convert themselves into mass organisations, pressing for democratic socialism and opposing the machinations of the *Dergue*. This struggle culminated in the 'Red Terror' in 1977-78, where the *Dergue* moved to eliminate internal dissidents, particularly urban educated youth aligned with left-wing parties such as the Ethiopian Peoples Revolutionary Party (EPRP). Searches, arrests, and summary executions of thousands of youth followed, touching off bloody armed conflict in urban centres across the country. To reclaim the corpses of youths executed by the *Dergue*, families sometimes had to pay for the bullets used to execute them (Marakakis and Ayele, 1986: 167n). In early May 1977 alone, the government executed 1000 in the capital, leaving their bodies on the streets. Eventually, most organised opposition to the *Dergue* was crushed, and Ethiopia's main external ally had shifted from the USA to the USSR. These grisly events cemented the ideology and power of an inner circle of radicals in the *Dergue*, and traumatised the educated and urban population; few contemplated open dissent after 1978 (Donham, 1999: 15-35; 130-136). By this point, Colonel Mengistu Haile Mariam and an inner circle of hard-liners were firmly in charge of the *Dergue,* and of the country (Lefort, 1983; Marcus, 1994; Marakakis and Ayele, 1986).

Appendix B. Sorghum germplasm introduction and screening results in ESIP, 1974-82.

	Collection	Requested by ESIP?	No. lines	No. advanced	Immediate fate *	Comments
1975	Total introductions 1974/75	No	2000	~100	CB & ASS	
1975	Germplasm collection	?	1800	?	CB & ASS	Preliminary results: more information needed
1976	Germplasm collection	?	795	44	11CB78; 23 anthrac.resis; 10ASS	10 of 14 regions covered; 17% did not set seed in highlands
1976	Other collections	?	1300	27	ASS77: of this, one to ASS78	Described in 1977; may include ESGPC 76
1977	Germplasm collection	?	164	?		Collected from Shewa, Gojjam, Welo
1977	Int'l Sorghum Population Progeny Trials	No	722	85	85 selected	Standard trial, sent out to NARS; some Texan lines thrown in
1977	Int'l Grain Grass Sorghum trial	?	25	0	0 selected	Discontinued this pursuit
1977	Int'l Striga-resistant nursery	No	50		Further investigation	
1977	Sorghum elite progeny nursery	No	72		Will try again in lowland	F_4s from parents with wide adaptation and grain mould tolerance
1977	Int'l sorghum grain mould nursery	No	27	4	CB78 and ASS	All race *kafir* from South Africa
1977	Int'l sorghum leaf disease nursery	No	25	1	CB78	
1977	Int'l sorghum disease and insect nursery	No	30	3	CB78, and hybrid program	
1977	West African population crosses	Yes	13	1	CB78	Wanted later –maturing sorghum with good grain quality
1977	Early IS numbers	Yes	88	5	CB78 or YT	Wanted something with maturity under 100 days
1977	Broomcorn varieties	Yes	29	5	further evaluation	Sought 'broom' types for cottage industry. Not pursued.
1977	Type collection'	Yes	60	4	CB78	No initial plans to select, but included these after observations
1977	Int'l Cold Tolerance Sorghum Adaptation Nursery	?	144	0		Poor comparison with local élite lines (FVs)
1977	Sudanese selection	Yes	150	4	2 CB78, 2 for more observations	Request to NARS by L. House in ALAD (Beirut)
1977	FAO regional cooperative sorghum yield nursery	No	16	1	ASS	Near-east origin: out-performed by local check
1978	IS numbered 'Ethiopian' collections	Yes	1073	0	further evaluation in lowlands	All too short/early for highlands; contaminated or dubious ID?
1978	Int'l sorghum preliminary yield trial 1, 2 and 4	No	290	17	CB79	200 were only planted at Kobo, which failed, due to drought
1978	Int'l Striga Resistant Nursery	No	81	0		Poor performance against *Striga* and drought
1978	International Sorghum Grain Mould Nursery	No	30	0		Poor agronomic performance
1978	Int'l Sorghum Leaf Disease Nursery	No	30	0		Poor adaptation to high altitudes
1978	Sorghum elite progeny nursery	No	48	0		Moisture stress (Kobo) or poor adaptation (Alemaya)
1978	Indian Hilly Sorghum	Yes	81	58	ASS	Specific request for high-altitude material: none used in long term
1978	South African Kafirs	Yes	278	17	ASS	" " " " " " "
1978	Cameroon Collections	Yes	22	14	ASS	" " " " " " "
1978	Working Collection selection	?	14	1	ASS	" " " " " " "
1978	Int'lFood Grain sorghum yield trial	No	26	11	ASS	John Axtell and Gebissa Ejeta selected
1978	Purdue 954 thousand series	No	16	0		'zerazera' types from Gambella, but poor expression
1978	Texas sorghums	?	177	24		
1978	Uniform Sorghum Adaptation Trial	?	16	1		
1978	Lowland Tropical Sorghum Selection	?	249	5		
1978	cool-tolerant sorghums	?	28	0		

1978	Upper-Volta collection	?	39	1		
1978	Nigerian sorghums	?	7	0		
1978	Kenyan sorghums	?	171	1		
1978	Sorghums from GB Pant U.	?	6	1		
1979	Int'l sorghum preliminary yield trial1&2	No	90	9	ASS/CB	Kobo/Miesso too dry to evaluate most
1979	Int'l sorghum drought resistant observation nursery	No	37	0		Went through two drought-resistant test screens at ICRISAT
1979	Sorghum elite progeny observation nursery	No	60	9	ASS/CB	Adapted x mould-resistant: too dry at Kobo to evaluate
1979	Int'l sorghum leaf disease nursery	No	30	0		Mostly sterile
1979	Int'l sorghum grain mould nursery	No	30	0		" "
1979	Int'l sorghum stem borer nursery	No	20	0		Kobo too dry to evaluate
1979	Int'l Striga resistant sorghum trial-3	No	45	5	ASS/CB	Striga at Kobo and drought: poor expression
1979	Striga virulence test-1	No	15	2		" " " " " "
1979	low-stimulant lines	No	196	3	ASS	" " " " " "
1979	Striga working collection	No	585	9		" " " " " "
1979	F_3 progeny bulks	No	197			" " " " " "
1979	RS1 x VGC improved lines trial	No	40	3		Kobo too dry to evaluate: results of breeding at ICRISAT
1979	Sorghum lines from Introgression project	No	135	1		
1979	F_3 bulk lines from populations	No	29	7		
1979	Int'l cold tolerance sorghum adaptation nursery	No	15	0		Poor performance at Nazareth
1979	Elite P-721 lines	Yes	38	3		Evaluating high protein lines
1979	Elite observation nursery	Yes	175	3		
1980	Int'l sorghum preliminary yield trial1&2	No	65	8	Preliminary Yield Trial 1981	
1980	Sorghum elite progeny observation nursery	No	39	7		
1980	Int'l sorghum preliminary hybrid trial	?	25	0		*Quelea* bird attack
1980	ICRISAT sorghum preliminary hybrids	?	42	0		" " "
1980	Preliminary sorghum yield trial 1&2	?	36	1		
1980	A&B lines (F1 hybrid production)	?	16	0		Poor performance
1980	Breeding stocks	?	21	2	Initial screening of hybrids, 1981	
1980	Sweet sorghum lines	?	6	1		US Department of Agriculture source
1980	Int'l Striga resistant sorghum trial	?	14	0		Upper Volta source
1980	F_5 progenies of IS8686 and N13 crosses	?	143	5		
1980	Basmatic sorghums	?	2	0		
1981	Sorghum preliminary hybrid observation	No	36	0		Hybrids in bad section of field: poor performance
1981	Int'l coordinated sorghum hybrid trial-1&2	No	45	0		" " " " " "
1981	Int'l coordinated sorghum variety trial	No	25	10		Selected in 1982
1981	Int'l sorghum preliminary yield trial-1	No	25	13		
1981	Int'l sorghum preliminary yield trial-2	No	27	5		
1981	Int'l testing of Striga-resistant sorghums	No	32	4		Selected in 1982
1981	Sorghum elite progeny observation nursery	No	48	18		" " "
1981	Int'l coordinated sorghum hybrid trial-2	No	21	0		Hybrids in bad section of field: poor performance

1981	Int'l sorghum leaf disease nursery	No	30	0	
1982	Int'l sorghum stem borer nursery	No	24		Lost to birds
1982	Int'l sorghum Striga nursery	No	19		Grown in 1983 at Kobo
1982	Int'l sorghum hybrid adaptation trial	No	23		
1982	Int'l sorghum variety adaptation trial	No	23	8	Grown in 1983

Source: ESIP Annual Reports 1974-82. (* fate of selected lines listed, if described. CB=Crossing Block; ASS = Advanced Sorghum Selection trials; YT = Yield Trials).

Appendix C. Use of cytoplasmic-genetic male sterility for generating F_1 hybrid sorghum.

Large-scale production of F_1 hybrid seed in sorghum requires three types of lines with specific characteristics, A, B, and R lines (though two-line hybrids do exist; Murty, 1995). The A line has sterile cytoplasm and produces no viable pollen. The B line, or maintainer line has normal cytoplasm, but is otherwise genetically identical to the male sterile A line. To maintain or increase the A line, it needs to receive wind-borne pollen from the B line planted adjacent. To produce the actual F_1 hybrid, the A line is planted adjacent to the R, or restorer, line. Like the B line, the R line has normal cytoplasm and can maintain itself through self-pollination. However, the R line is also homozygous for a dominant gene (*Rf Rf*) that restores fertility, regardless of the type of cytoplasm present. The A/B lines are recessive at this locus (*rf rf*) (Rooney and Smith, 2000).

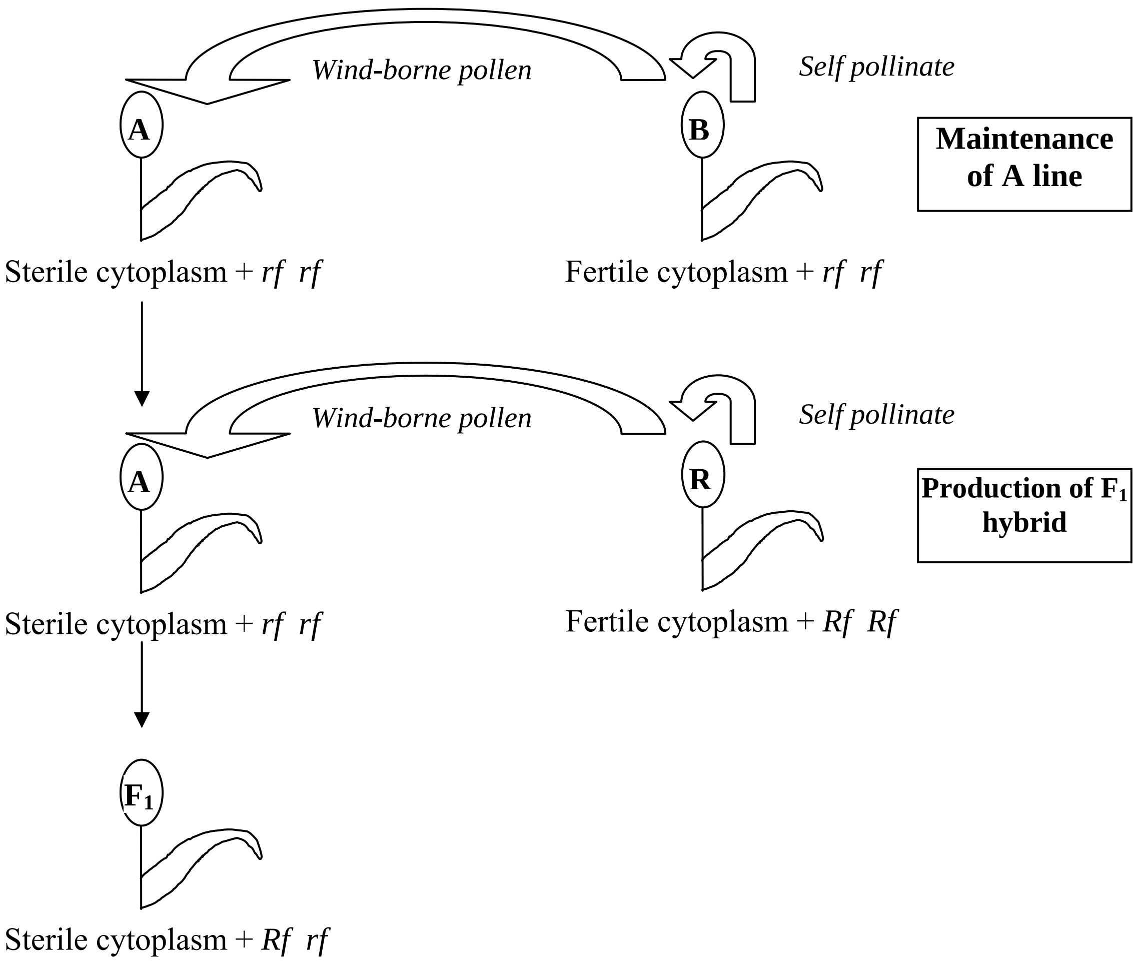

Figure C.1 Schema explaining the use of A, B, and R lines for F_1 hybrid seed production in sorghum.

Even with a good A/R combination, seed production at the field level requires flowering dates of both lines to coincide (what is called 'nick'). Since the A and R lines are usually quite different genetically, their developmental times may differ and respond in different ways to stresses, particularly when these vary within a field.

For adequate seed production, fields with the A and R lines should be monitored through vegetative development, possibly inducing stress or applying fertiliser or water on the plants of one parent, to modify its rate of development enough so that it is in good nick with the other parent. Until there is specific experience of managing the interactions of particular parents, environments, and season conditions, hybrid seed yield can be very low. House (1985) cites 50-300 kg/ha as typical.

Appendix D. Farmers' reasons for seed source preferences.

In surveys, farmers were asked, if seed from their own farm were unavailable, what would be the best and the worst source of off-farm seed, in their view. The reasons they gave for these preferences are summarised in the tables below.

Table D. 1 Reasons given for **other farmers** being the **best** source of off-farm seed.

Reasons that other farmers are best seed source	Chiro count	Miesso count
Terms of exchange favourable/flexible/simple	10	3
Reciprocity; we know them, are related to them	9	3
Variety choice is adapted/appropriate/wide	6	7
Supply is timely	3	1
Source is nearby	2	-
Can supply the small amount I require	1	-

Table D. 2 Reasons given for **merchants** being the **best** source of off-farm seed.

Reasons that merchants are best seed source	Chiro count	Miesso count
Obtaining seed is simple (if you have money)	6	12
Supply is timely	-	2
Supply appropriate type (FV from other farmers)	-	1
Supply novel types from distant locations	1	-

Table D. 3 Reasons given for the **government** being the **best** source of off-farm seed.

Reasons that government is best seed source	Chiro count	Miesso count
Germination is good	4	2
Supply 'selected' (i.e. MV) seed	2	2
Government's power/role is to supply	3	2
Supply is timely	2	-
Supply comes with other inputs or advice	3	-
Terms of supply good (i.e. include credit)	2	-

Table D. 4 Reasons given for **other farmers** being the **worst** source of off-farm seed.

Reasons that other farmers are worst seed source	**Chiro** count	**Miesso** count
They promise, but do not always deliver	2	2
I do not believe in asking without paying	-	1
Their supply is not timely	2	-
When weather poor, nobody can supply seed	1	-
They do not have MVs, therefore uninteresting	1	-

Table D. 5 Reasons given for **merchants** being the **worst** source of off-farm seed.

Reasons that merchants are worst seed source	**Chiro** count	**Miesso** count
Price is high and unaffordable to me	7	2
Merchants are untrustworthy profiteers, or selling for money is wrong	5	
Poor germination of their seed	4	3
Varieties have unknown origins/adaptation, and can give poor results	3	1
Seed is impure	1	-
Supply is not timely	1	-
May have distant origins (not locally adapted)	1	-

Table D. 6 Reasons given for the **government** being the **worst** source of off-farm seed.

Reasons that government is worst seed source	**Chiro** count	**Miesso** count
Seed we request never arrives on time	10	6
No point requesting / the seed never comes	1	4
Seed requests and distribution through committee, not direct	1	4
Seed is not adapted	1	1
Seed is not given for free	2	-

Appendix E. Sorghum varieties in study locations.

Table E. 1 The sorghum varieties that **highland** farmers stated they grew in 1998, according to a mid-season survey, with the number naming each variety, and the percentage of the 53 farmers surveyed who had it (i.e. patch-occupancy at the household level).

Variety	Households with this variety	% of households
Gababi Adii	13	24.5
Murata	7	13.2
Cheferee	6	11.3
Abdelota	5	9.4
Cheferee Diima	5	9.4
Murata Diima	5	9.4
Murata Daalech	4	7.5
Masugi Diima	4	7.5
Bulloo Diima	3	5.7
Gababi Diima	3	5.7
Wararbi	3	5.7
Muyra	2	3.8
Abdelota Adii	1	1.9
Alixii	1	1.9
Balemilik	1	1.9
Bulloo	1	1.9
Gababi 'Open head'	1	1.9
Hadhoo Adii	1	1.9
Jelidi Daalech	1	1.9
Maleta Diima	1	1.9
Masugi	1	1.9
Murata Adii	1	1.9
Muyra Diima	1	1.9
Tiquree	1	1.9
Tomis Diima	1	1.9
Wararbi Adii	1	1.9
Wararbi Diima	1	1.9
Wogere Adii	1	1.9
Wogere	1	1.9

Table E. 2 The sorghum varieties that **lowland** farmers stated they grew in 1998, according to a mid-season survey, with the number naming each variety, and the percentage of the 41 farmers surveyed who had it (i.e. patch-occupancy at the household level).

Variety	Households with this variety	% of households
Masugi Diima	16	39.0
Abdelota Diima	8	19.5
Masugi	7	17.1
Masugi Adii	6	14.6
Sarude	4	9.8
Abdelota	3	7.3
Harka Bas	3	7.3
Masugi Daalech	2	4.9
Jelidi Adii	1	2.4
Jelidi Diima	1	2.4
Jelidi	1	2.4
Qillee Adii	1	2.4
Muyra Diima	1	2.4
Sarude Adii	1	2.4
Wacheela Adii	1	2.4

Table E. 3 Sorghum varieties on 15 farms in Funyaandiimo FA, based on field observations at harvest time, and the percentage of these households who had it (i.e. patch-occupancy) (***** Variety name unknown to farmer.)

Variety	**Households with this variety**	**% of households**
Wogere Diima	11	73.3
Tiquree	9	60.0
Muyra	8	53.3
Wogere Adii	7	46.7
Hadhoo	7	46.7
Zengada	5	33.3
Cheferee	4	26.7
Muyra Adii	4	26.7
Daslee	2	13.3
Qirimindahi	2	13.3
Unknown *	**2**	**13.3**
Wararbi Diima	2	13.3
Wogere Adii 'Murata'	2	13.3
Chalee	1	6.7
Gababi	1	6.7
IS2284 (MV)	1	6.7
Masugi Diima	1	6.7
Murata	1	6.7
Muyra Diima 'Goruu Geddu'	1	6.7
Muyra Diima 'Ituu'	1	6.7
Wararbi Adii	1	6.7
Wogere Adii 'German'	1	6.7
Wogere Bullo	1	6.7

Table E. 4 Sorghum varieties on 21 farms in Miesso area, based on field observations at harvest time, and the percentage of these households who had it (i.e. patch-occupancy). (***:** Variety name unknown to farmer. **†:** One farmer supplied three different variants of *Qirimindahi*, and considered them distinct from the 'standard' FV.)

Variety	Households with this variety	% of households
Masugi Diima	13	61.9
Unknown *	**9**	**33.3**
Masugi Adii	8	38.1
Wacheela	8	38.1
Masugi Daalech	7	33.3
Sarude (MV)	7	33.3
Chaalee	4	19.0
Sarude Adii (MV)	4	19.0
Sarude Diima (MV)	4	19.0
Qirimindahi	4	19.0
76 T1#23 (MV)	3	14.3
IS9302 (MV)	3	14.3
Qillee	2	9.5
Tejjo	2	9.5
Qirimindahi 'orange'†	1	4.8
Qirimindahi 'red'†	1	4.8
Qirimindahi 'blue'†	1	4.8
Demee Segel	1	4.8
Ahmed Isee (MV)	1	4.8
Abdelota 'Alaa'	1	4.8
Ama Jigitta	1	4.8
Daslee	1	4.8
Fandisha	1	4.8
Filatta	1	4.8
Gambella (MV)	1	4.8
Jammal Abdalla	1	4.8
Yemeni	1	4.8

Table E. 5 Varieties used in taxonomy trials in Funyaandiimo FA, showing their grouping for use with farmers, with the name and stalk sweetness as stated by the donating farmer.

Group	Name given by donor	Juicy stalk?	Donor farmer	Collection location	Coll. No.
Muyra	*Muyra Diima 'Goruu-Geddu'*	No	YMA	Balina	59
	Muyra Diima 'Ittu'	No	"	"	60
	Muyra Diima	No	AA	Hulla Hulloo	62
	Muyra Adii	No	"	" "	63
	Muyra	Yes	IA	" "	55
White	*Wogere Adii*	?	IMY	Balina	12-1-5
	Daslee	?	IA	Hulla Hulloo	54
	Murata Adii	No	BN	Qalewa	82
Red	*Bulloo Diima*	No	YMA	Balina	58
	Masugi Diima	Yes	KW	Seqeree	70
	Meta	Yes	SBB	Dheefo	68
	Wogere Diima	No	SMA	Selale	72
	Murata Diima	Yes	BN	Qalewa	81
Wararbi	*Wararbi Diima*	Yes	MAA	Funyaandiimo	71
	Wararbi Diima	Yes	DM	Dheefo	80
	Wararbi Diima	No	SJT	Dheefo	74
	Wararbi Adii	No	"	"	75
Other	*Chalee*	No	ADO	Hulla Hulloo	53
	Jengaa	No	BA	Funyaandiimo	56
	Hadhoo	No	AA	Hulla Hulloo	64

Table E. 6 Varieties used in taxonomy trials in Melkaa Horaa FA, showing their grouping for use with farmers, with the name and stalk sweetness as stated by the donating farmer.

Group	Name given by donor	Juicy stalk?	Donor farmer	Collection location	Coll. No.
Qirimindahi	*Qirimindahi* 'blue'	No	AH	Arkoncha FA	17
	Qirimindahi 'red'	Yes	"	"	18
	Qirimindahi 'orange'	Yes	"	"	19
	Qirimindahi 'brown'	Yes	"	"	20
Red Trial	*Masugi Diima*	Yes	YSR	Harchaffeta FA	10A
	Ahmed Isee (IS2284)	Yes	DA	Gorbo FA	49
	Abdelota Diima 'Boruu Odaa'	Some	JY	Luleha FA	34
Chalee	*Chalee*	No	MA	Rekete	3
	Unknown	No	AH	Arkoncha FA	22
	Amaa Jigitta	Yes	BAS	Hussee	12
White seeded	Unknown	No	BAS	Hussee	14
	Torserawit	Yes	TSM	Biililoo FA	47
	Qiilee	Some	UAA	Hussee	51
Brown seeded	*Baqqar Boqee*	Yes	AR	Hama Resa FA	41
	Baqqar Boqee	No	"	" "	42
	Tejjo	No	JA	Miesso	37
Unknown	Unknown	No	HG	Chacholee FA	24
	Unknown	No	STT	Toquuma FA	26

Appendix F. Individual farmer selections in selection simulation

Table F. 1 For the selection simulation exercise in Funyaandiimo (Chiro), the mean and standard deviation of the population from which 11 farmers selected, and the mean values for each farmer's selection, at 30% intensity, as well as the mean selection differential (S) across all traits.

Character	**Base population**		**Mean of each farmer's selections**										
	mean	**Std. Dev.**	**IMY**	**AAM**	**SA**	**IA**	**NE**	**HH**	**AA**	**ADO**	**JA**	**MY**	**AI**
Fresh plant biomass (g)	**1061.3**	523.6	1151.0	1019.8	1190.8	905.0	1032.5	1019.8	1148.3	1225.8	921.5	956.5	1440.8
Plant height (cm)	**344.0**	39.6	340.8	332.7	351.3	353.3	347.8	332.7	353.8	356.2	352.0	326.8	368.0
Panicle weight (g)	**202.9**	137.9	325.0	319.2	329.2	219.2	265.0	319.2	283.3	320.8	237.5	270.0	360.8
Panicle length (cm)	**177.6**	37.4	210.2	202.2	202.3	173.0	182.8	202.2	184.8	197.7	190.5	185.7	217.2
Panicle width (cm)	**113.2**	38.1	145.6	143.7	142.8	112.3	125.7	143.7	132.5	138.8	126.7	133.5	153.5
Threshed grain wt. (g)	**121.0**	105.4	229.4	219.8	229.9	138.3	169.6	219.8	173.8	210.8	162.6	169.5	243.0
Grain # / panicle	**3425.5**	3754.8	6706.4	6328.8	6537.0	3294.0	4046.0	6328.8	4020.7	6181.0	3722.2	4567.8	6759.3
1000 grain weight (g)	**37.0**	8.7	39.7	39.8	40.1	41.6	41.2	39.8	43.4	39.0	43.4	39.0	41.2
Mean S across all traits			**0.61**	**0.50**	**0.63**	**0.07**	**0.26**	**0.50**	**0.39**	**0.56**	**0.26**	**0.20**	**0.89**

Table F. 2 For the selection simulation exercise in Melkaa Horaa (Miesso), the mean and standard deviation of the population from which 8 farmers selected, and the mean values for each farmer's selection, at 30% intensity, as well as the mean selection differential (S) across all traits.

Character	**Base population**		**Mean of each farmer's selections**							
	mean	**Std. Dev.**	**NME**	**AAS**	**MYB**	**ME**	**MAM**	**JAG**	**HIA**	**ANA**
Fresh plant biomass (g)	**398.3**	193.7	452.0	549.0	602.0	478.0	602.0	569.0	455.0	601.0
Plant height (cm)	**207.6**	37.7	232.0	242.6	249.0	225.2	249.0	233.6	203.8	233.2
Panicle weight (g)	**104.0**	53.1	112.0	147.0	164.0	126.0	164.0	148.0	120.0	154.0
Panicle length (cm)	**106.7**	19.6	106.4	123.4	125.0	105.6	125.0	120.0	112.2	118.6
Panicle width (cm)	**65.1**	13.4	66.0	74.4	75.6	67.0	75.6	71.0	65.8	71.0
Threshed grain wt. (g)	**63.9**	36.5	75.0	97.5	108.4	77.7	108.4	96.1	79.8	98.0
Grain # / panicle	**1252.5**	647.5	1548.8	1793.4	1986.4	1481.8	1986.4	1687.2	1483.8	1743.8
1000 grain weight (g)	**51.4**	11.5	48.8	55.7	55.7	50.7	55.7	58.0	52.0	56.4
Mean S across all traits			**0.2**	**0.7**	**0.9**	**0.2**	**0.9**	**0.7**	**0.2**	**0.7**

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Samenvatting

Plantenveredeling en zaadvoorziening spelen een kernrol in landbouwontwikkeling, waarbij een groot aantal uiteenlopende organisaties voor onderzoek, zaaizaadproductie en voorlichting actief zijn. Ontwikkelingslanden besteden een groot deel van hun overheidsuitgaven aan pogingen om verbeterde gewasvarieteiten te ontwikkelen en vervolgens te leveren aan boeren. Deze pogingen worden echter om veel redenen bekritiseerd; vanwege het geringe adoptie van verbeterde varieteiten (vooral in Afrika, waar landbouwsystemen vaak onder grote druk staan of divers zijn), vanwege de versmalling van de genetische basis van landbouw, en vanwege de beperkte rol die boeren in het onderzoeksproces spelen. Recentelijk hebben zulke kritieken geinspireerd tot hervormingen, zoals in de vorm van Participatieve Plantenveredeling (Participatory Plant Breeding, PPB) en gedecentraliseerde zaadvoorziening, welke als doel hebben de verbetering van praktijken door meer participatie van boeren. Deze alternatieve benaderingen kennen hun successen, maar er zijn belangrijke hiaten in de analyses die hen ondersteunen. De meeste van de hervormingen hebben een ‘modulaire’ focus, en geven aandacht aan veranderingen in een enkel gebied van gewasverbetering of zaaizaadvoorziening (zoals bijvoorbeeld het verbeteren van de kennis van de wetenschappelijke veredelaar over de criteria die boeren hanteren om nieuwe soorten te kiezen, of de lokale beschikbaarheid van het zaaizaad), zonder noodzakelijkerwijs te analyseren hoe een veranderingop een dergelijk praktijkgebied zich verhouden tot andere praktijken van gewasverbetering. Het risico hiervan is dat belangrijke interacties tussen plantenveredeling en zaadvoorziening gemist worden. Bovendien, de meeste hervormingen sluiten slecht aan bij de gangbare boeren praktijken ter verkrijging, uitwisseling en selectie van zaaizaad, ten dele omdat er nog steeds weinig empirisch begrip bestaat omtrent deze praktijken. Tenslotte zijn er veel hervormingen die niet de rol van instituties analyseren of de bredere beleidscontext, waarmee het risico gelopen wordt dat veranderingen in instituties of praktijk mislukken of niet duurzaam blijken te zijn. Zonder een voldoende brede analyse van de huidig context zullen hervormingen met het oogmerk om participatie van boeren te bevorderen inadequaat zijn om de principiele problemen in gewasontwikkeling en zaadaanbieding het hoofd te bieden.

Dit proefschrift benadert daarom pogingen tot gewasverbetering, èn de huidige praktijk van boeren met behulp van een systeem-analyse als een basis om na te denken over mogelijke hervormingen. Deze analyse concentreert zich niet op een geïsoleerde activiteit, maar op het gehele zaadsysteem van een gewas. Een zaadsysteem omvat alle praktijken en instituties die te maken hebben met plantenveredeling en zaadvoorziening, alsmede de daaraan gerelateerde regelgeving. Dit proefschrift geeft bovendien gelijke aandacht aan het *formele zaadsysteem*, gehuisd in onderzoek- en ontwikkelings-instituten, en het *boeren zaadsysteem*, waarin de zaaizaadruil en -selectieactiviteiten van boeren plaatsvinden. Een paralelle analyse van beide systemen kan een beter basis geven voor de hervorming van zaadsystemen die een effectieve samenwerking tussen boeren en wetenschappers tot stand kunnen brengen. Deze methode onderstreept de sterke en zwakke punten van beide systemen, en analyseert de technische en sociale context waarbinnen mogelijke verbindingen tussen de formele en boerensystemen te identificeren zijn. Deze analyse gebruikt sorghum in Ethiopië als casus. Onderzoek in de openbare sector in Etiopië geeft prioriteit aan de promotie van landbouwontwikkeling, met een kernrol voor de Ethiopische Organisatie voor Landbouw Onderzoek (Ethiopian Agricultural Research Organisation, EARO). Sorghum (*Sorghum bicolor* [L.] Moench) is een belangrijk gewas in Ethiopië voor het veiligstellen voedselzekerheid, en de zaadsystemen van boeren hebben in dit land een zeer brede genetische diversiteit. Het formele zaadsysteem in Ethiopië heeft een geavanceerd programma van sorghumveredeling, maar de impact is laag.

Zaadsystemen van sorghum in Etiopië bieden daarom een bijzonder nuttig voorbeeld om de mogelijkheiden en uitdagingen van hervormingen te analysen.

Dit proefschrift ontwikkelt een trans-disciplinair analytisch kader, waarin sociale en technische aspecten van formele en boeren-zaadsystemen voor sorghum geïntegreerd worden. Het heeft als doel om verder te gaan dan eenvoudige modellen ten einde de rijkdom en complexiteit van deze systemen te onderstrepen. Niet alle belangrijke acties van boeren of wetenschappers hebben hun basis alleen in bewuste theorieën, want culturele normen, gebruikelijke activiteiten, of zelfs toevallige gebeurtenissen kunnen óók een invloed op praktijk hebben. Dit proefschrift gebruikt 'praktijk' als analytisch beginpunt, maar altijd met interesse in de kennis die deze praktijken ondersteunt –empirische kennis, of kennis met een basis in sociale of institutionele relaties.Inzichten van sociaal constructionisme zijngebruikt, welke laten zien hoe categorieën die gebruikt om de materiële wereld te omschrijven (bijvoorbeeld "gewassen met hoge productie") verschillend geïnterpreteerd kunnen worden door diverse actoren. Voeg hieraan nog toe het concept van "pad-afhankelijkheid", dat aan technologieën autonomie geeft in de vorming van de structuren van mensen en instituten, en soms de vrijheid beperkt om nieuwe technologische wegen te bewandelen. Deze theoretische benaderingen zijn toegepast om de formele en boeren-zaadsystemen in Etiopië te analysen.

Hoofdstuk 2 beschrijft de twee districten waar het onderzoek van boerenzaaizaad-systemen plaatsvond. Beide zijn in West Harerghe Zone, maar zijn duidelijk contrastrerend: één district (Chiro) in het hoogland, het andere (Miesso) in het laagland. Na een beschrijving van de onderzoeksmethoden omschrijft dit hoofdstuk het klimaat en de ecologie, met de nadruk op de variatie in milieu en sociale condities, en op de ontwikkelingen van de laatste jaren. Boeren uit de hooglanden en de laaglanden zoeken zeer bepaalde groepen van sorghumvarieteiten, maar huishoudens binnen elk gebied kunnen ook aan verschillende eigenschappen van sorghum de voorkeur geven omdat hun bodem, topografie, of bestaansstrategie van elkaar verschillen. Verder brengt de variabiliteit in neerslag met zich mee dat boeren, afhankelijk van het seizoen, sorghum-varieteiten zoeken, vooral wanneer het zaaien vroeg in het seizoen in de laaglanden mislukt. Laatrijpende sorghum-varieteiten worden in dat geval tijdelijk vervangen door vroegrijpende varieteiten. Bovendien veroorzaken variatie in eigendom, vooral van runderen, verschillende strategieën op huishoudniveau om met onzekerheid om te gaan. Met een schets van risico's en de strategieën om daarmee om te gaan, geeft dit hoofdstuk een context voor een discussie over de zaadsystemen van boeren en hoe voorkeuren voor sorghum kunnen veranderen tussen seizoenen of sociaal-economische condities, twee aspecten van variatie waar hervormingen in zaaizaadsystemen niet vaak rekening mee houden. Dit hoofdstuk omschrijft daarmee de grote uitdagingen voor het sorghum-zaadsysteem in een regio, met name omtrent de toegang tot diversiteit, en de behoefte aan flexibele landbouw strategieën om om te gaan met moeilijke omstandigheden.

Hoofdstukken 3 en 4 analyseren het formele zaadsysteem in Etiopië, met respectievelijk de nadruk op sorghum-plantenveredeling en zaaizaadvoorziening. Deze hoofdstukken indentificeren de beperkingen van het formele zaaizaadsysteem in een uitgebreidere historische en institutionele context, iets wat niet altijd in gebeurt in de literatuur over zaadsysteem-hervormingen.

Hoofdstuk 3 vraagt waarom er zo weinig duidelijke adoptie is van Moderne Varieteiten (MV) van sorghum in Ethiopië, ondanks het feit dat het Ethiopisch Programma voor Sorghum Verbetering (Ethiopian Sorghum Improvement Program, ESIP) een geavanceerd technisch en organisatorisch niveau heeft. Het geeft de bredere context van Ethiopische politiek en de ontwikkeling van onderzoeksinstituten. Het hoofdstuk volgt de ontwikkeling sinds 1973 van ESIP, en hoe beslissingen vroeg in het programa huidige praktijken beïnvloeden. Deze beslissingen omvatten de identificatie van macro-ecologieën voor veredeling, germoplasma, veredelingsmethoden, en condities en praktijken op proefstations. De gecentraliseerde organisatie van ESIP was van invloed op andere programma's, en stimuleerde een sterke "groeps-identiteit" voor ESIP medewerkers, waar een klein aantal van plantenveredelaars – die allemaal in het centrum van Etiopië wonen – werk organiseren voor een enorm gebied, en die op korte selectiebezoeken gaan op proefstations ver in de provincies van het land. Sinds de jaren 60 zijn **"**input-paketten**"** een constant element in de landbouwontwikkelingsstrategie in Ethiopië, waar ideeën over een "optimaal" teeltmilieu verbonden zijn met het doel om de landelijke graanoogst te maximaliseren. Dit beleid beïnvloedt dus veronderstellingen van ESIP omtrent optimaal input- en gewasbeheer in hun veredelingsstrategieën, maar gangbare opinies over hoe te veredelen voor 'brede aanpassing' hebben ook hun invloed. Gangbare verhalen, en de technologische 'pad-afhankelijkheid' die hiermee zijn verbonden (bijvoorbeeld, in de keuze van germplasme, veredelingsstrategieën op de lange termijn, en de plaatsing van proefstations), betekenen dat veranderingen van instituties in gevestigde programma's zoals ESIP moeilijk zullen zijn, zeker moeilijker dan de hervormingsliteratuur veelal suggereert. Het is niet waarschijnlijk dat hervormingen gebaseerd op Participatieve Plantenveredeling waarbij wetenschappelijke veredelaars en boeren elkaar ontmoeten voor een dag op een station, de grootste problemen omtrent ESIP's impact op zullen lossen. Noch is de kans groot dat zulke hervormingen een prikkel vormen voor duurzame institutionele veranderingen. Om dit te laten gebeuren, zullen we verder moeten kijken dan de onmiddelijke kennis en praktijken van individuele veredelaars, en liever denken over beleid en institutionele organisatie. Bijvoorbeeld, de scheiding tussen plantenveredeling en zaadaanbieding vermindert de kennis van veredelaars over de invloed van hun producten. Verder kan de gecentraliseerde organisatie van ESIP, met zijn groep-structuur en processen voor evaluatie van onderzoek – alhoewel belangrijk om een collectieve identiteit en missie te bevorderen –innovatieve veranderingen in de weg staan. Hoofdstuk 3 stelt dat de principiele uitdagingen voor hervormingen zijn: het vinden van nieuwe manieren om de veredeling en van ondersteunende instituties zodanig te organiseren dat technische organisatie en striktheid garandeerd zijn, terwijl nieuwe, meer flexibele strategieën voor gedecentraliseerde veredeling kunnen verschijnen die better passen bij de huidige situatie van boeren.

Hoofdstuk 4 toont het belang aan van zaaizaadvoorzieningsinstituties om de invloed van formele veredeling te begrijpen. Dit hoofdstuk onderzoekt de uitdagingen van de formele zaaizaadvoorziening met betrekking tot de schatting van de omvang van de vraag, de invulling van het aanbod, en de ontwikkeling van passend beleid om toegang en kwaliteit te controleren. Zaaizaadvermenigvuldiging in Ethiopie loopt tegen belangrijke risico's aan; niet alleen qua opslag en de controle van kwaliteit, maar ook ten aanzien van de logistieke problemen van vermenigvuldiging over meerdere seizoenen op enkele grote gecentraliseerde (en meestal in het hoogland gelegen) zaaizaadproductieboerderijen, om de verspreide en anti-cyclische vraag te kunnen invullen. Regelgevende instituten maken in feite een soort van "institutionele selectie" in de resultaten van veredeling; de Commissie voor Varieteiten beslist welke kandidaat-MV uitgebracht zal worden, terwijl de hoeveelheid zaad van een bepaald MV dat wèl geproduceerd wordt, beïnvloed wordt door schattingen van regionale ambtenaren omtrent de gevraagde hoeveelheid, en door de locatie van zaaizaadproductiebedrijven. Het gebrek aan plaatsen voor zaadproductie in de laaglanden betekent dat zeer weinig zaad van MV van laagland-sorghum beschikbaar is, ondanks de vraag van boeren naar snel-rijpende varieteiten als het vroege regenseizoen mislukt.

Hoofdstuk 4 onderzoekt dan de huidige hervormingen van zaadvoorziening in Ethiopië, met name van programma's die proberen een vergroting van beschikbaar zaaizaad van MV door productie op kleine boerderijen tot stand te brengen, en van programma's die de vraag naar zaaizaad pogen te vergroten door een aggresieve promotie van input-pakketten. Deze programma's streven naar een hogere voorspelbaarheid van respectievelijk vraag en aanbod. Tevens streven zaaizaadregulatiehervormingen in Ethiopië naar snellere processen van het uitbrengen van MV, en naar strengere standaarden voor zaaizaadkwaliteit. Alhoewel deze doelen prijzenswaardig zijn, loopt de planning meestal van boven naar beneden, concentreren ze zich op tarwe en maïs (waarin MV-adoptie goed is), en leiden ze niet tot een systeem dat vraag-gevoelig is. Zulke hervormingen richten zich op de "hardware" van zaadsystemen, maar zien de "software" van sociale netwerken van actoren die noodzakkelijk zijn om een vraag-gevoelig systeem op te bouwen over het hoofd. Deze analyse demonstreert hoe een nadruk op vraag of aanbod in isolatie beperkend kan zijn. Een beter begrip van lokale vraag is nodig, vooral over welke boeren formele bronnen of marktbronnen gebruiken om zaad te verkrijgen, en waarom.

Hoofdstukken 5 en 6 belichten de belangrijkste processen in de zaaizaadsystemen van boeren, en de invloed van de praktijken van boeren op de eigenchappen van de systemen. Hoofdstuk 5 onderzoekt de eigen methoden van boeren om zaad te verkrijgen. Zaaizaadzekerheid is een hoofdzaak voor veel huishoudens, en het regelmatig aanbod van zaad van buiten de boederij speelt hier een cruciale rol. Andere boeren zijn een belangrijke bron, en ook lokale markten, waar de laatstgenoemden de belangrijkste aanbieders zijn van snel-rijpende sorghum-varieteiten als de zaai vroeg in het seizoen mislukt. Boeren die zaad aanbieden aan hun buren neigen meer voordeel te hebben dan de ontvangers van dat zaad, en een klein aantal bieden regelmatig grote hoeveelheden aan aan andere boeren. De hoeveelheden, het juiste tijdstip, voorwaarden (e.g. voor geld, of in ruil), en de keuze van de varieteiten die worden aangeboden zijn allemaal belangrijk voor boeren, en verschillen naar gelang de bron (markt, boer, regering), en de aard van de sociale relatie (bijvoorbeeld verwantschap of ander verband). Terwijl er een "morele economie" van zaadruil lijkt te zijn waarin iets rijkere boeren hun armere buren steunen, suggereert mijn analyse dat deze relaties aan het veranderen zijn, of zelfs aan het afbreken, omdat sociale en arbeidsrelaties in transitie zijn, en de algemene vraag naar zaad hoog is. Dus, de toegang tot zaaizaad voor een individuele huishouden en zijn voorkeur voor bepaalde bronnen voor zaad van buiten de boederij, hangen af zijn financiele of sociale voordelen; dit toont aan hoe het niveau van toegang tot zaaizaad socio-economische verschillen vertoont. Hoofdstuk 5 toont het belang van de agro-ecologische èn sociale aspecten van de lokale zaaizaadsystemen, maar ook dat de condities aan het veranderen zijn, met belangrijke consequenties voor het veiligstellen van de beschikbaarheid van zaad voor alle boeren, behalve de minst kwetsbare.

Hoofdstuk 6 behandelt het beheer door boeren van genetische hulpbronnen op een breder niveau, en onderzoekt hoe praktijken van boeren de genetische kwaliteit en fysieke kwaliteit (bijvoorbeeld gezondheid) van zaden beinvloeden. Het onderzoekt de boerenkennis en -praktijk in het geven van namen aan sorghum-soorten, hoe ze de zuiverheid van varieteiten handhaven, en de selectie en bewaring van zaad uitvoeren. Een hoog niveau van diversiteit op boederijen en een snelle 'turn-over' van varieteiten weerspiegelen een dynamisch systeem, waarin nieuwe diversiteit regelmatig geïntroduceerd wordt, maar ook weer verdwijnen. Hereboeren hebben in het verleden geholpen met het evalueren en introduceren sorghum-varieteiten voor een gebied, maar dit is tegenwoordig meer een *ad hoc* proces, omdat mensen op reis een nieuwe varieteit ontdekken, en nieuwe varieteiten verschijnen als "toevallige" introducties in samenstellingen van gemengd zaaizaad. Lokale systemen voor het toekennen van namen leggen de nadruk op belangrijke eigenschappen, en tonen de invloed van boeren aan in het beheren van 'off-types'. De complexiteit en lokale eigenheid van deze systemen van benoemen kunnen boeren echter verhinderen een specifieke varieteit te vinden. In ieder geval weten boeren vaak weinig over de lokale of regionale beschikbaarheid van varieteiten waarvan ze de namen of uiterlijke eigenschappen zouden herkennen; dit verhoogt de “transactie-kosten” om nieuwe soorten te vinden. De kennis en praktijken van boeren in zaadselectie werd ook bestudeerd. Sommige participatieve hervormingen van plantenveredeling proberen de “beste boerenpratijken” te ontwikkelen, en leggen de nadruk op samenwerking met de meest vakkundige boeren, welke als vertegenwordigers van “de beste lokale pratijk” gezien kunnen worden. Echter, de “beste praktijk” in zaaizaadselectie heeft misschien slechts een kleine invloed vanwege variaties in milieucondities of de genenuitwisseling tussen boerderijen. De extra moeite om op deze manier zaaizaad te selecteren zal wellicht ook niet toegankelijk zijn voor alle boeren. Het hoofdstuk concludeert dat interventies die innovatie in de evaluatie van nieuwe varieteiten en de beste praktijken in zaadbewaring bevorderen, meer potentie hebben dan selectiepraktijken ter ondersteuning van belangrijke processen in de boeren-zaadsystemen van West Harerghe.

Deze analyses van formele en boeren-zaaizaadsystemen geven een indruk van hun complexiteit. In beide systemen zijn plantenveredeling en zaadvoorziening sterk verbonden en reflecteren de biologische factoren (zoals de karakteristieken van soorten, of ecologische variatie) èn sociale factoren (zoals beleid, de institionele cultuur, of sociale verbindingen) die belangrijk zijn in hun vorming. Het laatste hoofdstuk bevat een beschouwing over de modulaire focus van de meerderheid van interventies die de hervorming van zaaizaadsystemen beogen. Veel hervormingen modelleren een enkel aspect van een zaaizaadsysteem, en missen dus interacties tussen factoren, de invloed van de sociale context, of de politieke of institutionele beperkingen voor effectieve hervormingen. Dit onderstreept de waarde van het brede trans-disciplinaire kader gebruikt in dit proefschrift. Het proefschrift eindigt met een discussie over het concept van “gezondheid van systeem”, gebruikt in milieusystemen, als een mogelijk kader voor analyses van hoe een zaaizaadsysteem functioneert, en ook om prioriteiten voor mogelijke interventies te identificeren. Het leggen van de nadruk op zaaizaadzekerheid voor boeren geeft een nuttig startpunt voor de ontwikkeling van indicatoren voor de gezondheid van zaadsystemen, gesteld dat diverse belanghebbende groeperingen vertegenwoordigd zijn. Op die manier kunnen individuele hervormingen van zaadsystemen beter gecoördineerd worden om nuttige interacties tussen boeren en wetenschappers te identificeren, en om de belangrijkste uitdagingen het hoofd te bieden.

About the author

Shawn Joseph McGuire (born in Woodstock, New Brunswick, Canada in 1970) attended Woodstock High School and the Lester B. Pearson United World College of the Pacific. He began his BSc studies in Biology 1989 at the University of Ottawa, focusing on plant ecology. His Honours dissertation was on the spatial dynamics of nitrogen transfer in montane spruce-moss systems in the Rockies. During and immediately after his studies, he worked in ecology laboratories at the Universities of Victoria (biogeography and taxonomy of hydrothermal vent fauna) and Calgary (forest fire disturbance), and at Agriculture Canada in Ottawa. For the latter, he was involved in modelling nitrogen dynamics and greenhouse gas production in agricultural soils. In 1994, he conducted ethnobotanical research in Ethiopia to assess the conservation risk of well-known medicinal plants there, working in association with the Plant Genetic Resource Center of Ethiopia. In 1995-96, he studied an MSc in Agriculture, Environment and Development at the School of Development Studies, at the University of East Anglia in Norwich, UK. His dissertation research there investigated the privatisation of plant breeding in the UK, and how it influenced changes in institutional relations and in the use of genetic resources.

In late 1996 Shawn joined the Technology and Agrarian Development research group at Wageningen University, with financial support from the Natural Sciences and Engineering Research Council and the O'Brien Foundation. Fieldwork in Ethiopia took place in 1998-99. During his time in the Netherlands, Shawn also worked for the Participatory Research and Gender Analysis Program of the CGIAR, helping to draft a comparative analysis of participatory plant breeding projects, and participated in several workshops on the subject. Other consultancy work with the Intermediate Technology Development Group and Overseas Development Institute took him on several visits to Kenya and Zimbabwe to assist in the design and analysis of policy-related studies on farmers and agricultural biodiversity. Shawn also advised research projects at the Food and Agricultural Organization of the UN on seed systems analysis in Ethiopia.

Since 2002, he returned to the School of Development Studies in Norwich to lecture in natural resource conservation, environmental policy, and development. His current research interests include the impact of emergency seed relief on seed security, local genetic resource management, and how projects developing 'biotechnology for the poor' shape plant breeding goals.