Chapter 4

SEED DEMAND AND SUPPLY RESPONSES

David J. Spielman and Dawit K. Mekonnen

For centuries, efforts to improve, multiply, and distribute teff seed have relied on informal mechanisms, primarily farmers' own selection of varieties exhibiting desirable yield, taste, color, or stress-resistance characteristics, and farmer-to-farmer exchanges of seed embodying these traits. It was not until the mid-20th century that Ethiopia—like many other developing countries—developed a system based on modern science to breed improved teff cultivars, distribute improve teff seed, and accelerate the contribution of genetic gain to teff yield growth across the country's smallholder farming systems. Today, these informal mechanisms still account for up to 90 percent of seed supply, with the modern infrastructure accounting for the remainder (Bishaw, Sahlu, and Simane 2008; Sahlu, Simane, and Bishaw 2008). This suggests that there are challenges still to be overcome in enhancing teff productivity—in increasing output per area, maintaining yield gains from prior investments in research, reducing yield variability within and across seasons, and increasing tolerance and resistance to biotic and abiotic stresses.

Part of Ethiopia's challenge relates to the fact that teff is a neglected species (more pejoratively referred to as an "orphan crop"). Teff is not cultivated extensively in any other country and is thus not a destination for public investment in breeding. Teff is not a food security crop of global importance and is thus not a priority crop in the international agricultural research system—unlike rice, wheat, and maize. Teff is, in effect, unable to benefit from research spillovers from public investment in national (until recently) and international plant breeding programs, international exchanges of germplasm, and modern seed supply systems.

Nor is teff improvement a destination for private investment of any sort. Consumers of quality seed for improved teff varieties are, by and large, farmers with limited purchasing power and market access, vulnerable to both price and weather shocks that make them poor customers for most seed companies. Furthermore, because teff is a self-pollinating crop—meaning that farmers can save seed and replant it the next year without significant loss in

genetic purity—private breeders and seed companies cannot appropriate the gains from investments they might make in breeding. In short, the breeding, production, and distribution of improved teff is a fairly unprofitable venture for most private companies. This is particularly the case when compared with hybrid maize, where private seed companies in Ethiopia and many other developing countries have made considerably more progress (for example, see Langyintuo et al. 2010; Morris 1998).

Yet there are other means—other strategies—through which access to improved teff varieties, quality teff seed, and the productivity benefits associated with superior genetics can be enhanced for Ethiopia's smallholders. The success of these strategies is largely determined by the institutional architecture put in place to improve, multiply, and distribute quality seed of improved teff cultivars. The strength of this architecture, in turn, depends on the extent of integration between the formal and informal seed systems as well as the roles played by the state, the private sector, and civil society actors (de Boef and Bishaw 2008). While there are lessons to be learned from successes with other self-pollinating crops such as wheat and rice (Byerlee and Dubin 2008; Dalrymple 2008), the neglected nature of teff makes for a unique case. In short, Ethiopia's challenge is to design an architecture that engages diverse actors and integrates formal and informal seed systems into a widely accessible source of continuous genetic improvement for teff.

Efforts in this direction have been pursued in Ethiopia's recent past. Projects to transition informal seed systems into more modern farmer-based seed production and marketing systems have existed in Ethiopia since the 1980s in selected areas, albeit at relatively small scales (Sahlu, Simane, and Bishaw 2008; Beshir 2005). Their contribution to genetic resource conservation, cultivar improvement, variety popularization, seed production, and seed distribution is fairly well documented (Thijssen et al. 2008). There is also an extensive literature on the contribution made by Ethiopia's formal seed system, including the contributions of public research, extension services, cooperatives, and the Ethiopian Seed Enterprise (ESE) to breeding, production, and distribution (Alemu 2010; Spielman et al. 2010; Bishaw, Sahlu, and Simane 2008).

These systems have operated both in parallel and in collaboration with a modern seed sector comprising the state's agricultural research system, extension services, area development projects, and the parastatal seed enterprise. But there are still broad policy questions about how to integrate farmer-based seed systems with the state's formal system for teff breeding, production, and

distribution. Precisely what type of integrated solutions should policy makers explore, and where should they invest scarce public resources? How will these solutions address Ethiopia's goals for agricultural development and economic growth, and how will they fit into a rapidly growing agricultural sector and national economy? Which policies encourage innovation, production, and competition in a seed system that is beneficial to both farmers who cultivate teff and consumers who rely on it as a basic food staple?

This chapter examines these questions by assessing the challenges facing Ethiopia's teff seed system. Specifically, the chapter explores the demand for teff seed and the capacity of the current system to supply quality seed for improved teff cultivars in response to demand. Several recommendations are made aimed at strengthening Ethiopia's seed system and its contribution to teff productivity growth through improved genetics. First the chapter describes the data and data sources used throughout. Next the chapter characterizes teff seed demand, highlighting the heterogeneity across regions and households. Seed provisioning strategies are then examined. The chapter concludes with policy recommendations for integrating informal and formal teff seed improvement, multiplication, and distribution systems to strengthen the supply of quality seed for improved teff cultivars to Ethiopia's smallholders.

Data and Data Sources

The data presented and analyzed in this chapter are drawn from several primary and secondary sources. Official figures on seed production, distribution, and use were collected in 2012/2013 from a variety of official documents from government agencies and personal communications with government officials. Data on seed use disaggregated by crop, season, region, and landholding size were obtained from the Agricultural Sample Surveys of Ethiopia's Central Statistical Agency (CSA) from various years. Data on seed production were obtained from the ESE and the regional seed enterprises in Amhara, Oromiya, and Southern Nations, Nationalities, and Peoples' (SNNP) region. Data on seed distribution were gathered from the bureaus of agriculture in Amhara, Oromiya, Tigray, and SNNP, and the Agricultural Input and Marketing Directorate of the Ministry of Agriculture (MoA). Data on specific teff varieties and their characteristics were obtained from the Ethiopian Institute of Agricultural Research (EIAR). These data were supplemented with observations and insights from key informant interviews, recent publications in the grey and academic literature (cited throughout the chapter), and feedback

from seed system actors that was provided at two stakeholder events held in 2013.[1]

Additional household data on seed use come from the Ethiopian Agricultural Transformation Agency (ATA) Baseline Survey that was conducted between June and September 2012 by EIAR and the International Food Policy Research Institute (IFPRI). The aim of this survey was to (1) provide baseline information on the livelihoods of agricultural households in Ethiopia, particularly in the 83 woredas where ATA focuses its attention, and (2) to generate information about the agricultural economy that will help the ATA design and implement its interventions. The sample covered 3,000 households across 100 woredas throughout the four main agricultural regions of Ethiopia (Amhara, Oromiya, SNNP, and Tigray). In each woreda 2 kebeles were randomly selected for inclusion in the survey sample, and within each kebele 15 households were randomly selected. Approximately two-thirds of the sampled woredas were drawn from the 83 woredas targeted by the ATA. The survey covers agricultural production and marketing, use of inputs, soil conservation, storage, livestock activities, nonfarm income, the role of cooperatives, and credit, among other topics, for the 2011 belg season and the 2011/2012 meher season. The survey also introduces a unique set of questions on the topic of seed use, purchasing, and sourcing at a crop-specific level. These questions improve the resolution and accuracy of standard questions relating to the use of improved, high-yielding, or modern seeds that generally do not provide sufficient information of what, where, and how frequently purchases are made in the formal seed market.

A few caveats are needed to fully contextualize the presentation and analysis of these data and the inferences and interpretations offered throughout this chapter. First, the data are not necessarily representative of all teff-producing areas or households in Ethiopia. Official data presented here only cover Amhara, Oromiya, SNNP, and Tigray regions because CSA data indicates that more than 99 percent of teff production in Ethiopia is concentrated in these four regions. Data from the 2012 ATA Baseline Survey offer even less coverage and are not necessarily representative of the sampled population described above because of low response rates to many questions relating to

1 "Seed Demand Assessment in the Ethiopian Formal Seed Sector Agenda: Results of the Draft Seed Demand Assessment Study in the Ethiopian Formal Seed Sector," workshop convened by the Ethiopian Agricultural Transformation Agency, Addis Ababa, January 3, 2013; "Improved Evidence towards Better Policies for the Teff Value Chain," conference organized by the Ethiopian Agricultural Transformation Agency, the Ethiopian Development Research Institute, the International Food Policy Research Institute, and the Ethiopian Institute of Agricultural Research, Addis Ababa, October 10, 2013.

teff seed and varieties. Moreover, since two-thirds of the 100 districts under study are from the high-potential woredas, it is possible that the figures provide values that are greater than the national average. What these data do provide, however, is an illustration of how higher-resolution household data can be used to better characterize the demand for seed and specific varietal traits that, in turn, can help shape policy and market responses aimed at accelerating the productivity gains associated with the cultivation of improved teff varieties in Ethiopia.

Seed Demand and the Teff Seed Market

The demand for teff seed is derived from several factors including, primarily, the demand for teff as a cereal for consumption but also several other price and nonprice determinants, such as farmers' weather expectations, farmers' preferences for particular traits in the cultivar, the price of complementary inputs such as fertilizer, and the availability of substitutes such as saved seed. To get a sense of the size and depth of the teff seed market in Ethiopia, it is necessary to first consider the official statistics from the CSA's Agricultural Sample Surveys (Table 4.1).

In the meher season of 2005/2006, 2.25 million hectares of land were under teff cultivation, accounting for 22 percent of the total area under grain cultivation. This made teff the single most important crop in Ethiopia in terms of area under cultivation. By 2012/2013, area under teff cultivation had increased by 20 percent to 2.73 million hectares and still accounted for 22 percent of total area under grain cultivation. On the intensive margin, teff yield has increased from 9.7 quintals per hectare in 2005/2006 to 13.8 quintals per hectare in 2012/2013. Area expansion coupled with yield improvements has led teff production to increase by more than 73 percent from 21.8 million quintals in 2005/2006 to 37.6 million quintals in 2012/2013. Though yield improvements of 4 quintals per hectare within a period of seven years is impressive, there is likely to be additional scope to increase yields with the use of improved teff varieties, traits, and other inputs. While the proportion of land under teff cultivation with fertilizer use has increased from 59 percent in 2005/2006 to 75 percent in 2012/2013, the corresponding proportion of land under teff cultivation with improved seed within the same period remained at about 1 percent, although this figure is slightly underestimated as we argue below.

Across this area under teff cultivation in 2012/2013, CSA figures indicate that improved seed accounted for only 1.4 percent of area under cultivation, or

TABLE 4.1 Land under teff cultivation and use of improved seed and complementary inputs in teff production during meher season, 2005/2006 and 2012/2013

	2005/2006				2012/2013			
	Tigray	Amhara	Oromia	SNNP	Tigray	Amhara	Oromia	SNNP
Area under teff cultivation (hectares)	138,346	907,057	985,666	193,193	161,798	1,090,139	1,256,565	202,376
Area under teff cultivation with improved seed (hectares)	3,458	7,664	6,304	7,286	4,545	21,132	6,832	5,771
Area under teff cultivation without improved seed (hectares)	134,654	899,182	978,880	185,831	157,253	1,068,939	1,249,732	196,604
Quantity of improved teff seed (kilograms)	159,889	259,449	366,498	394,965	223,034	635295	278,294	233,046
Quantity of indigenous teff seed (kilograms)	6,551,042	41,485,855	57,901,882	9,025,720	7,914,462	52,435,428	66,397,113	9,197,232
Seeding rate for improved teff seed (kilograms per hectare)	64	39	71	63	56	31	41	45
Seeding rate for indigenous teff seed (kilograms per hectare)	69	54	72	57	67	53	64	59
Area under teff cultivation with fertilizer use (hectares)	82,162	511,731	630,019	97,673	127,075	793,476	970,387	128,997
Area under teff cultivation with irrigation (hectares)	4,464	892	1,092	1,436	1,028	2,775	1,473	728
Teff production in quintals	1,244,213	8,658,240	10,224,520	1,454,743	2,122,235	15,281,977	17,535,597	2,515,409
Teff yield (quintals per hectare)	8.99	9.55	10.37	7.53	13.12	14.02	13.96	12.43

Source: Ethiopia, CSA (various years).

Note: SNNP = Southern Nations, Nationalities, and Peoples' region.

just over 38,000 hectares of land. This amounts to approximately 1,710 metric tons of improved teff seed. Although these figures suggest a thin market for improved teff seed in Ethiopia, they should also be treated with caution. Specifically, the way in which the question is asked of surveyed households—roughly, "Do you plant an improved or local variety of teff?"—obscures the contribution made by farmers who save seeds of improved varieties. This means that the survey is likely to capture only whether respondents had obtained (through purchase or trade) and planted seed of an improved variety in the immediate or most recent season. This also means that the survey probably does not capture whether respondents had planted seed from an improved variety that had been obtained in other prior years. Affirmative answers to both should be taken as an indication that the surveyed households are cultivating improved varieties, but it is likely that the survey only captures the current-year varietal choice. This suggests that the prevalence of improved teff cultivation is being underestimated, thereby muddling the estimation of demand for seed of improved teff varieties and thus obfuscating the market's potential viability.

To illustrate this further, the CSA figures for wheat are considered, which indicate that improved varieties accounted for 4.3 percent of area under cultivation in 2012/2013. In contrast, data from the Diffusion and Impact of Improved Varieties in Africa project (DIIVA 2013) for 2009 suggest a different figure, based on entirely different data collection methods and different definitions that aim to provide a better accounting of improved cultivar prevalence. DIIVA data indicate that through both seed purchases and saving practices, improved varieties accounted for 62 percent (based on a weighted average for both durum and spring bread wheat, which are treated separately by DIIVA).[2] In effect, CSA data are limited in what they reveal about demand for improved teff varieties or the teff seed market in general.

The question, then, is exactly how large is the market for improved teff seed? There is no easy answer, primarily because the combination of frequent seed supply shortfalls, state-run distribution channels, and state-determined seed prices obscure information on the underlying market price at any point in time. That said, a rough way of estimating market size is to consider both the frequency at which farmers purchase seed and the quantity of teff seed that is purchased by farmers in a given year. This calculation is made only for white teff since genetic improvements have been primarily introduced

2 Note that the DIIVA data are not necessarily more accurate than CSA data as they do not rely on nationally representative surveys but rather a combination of surveys and expert opinion. A more complete explanation of DIIVA's methods is in DIIVA (2013).

by Ethiopia's research system in white teff varieties and not in landraces commonly described as black, red, or mixed teff varieties.[3] Again, exercising caution in interpreting these results is encouraged because of limitations associated with the data, as detailed earlier.

This calculation is made by examining data from the 2012 ATA Baseline Survey on the share of farmers who purchased white teff seed. The data indicate that 28 percent of farmers who purchased white teff seed did so in the previous year, with another 12 percent having purchased white teff seed two years ago, 15 percent three years ago, and so on (Table 4.2). This means that in any given year, approximately 70 percent of farmers who cultivated white teff had also purchased seed within the past five years, which is the recommended seed replacement rate for teff.[4] Of those white teff farmers who purchased seed within the past five years, 34 percent did so from formal sources that have the mandate and capacity to supply improved varieties (that is, cooperatives and bureaus of agriculture), with the remaining 66 percent purchasing from other sources that have no such mandate (that is, other farmers and grain traders). This means that in any given year, 14 percent of farmers purchased seed of improved teff varieties.

Next, a few assumptions and calculations are made. First, it is assumed that white teff seed purchased from these formal sources is exclusively improved—that is, it is one of the 18 or so teff varieties released by the national agricultural research system and produced by state-owned seed enterprises. Second, it is estimated that white teff accounts for 60 percent of all area under teff cultivation, or 1,627,000 hectares of land, based on land allocation data from the 2012 ATA Baseline Survey. Third, the landholding sizes of households cultivating improved (white) teff varieties purchased from formal sources is calculated to be 0.30 hectares, which is slightly smaller than the average landholding size for all white teff farmers, which is 0.38 hectares.

With these figures in hand, an alternative estimate of the area under improved (white) teff in Ethiopia is approximately 228,000 hectares in 2011/2012. Our computation shows that 14 percent of the land under white teff is cultivated with improved seed, which is still small but much higher

3 Landraces is a term referring to indigenous farmers' varieties.

4 Note that it is not the case that this figure is skewed by some farmers (for example, larger landholders or wealthier farmers) purchasing seed more frequently than other farmers (for example, smaller landholders or poorer farmers). In general, the distribution of years since the last purchase of teff seed is consistent across these dimensions of heterogeneity (for example, landholding size and wealth) in the sampled population.

TABLE 4.2 Years since last purchase of teff seed, 2011/2012

Years since last purchase of teff seed	Red teff		White teff	
	Frequency	%	Frequency	%
1	92	15	208	28
2	68	11	90	12
3	100	16	113	15
4	74	12	88	12
5	30	5	12	2
>5	63	10	34	5
Never	183	30	186	25
Observations	**611**	**100**	**732**	**100**

Source: Authors, based on data from the Ethiopian Agricultural Transformation Agency (ATA) 2012 Baseline Survey.

than official statistics. Given an average seeding rate of 38 kilograms per hectare, this translates into a market volume of 8,664 metric tons of improved (white) teff seed. Even when accounting for regional variation in years since last purchase of teff seed or variation in seeding rates by landholding size (see Appendix Table 4.A1 and 4.A2), these rough calculations are clearly several orders of magnitude larger than CSA's figures. This suggests that the prevalence of improved teff cultivation in Ethiopia is probably more than previously estimated.

This is a useful starting point for estimating demand and market size. But for several reasons these measures are still insufficient in gauging seed system development if the primary objective is to encourage productivity growth. First, because these figures rely on seed replacement rates, they do not identify whether seed was purchased by farmers to simply refresh the quantity and quality of their seed stocks, or whether seed was purchased to obtain better cultivars with superior genetic traits. Second, because these figures simply measure the purchase of seed of an unspecified quality of what may be cultivars of an unspecified age, they obfuscate any information on the seed system's capacity to provide farmers with superior genetics or quality seed products. Third, these figures overlook the distributional dimension of who actually purchases seed and what types of farmers—measured in terms of land tenure, wealth, income, or geographic location—have access to seed embodying superior genetics. In short, a better measure of demand needs to incorporate information on specific teff varieties.

To do this, measures of varietal turnover are considered to get a sense of whether farmers are accessing superior genetics. These measures have proven useful in gauging the contribution of genetic improvement to productivity growth in rice and wheat in South Asia, both during the Green Revolution of the late 1960s and early 1970s when the shift from landraces to modern varieties resulted in a doubling of yields and output. In the subsequent decades yield growth rates stagnated with the slower shift from first-generation to newer modern varieties (Dixon and Gulliver with Gibbon 2001; Heisey et al. 1997; Heisey 1990). If a similar pattern were to prevail for teff in Ethiopia, rapid yield gains might be expected where a significant share of farmers switched from teff landraces to improved varieties, while smaller, more incremental gains might be expected in areas where improved teff cultivation is already prevalent, or where farmers have concentrated cultivation around a few high-performing cultivars such as Quncho (see Chapter 9). Necessarily, this productivity growth pattern is contingent with the development of improved varieties that are adapted to the agroecological constraints and risk preferences that shape farmers' willingness to adopt a new technology and on the provision of seed, fertilizer, credit, extension services, and other complementary inputs. This does not run counter to the prevailing focus of public policy and investment on Ethiopia's high-potential areas but does suggest the need for a higher resolution of understanding on how the largest gains are achieved in teff productivity and in the best way possible.

The importance of variety-specific information is examined by calculating the extent to which farmers are cultivating recently released teff varieties or relying instead on older varieties (Table 4.3). Despite the limited number of observations—possibly due to the inability of survey respondents and enumer ators to identify varieties by either their official or local names—it appears that DZ-CR-387 (Quncho) is relatively more prevalent than other named varieties.[5] This may suggest that some farmers are benefiting from more recent varietal releases from current research. Importantly, this also suggests that variety-specific data can be obtained with a degree of consistency and that this information can in turn be used to gauge the prevalence of more recently released improved varieties.

5 The 2012 ATA Baseline relied on postcoding of local names for teff varieties and matching those names with the official variety names published by EIAR. Future efforts to obtain variety-specific data would benefit from a more careful precoding of both local and official variety names.

TABLE 4.3 Area under teff cultivation by variety, 2011/2012

Variety name (number of observations)	Year of release	Variety's share of households that are cultivating a known/named variety (%)[a]	Variety's share of area under teff cultivation (%)[a]
Quncho: DZ-CR-387 (60)	2005	2.58	3.46
Key tena: DZ-01-1681 (13)	2002	0.46	0.78
Magna: DZ-01-196 (7)	1978	0.30	0.27
Tseday: DZ-CR-37 (3)	1984	0.23	0.23
Ambo: DZ-01-1278 (1)	1999/2000	0.08	0.05
Other white teff variety (894)	—	45.30	50.00
Other red teff variety (949)	—	51.06	44.80
Unknown white or red teff varieties (7)	—	—	0.49

Source: Authors, based on data from the ATA Baseline Survey (2012).
Note: [a] Figures total to slightly more than 100 percent due to rounding; — = data not available.

Next, to get a sense of the structure of the teff seed market, the sources from which farmers procure teff seed, the distances they travel to obtain it, and the prices they pay are examined. As before, this information is drawn from the 2012 ATA Baseline Survey. Both white and red teff are included to provide insight into how these separate market segments compare. As with other data and analysis presented earlier, these investigations are interpreted with caution due to limited numbers of observations and representative data.

Sourcing strategies based on own-saved seed or farmer-to-farmer exchanges account for 88 percent of the white teff seed market and 98 percent of the red teff seed market (Table 4.4). Cooperatives and bureaus of agriculture constitute the next most important source of white teff seed, accounting for 10 percent of the market. When asked how much travel time was incurred in obtaining purchased seed using normal transportation (that is, any combination of transportation methods), farmers' responses suggest that it takes about 50 to 60 minutes to obtain seed from other farmers, cooperatives, or bureaus of agriculture, while it takes about 90 minutes to obtain seed from grain traders. The fact that distance to other farmers is more or less similar to that of cooperatives and bureaus of agriculture may suggest that farmers are likely to invest time to search for good quality seeds and traits in their surrounding villages, rather than getting any seed from a neighbor. While the absence of heterogeneity is of limited analytical relevance here (and while the analysis is limited by small sample sizes across several types of suppliers and for red teff),

TABLE 4.4 Farmers' sources of teff seed and associated travel times to purchase seed, 2011/2012

	White teff			Red teff		
Source of teff seed	Percentage of farmers (%)	Mean travel time (standard deviation)	Number of observations	Percentage of farmers (%)	Mean travel time (standard deviation)	Number of observations
Saved per self	72			86		
Other farmers	16	52.72 (63.27)	79	12	44.04 (55.62)	74
Cooperative	8	56.29 (34.43)	53	0	35 (7.071)	2
Bureau of Agriculture	2	50.74 (73.44)	13	0	30 (n.a.)	1
Grain trader	2	90.28 (72.94)	23	2	56.27 (55.74)	21
Total	**100**			**100**		

Source: Authors, based on data from the ATA Baseline Survey (2012).
Note: n.a. = not applicable.

the figures do provide a baseline that can be used to gauge future progress in improving the accessibility of quality seed or improved cultivars.[6] They also open the door to further exploration of why farmers travel so extensively to obtain teff in instances where they do not rely on own-saved seed.

Exchanges in these markets are primarily cash-based: 81 percent and 77 percent of white and red teff seed purchases, respectively, are cash transactions, while financing for credit-based transactions comprise fewer than 5 percent of all purchases. While it is possible to interpret this as a credit constraint on seed purchases, it is more likely that the use of cash is a reflection of the relatively low cost of seed acquired through both farmer-to-farmer exchanges and the public distribution networks. The average price paid for white teff was 12.1 Ethiopian birr per kilogram and for red teff was 11.4 birr per kilogram; households spent on average 187.6 birr on seed purchases (Table 4.5).

Finally, several indicators of seed quality are examined to provide a sense of how satisfied farmers are with purchased teff seed. Overall, farmers who purchase teff seed appear to be satisfied with seed quality and the timeliness of its delivery. Across all sources, there is no evidence of complaints with respect to quality attributes of seed such as timeliness, adulteration, germination, price,

6 The value of intertemporal spatial analysis is demonstrated by Ariga and Jayne (2010) in Kenya with evidence showing that travel times required to purchase synthetic fertilizer and improved maize varieties and hybrids had significantly decreased between 1997 and 2007, contributing to higher maize yields, increased farm incomes, and improved national food security.

TABLE 4.5 Seed prices and average household expenditures on teff seed, 2011/2012

Indicator	White teff (standard deviation)	Red teff (standard deviation)	Total (standard deviation)
Average seed price paid for teff seed (birr per kilogram)	12.13 (5.927)	11.40 (5.422)	11.95 (5.807)
Average household expenditure on teff seed (birr)	208.8 (178.1)	121.70 (109.1)	187.6 (168.0)
Number of observations	167	88	255

Source: Authors, based on data from the ATA Baseline Survey (2012).

TABLE 4.6 Farmer perceptions of teff seed quality, by source, 2011/2012

	Seed source			
Type of problem with seed	Other farmers (n = 181)	Cooperatives (n = 50)	Bureaus of agriculture (n = 12)	Grain traders (n = 23)
Delivered late	4%	0%	0%	0%
Mixed with other seed	1	0	0	1
Poor germination	1	0	0	0
Too expensive	0	0	11	6
Incorrect label	0	0	0	0
Other quality problem	2	1	0	1
No problem	91	98	89	92

Source: Authors, based on data from the ATA Baseline Survey (2012).

and labeling (Table 4.6). Responses to these questions are necessarily open to interpretation.

Given a choice of specific seed traits, a majority of farmers naturally expressed demand for higher-yielding teff cultivars (Table 4.7). In addition to yield improvements, farmers expressed demand for cultivars that offer improvements in grain size and tolerance to disease and drought. For white teff in particular, farmers expressed an interest in market-related traits such as color and taste that are generally rewarded by higher prices from consumers.

Considered as a whole, the data and analysis presented here paint a detailed picture of the size of the teff seed market, the frequency at which farmers purchase teff seed, the prevalence of and preferences for superior genetics embodied in seed, and the effort farmers make to obtain quality seed and traits. Although these observations should not be interpreted as conclusive market

TABLE 4.7 Farmer opinions of important varietal characteristics for teff, 2011/2012

	First most important characteristic		Second most important characteristic	
Trait or characteristics	White teff (n = 185)	Red teff (n = 85)	White teff (n = 146)	Red teff (n = 69)
Grain yield	72%	59%	16%	18%
Grain size	13	23	15	30
Disease or pest resistance	3	5	6	24
Drought resistance	4	0	17	13
Flood resistance	3	0	5	0
Low labor needs	0	1	1	1
Low input needs	0	3	5	2
Ease of processing	0	2	0	0
Market demand	3	0	13	1
Good taste	1	5	8	2
Good color	1	1	3	5
Fodder quality	0	0	1	2

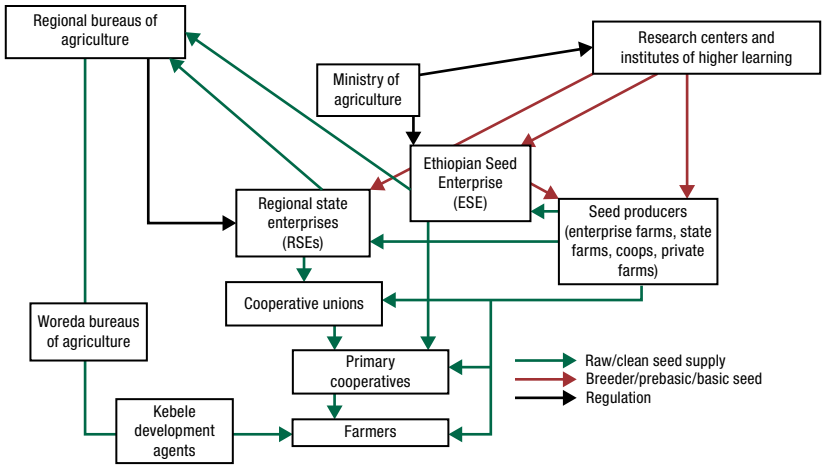
Source: Authors, based on data from the ATA Baseline Survey (2012).

research and intelligence, they do suggest that the demand for quality seed for improved teff varies significantly from what might otherwise be inferred from official statistics. They also suggest that unmet demand is likely for better teff seed and traits, and that more detailed, variety-specific data can help in considering how to integrate farmer-based seed systems with the state's formal system for teff breeding, production, and distribution. This introduces the next section, which explores Ethiopia's teff seed supply system and alternative provisioning strategies.

Teff Seed Supply and Provisioning Strategies

While farmer-saved seed and farmer-to-farmer exchanges are the main sources of teff seed supply in Ethiopia, national efforts to make superior genetic material widely available rely primarily with the country's formal seed system and the organizations mandated to conduct breeding, extension, production, and distribution. This formal system is chiefly a state-led venture and is managed through the federal and regional governments' extensive infrastructure for cultivar improvement and seed supply (Figure 4.1). There are well documented

FIGURE 4.1 A schematic of the supply system for teff seed in Ethiopia



Source: Authors, adapted from Spielman, Mekonnen, and Alemu (2012).

shortcomings of the seed system, with problems related to its coverage, the timeliness of seed delivery, and the quantity and quality of seed delivered to farmers (Teklewold et al. 2012; Spielman et al. 2010; DSA 2006).

Official Ministry of Agriculture (MoA) estimates of teff seed supply suggest that shortfalls have been a common occurrence over the past two decades (Table 4.8) and that in no single year did supply exceed demand. However, these figures reflect official demand figures and production targets that are poorly grounded in reality at the farm level and thus do not provide a completely accurate record of seed supply system performance (Spielman et al. 2010; Spielman and Mekonnen 2013; Sahlu, Simane, and Bishaw 2008). Drawing on the calculations given earlier in this chapter, the actual gap between demand and supply is likely to be much higher than these figures, although the absence of significant variation in seed prices makes it difficult to arrive at any strong conclusions.

A more informative way of estimating supply and demand data is to use more detailed, variety-specific measures. Table 4.9 provides data from 2010/2011 on variety-specific seed production, variety-specific shortfalls, and a calculation of the average age of all teff varieties supplied weighted by share of teff seed supply. The key metric calculated in this analysis is the average age of teff varieties under production, weighted by each variety's share in total production. This calculation is based on an approach developed by Brennan

TABLE 4.8 Official estimates of teff seed demand, supply, and deficits, in quintals, 1995/1996–2012/2013

	(quintals)			Supply as a share of demand
Year	Demand	Supply	Deficit	(%)
1995/1996	29,045	3,576	–25,469	12
1996/1997	32,626	2,788	–29,838	9
1997/1998	28,321	301	–28,020	1
1998/1999	2,998	2,442	–556	81
1999/2000	—	—	—	—
2000/2001	6,215	953	–5,262	15
2001/2002	508	508	0	100
2002/2003	—	—	—	—
2003/2004	32,439	1,329	–31,110	4
2004/2005	4,017	2,072	–1,945	52
2005/2006	78,389	4,197	–74,192	5
2006/2007	29,847	3,527	–26,320	12
2007/2008	29,847	6,516	–23,331	22
2008/2009	34,906	6,466	–28,440	19
2009/2010	35,984	7,872	–28,112	22
2010/2011	63,931	19,554	–44,377	31
2011/2012	89,957	43,508	–46,449	48
2012/2013	91,427	81,216	–10,211	89

Source: MoA (2012).
Note: — = data not available.

and Byerlee (1991) whereby data collected from MoA and ESE is used. The analysis showed that two teff varieties accounted for 90 percent of all production: DZ-CR-387 (Quncho), released in 2005 and accounting for 53 percent of production, and DZ-CR-37 (Tseday), released in 1984 and accounting for 37 percent of production. Shortfalls for these popular varieties are apparent.

But more important, the production-weighted average age of varieties produced by the seed supply system is 16 years. This suggests that despite the shortfalls, the seed supply system has some capacity to move superior genetic material (in the form of newly released improved teff varieties) into seed production and ultimately out to farmers. By giving more attention to the goal of maintaining a relatively low production-weighted average variety age and expanding seed production for new teff varieties, decision makers in the seed system—including policy makers at the federal and

TABLE 4.9 Seed demand and supply for selected teff seed varieties, 2010/2011

Teff variety	Year released	Variety age as of 2010/2011 (years)	Demand from the regional states (quintals)	Supply from the federal government (quintals)	Supply from the regional states (quintals)	Total seed supply (federal + regional supply) (quintals)	Deficit (quintals)	Supply as a share of demand (%)	Share of variety in total supply of teff seed (%)
DZ-CR-37 (Tseday)	1984	27	44,621	1,453	5,445	6,898	–37,723	15	37
DZ-01-196 (Magna)	1970	41	6,561	207	143	350	–6,211	5	2
DZ-CR-387 (Quncho)	2005	6	31,755	2,583	7,355	9,938	–21,817	31	53
DZ-01-354 (Enatite)	1970	41	6,971	349	250	599	–6,372	9	3
DZ-01-974 (Dukem)	1995	16	1,468	506	580	1,086	–382	74	6
DZ-01-182	—	—	50	—	—	—	–50	0	0
Lakech	—	—	1	—	—	—	–1	0	0
DZ-01-1282	2002	9	n.a.	20	n.a.	20	20	—	<1
Total	**n.a.**	**n.a.**	**91,427**	**5,118**	**13,773**	**18,891**	**–72,536**	**21**	**100**
Average age of all teff varieties supplied, weighted by share of teff seed supply (years)									16.00

Source: Authors, based on data from the Ethiopian Ministry of Agriculture (MoA) and the Ethiopian Seed Enterprise (ESE).

Note: — = data not available; n.a. = not applicable.

regional levels—would have reasonable performance metrics by which to measure progress.

However, the capacity to meet these performance metrics depends acutely on investments made by several key actors. First and foremost is the Ethiopia's research system—led by the Ethiopian Institute of Agricultural Research (EIAR)—and the Debre Zeit Agricultural Research Center (DZARC), where most teff breeding efforts are conducted. Although investment in agricultural R&D (specifically cultivar improvement) has been repeatedly demonstrated to increase productivity and reduce poverty (Evenson and Gollin 2003; Fan 2000; Fan, Hazell, and Thorat 2000; Fan and Pardey 1997), funding for DZARC and the wider research system remains insufficient relative to the needs and expectations of Ethiopia's economic development strategy. From a peak in 2001 and 2002 of approximately US$100 million (measured in constant [2005] Purchasing Power Parity–adjusted US dollars), public spending on agricultural research dropped below US$70 million by 2008 (Table 4.10). Financing has been erratic partly due to the completion of several large donor–funded projects that began in the previous decade, while structural and management challenges remain a focus of concern across the system, with consequences for teff improvement and research productivity more generally (Flaherty, Kelemework, and Kelemu 2010).

The challenges of the seed supply system do not, however, reside only at the research center level. There are also challenges in the handoff of breeding material used in seed production (that is, pre-basic and basic seed for finished varieties) to the state-owned ESE and the regional state enterprises (RSEs) in Oromia, SNNP (established in 2008), and Amhara (established in 2009). As the primary producers of certified seed for improved teff, the ESE and RSEs are responsible for managing complex operations involving seed multiplication conducted on their own production farms and through outgrowers—primarily state farms, cooperatives, and private subcontractors (Figure 4.1).

These enterprises, alongside the MoA and regional bureaus of agriculture, have consistently argued that seed supply shortfall are the result of poor quality data with which to calibrate seed production with expected demand (Teklewold et al. 2012). These data are collected by development agents (DAs) at the kebele level, compiled at woreda and then regional levels, and eventually transmitted to the ESE and RSEs as production targets. These data rarely constitute a reliable basis for making seed production decisions, but efforts to improve accuracy by further investing in the existing data collection system are probably a poor use of public resources (Spielman and Mekonnen 2013).

TABLE 4.10 Financial and human resources allocated to agricultural research in Ethiopia, 1991–2008

Year	Public-sector spending on agricultural R&D (constant [2005] US$millions PPP)	Public-sector research staff (full-time equivalent staff)	Public agricultural R&D spending as a share of agricultural GDP (%)	Public agricultural R&D spending per researcher (constant [2005] US$millions PPP)
1991	31.4	403.7	0.21	0.08
1992	23.9	397.1	0.16	0.06
1993	25.8	463.9	0.16	0.06
1994	38.0	477.9	0.26	0.08
1995	36.5	473.1	0.24	0.08
1996	38.4	534.4	0.23	0.07
1997	36.2	542.5	0.21	0.07
1998	48.4	570.2	0.32	0.08
1999	41.5	651.1	0.27	0.06
2000	49.4	750.7	0.31	0.07
2001	96.2	850.3	0.58	0.11
2002	100.5	976.2	0.65	0.10
2003	90.5	1068.1	0.63	0.08
2004	86.4	1098.1	0.51	0.08
2005	81.2	1148.5	0.4	0.07
2006	81.8	1201.5	0.35	0.07
2007	80.7	1291.0	0.32	0.06
2008	68.6	1318.3	0.27	0.05

Source: ASTI (2013).

Note: PPP = Purchasing Power Parity.

Rather, more information could be garnered from credible marketing efforts on the part of ESE and the RSEs that aim to collect more market intelligence about farmers' preferences and willingness to pay for seeds and traits.

This is where cooperatives may play a critical role. An important dimension of this seed supply system is the role of cooperatives. In many developing and industrialized countries, cooperatives and other types of farmer organizations play a central role in the production of seed for self-pollinating crops—crops that offer insufficient profit incentives to private firms. For example, Limagrain, a global supplier of wheat seed, is an agricultural cooperative owned and operated by French farmers and hosts annual sales revenues on the order of 2 billion euros over 39 countries. Some of the leading seed companies have subsidiaries with roots in farmer organizations and cooperatives

that supply seed that operate in Canada, China, India, the United States, and many other countries at both national and local levels.[7]

In Ethiopia, cooperatives and cooperative unions are a central pillar of the country's rural development strategy and are being positioned to play an increasingly significant role in seed supply. At present, however, their role revolves primarily around the distribution of seed procured from ESE and the RSEs. They have limited capacity to gather market intelligence, negotiate seed supply contracts with ESE or RSEs, operate commercially oriented seed production units, or market seed at the wholesale and retails levels. The broader regulatory system also has limited capacity to credibly ensure the quality of the seed they produce and market, whether through certification or quality assured seed (the two most prevalent regulatory practices in place) or through point-of-sale monitoring or legal recourse against untruthful labeling, which are regulatory practices pursued in many other countries (Spielman and Kennedy 2016). But these are potentially the roles that cooperatives could play in a teff seed system designed to make superior genetics continuously available to Ethiopia's smallholders.

Discussion

Having described the challenges facing Ethiopia's market for teff seed and genetic improvements embodied in that seed, some of the potential solutions to improving teff breeding, production, and distribution in the country can be discussed. One critical solution is the reallocation of tasks toward those actors that have the strongest incentives to perform them. At present, the federal and regional governments assume the entire costs of seed production, marketing, promotion, and popularization, along with all the risks associated with storage losses, defaults on credit taken by cooperatives and cooperative unions for the purchase of bulk seed, and any reputational damage resulting from farmer dissatisfaction with insufficient seed supply, poor quality seed, or late seed delivery. A more effective seed system would benefit from shifting some of these costs and risks from the regional and federal governments to seed producers (cooperatives, cooperative unions, and small and medium seed enterprises)

7 In the United States, for example, legislation enacted in 1914 to create the federal-state Cooperative Extension Service required local extension agents to work through formal farmer organizations. This partnership gave birth to what became the American Farm Bureau Federation, which, in DeKalb County, IL, developed and spun off the DeKalb Agricultural Association, which eventually evolved into DeKalb, a major hybrid corn seed company that exists to this day, currently as a subsidiary of Monsanto (DCFB 2004).

and seed consumers (cooperatives, cooperative unions, and farmers). Steps in this direction would require significant changes in public policies, specifically the removal of explicit or implicit seed production targets, distribution quotas, and prices that are set by the regional bureaus of agriculture. By removing these distortionary policies, seed producers and seed consumers can more effectively negotiate over the terms of exchange and assume responsibility for production and consumption.

In effect, this suggests an opportunity to create a rudimentary market in which seed demand assessment is done by those who have the incentive to assess demand accurately, and where seed supply is carried out by those who have an incentive to provide the right quantities of quality seed delivered in a timely manner. Policies designed and implemented around this idea must necessarily be nuanced to balance market creation with the limitations in market infrastructure, equity concerns, and incentive compatibility. A rudimentary market-based design for Ethiopia's seed market, if coupled with other strategic public interventions, can improve the quantity of high-quality seed delivered to smallholders. A better seed system that is introduced in conjunction with input market reforms and stronger commodity markets can, in turn, contribute to increases in productivity and income for smallholders and reductions in the price of teff for food-insecure consumers in both urban and rural areas.

An experiment in this direction began in 2013 with the Direct Seed Marketing (DSM) initiative of the Ministry of Agriculture, ATA, and regional bureaus of agriculture, which builds on the Integrated Seed Sector Development (ISSD) project (see Benson, Spielman, and Kassa 2014). Piloted in the Amhara, Oromia, and SNNP regional states, the initiative authorized and supported a program of direct marketing of certified seed—primarily maize—by seed producers to farmers across 31 woredas and subsequently has been scaled up across a larger number of woredas. While the productivity impact of this scale-up has yet to be determined, there are some early indications of gains for seed market development. Nonetheless, translating those gains from a market for maize hybrids to a market for self-pollinating teff will be challenging.

Specifically, the architecture of a teff seed market along similar lines will require several structural reforms. First, an increase in public investment in teff breeding at DZARC and other centers is probably warranted. Second, an eventual withdrawal of ESE and RSEs from the business of producing certified teff seed could be pursued so that these enterprises could instead concentrate on producing adequate quantities of high-quality foundation seed for other seed producers. Third, stronger policy signals and public investments

could be channeled toward enterprising farmers, community-based initiatives, and cooperatives to produce teff seed for onward distribution to individual farmers.

Ethiopia's cooperatives offer a real opportunity for seed system development. Cooperatives can serve as both consumers and producers of teff seed, depending on the types of farmers they serve, what crops their members produce, and what level of maturity their enterprises embody. Of course, considerable investment would be needed to strengthen their capacity to produce and market seed on a commercial basis. This necessitates investing public resources in programs designed to build farmers' technical skills and expertise in areas such as seed production operations, enterprise management, and marketing. It also requires investing public resources in systems to credibly monitor seed quality, whether based on the current seed certification system or some other standard such as quality assurances or truthful labeling of seed.

It is unlikely that cooperative seed enterprises will be able to compete against one another on the basis of superior genetics. This is because the national agricultural research system is likely to remain the sole source of improved teff varieties. However, this does not preclude cooperatives from competing on the basis of other product attributes such as timeliness of delivery, seed quality, packaging, and commission rates to distributors. If teff seed price-setting practices were withdrawn, then cooperatives could also compete on the basis of price. While further analysis, ground-truthing, and pilot evaluations are needed to determine what is possible and practical, there is already a body of evidence in Ethiopia suggesting scope for growth and expansion of cooperative seed enterprises (Thijssen et al. 2008). So long as the teff seed system is driven by farmer demand, remains flexible and responsive, and maintains open exchanges of information and materials between the national research system, extension services, seed enterprises, cooperatives, and farmers, then there are real opportunities to be seized.

Conclusion

There is probably no better time than the present to capitalize on the willingness and ability of Ethiopia's policy makers, entrepreneurs, and farmers to effect change in Ethiopia's teff seed system and accelerate the contribution of improved genetics to teff productivity growth. But it is not easy to design an architecture that integrates formal and informal seed systems and bridges the gaps between state, private, and civil society actors in the provisioning of seed. This chapter has attempted to design a road map that could strengthen

Ethiopia's teff seed system. It has illustrated how better measurement of seed demand and supply can provide information that is critical to designing seed systems that are responsive to farmers' needs and the capability of seed producers. It has described an innovative role for the public research system, state-owned seed enterprises, and cooperatives in a more robust market for teff seed. Moreover, it has provided a sense of the essential policies and investments needed to move this road map toward a reality where actions are more likely to be fulfilled. Many of the policies and investments recommended here are consistent with the strategies for agricultural development, economic growth, and poverty reduction set forth under Ethiopia's 2011–2015 Growth and Transformation Plan (GTP). They reinforce the 2013 seed sector strategy developed by the Ministry of Agriculture, the Agricultural Transformation Agency, and allied bodies of the government of Ethiopia. In addition, they build on a host of seed enterprise activities and seed sector development initiatives already occurring across Ethiopia. However, the ultimate success of these strategies, activities, and initiatives will depend on the successful introduction of an institutional architecture—the public policies and investments—that incentivize state, private, and civil society actors to play new and more effective roles in the improvement, production, and marketing of quality seed for improved teff varieties.

Appendix

TABLE 4.A1 Number of years since last purchase of seed for white teff, by region, 2011/2012

Years since last purchase of teff seed	%			
	Tigray (n = 12)	Amhara (n = 356)	Oromiya (n = 249)	SNNP (n = 41)
1	23	23	32	59
2	20	12	13	8
3	14	10	23	15
4	9	10	16	8
5	7	2	1	0
>5	18	7	1	0
Never	9	35	15	9
Observations	**100**	**100**	**100**	**100**

Source: Authors, based on data from the ATA Baseline Survey (2012).
Note: SNNP = Southern Nations, Nationalities, and Peoples' region.

TABLE 4.A2 Teff seeding rate during the meher season, by landholding size, 2005/2006 and 2012/2013

	2005/2006			2012/2013		
Seeding rate (kilograms per hectare)	Large farmers (> 2 hectares)	Medium farmers (0.9 to 2 hectares)	Small farmers (<0.9 hectares)	Large farmers (> 2 hectares)	Medium farmers (0.9 to 2 hectares)	Small farmers (<0.9 hectares)
Improved teff	53	54	77	31	42	54
Indigenous (local) teff	61	61	67	58	58	65

Source: Ethiopia, CSA (various years).

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