The Role of Crop Genetic Diversity in Coping with Agricultural Production Shocks: Insights from Eastern Ethiopia

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Abstract

Improving agricultural productivity and farm level resilience to agricultural production shocks is a critical component of reducing poverty and improving household food security throughout the developing world, and particularly in Ethiopia which is among the poorest countries in the world.

This paper explores how agricultural households in the Hararghe region of eastern Ethiopia, an area rich in crop genetic diversity, but with low and variable agricultural productivity and high rates of poverty, manage their crop genetic resources to cope with drought, a prevalent source of agricultural production shocks. Our analysis looks at reasons for cultivating modern varieties versus landrace crop varieties of sorghum, and the implications for farm level resilience to drought as well as choice of coping strategy when such shocks occur. The analysis is run using a unique dataset collected during 2002-2003 production season when eastern Ethiopia experienced a major drought with widespread crop failure ensuing.

Our results indicate that there are linkages between crop genetic diversity and the choice of mechanism for coping with drought that households adopt. The results suggest that MV adoption is not an ex ante risk coping strategy, and that indeed households growing modern sorghum varieties are more likely to have a crop failure than those who grow only landrace sorghum. The results indicate also that small and medium producers on marginal lands are most likely to be vulnerable to a crop failure, particularly if they are also MV adopters moreover location is found to be a critical determinant of the choice to replant sorghum. Further analysis is requires to formulate any definitive policy prescriptions, however our results suggest that sorghum MVs despite their early maturity, are not resilient in the face of a drought related production shocks, and that local sorghum crop genetic diversity is an important means of coping with these shocks.

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Key Words: agricultural production shocks, poverty alleviation, household food security, crop genetic resources, copying strategies, Ethiopia.

JEL: D81, D92, O13, Q57.

I. Introduction

Improving agricultural productivity and farm level resilience to agricultural production shocks is a critical component of reducing poverty and improving household food security throughout the developing world, and particularly in Ethiopia. Bruinsma (2003) estimates that agricultural intensification will be the primary source of crop production growth globally over the next 25 years. The same report showed substantial gaps between actual and attainable yields, approximately 2.8 tonnes/hectare for Ethiopia, the country of focus here. An important aspect of narrowing the gap involves improving the management of crop genetic resources (Bruinsma, 2003). One problem is that modern crop varieties have been developed primarily for high potential production conditions, requiring a set of complementary inputs such as fertilizer, insecticides and irrigation. Such varieties are often not suitable for low income farmers in marginal production areas facing highly variable production conditions (Evenson and Gollin, 2003). Landraces or traditional varieties have been found to have higher stability (adaptation over time) in marginal environments, and thus their cultivation may contribute to farm level resilience in the face of production shocks (FAO, 1998; Ceccarelli and Grando 2002). An important requirement for the development of strategies for improving crop genetic resource management under marginal production conditions is gaining better insight into the experience with MV adoption among farmers operating in such areas.

Since the 1970's another concern has arisen as well; the erosion of crop genetic diversity through the widespread replacement of traditional, landrace varieties with improved modern varieties (Frankel, 1970; Harlan, 1973; Hawkes, 1983; Brush, 1995; Bellon, 1996; Perales 1996). The cultivation of landraces provides in situ conservation of crop genetic diversity, preserving an evolutionary process affected by both human and natural selection. In situ conservation is valuable not only to meet current and future food preferences but also as insurance against future disease threats. The FAO-sponsored International Treaty on Plant Genetic Resources and the UN-sponsored Convention on Biological Diversity are international agreements that recognize the important role that genetic diversity conservation plays in current and future food and agriculture production.

In this paper we explore how agricultural households in the Hararghe region of eastern Ethiopia manage their crop genetic resources to cope with drought, a prevalent source of agricultural production shocks, focusing in particular on the implications of cultivating modern versus landrace crop varieties for sorghum, an important crop for food security. We use a unique dataset from eastern Ethiopia, an area rich in crop genetic diversity, but with low and variable agricultural productivity and high rates of poverty. The study area is a center of origin and domestication for sorghum, and about three quarters of the farms are growing landrace varieties of sorghum rather than improved varieties. Rapidly maturing improved varieties of sorghum have been developed and disseminated in the area, and these were developed as a means of coping with low and variable rainfall.

This paper looks at reasons for why improved varieties are adopted and the implications for farm level resilience to drought and choice of coping strategy when such shocks occur. The dataset combines rich crop and physical data on plant varieties (independent field work was used to validate that plant varieties had mutually exclusive forms and structures) with rich household-level wellbeing data (including income, assets and debts from both farm and off-farm sources) during a shock year. In the year that the data were collected (2002-2003 production season) eastern Ethiopia experienced a major drought with widespread crop failure ensuing. Use of a shock year is important, because households use a variety of methods to cope with the shock, with varying implications for resource damage and extraction.

II. Public and private values of crop genetic diversity in the Ethiopian context

Crop genetic resources are the product of the interaction between human and natural selection of the environment, yielding a set of domesticated crops and varieties used in agricultural production. Crop genetic resources are embedded in seeds and they are an important determinant of the characteristics and attributes of the crop species, together with environmental and human management factors. Farmers choose crops and seeds to provide a set of attributes that meet their specific production and consumption needs. However, since seeds are simultaneously a physical input to crop production and a source of genetic code, their pattern of utilization provides both a private value to the farmer, and also a public value through contributing to the conservation and evolution of genetic resources and crop genetic diversity. This dual role may give rise to conflicts between public and private interests in terms of the desirable pattern of seed use (Smale and Bellon, 1999).

The distinction between the cultivation of landraces and modern varieties is one means of measuring diversity on farm. Modern varieties are by definition genetically uniform and stable, whereas landrace cultivars are more volatile, encompassing a population of genes and alleles that are adaptable to natural and human selection pressures (Ceccarelli and Grando, 2002). The farm level choice of cultivating a modern variety versus landrace for any one crop is driven by a set of supply and demand side factors. In many cases modern varieties do not exist that meet the production or consumption needs of farmers, particularly those in marginal areas. Even if a variety is available that farmers desire, the accessibility may be limited due to poor distribution networks, high prices relative to returns and lack of credit. All three are problems in Ethiopia (Mulatu, 2000). McGuire (2005) cites the lack of agricultural extension as a major barrier to adoption of MVs, particularly in more marginal production areas.

Ethiopia is recognised as an important source of the public goods associated with crop genetic diversity conservation, as it is a primary or secondary centre of diversity for several crops. The tremendous variation in altitude, temperature, rainfall, soil type and ecological settings, as well as the diverse social and cultural conditions together with different levels of market integration are some of the possible explanations for the existence of remarkable genetic variation of crop varieties in the country. Ethiopia is centre of origin for crops such as: sorghum, teff, coffee and enset, and is centre of diversity for many others such as: wheat, barley, Ethiopian mustard, chickpea lentils and finger millet (Tanto and Demissie, 2000; Vavilov, 1956; McGuire, 2000). The number of crop accessions of Ethiopian origin that have been introduced to various international and foreign national crop improvement programs and seed companies is enormous: more than 1800 for wheat and more than 4500 for sorghum, around 2500 for barley and more than 900, large numbers are also reported for chickpea, lentil and finger millet (ICPPGR/FAO, 1997).

Several studies have also indicated high private values of landrace varieties in Ethiopia (Gebremehdin,1992; McGuire, 2005; Unruh, 2001; Mulatu, 2000). Attributes such as yield under stressed or marginal production conditions, as well a desirable consumption characteristics are primary drivers of the demand for landraces. Unruh (2001) discusses the importance of landrace varieties in managing risk in the Ethiopian highlands and posits that the highly risky production environment in Ethiopia necessitates frequent replanting in response to crop failure. Replanting leads to higher levels of diversity, as different varieties or crops are selected to address the problem causing the failure. He also argues that the modern varieties are not very well suited to the small plot sizes of highland Ethiopian agriculture, requiring a minimum area for plowing, and the necessity of taking on debt which may require the sale of productive assets to repay will also result in low rates of modern variety adoption.

III. Crop Genetic Resources and Agricultural Productivity in Ethiopia

Ethiopia's economy is mainly based on small-scale agriculture, accounting for half of GDP and employing 85% of the labor force (MEDAC, 1999; Zegaye, 2001; Shiferaw and Holden, 1999). Unfortunately, the agricultural sector suffers from frequent drought, poor cultivation practices and limited farm endowments. In eight of the past 15 years, major droughts have affected 5-14 million people. In 2000 and 2003 production seasons the number exceeded 10 million (Bramel et. al. 2004). Ethiopia is the second most populous nation in Africa and one of the poorest of the world with an estimated population of over 67 million of which 40 to 50 percent is estimated to be food-insecure. The high density of the population together with the practice of dividing holdings between offspring, leads to land fragmentation and small field sizes (frequently less than one hectare) (Unruh, 2001). The resulting increased intensification, characterized by absence of fallowing, lack of technical change and total absence of conservation practices and furthermore complicated by frequent drought, is creating a high degree of land degradation and, therefore, a decline of land and grain productivity (Shiferaw and Holden, 1997).

The major food crops grown by the small-farm sector include cereals (sorghum, maize, wheat, barley, millet, tef, and oats), pulses (faba beans, field peas, lentils, chickpeas, and haricot beans), and oil crops (flax and noug) (CSA, 1999). Livestock production also plays a crucial role in Ethiopia's economy, contributing to about one-third of agriculture's share of GDP.

The combination of, high population pressures, poor agricultural policy making, conflicts and environmental degradation have left Ethiopia a country with low agricultural productivity, high rates of food insecurity and high rates of dependency on external food sources. Recent estimates (USDA, 2005) indicate that Ethiopia's annual food deficit is 4.7 million tons (the amount required to bring the poorest up to a minimum nutrition standard), making it the least food-secure country in the world. This food deficit persists despite the fact that food aid constitutes about 10 percent of total food availability in Ethiopia.

Increasing agricultural production is the policy the Government of Ethiopia has adopted to address the problem of food security and economic growth, through the adoption of the "Agricultural Development Led Industrialization" strategy, although at present the country is heavily reliant on food aid as a source of food security for the country. The impact of food aid on the long term growth capacity of the agricultural sector is controversial, but in Ethiopia's case, the sheer volume and length of time of Ethiopia's food aid imports indicates that the dependency and disincentive effects in agricultural markets are likely to be substantial (Devereux, 2000).

Increasing the productivity in the intensive margin is the main means by which Ethiopia can increase domestic production, due to a lack of new lands to bring into agricultural production. Improving the productivity of crop genetic resources and their accessibility to farmers is a key aspect of the government strategy, particularly the promotion of improved technological inputs and practices in order to raise agricultural productivity. Food production in Ethiopia is expected to grow at 4.2% per year over the next ten years, while population is expected to grow at only 2.5%. Estimates are that in 2014 the food deficit will be less than half what it is today USDA (2005).

IV. The Ethiopian Formal Seed Sector for Sorghum

Ethiopia, with one of the largest national agricultural research systems in Africa in terms of staff and budget, has been following an agricultural-led growth strategy for years (Weijenberg et.al., 1995), with crop breeding for modern varieties a major focus of efforts. Due to the importance of sorghum in food security the government has allocated considerable resources to the breeding program (McGuire, 2005). Approximately one million hectares are sown to sorghum, making it the third most important crop grown in the country, and it is a major staple in the diet of the population - particularly the poor. A breeding program for sorghum has been in place since the 1950's with somewhere between 27 to 30 modern varieties of the crop released since then (McGuire, 2005).

In terms of formal seed sector multiplication and distribution, sorghum has received relatively little attention however (Mulatu, 2000). The Ethiopian Seed Enterprise (ESE) until recently had a monopoly on the production of modern varieties released from the agricultural research and development sector. The production and storage capacity of the institute is quite limited. The primary focus of MV seed production has been on wheat and secondly maize Mulatu (2000). finds that for several years, ESE produced less than 1% of the total potential MV seed required in the country, using an estimation based on area sown, seeding rate and replacement rates,.

Adoption rates of MV sorghum varieties in Ethiopia are not well measured, but there seems to be agreement that they are low (McGuire, 2005; Mulatu, 2000). One obvious reason may be a lack of supply due to the low production levels cited above. However, ESE has reported some years of excess seed supply, even with the very small production levels of sorghum it has attained. Another issue may be pricing. Sorghum MV selling prices from ESE increased 130% over the period 1992-2000, with a major increase in the 1999-2000 production season (Mulatu 2000).

Low adoption rates may also be related to the demand side: if the MV sorghum cultivars do not provide the attributes farmers want. The main focus of the formal sector breeding program was the development of early maturing cultivars as a means of coping with drought. Although this characteristic is important for marginal areas, these varieties were developed with grain yield as the main performance indicator, and indications are that other characteristics such as stalk yield (for use as livestock feed and building materials) as well as consumption characteristics (good taste) are important determinants of sorghum variety choice (McGuire 2005).

Demand for sorghum seed by farmers in the Hararghe region of Ethiopia (see map) is driven by the highly heterogenous agro-ecology and very low levels of farm household income in the area. Farms in the Hararghe region (and Ethiopia in general) are small, with average sizes of landholding in the area is .25 hectare and this may be divided among several plots. The area is characterized by high agro-ecological heterogeneity, as well as high variability over time of climatic and production conditions. The high level of spatial and temporal variability means there is strong demand for diversity - no one crop or variety can meet the variety of needs of the farm household. This is especially true because of the low use of complementary inputs, very little irrigation and scarce use of fertilizers or pesticides.

V. Household food security, coping strategies and crop genetic resources

One of the primary causes of household food insecurity in Ethiopia is the presence of production risks in the form of drought and pests which result in frequent crop failures, and thus reduced agricultural production and incomes (Dercon, 2001 Devereaux, 2000). Using a simulation model and data from six rural Ethiopian communities, Dercon 2001 estimates that the poor rainfall together with illness shocks and population growth resulted in a 13 percent decline in per adult consumption and 23 percent increase in poverty between 1989 to 1995. He notes that a lack of capacity to insure against rainfall and illness shocks and the absence of safety nets significantly reduces agricultural growth and poverty reduction in the studied areas.

Farmers do adopt a number of coping strategies to manage risk, both ex ante and ex post. The coping strategies farmers adopt in the face of such vulnerability is linked to their overall livelihood strategy. Some of the strategies both depend on, and impact crop genetic diversity, and the accessibility of CGRs is likely to be a determinant of the livelihood and coping strategies farmers adopt. The adoption of improved sorghum varieties which are more adapted to low and variable rainfall patterns than traditional varieties is one potential strategy for coping with drought risk ex ante. To the extent that this is the case, we would expect that sorghum modern variety adopters would experience lower rates of crop failure in the case of drought.

An ex poste strategy for coping with drought risk is replanting the crop in the wake of an initial failure. Replanting may be with different (usually faster maturing) varieties of the same crop or switching to a different and shorter season crop. In this paper we focus on the former, although both cases are found in the study area. The implications for variety choice for replanting are somewhat unclear in the context of sorghum. Unruh (2000) argues that the replanting is most likely to be with a traditional variety – as these are more likely to have attributes which address the production problem. However in the case of sorghum, since modern varieties are shorter maturing than the traditional varieties, it may be the case that modern varieties would be preferred.

Households may turn to other ex poste means of coping with shocks as well. Liquidating assets is clearly one important strategy utilized. Falling livestock prices associated with a high volume of liquidation sales on the part of households needing income for food purchases is one of the key indicators of an impending food shortage in Ethiopia (Ahmed, personal communication). Increasing off farm sources of income is another important coping strategy adopted in Ethiopia, involving activities such as firewood collection and sales, agricultural labor exchange and temporary migration. Finally, receiving emergency assistance and gifts of food from government, NGO and local community members is another very important coping strategy used. Emergency seed relief is an important part of a coping strategy; seeds may be used for replanting or in many cases for consumption as grain.

The four main ex poste coping strategies a household can adopt in response to shocks can be categorized as follows: 1) replant 2) receive relief or gifts of food and seed 3) increase off farm income and 4) liquidate assets. Households may choose[1] to pursue one or more of these. In this study, we are interested in focusing on the impact of the supply of crop genetic resources, through local diversity as well as modern varieties, on the choice of strategy. Clearly replanting is a strategy which relies upon the availability of a stock of genetic resources which meet problematic production conditions – e.g. drought or pest incidence. In the case of sorghum, replanting with sorghum after a crop failure associated with drought (as is the case in our case study) requires the presence of seeds of short season varieties – e.g. modern varieties. Alternatively, seeds for short season crops (wheat or barley) could also allow for replanting.

[1] In Ethiopia households are usually selected by administrative officials to receive government distributed emergency aid, so participation in this type of scheme is exogenous to household decision-making. Receiving gifts of food and aid from family members and others in the community is something the household can decide to pursue however.

VI. Farm Household Survey

The farm household survey used to investigate seed systems in greater depth was built around a larger case study of the impacts of a seed system intervention implemented by the Hararghe Catholic Secretariat (HCS), a non-governmental organization, in the drought-prone Hararghe area of Ethiopia. The seed intervention involved selecting and cleaning local landraces of wheat and sorghum for multiplication and distribution to seed-insecure households. Seeds were provided under a credit arrangement which required repayment in the form of seed with a 15% interest charge.

The case study involved a household survey, a community survey, a market survey, an agro-morphological survey, and community focus groups. A total of 720 households were surveyed in 30 Peasant Associations. Of these, about 50% were HCS participants. Of the remaining 50% about half were non-participants residing in participant communities, and half non-participants in non-participant communities. The sample was limited to uplands and midlands area in order to reduce the degree of variation arising from agro-ecological factors and to better isolate the impacts of the project. The non-project participant households (e.g. the control group) were selected to match the characteristics of HCS project participants to the extent possible. The agro-morphological and community focus group surveys were used to collect information for measuring crop genetic diversity and for validating variety names. The market survey involved the weekly collection of quantities and prices of varieties sold in market places over a period of two months. Finally, the community survey provided data on infrastructures, services, distance to main markets, outside interventions and general information common to the entire community where households reside.

The household survey was conducted in two rounds: the first was in August 2002 after the planting of the main crop of the year, and the second was in February 2003 after the harvest. The survey was designed to collect direct information from farmers necessary to measure household well-being as well as farmer's preferences towards varieties and sources of seeds (i.e. household demographics, socio-economic conditions, agricultural and non-agricultural labor and investment activities). Farm level data necessary to control for land endowments and agro-ecological conditions were also collected as well as information on seed acquisition, including the means of acquiring seeds, the criteria for seed selection, source and price of purchase, access to varieties and to seeds, formal and informal seed markets, and the transaction costs associated to interacting with seed system. Finally, data included the varieties planted, seed acquisition sources, seed information sources, and the household's perception of positive and negative characteristics of different varieties were elicited.

VI. Data and Methods

This paper uses data from the first and second household visit. Descriptive data from the survey is included in Table 1. Three estimations are made to examine the characteristics of those who adopted the modern variety of sorghum, the impact of MV sorghum adoption on the incidence of sorghum crop failure in the 2002-2003 production year, and the impact of sorghum MV adoption on the decision to replant as a coping strategy in the wake of a crop failure.

Characteristics of the farm, farmer, and farm household were included in the regressions. The regression on sorghum MV adoption included explanatory variable at the farm level on the size of the farm in terms of operated area (i.e. land owned, plus land rented in, less land rented out); the physical characteristics of the plots, including farmer-reported average slope of the land and the average fertility of the land (farm values were calculated as a weighted average of plot-reported variables). The belief that complementary inputs are required for modern variety adoption would be supported by positive correlation with soil fertility, because adoption would not be beneficial on poorer soils. Likewise, complementary inputs, such as fertilizers and water, are less likely to be used on hillsides, so that modern variety adoption would be negatively associated with sloping fields. Two geographic farm descriptions were used, the location of the farm defined both by the municipal association and the farm defined in terms of altitude. Some evidence that uneven seed distribution and agricultural extension services contribute to patterns of adoption. Likewise, lower elevations are reported to be more favorable to the adoption of useful modern varieties of sorghum. Non-grain demands for sorghum, including demands for stalks by oxen, are presumed to remove incentives to adopt new varieties.

Farmer variables included in the adoption regression include age of the household head, presumed to be negatively associated with adoption. Also, the total number of sorghum varieties cultivated on the farm was included. Theoretically, the relationship would be positive; farm households that meet their differentiated consumption needs through sorghum (own consumption, plus market consumption, plus secondary uses for livestock and construction) might manage a larger portfolio of varieties, and that a larger portfolio would be more likely to include at least one modern variety.

Farm household variables included in the adoption equation include the value of non-farm income, the number of crop failures due to drought suffered by the household over the previous ten years, and the manner by which households reported coping with these losses. We expect that those farmers with greater non-farm income would be able to purchase seeds and complementary inputs, and therefore expect a positive correlation between off-farm income and new variety adoption. We expect that under complete markets the existence of highly uncertain outcomes, characterized by many crop failures due to drought, would encourage the adoption of short-season, modern crop varieties.

Households were also asked to comment on the principal advantages of the sorghum varieties that they chose to grow on their land. We classified these responses according to whether they were advantages that are related to consumption such as taste and quality of grain and fodder or whether they would provide benefits associated with production (e.g. grain yield performance) We would expect that modern varieties are adopted in search of production characteristics, such as good yield, resistance to adverse climates and pests and maturity-based criteria, while land races are favored by those valuing characteristics related to the quality of grain and fodder, and adaptability to taste and cooking preferences.

From the modern variety adoption equation, we estimate two auxiliary regressions on the propensity to experience a sorghum crop failure and propensity to replant a subsequent crop after a sorghum failure. These regressions made use of many of the same variables included the "predicted" value from the modern variety adoption equation, as well as additional variables for the purposes of separately identifying the failure and the replant equations. The sorghum failure equation included a variable on past crop failures, assumed positive, and the replant equation included variables on the extent of hunger in the household, and how the household copes with crop losses in general – either through aid, off-farm incomes, or financial smoothing such as savings or loans.

We test the hypothesis that households growing modern sorghum varieties are more likely to have a crop failure than those who grow landraces, assuming that landraces are adapted to local conditions and are also adaptable to intra-year variability in weather patterns. We also test whether households that choose to replant as an ex poste coping strategy are more likely to use a modern variety of sorghum because modern varieties are quicker to mature. Because replanting is by definition carried out in a shortened growing season, we expect the correlation between modern varieties and replanting to be positive. Another variable included in the replanting regression was one based on how farm households coped with previous crop losses due to drought. The "coping" variable was created that included responses to a question on how households responded to crop losses, which were grouped into the four coping strategies identified above: 1) replanting their crops using either HCS or other government-provided seed; seeking work on other farms, replanted, or intercropped were choosing farm-related coping strategies. We expect that households that coped using a household strategy based primarily on agriculture in the past would be likely to do so under the survey year as well.

VII. Results

Regression results for all three equations are shown in Table 2 and summarized in Table 3. The results of the estimation are consistent with other studies of factors influencing MV adoption. Adoption of modern varieties of sorghum was shown to be correlated with the very largest size farms. The relationship between technology adoption and the largest farms is understandable, as larger operations are typically the early adopters. Adoption is also shown to be influenced by local markets (measured by distance to market), perhaps because farms that are closest to markets could have better access to modern varieties than farms in more outlying areas. Next, modern variety adoption was associated with flatter or nearly flat plots of land compared to more steeply sloping lands. This confirms part of the complementary input hypothesis. Some farm-related geographic variables were significant, with farmers in Dire Dawa district more likely to adopt. Dire Dawa district is the site of a major city and this is likely to have influenced adoption. Altitude had little impact on modern variety adoption of sorghum.

The age of the head of the household was not a significant factor in explaining MV adoption, although the number of years of formal education among household adults was. The number of sorghum varieties grown was positively associated with modern variety adoption, which may allay some concerns over whether modern varieties substitute for landraces on the farms of adopters.

Farms that were small to medium sized, with low fertility and on sloping fields, and at lower elevations were found to suffer crop failure in the year studied. Households with sorghum crop failure were found to be more likely to have picked the particular sorghum variety grown for its consumption characteristics rather than production characteristics. Also, the household was more likely to be headed by adults with lower education levels, and to be located in a community where HCS, a local nongovernmental organization, offered agricultural extension services. Farms in the Dire Dawa region were least likely to experience a sorghum crop failure. Finally, the predicted probability of adoption of modern sorghum varieties, estimated at the household level, was positively associated with sorghum crop failure.

Principal findings related to which households took up replanting as a response to crop failures experienced on one or more household plots are now detailed, with respect to farm, farmer, and farm household variables. In general, medium-sized farms, and farms with poorer soils, particularly in the Meta region were the most likely to replant in the face of a crop failure. Households in the Dire Dawa region were less likely to replant. Farm households located in a community where HCS was located were also more likely to replant, perhaps due to the availability of needed inputs. Notably, the probability of growing a modern sorghum variety didn't have an influence on the likelihood of replanting, and the sign on the coefficient was negative.

VIII. Discussion and Conclusions

Our analysis has indicated that there are linkages between crop genetic diversity and the choice of mechanism for coping with drought that households adopt. The results suggest that MV adoption is not an ex ante risk coping strategy, and that indeed households growing modern sorghum varieties are more likely to have a crop failure than those who grow only landrace sorghum. The results indicate that small and medium producers on marginal lands are most likely to be vulnerable to a crop failure, particularly if they are also MV adopters. While this finding is consistent with other studies, it is somewhat surprising given that the sorghum MVs were developed with drought resistant traits (e.g. short season). One possible explanation is that the reduction in rainfall was so severe in the 2002-2003 year, that is was insufficient for even short season varieties to provide a harvest. It is also important to note that the results are crop specific: estimations on the determinants of crop failure in wheat not reported on in this paper found no significant relationship between MV adoption and failure[2]. Most wheat produced in the area is with MVs and there is little local level diversity.

We did not find that the choice of MV versus landrace sorghum to be important in determining the decision to replant sorghum in the wake of a crop failure as we had expected. The negative sign on modern varieties in the replant estimation is somewhat unexpected, since MVs can be planted late into the season and thus would be expected to be a good replant candidate for farmers with crop failure. Our results seem to support Unruh's argument of the importance of landraces in the decision to replant crops, suggesting the importance of the availability of local crop genetic diversity as both a means and outcome of replanting.

Our analysis indicates that location is the critical determinant of the choice to replant sorghum; producers located in more isolated areas (Meta *vis a vis* Dire Dawa) where the HCS NGO was operational (potential source of seeds) were the critical determinants of strategy. Interestingly, measures of poverty and food security were not found to be significant predictors of the choice of replanting as a coping strategy.

We found that the farmers who planted MV sorghum maintained their landraces as well, which essentially expanded the set of potential attributes they could obtain from the sorghum crop. At this point in time, MV adoption contributes to on farm diversity rather than reducing it. This is only weakly reinforced in our results for sorghum, as the signs for consumption and production oriented attributes were negatively and positively associated with modern varieties, respectively, but not at conventional confidence intervals.

Insignificant coefficients for alternative coping strategies in the replant estimation suggests that replanting appears to be a stand-alone primary coping strategy, rather than an accompanying strategy in response to crop failure. Institutional influence on household actions seems to be an important issue as well, given the significance of the local NGO coefficient on the likelihood of a failure in the sorghum crop and replanting. How the NGO presence affects these factors is not clear: does their presence in the community increase income and thus ability to undertake

[2] The wheat regression results are not very robust as only 7% of the wheat growers surveyed grew traditional varieties of wheat and the number of observations is small, however they do suggest that significant differences exist between crops in terms of the impacts of MV adoption on production stability.

replanting, or reinforce the safety net in some way that the households are more willing to engage in riskier activities? Do they distribute a variety that primarily has production rather than consumption characteristics?

At this point the results of the analysis are too inconclusive to base any definitive policy prescriptions upon. Questions such as why the MV adopters were more vulnerable to crop failure and why sorghum MVs are not being utilized to support replanting need to be answered before specific recommendations can be made. However these results are suggestive that sorghum MVs despite their early maturity, are not resilient in the face of a drought related production shocks, and that local sorghum crop genetic diversity is an important means of coping with these shocks. Given the importance of sorghum in the local agricultural economy, the high incidence of drought and other production shocks in the area, and their substantial impacts on agricultural productivity and poverty – together with significant commitments of government resources to sorghum breeding research in the past - some revisiting of sorghum breeding strategies seems to be warranted. One issue is the degree to which formal sector breeding of improved sorghum varieties is likely to be useful for a crop used primarily for subsistence purposes, which farmers are unlikely to use complementary inputs with, and for which there is a rich pool of local diversity available. Strategies that enhance the performance and accessibility of local crop genetic resources, such as participatory plant breeding, and the selection and multiplication of desirable sorghum landraces may in fact be a more effective breeding strategy for this crop in this area. This is not to say that modern variety development is not relevant for these farmers however. The development of MV sorghum breeds that are both drought tolerant and meet farmer demands for subsistence oriented traits such as stalk bulk and taste may also be an effective strategy. Focussing formal sector activities on alternative crops is another option. Our survey indicated a high rate of MV adoption for wheat in our sample. Wheat is grown for primarily commercial purposes, for which there is relatively little local crop genetic diversity available. Wheat is one of the crops that farmers turn to in the wake of sorghum crop failure, thus investment in further breeding and distribution of MVs for wheat could be a more effective breeding strategy for coping with production shocks, as compared with further sorghum MV development. The scope of this study is insufficient to identify which breeding strategy is likely to be most effective, however it does make clear that considering the farm level demand for production and consumption traits associated with individual crops, their potential availability from local level crop diversity, as well as the potential for substitution among crops to obtain them are important factors to consider in setting formal sector crop breeding priorities.

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Table 1, Descriptive statistics, Hararghe region, Ethiopia

Variable	Description	Mean	SD.
Planted sorghum modern varieties	Dummy =1 if yes, else 0	0.118	0.32
Area operated	in timmad (1 timmad=1/8 of a hectar)	3.221	2.97
Totareasq	Total area square	19.191	49.85
Age of household head	years	39.716	12.62
Average slope across all plot	1=gentle; 4=steep	2.409	1.11
Average fertility across all plots	1=low; 3=good	1.761	0.67
Consumption advantages to sorghum	dummy=1 if main advantage of sorghum grown is consumption driven, else 0	.0783	.269
Management advantages to sorghun	dummy=1 if main advantage of sorghum grown is management driven, else 0	.878	0.33
Poverty index	1=rich; 2=medium; 3=poor	25.98	14.45
Ave. years education, adults	average number of years of education (adults)	1.150	1.53
Oxen	Nr of oxen owned	0.410	0.62
Irrigated	dummy=1 if any operated plot irrigated, else 0	0.330	0.47
Failure	dummy=1 if any crop planted has failed, else 0	.383	0.49
Kmtomkt	Distance to nearest market in km	9.385	8.81
Wheat	dummy=1 if HH grows wheat, else 0	.383	0.49
HCSparticipa	dummy=1 if Hh participates in HCS program, else 0	.781	0.41
Altitude	Altitude of village in meters	2054.685	330.13
_Iwor_2	Meta woreda	0.524	0.50
_Iwor_3	Dire Dawa Woreda	0.137	0.34
cop_aid	dummy=1 if main coping strategy is getting external aid (food or seed), else 0	0.256	0.44
cop_off	dummy=1 if main coping strategy is off farm activities, else 0	0.427	0.49
cop_saf	dummy=1 if main coping stratey is selling assets owned, else 0	.138	0.35
noteat	Dummy=1 if HH food insecure, else 0	0.207	0.41

Table 2. Sorghum Regression results	(1)	(2)	(3)
	Planted modern variety of sorghum	**Sorghum crop failed**	**Replanted after a crop failure**
Total area < 1.75 timmads	-0.112	0.329	0.220
	[0.52]	[1.74]*	[0.85]
1.75 < total area < 3.3 timmads	-0.599	0.916	1.135
	[2.20]**	[3.89]***	[3.79]***
Age of household head	0.031	-0.000	0.055
	[0.94]	[0.00]	[1.63]
Age of head squared	-0.000	-0.000	-0.001
	[0.76]	[0.11]	[1.83]*
Altitude	0.001	-0.001	-0.000
	[0.97]	[2.72]***	[0.93]
Average slope across all plot	-0.232	0.122	0.108
	[2.64]***	[1.74]*	[1.26]
Average fertility across all plots	0.187	-0.480	-0.388
	[1.39]	[4.23]***	[2.88]***
Sorghum grown for consumption characteristics	-0.196	0.809	-0.185
	[0.45]	[2.70]***	[0.53]
Sorghum grown for production characteristics	0.783	0.333	0.176
	[1.54]	[1.27]	[0.61]
Years of education of adults	0.120	-0.116	0.015
	[2.23]**	[2.21]**	[0.23]
Irrigated land	0.008		
	[0.04]		
Kilometers to closest market	-0.043		
	[3.26]***		
Household grows wheat	-0.313		
	[1.28]		
HCS participant community	-0.163	0.804	0.386
	[0.65]	[4.25]***	[1.78]*
Meta region	-0.357	0.545	0.645
	[1.16]	[2.27]**	[2.29]**
Dire Dawa region	0.619	-0.990	-1.174
	[1.74]*	[4.12]***	[2.52]**
Number on-farm sorghum vars.	0.853	-0.263	0.520

	[4.65]***	[0.98]	[1.63]
Predicted modern sorghum variety adoption		1.708	-1.974
		[1.83]*	[1.43]
Crop failures last 10 years		-0.047	0.076
		[0.88]	[1.18]
Poverty index, derived			0.008
			[1.32]
Coped through receipt of aid			-0.190
			[0.80]
Coped through off-farm income			-0.366
			[1.58]
Coped through smoothing			-0.163
			[0.58]
Hunger in Hhold at least 2 days			0.020
			[0.09]
Total number of adult within the HH			-0.034
			[0.55]
Constant	-4.103	1.442	-2.241
	[2.80]***	[1.30]	[1.62]
Pseudo R2	.2191	.1717	.2211
Observations	496	445	445

Absolute value of z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Summary of Estimation Results for Sorghum Producers	
Who planted MVs?	*Small and large size farms – not medium *Farms with good land quality (flat, fertile) *Educated people living close to markets * Farmers in Dire Dawa (Close to a major city – also likely to be lower elevation than other two Woredas)
Who had a failure of the crop in 2002-2003 production season?	* Small and medium sized farms * Farms with poor quality lands (steep, infertile) * Farmers who selected sorghum varieties based on consumption oriented traits * Farms located in communities where NGO operated * Farms who adopted sorghum MVs * Farms in Meta – but not Dire Dawa
Who replanted the crop after the crop failure?	* Medium sized farms * Farms with low land fertility * Farms located in communities where NGO operated * Farms in Meta – but not Dire Dawa

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