Storage, Transportation and Aggregation of Agricultural Products for Smallholder Farmers in Sub-Saharan Africa

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Prepared for the Agricultural Policy and Statistics Division of the Bill and Melinda Gates Foundation

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August 10, 2009

Overview

This report summarizes research on the challenges and innovations in linking smallholder producers of staple grains to markets in Sub-Saharan Africa (SSA), with a focus on post-harvest issues including storage, aggregation, and transportation. Our review of the literature and interviews with experts revealed a large literature on the constraints to smallholder production and marketing, but very little material or research on innovations targeted explicitly towards smallholders and staple food grains. The paper begins by briefly outlining the major challenges in the post-harvest staple food system and discusses previous efforts and current innovations in this area.

The briefing is followed by an appendix that presents detail on specific storage, aggregation transportation and market linking technologies we discovered in the course of our research. The extensive bibliography also contains a list of individuals consulted during the preparation of the briefing.

Smallholder Market Access and the Post-Harvest System

Smallholder farmers in Africa are largely located in poor rural areas (Dorward, Kydd, & Poulton, 2006). Smallholder farmers are often geographically dispersed and have limited access to road and communication infrastructure, thus raising the cost of market participation (Dao & Hazell, 2004). This is especially true for farmers growing relatively low value staple crops. Two key patterns emerge from the literature on smallholder production in Africa: first, few smallholders actually sell staple food grains and second, market participation is consistently associated with landholding size, market access and agro-ecological zone (Barrett, 2008). Recent estimates suggest that in Kenya, Ethiopia and Zambia, less than 30% of smallholders are net food sellers of the main staple grain (Jayne, et al, 2006). For many rural farmers, fixed transactions costs (such as transport) represent a substantial implicit tax on crop sales (Renkow et al., 2004). In addition, substantial risk in the form of price volatility may impede market entry for many smallholder producers of staple grains (Fafchamps, 2004; Heltberg and Tarp, 2002). A recent survey of 391 development practitioners in the field of agricultural development indicated that the largest perceived impediments to smallholder participation in higher-value production markets all had to do with infrastructure, and included poor rural transport infrastructure, high cost of transport service, and weak marketing infrastructure (Henson et al., 2008). The next most important constraints were perceived as reliable access to inputs and finance.

Many development efforts focus on increasing the production capacity of smallholder farmers in order to increase their incomes. However, in the absence of strategies that increase market access and augment the limited demand, production increases may actually depress commodity prices and incomes (Dao & Hazell, 2004). Similarly technology adoption that results in increased production may not lead to welfare increases in the absence of integration with national and global markets (Barrett, 2008). Moreover, for any given farm household, the welfare effects of price increases will depend on whether the household is a net buyer or net seller of crops. Therefore, improvements in production capacity need to be coordinated with storage, transportation, aggregation and market information efforts in order to be successful. Many of the experts we spoke with emphasized that while a number of promising interventions to improve production and storage for smallholders had been developed over the years, such efforts typically were not backed up with sufficient on-farm testing or adequate extension services to encourage widespread adoption.

The post harvest system, incorporating all stages from harvest to consumption, links together a system of actors who work in conjunction to supply food to consumers (FAO, 1998). This process begins with harvesting, drying, threshing and winnowing, transport to the store, storage, and finally, aggregation and transportation of the crops. Estimates of post harvest losses in Sub-Saharan Africa during this process vary substantially, with estimates ranging from as low as 10% to as high as 40-50% (Haile, 2006). Reducing post harvest losses through proper storage, aggregation, and transportation processes can help increase the quantity and quality of the products, improving food security and profitability for both the buyer and seller

This paper follows the post-harvest storage chain from the field to the store and transport to market. For each of these stages, the paper first briefly describes challenges faced by farmers then describes what is known about current efforts to address these challenges.

Drying and Storage Preparation

The biggest threats to crops during storage are moisture and pests. Available estimates of grain losses from harvesting and drying range from 16.3% in Swaziland to 6-9% in Zimbabwe (Hodges, 2007). Inadequately dried grain can result in aflatoxicosis as well as mold and rot. Sun-drying grains is the most prevalent method in Africa and has been used for centuries (Proctor, 1994). Traditionally, African farmers would often spread grain on mats or stones on the edge of the road so that the grains could dry in the sun before storage (Murdock et al., 2003). In some countries in West and Central Africa, however, the climate makes sun-drying difficult. Without adequate drying facilities, storage makes little sense for many farmers if the opportunity to sell exists (Armah & Asante, 2006).

Improved Solar Driers

The use of solar driers has been shown to be faster, more efficient, more hygienic, healthier, and cost effective when compared to sun drying (Sharma et al., 2009). When compared to the traditional sun drying method, solarization techniques are often more hygienic and efficient in protecting certain grains from infestations and decay. Depending on the crops, climate, and available resources, many different types of solar driers have been developed. In areas of Ghana, for example, farmers were encouraged to build driers that are longer and thinner than traditional driers, maximizing exposure to winds. But these driers were expensive to build and were susceptible to termite damage (Shepherd, 2009).

Another solar grain dryer was developed for drying maize in rural central Africa that used a fan. Previous grain driers had limited or no air circulation, lowering the effectiveness of the drying system. A grain dryer using solar photovoltaic powered air circulation was designed that limited the inputs necessary to operate. It was shown to be cost-effective with a payback period of less than a year if used to dry surplus grain for selling at market (Mumba, 1996).

The ability of small-scale traders to purchase and dry grain appears to be limited in most areas and many of the improved driers that have been developed are too costly for most sub-Saharan African farmers (see Proctor, 1994 for a review). Many experts we spoke with perceived an efficient, low-cost drier as being potentially quite useful, but none knew of such an initiative currently under way (personal communication with Stephanie Gallatova, FAO, 23 June 2009).[1]

Solarization with Plastic Sheeting

Plastic sheeting can be used to accelerate the solarization process. Murdock and Shade (1991) show how the cowpea weevil can be eliminated by heating up the grain to a very high temperature by placing two layers of plastic over the grain. This technique traps heat under the plastic, increasing the grain's temperature high sufficiently to kill the pests. Another study determined that this technique was practical, useful, and economical (Kitch et al., 1992 as cited in Murdock et al., 2003). This technology is affordable and simple to use, and was able to kill the pests without damaging the cowpea germplasm or overall grain quality. Another advantage is that this technique did not require the use of pesticides or other inputs. Research has shown that cowpeas are able to withstand the high heat created by solarization, but for adoption rates to increase throughout SSA, research needs to be conducted on a wider variety of crops. Certain grains' germplasm may not be able to withstand the high heat making them unusable for seed the following season.

Ash and Sand

Abrasive mineral dusts, wood ash, plant mineral with repellant or insecticidal properties have been studied in depth (O'Kelly & Forester 1983). Much of the research is focused on laboratory experiments and small-scale tests, and does not evaluate the practical application of these products on a large scale. Work by Baier and Webster (1992) demonstrated the viability of using vegetable oils, kitchen ash, and black pepper through on-farm trials. Their evaluations indicate that these tools may be highly cost effectiveness and be widely accepted

[1] Stephanie Gallatova is a researcher at the Food and Agricultural Organization (FAO) in Rome.

by farmers because they use familiar materials that are easily available, and they do not adversely impact product qualities such as cooking time, palatability, and germination.

A study in Eritrea found that wheat, sorghum and chickpeas treated with ash and edible oil had a significantly lower percentage of damage and weight loss than the untreated control groups (Haile, 2006). Ash dust reduced the relative humidity of the storage, which may have assisted in preventing pest infestation. One limit to this technology is that natural products such as ash, sand, or taff can settle to the bottom of the storage container over time, reducing effectiveness.

In many parts of SSA, farmers mix their cowpea harvest with sieved ash from cooking fires or sand in order to prevent a cowpea weevil infestation (Golob and Webley, 1980). Experiments by Purdue University tried to determine the effectiveness of using ash for grain storage. They found that the use of ash protected cowpeas from major infestations, but that any larvae present in the cowpea grain at the time of storage were still able to develop and leave exit holes (Murdock et al., 2003). According to Dr. Larry Murdock from Purdue University, placing the ash on top of a grain store acts as a layer of earth, and since cowpea weevils do not burrow this prevents them from attempting to enter cowpea grain stores (personal communication with Dr. Larry Murdock, 7 July, 2009)[2]. Advantages of ash storage technique are its simplicity and very low cost. The major disadvantage is that sufficient quantities of ash may not be available for larger quantities of grain (Murdock et al., 2003).

Diatomaceous earths

From the mid-1990s through 2006, the Crop Post-Harvest Programme of the United Kingdom's Department for International Development (DFID) commissioned several research projects exploring the use of diatomaceous earths (DEs) as a grain protectant in storage. Diatomaceous earths are soft whitish powders formed from the fossils of aquatic plankton and are composed mainly of hydrated silica (Quarles, 1992; Stathers, 2004). After being processed, these earths can be mixed with grains to kill insects. The project found that the use of diatomaceous earths were very effective as grain protectants in Tanzania and Zimbabwe (Sanginga et al., 2009).

This technology was readily usable by smallholder farmers, and food stocks, such as maize and sorghum, were protected for periods of more than 8 months (Stathers et al*.,* 2008). DE is cost effective for smaller quantities of grain, roughly 1 to 50 sacks of grain. Dr. Tanya Stathers of the Natural Resources Institute, along with several other researchers, has been conducting research for over a decade and have shown DEs to be effective against *Prostephanus truncatus* (Larger Grain Borer), a particularly destructive pest (personal communication with Dr. Tanya Stathers, NRI, 6 July 2009).[3]

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[2] Dr. Larry Murdock is a leading researcher on cowpea storage and drying techniques through his work on preventing infestations by the cowpea bruchid. Currently, Dr. Murdock is at Purdue University. Interviewed 7 July, 2009.

[3] Dr. Tanya Stathers is a researcher in the Enterprise, Trade and Food Management Group of the Natural Resources Institute (NRI) at the University of Greenwich. NRI is an internationally recognized multi-disciplinary center for research, consultancy, and education for the management of natural and human

Further research is needed on the use of local diatomaceous earths in Africa, and the development of protocols relating to safety, extraction and processing (Sanginga et al., 2009). Some of the largest impediments to wide-scale use of DEs in SSA are the lack of DE markets. Some experts in the field feel that if private companies registered DEs in SSA, and proper extension services were in place, the widespread use of DEs would be practical (personal communication with Dr. Tanya Stathers, NRI, 6 July 2009).

Botanicals

Some years ago, researchers in Senegal examined the use of metal silos and botanical protectants. The project used leaves of *boscia senegalensis*, a plant known as having an insecticide effect, as an alternative to phosphine. The results were promising, but the use of *boscia* did not appear to be sustainable on a large scale (personal communication Jose Machado, FAO, 17 June 2009)[4].

One of the most interesting prospects is the use of neem as a grain protectant. Neem is an Indian tree that has been introduced to SSA and is now widely available. Traditionally, Indian farmers placed neem leaves in their grain stores and scientists have shown that chemicals present in the leaves disrupt insect maturation. Neem-based insecticide products are available in the United States, and are now becoming available in SSA. The use of neem leaves is simple and low cost due to the plentiful supply (Vietmeyer, 1996; Adda et al., 2002).

Farm-level Storage Facilities

Once harvested, more than 70% of all grain in Africa is stored on the farm for home consumption (Golob, undated). Of staple grains, maize is more commonly stored than wheat (Shepherd, 2009). Where there is only a single rainy season, grain can remain in storage for nine months or more. Many farmers in developing countries store grain in simple structures constructed from locally available materials, such as straw, reeds, bamboo, mud or bricks (O'Kelly & Forester, 1983; Shepherd, 2009). Wheat and other grains are generally stored in bags, bins, drums, or else simply piled in farm buildings that often lack proper flooring, doors, windows, and ventilation. Despite these problems, traditional storage structures have been developed over long periods of time to meet the climatic and social needs of a population and its traditional varieties of grain (Golob, Farrell, & Orchard, 2002) and are normally relatively inexpensive.

Evidence suggests that while many traditional storage facilities do a reasonable job of preventing post-harvest losses, the introduction of hybrid varieties and new pests render some of these technologies less appropriate (Hodges, 2007; Shepherd, 2009; Golob, undated). A major challenge to the development of new technologies is that storage devices often need to be crop and climate specific (Golob, Farrell, & Orchard, 2002). For example,

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resources. NRI has done extensive work in storage technology in SSA. Stathers, with Dr Brighton Mvumi, University of Zimbabwe; William Riwa, Plant Health Services, Ministry of Agriculture, Food Security and Cooperatives, Tanzania; and Mike Morris, World Wildlife Fund (WWF), have conducted research on the use of DEs in Tanzania and Zimbabwe (personal communication, 6 July 2009).

[4] Jose Machado is a researcher at the Food and Agricultural Organization.

in Benin there are four agro-ecological zones (AEZs). A 2000 study showed that maize storage device types varied widely by zone. Over 70 percent of farmers in the southern AEZ relied upon baskets for maize storage as compared to only 19 percent in northern AEZ (Hell et al., 2000).

Estimates of storage losses also vary widely. In general, losses for local, traditional crops are very low, often less than 5%, but can be much higher for improved varieties (INPhO, 1999). For example, early dissemination of hybrid maize in Zambia did not take into account the crop's poor storage characteristics. In response, women reverted to traditional crop varieties after sustaining post harvest losses using the hybrid crop (World Bank, 2009).

Overestimates of storage losses may be one explanation for low adoption of new storage technologies (Shepherd, 2009). Research also indicates that there is a strong correlation between a farmer's wealth and the use of improved storage devices (Shepherd, 2009). For example, smallholder farmers in Tanzania are significantly less likely to use metal bins than their wealthier counterparts (Shepherd, 2009).

With increasing market liberalization some farmers are more likely to store grain for future sales, holding out for higher prices (Shepherd, 2009). Current storage devices may not be appropriate for longer-term storage (Golob, Farrell, & Orchard, 2002). In a study of smallholder farmers, the highest levels of grain loss occurred during the sixth and seventh month after storage (Haile, 2006). In some situations, smallholder farmers may also need to change their traditional technologies in order to adapt to a change in the availability of natural resources for building and construction materials (Golob, Farrell, & Orchard, 2002).

General Mills recently started a Science and Technology Transfer Initiative with the goal of introducing more effective agricultural techniques, including storage, to smallholder farmers in Africa. Many of the farmers involved with this initiative expressed serious concern about the safety of their storage systems (personal communication with David Cummings, 8 May 2009).[5] Safety is a common storage concern among African smallholder farmers, and can lead farmers to harvest crops before maturity or sell their harvest earlier than ideal (Shepherd, 2009). Other concerns, such as privacy were also very important to smallholders, as farmers did not want everyone to be aware of the success or failure of their harvest.

Bagging

An intervention in West Africa replaced plastic bags with natural fiber bags and found that fiber bags were effective in preventing aflatoxin spoilage (Turner et al., 2005). Jute or other natural fiber bags allow air movement through the grain reducing moisture content when kept dry and stored on raised platforms (INPhO, 1999), unlike plastic and synthetic bags that can promote humidity (Turner et al., 2005). Jute bags are easily transportable, and can be repaired and reused (INPhO, 1999). However, they have several drawbacks: they tend to

[5] David Cummings, a volunteer with the Science and Technology Transfer Initiative of General Mills. The Science and Technology Transfer Initiative is a volunteer program organized by General Mills, which connects Small to Medium Size Enterprises (SMEs) with knowledgeable practitioners, engineers, and food science experts from General Mills (personal communication, 8 May 2009).

have a high initial cost, they are vulnerable to rips and tears during transportation, and if stored improperly, they can be stolen or exposed to water and pests.

The use of plastic bags in African grain storage has also had some remarkable successes. The Bean/Cowpea Collaborative Research Support Program (CRSP) began its work in 1987 examining new cowpea storage techniques in Senegal and Cameroon. One innovation they pioneered was what became known as the "triple bagging" technique (Murdock et al., 2003). Researchers found that by placing cowpea grains within three plastic bags and sealing it tightly that it was enough to stop development of a cowpea weevil infestation, and protect the grains during storage. Researchers believe the weevils were killed due to the low oxygen content within the bags. This is a low cost, and effective technique due to its use of readily available materials as many farmers already use plastic bags for storage.

During storage, wooden pallets can also help to prevent bags from being stored on the floor or on stones directly, preventing humidity buildup in the grain (Turner et al., 2005). Pallets can be constructed from local materials at a low cost (INPhO, 1999). These pallets can be used during the drying process as well as for storage.

Metallic Drums, Bins, and Clay Pots

Metallic drums, bins, and clay pots can be hermetically sealed with proper inputs. They are durable, and provide good protection from pests (INPhO, 1999). Because they are sealed, however, if grain is not properly dried it is vulnerable to moisture development. To minimize this risk, grain must be properly dried before storage, and containers must be stored in the shade away from exposure to direct sunlight. The use of oils near the opening helps provide an airtight seal, protecting the grain and preventing losses.

Cement or metal can be used to modify traditional storage structures (O'Kelly & Forester, 1983). Cement and metal are durable, moisture proof (when sealed tightly), and protect against pest infestation. For example, petrol or vegetable oil drums and kerosene tins can be used to store grains. These drums can hold approximately 140 kg and 12 kg of grain, respectively. When metal is used, the storage container should not be exposed to sunlight because moisture may develop inside. Discarded drums may have small openings (especially if they were originally used for oil), and these need to be modified to allow for proper grain storage.

Mud and Brick Silos

Mud silos offer the benefits of improved security by reducing storage losses at a relatively low cost. The silos enable crops to be stored for longer periods of time, increasing farmers' market flexibility (NRI, 2004). In order to achieve maximum protection of grain in mud silos, farmers require training in the proper construction of silos. Anecdotal evidence from farmers suggests that grain loss due to infestations and other pests decline with use of the mud silos. In order for the mud silos to be most effective they should be built following the wet season since the huts need approximately 3 months to cure, making them difficult to construct in some agro-ecological zones (NRI, 2004).

The promotion of improved brick and cement storage structures has met with uneven success. In Zambia, the promotion of relatively expensive brick and cement storage has given way to promotion of less expensive mud-plastered traditional stores. Similarly in Cameroon, Benin, and Burundi, more expensive breeze-block ferro-cement bins proved not to be economically viable (Shepherd, 2009).

Metal Silos

Metal silos are simple structures that allow grains to be stored for long periods of time and prevent attack from pests such as insects, rodents, and birds (FAO, 2008). Household silos hold roughly 100 to 3000 kilos and larger silos can range to sizes to store 2 mT. A household kilo with a capacity of 1000 kilos can conserve enough grain to feed a family of five for one year (FAO, 2008). The FAO considers this a critical post-harvest technology due to its track record in other countries, proven effectiveness at protecting grains, low expense, ability to be built in situ with local labor and available materials, and potential to last for up to 15 years (FAO, 2008). The FAO argues that these silos are relatively inexpensive, ($20-100 depending on size) and have demonstrated the ability to protect grain over a relatively long period. Many farmers will require subsidies or financing, however, to acquire these silos and the silos have to be adequately protected from sun and rain.

Other evidence on the adoption of metal silos is less positive. Farmers in Malawi showed reluctance to use larger metal silos due to concerns about theft and because they were uncertain about pre-storage fumigation requirements (Shepherd, 2009). Attempts to disseminate silos in Mozambique failed due to inadequate local fabrication capacity (Shepherd, 2009). Catholic Relief Services (CRS) is engaged in an effort to promote household bins that hold the equivalent of three bags of maize and can be used inside the home. Such bins, however, costs US $ 100-175 and CRS has found it necessary to provide savings and credit to support adoption (Namwonja, 2009). The Swiss Development Corporation and the International Maize and Wheat Improvement Center (CIMMYT) are currently working to promote an 820 kg household metal storage bin based on success with such storage units in Central America (SDC, 2008).

Village Level and Trader Storage

Village-level stores offer a common storage site for multiple smallholder farmers and can also be used for aggregation and distribution. Such bulk granaries are found throughout Africa, but most are currently empty, suggesting that village level storage efforts should be viewed with caution (Shepherd, 2009). In part, under-utilization of community-level storage may be a result of grain market liberalization and the dismantling of many state procurement systems. In Tanzania, donor-financed stores for cooperative societies fell into disuse because farmer preferred to store their maize at home (Shepherd, 2009).

In Sierra Leone, a FAO project constructed 50 village stores with a 50 ton capacity. These stores were eventually used but farmers were initially quite reluctant, not wanting others to observe the quantity of their harvest, lacking confidence in collective record keeping, and fearing seizure by the government (Shepherd, 2009). The construction of village level stores was done under several assumptions: 1) that farm-level storage losses were quite high; 2) that prices charged by traders were exploitative, and 3) that traders would be more likely to buy if they could pick up grain at a single location. However, the accumulated evidence suggests that, especially for grains, the storage for the collective marketing does not necessarily need to take place at one location (Shepherd, 2009).

Cereal Banks

Following famines in the 1970s and 1980s, NGOs and governments created thousands of cereal banks in the hopes of avoiding famines in the future. The banks were intended to prevent farmers from "over selling" at low prices and then buying back at high prices, help farmers avoid exploitation by middlemen, and help farmers with surpluses to find markets (Coulter, 2007). Cereal banks would buy grains from farmers during the harvest, and then sell back the harvest on the market as prices began to rise, with the profits used to buy back next years crop (Shepherd, 2009). Cereal banks had high rates of failure; in Benin the failure rate was reported to be over 90% (Kent, 1998). Subsequent evidence suggested that farmers were not in fact forced to sell off most of their harvest during low-price season. In addition, trading margins for grains were found to be quite thin; traders were not exploiting farmers and cereal banks tended to disrupt – rather than support – patterns of trade. Cereal banks often suffered from default, corruption, weak management, and were not nimble enough to compete with private traders who were also engaging in this type of arbitrage (Coulter, 2007).

Cereal and Seed Fairs

In the past several decades several other aggregation techniques have been employed, with various levels of success. In Mali, in order to help producers organize and lower traders' transaction costs, Afrique Verte, along with their partner, L'Association Malienne pour la Sécurité et la Souveraineté Alimentaires (AMASSA), started organizing cereal fairs with the support of the government of Mali. Mali is landlocked and has limited transportation infrastructure which severely limits marketing options for many smallholders. Cereal fairs encourage production by tackling aggregation and transportation constraints. Farmers need to arrive at the fair with only a sample of their goods, thereby easing transportation cost. The common meeting point supports information dissemination about product availability and quality and helps to set a common market price for goods. Buyers come to the cereal fairs, view samples of the grains, and sign contracts with farmers. Legal advisors, provided by the NGOs, help to enforce agreements made at the cereal fairs between buyers and the smallholder farmers (Film transcript of *Grain Exchange Fairs in Mali,* undated).

In several drought-prone areas in Eastern and Southern Africa, a number of NGOs and donor agencies have been running seed voucher and fair (SV&F) programs to help farmers cope with loss of seed and to encourage the development of local seed markets (Orindi and Ochieng, 2005; Gumbo, 2009). Seed shows are day-long events that are organized locally and provide an opportunity for local famers with surplus seed and local seed producers to meet up with buyers (Leonardo, 2001). Such fairs are often combined with a voucher system in which needy families are given vouchers to purchase seed. Seed fairs have the advantage of providing farmers with locally appropriate seeds at the appropriate time and maintaining local biological diversity. The use of local judging panels helps to certify seed quality. Experiences in a number of countries suggest that even in drought situations, sufficient quantities of seed area available locally and such fairs can successfully promote local market development (Orindi and Ochieng, 2005). NGOs with experience in this area include Catholic Relief Services (CRS), the German aid agency GTZ, Save the Children, and Intermediate Technology Development Group (ITDG, now Practical Action).

Storage by Traders

Traders play a critical role in the development of Africa's markets. Compared to most industrialized countries, traders in Africa often conduct a higher volume of transactions for smaller amounts and operate on a 'cash and carry' basis, resulting in relatively high marketing costs (Fafchamps, 2004). Storage is a particularly difficult issue for traders given the high transaction costs they already encounter, and the great distances they often cover.

Traders also contend with security issues when traveling over large distances collecting a large amount of goods that are easily stolen (Fafchamps, 2004). In many countries, weak rule of law means that traders are unlikely to cover any goods once stolen. A study in Malawi, Madagascar, and Benin showed that most overnight storage is locked and guarded. For traders transporting goods between towns, a significant minority paid for protection or travelled in convoys. Many traders also indicated they avoided hiring others for fear of employee-related theft (Fafchamps, 2004). Due to the risks inherent in trade, many traders form solidarity alliances and trade groups to both mitigate risk and expand markets (Fafchamps, 2004). In some cases, governments facilitate this coordination. The government of Benin has organized trader associations in each market town. These associations work to solve coordination failures such as a common storage site for all traders and determining market days (Fafchamps, 2004).

Small traders typically function by rapidly turning around stock. Evidence suggests that traders typically hold stock for anywhere from half a week to two weeks (Shepherd, 2009). In Ghana, 78% of long-distance traders reported that they did not have a crib or secured warehouse for maize. Since Ghana is 99% self-sufficient in maize, inadequate storage both at the farm and trading level appears to be a primary cause of maize price variability (Armah & Asante, 2006). Similarly storage by millers also appears to be relatively rare in most of Africa (Shepherd, 2009).

Warehousing Programs

Warehousing programs help improve smallholder farmers' storage capabilities by providing better structures to protect grain and increasing access to extension services provided by many warehouses (Dorward, Kydd, & Poulton, 2006). We do not review these programs in detail, since BMGF are already involved in the World Food Program's "Purchase for Progress" Program.

Warehousing programs can reduce storage risks for smallholder farmers by transferring responsibility for long-term storage of agricultural products. Warehouses can also serve as a way to improve quality and trade standards, promote more efficient use of storage space, and increase the opportunities for farmers and traders to build a formal record of performance (Dorward, Kydd, & Poulton, 2006). These programs can help improve marketing systems by working collectively with processors and distributors on behalf of smallholder farmers.

However, there are high fixed costs of operating such a program and these costs can discourage smallholder farmers. Some farmers have indicated they do not like the public aspect of storing grain in a community warehouse since other people have access to information about the status of their harvest (Shepherd, 2009). Warehouses may operate some distance from the various smallholder farmers making it difficult to fill the entire warehouse with agricultural products. When this situation occurs, warehouses may not be able to cover their overall storage and management costs (Coulter & Onumah, 2002). Large aggregate stores can be used as distribution centers which assemble a mix of products to be shipped to markets (Thompson, 2001). In Niger, women and men were able to use crops stored in warehouses for loan guarantees (The World Bank, 2009). This project allowed farmers to store their products in a warehouse until prices rose and to access credit before their product was sold.

Recent Trends in Storage and Marketing

Shepherd (2009) notes that millers are becoming increasingly important suppliers of staples in many countries. Maize trade in Africa now moves from farmer-trader-mill-retailer-consumer, rather than farmer-trader-retailer-consumer with consumers arranging for milling themselves. Mills may therefore be looking for additional storage space or may increasingly seek to use traders for storage services, as is happening in Kenya and Zambia. Many mills appear to be moving toward bulk, rather than bag handling. In western Kenya, a milling company has constructed large-scale silos and plans to store maize purchased in western Kenya and Uganda; it is unclear, however, whether traders used to handling smaller bags of maize from smallholders will be able to trade in bulk. In Ghana, a trader is developing a network of rural silos that will feed into a central silo complex that can supply major urban centers. (All examples from Shepard, 2009).

Transportation

Africa is the world's least urbanized continent with only one-third of the population living in urban areas in 2000 (World Development Report, 2009). Africa also has one of the lowest road densities in the world, second only to Latin America (World Development Report, 2009). Unlike the majority of Latin Americans who live near the coast, one-third of all Africans reside in landlocked countries, magnifying the costs due to the lack of roads. A recent study estimated that road construction in Madagascar that reduced transport costs of rural households by $75/ton would raise household income by 50% (Jacoby & Minten, 2009).

In spite of the widespread agreement that poor infrastructure is a major impediment to market development for rural smallholders on the continent, we found very few examples of organizations working on technologies to overcome this barrier. The main projects we did find focused on intermediate means of transport, or IMTs. The Sub-Saharan Africa Transport Policy Program (SSATP) has sponsored much of the work in this area.

Intermediate means of transport (IMTs)

Motorized means of transportation are increasing in both rural and urban areas, particularly for long hauls. Meanwhile, human and animal-based intermediate means of transport (IMT) may offer a more affordable and sustainable means of transport. The World Bank defines IMT as "those means of transport, which are intermediate between the traditional modes of walking … and modern, conventional motor vehicles such as cars, pick-ups, trucks and buses (World Bank, 1996)."

IMTs are often missing in Sub-Saharan Africa, making transport of crops extremely difficult and costly. Some of the most common IMT methods are the use of wheelbarrows, handcarts, pack donkeys, sledges, animal-drawn carts, bicycles, bicycle trailers, and motorcycles/mopeds (World Bank, 1996). A survey of four Sub-Saharan Africa countries (Burkina Faso, Cameroon, Tanzania and Zambia) confirmed that bicycles remain the most prevalent and important IMT (Starkey, 2007). The surveys indicated that motorcycles were becoming more common in Cameroon and Burkina Faso, but were still rare in Tanzania and Zambia. Several agencies, including World Bicycle Relief, are experimenting with large-scale bicycle distribution to overcome these constraints. WBR's project will distribute 50,000 bicycles to students and teachers in rural Zambia.

The transportation of goods is a challenge for many smallholder farmers. A survey of rural transportation in Burkina Faso, Uganda, and Zambia found that ox and donkey-drawn carts were the primary forms of load carrying IMTs (Barwell, 1998). The carts were used to transfer goods to market, as well as used for transporting inputs to the farm. Topography and climate conditions often influence the type of transport used by smallholder farmers. Bicycles are often found in wealthier, flatter areas. While donkeys are used primarily in drier, hillier areas, and oxen in flatter areas away from dense forest (Starkey, 2001).

Trucks and other motorized vehicles are often very expensive to operate and maintain in many parts of SSA. Barwell's rural transport survey found that some farmers formed cooperatives to rent trucks in order to collect large amounts of cash crops from many different smallholder farmers and place the crops in a cooperative store in the village (Barwell, 1998). This method was only common if there was village store or a large market market, otherwise individual smallholders typically transported goods by oxen to the local market. Farmers also used wheelbarrows and bicycles, but these were primarily for small amounts of goods over very short distances (Barwell, 1998).

The limited supply of credit is often cited as a major reason for the lack of IMTs. Trials of improved IMTs have taken place with pack donkey in Tanzania, sledges and ox carts in Zambia, hand trucks and cycle trailers in Ghana, wheelbarrows in Tanzania, and hand carts in Malawi but so far few of these projects have seen widespread adoption (Starkey, 2001).

General Mills' Science and Technology Transfer Initiative tried to deal with issues of transport for smallholder farmers by threshing grains on site. If grains are threshed on site, then the total weight of stored grain will decrease and reduce the cost of transporting the crops (INPhO, 1999). While threshing and shelling on farm helps to reduce the weight of the product to be transported, some traditional techniques such as using animals or whets may result in grain loss and allow impurities which may lead to quality losses during storage (UNIFEM, 1994). Improved siting of markets and storage centers will be an important component of the solution to SSA's transportation problems (Starkey, 2001).

Aggregation, Marketing and Distribution

A variety of programs by NGOs, governments, as well as the private sector have attempted to improve the situation of smallholder farmers by linking them with sources of structured demand. Structuring demand allows for the procurement of smallholder surpluses by organizations thereby creating a stable market for farmers and incentives to invest in better grain storage and improve planting techniques. By creating these structured markets, organizations can help small farmers mitigate the risk of investing in new technologies by guaranteeing themselves as a purchaser.

One of the most significant challenges to programs that link smallholder s to markets is the need to efficiently aggregate enough product to sustainably support the program. Smallholder farmers are often in rural, remote areas imposing relatively high transportation and coordination costs. Contract enforcement presents another challenge: farmers may agree to contracts up front, but default on obligations at harvest time if the spot market price is higher than the contract price.

Linkages can be either "top down" in which sources of demand seek a group of farmers to fulfill that demand, or "bottom up" in which groups of farmers are developed which then seek sources to supply. Keys to success in both approaches include 1) identifying a reliable market; 2) ensuring that the activity is profitable for the entrepreneurs linked to farmers; and 3) linkages that provide farmers with higher income than from alternative opportunities (Shepherd, 2009). In many developing countries, urban high-value markets offer considerable market potential, although this potential is still limited by information and transportation bottlenecks in many SSA countries (Henson et al., 2008).

We found very few initiatives linking smallholder producers of staple grains to any source of structured demand. As expected, most of the initiatives linking smallholders to markets focused on higher-value crops. Below we review the main initiatives we found that work with smallholder producers of relatively low-value or staple crops and those initiatives that link smallholders with structured sources of demand. A list of the initiatives and sources is provided in the appendix.

Linking farmers to agroprocessors

Companies who are purchasing products from smallholder farmers may collect and store agricultural products themselves or hire local transport companies to pick up smallholder products for them. In some cases, collection happens at the farm level; often pick-up is organized at collection points where smallholder farmers drop off their goods. Some of these aggregate stores are run by SMEs, some are organized by producer organizations, and some are independently operated by other companies. While these collection sites represent a high capital cost they may help create another source of employment for local families. These storage, aggregation, and transport systems will not only vary widely by countries and regions but will also depend on the infrastructure and capital resources available (personal communication with Bill Guyton, 15 May 2009).

For example, SMEs, working with the Science and Technology Transfer Initiative at General Mills use a variety of practices to aggregate and transport millet from smallholder farmers in

Tanzania (personal communications, David Cummings, 8 May 2009). The SME distributes 100kg bags to designated collection points. Farmers take the bags to their farms, and are responsible for transporting filled bags back to collection points for pick-up. A major issue in moving forward is the lack of appropriate threshing technology. Better quality threshing prior to bagging would lower labor effort for farmers, reduce transport costs and result in fewer broken hulls and decreased rancidity (personal communication, David Cummings, 8 May 2009).

Contract farming has been used successfully by smaller companies as well as by large agribusinesses. Dave Cummings indicated that the majority of small to medium-sized Enterprises (SMEs) the Science and Technology Transfer Initiative works with are either currently working with smallholder farmers on a contract basis or are moving to contracting with smallholder farmers (personal communications, 8 May 2009). For SMEs, vertically integrating through contracting with smallholder farmers is a strategy for successfully improving control over their products and improving quality.

Concerns about market power arise if one company becomes the primary buyer, leading a community to rely on for its agricultural marketing (Goletti & Samman, 1999). In addition, the contractor or a vertically integrating company may force small traders, who may be sources of credit or important community members, out of business or out of the area (personal communication, Paul Healey, 20 May 2009).

Additionally, Bill Guyton of the World Cocoa Foundation noted that cocoa distributors and buyers rarely rely on pre-harvest contracts and primarily focus on post-harvest price negotiation (personal communication with Bill Guyton, 15 May 2009). Much of the literature noted that organizing pre-harvest contractual arrangements with smallholders presented challenges: when post-harvest spot prices were higher than negotiated prices, farmers often ignored contractual obligations and sold on the spot market.

In Togo, an innovative set of partnerships has brought smallholder producers into the soya production chain. The key innovation was the development of service provider and producer organizations (SPPOs) that support long-term cooperation between producer organizations and service providers/purchasers. The NGO Centre International de Développement et de Recherche (CIDR) has supported the development of Soja Nyo, a limited liability company that provides financing, extension and marketing services to producer *tontines* (a long-standing form of community organization in Togo). The shareholders in Soja Nyo are the tontines, its employees and CIDR. (Pernot du Breil, 2007). The famers participating in the program are all smallholders, but most did not cultivate soya prior to participation in the program. Soja Nyo procures the soya from farmers and engages in stocking, processing, packaging and delivery to domestic urban markets. The *tontines* act to facilitate cooperation among farmers and set internal rules to ensure that farmers meet their commitments. Soja Nyo provides seed on credit and farmers agree to sell a fixed amount to the company.

Reviews of projects linking farmers to agribusiness and agroprocessors suggest that the provision of extension services and education is critical to project success. Whether contracts are formal (written) or informal appears to have little bearing on project success, but the development of mutual trust among parties appears critical (Danson et al, 2004).

Linking farmers to retailers

In Uganda, the fast food chain Nando was worried about adequate supply of potatoes for French fries and was considering importing frozen fries. Instead, Nando worked with an NGO-facilitated farmers cooperative, the Nyabyumba United Farmers Group, that became the sole supplier of potatoes to the retail chain. Nando worked with the farmers to obtain the correct size and quality of potato for their operations and the cooperative worked to coordinate members to achieve year round harvests by varying planting dates and planting altitudes. Initial plantings were financed from a combination of savings, borrowing from family, and finance from a local moneylender. The NGO and other partner organizations provided on-going training in cultivation, sorting and grading of produce, and marketing. The farmers were willing to adapt production once the purchase of surplus crop was contractually guaranteed and trust had been established between the contracting parties (Based on Aliguma et al., 2007; Kaganzi, et al, 2008).

In South Africa, rurally-based franchise supermarkets of the SPAR chain were able to locally source horticultural produce from local farmers. The SPAR stores advertised for produce, vetted local farmers, and entered into verbal contracts with the farmers, who lived an average of 35 kilometers from the stores. Because the stores are relatively remote, the costs of negotiating with numerous local providers compare favorably with transport costs from urban centers. Most of the consistent suppliers had their own transport systems, however, and do not appear to be relatively large smallholders (Benienabe and Vermulen, 2007).

In Tanzania, a donor-supported program developed links between local farmers and safari lodges in the Serengeti Region. Pre-existing farmers groups entered into informal verbal contracts with lodges for weekly delivery of horticultural produce. A farmer-organized vegetable committee keeps records of on-going production and negotiates with individual farmers to set delivery commitments. Produce is collected weekly at a collection center, packaged according to lodge specifications, and transported by hired vehicle to the lodge (Mafuru, et al, 2007).

In Uganda, as well as other parts of southern and eastern Africa, the Regional Potato and Sweet Potato Improvement Network (PRAPACE) works with smallholder to find buyers for their crops. They connect exporters with smallholder farmers and help aggregate the harvest. PRAPACE, in collaboration with the International Potato Centre (CIP), also provide extension services, teaching farmers how to better develop seed potato and plant crops (Aliguma et al., 2007).

Local procurement of international food aid

Procuring food aid locally can be an important market developing mechanism and organizations like the World Food Program's P4P program have begun to focus on local procurement. A 2007 study done in Ethiopia on local food aid procurement found that organizations struggled to find enough smallholders to satisfy the aid need and most local aid procurement was channeled through a relatively small number of organizations, most of whom did not involve smallholders (Coulter, at al., 2007). Organizations such as the Ethiopian Government's Disaster Preparedness and Prevention Commission (DPPC), the World Food Programme and EuronAid tried to target farmer associations but ended up procuring most food aid purchases from large traders specializing in food aid supply (Coulter et al., 2007). In addition, large-scale local purchase of food aid locally often requires organizational approval, leading to lengthy delays. To cope with these delays the Ethiopian Food Reserve Administration provides a food aid bank that allows donors to draw down from its reserves for distribution and then allows the donors to procure locally to replenish the stocks (Coulter et al, 2007). In Ethiopia, food aid has supported the development of local markets and food processing enterprises. In both Uganda and Ethiopia, however, local purchase of food aid does appear to have resulted in greater price instability (Coulter et al, 2007).

In Uganda, the Agricultural Productivity Enhancement Program (APEP) and the Uganda Cooperative Alliance (UCA) have worked with primary level producers organizations to bulk agricultural production for second-tier bodies. Staple commodities (maize, beans and rice) constituted 38% by weight of total tones bulked in 2005 and many famers groups reported that bulking was profitable. Purchases of the World Food Programme to supply the internally displaced population in northern Uganda were key to increasing maize demand in this context (Coulter, 2007).

Food for Education Programs and Local Procurement

Food for education programs include both school feeding (SF) programs in which children are fed in school and food for schooling programs (FFS) where families are given food packages if their children are in school. Until relatively recently, most food for education programs in developing countries tended to rely on regionally or internationally procured food. In 2003 NEPAD, WFP and the Millenium Task Force on hunger launched a pilot home-grown school feeding and health program designed to link school feeding to agricultural development through local procurement. To date, Ghana and Nigeria have rolled out programs (Bundy, et al, 2009).

Reviews completed to date suggest a number of important considerations in scaling up local procurement via school feeding and food for schooling programs. A key consideration is whether local procurement is less costly than international procurement, given the potentially higher costs of dealing with a large number of suppliers. Care must also be taken that increases in local demand do not significantly raise local food prices, adversely impacting net food buying households. Increases in demand are predicated on the assumption that food intake from school feed is not substituted away from the child at home and that take-home rations are in addition to current household consumption (Ahmed, 2004). School-level implementation arrangements are also important. The strongest programs tend to have local ownership, parental and community involvement, and some sort of institutional structure that supports transparency and accountability in procurement (Bundy et al 2009). Finally, the evidence from programs implemented to date suggest that the transition to national management of school feeding programs and the inclusion of smallholders take a relatively long time. Initially, only the relatively small proportion of smallholder that are net food sellers are likely to be able to participate (Espejo et al, WFP, 2009).

The available evidence appears to support the idea that local procurement for school feeding and food for schooling programs has the potential for positive effects on local agricultural production, although there is very limited direct evidence on this impact. Evidence from the Philippines and Bangladesh suggests that school feeding meals are not substitutes for home feeding, suggesting that local procurement has the potential to raise local demand (Ahmed, 2004; Jacoby, 1997). Programs in Guatemala (Caldes and Ahmed, 2004); Indonesia (Studdert et al, 2004) and Chile (Bundy et al, 2009) all report positive effects of local procurement on local agricultural production. Local procurement can also stimulate local processing capacity as has been reported in Malawi, Laos, and Ghana (Bundy et al, 2009). Brazil is in the process of enacting a law that will require that 30% of all food for the national school feeding program be procured locally (Espejo et al, WFP 2009). While virtually no empirical data exists on the impacts of local procurement on local agricultural production and incomes, modeling exercises in the African context estimate that potential benefits to smallholders from local procurement could be relatively high, with estimate of income increases of $50/year for smallholders in Kenya (Brinkman, 2007 as cited in Bundy et al). Productivity gains are key to smallholders receiving benefits from local procurement (Ahmed and Sharma 2004; Bundy et al 2009). A modeling exercise for Kenya suggested that income gains would be much larger if procurement was combined with supply-side interventions designed to raise productivity (Espejo et al, WFP, 2009).

Institutional arrangements for linking school feeding programs to local production include procurement from cooperatives or associations, contract farming arrangements, and encouraging and supporting school committees to procure food in local markets (Bundy et al, 2009). Procurement directly from individual farmers is likely to be impractical (Espejo et al, WFP, 2009). Another challenge to local procurement is that local smallholders may not produce the particular types of food that are required for feeding programs. There two potential approaches to this problem. One is experimenting with partial substitution of locally available products. In Dodoma and Singida districts in Tanzania, ICRISAT and WFP have experimented with replacing maize with sorghum in school feeding programs, since sorghum is produced locally (ICRISAT, 2003). A second approach involves developing longer-term supply contracts with local producers who can adjust production to meet demand. Finally, local procurement of staple grains on a relatively large scale may also require warehousing and storage capabilities (Dank et al, 2007).

Several case studies demonstrate successful local procurement. In Guatemala, the sourcing for school feeding has shifted from industrial suppliers to local producers. Parents of school children supply the food and participate in preparation, generating extra income. In Bangladesh, provision of biscuits in schools led to a new market opportunity for local wheat farmers (Caldes and Ahmed, 2004). During Indonesia's economic crisis in the 1990s, the government-initiated school feeding scheme stipulated that all food should be procured locally, but that the local staple food should not be included in school lunches, to avoid meal substitution at home. Meals were prepared by local women's associations, and farmers reported that the project had increased their sales (Studdert, 2004; Sabates-Wheeler, 2008). The Chilean program Programa Alimentacion Escolar (PAE) has reportedly had good success with local procurement, but detailed documentation proved difficult to obtain.

Other attempts at moving towards national ownership and local procurement have seen mixed results. The Ghana School Feeding Program launched in 2006 with the explicit goal of boosting domestic food production. The program reportedly has exceeded coverage targets and boosted school enrollments, but a 2008 review found that in most areas of the country, less than 20% of foodstuffs had been procured locally (Ghana School Feeding Program website, 2009). A recent independent review also found evidence of 'widespread corruption in the national secretariat (IRIN, 2008).

The Midday Meals program in India covers 130 million children throughout India, using a decentralized implementation through the Food Corporation of India. Attempts to procure food locally from farmers have been limited because of the need to channel food through the public distribution system. In some states, including Kerala, local procurement has worked when local farmers sell rice paddy directly to mill owners, who in turn sell to the authorized wholesalers. The demand generated by the Midday Meals program, however, was a relatively small percentage of total production and therefore was not sufficient to significantly raise local demand. Other local procurement efforts in India were stymied by lack of smooth flows of funds, which meant procurement commitments were not steady for smallholders and difficulty adjusting supply and demand during vacations an unexpected school holidays. (India case study from Chettiparamb, 2007 as cited in Espejo, et al., WFP 2009). The World Food Program recently produced a guide to home grown school feeding programs that notes several successful programs in Chile, Brazil and Nigeria, but again, detailed information on these programs was difficult to obtain (Espejo et al, WFP, 2009).

Linking Farmers to Food-by-Prescription Programs

Another opportunity for local agricultural procurement may come through USAID "food by prescription" that supports the provision of supplementary food packages to HIV/AIDS patients through clinics. Most of program RFPs include a component designed to develop local production and processing capabilities. Food-by-prescription programs are underway in Kenya, Malawi and Uganda, and planned for Ethiopia, Zambia and Tanzania (Castleman, 2008). In the Kenya program, supplementary food packets are provided by a local processor, but this does not appear to involve very smallholder farmers.

A partnership that may provide links to smallholders is the Academic Model Providing Access to Healthcare (AMPATH) and its nutrition component, the HAART and Harvest Initiative, which is a partnership between Indiana University, Moi University in Kenya, IFPRI, USAID, and the Kenyan government. AMPATH developed four smallholder farms that supply locally acceptable, and nutritionist prescribed food baskets for HIV/AIDS patients and their families (Wagah, undated). A nutritionist screens every incoming patient, and if necessary they receive 100 percent of their food needs for the next six months. This program is looking to expand to include direct links to smallholder farmers in the future (personal communication, Naoimi Lundman, 21 July 2009)[6].

Conclusions

[6] Naoimi Lundman is the Associate Field Director of the Family Preservation Initiative, a program of AMPATH in El Doret, Kenya.

In our review we found relatively few examples of innovative or novel technologies designed to improve storage and transportation for rural smallholder producers in Africa. Those technologies we did find have often been around for some time but not have seen widespread adoption, apparently due to high costs or to inadequate funding for on-farm testing and extension. Most experts we spoke with stressed that many potentially innovative technologies had been developed, but few had seen sufficient field testing.

As we note above, the majority of programs linking smallholders to markets involve higher value products such as horticulture, milk or export products such as coffee. A key constraint to smallholder involvement is the lack of well-functioning cooperative or producer organizations that can coordinate participants and guarantee quality and quantity. The literature is somewhat divided as to whether interventions linking smallholder farmers to markets should be entirely market-driven and focus on linkages that can be profitable without subsidization, or whether NGO- and donor-driven interventions should play a role. Most of the successful examples of linkages we found, however (even for higher-value crops), involved some kind of external intervention, typically to support the organization of famers into producer groups or to support existing groups. The costs of coordination, extension and training for most groups – at least initially – appear to be high enough to require outside assistance. There was no one form of producer or supply chain organization that was preferable: the key in almost all intervention seems to be the development of trust along the supply chain so that all parties are willing to honor commitments, whether verbal or written. Finally, we note that the evidence on linkages involving truly smallholder farmers remains scarce. What little evidence exists, mostly on school feeding programs, seems to suggest that widespread community involvement is critical. This involves local committees that engage in food procurement, as well as of local associations, such as women's groups, in food preparation or packaging.

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Appendix 1 Storage, Aggregation, and Transport Initiatives

Farm-level Storage

Case	Evidence	Source
Diatomaceous earths, Tanzania and Zimbabwe, under research	Research has shown the use of diatomaceous earths (DEs) to be effective at protecting grain stores	Stathers et al., 2008
Tripple bagging, West Africa, in progress	Purdue Improved Cowpea Storage program (PICS) promotes the "triple bagging" technique to arrest cowpea bruchid infestation.	Murdock et al., 2003
Solar disinfestation (tarps), Senegal and Cameroon	By placing cowpeas on a tarp and then covering with another, research has shown farmers can raise temperatures enough to eliminate cowpea bruchid.	Murdock et al., 2003
Solar disinfestation (solar powered grain drier), Malawi	Developed a solar powered grain drier that uses a fan for circulation, improving the drying process. Has been field-tested for small scale use.	Mumba, 1996
Household metal silos, Burkina Faso, Chad, Madagascar, Mali, Malawi, Mozambique, Namibia, Senegal	The FAO has developed metal silos that are cheap and durable, and can be made on site using available materials and labor.	FAO, 2008
Metal drums, Senegal and Cameroon	Drums have been shown to be effective at preserving grain. Unfortunately they are expensive, and need to be maintained.	Murdock et al., 2003
CAST system, Australia	Controlled Atmospheric Storage Technology (CAST) is a system designed by the Australian Centre for International Agricultural Research (ACIAR). Combination of CO_2 and plastic containers.	Goletti & Samman, 1999
Neem, botanical insecticides, India and United States	Neem is a tree native to India whose leaves contain a natural insecticide. These trees grow in Africa and could be used for local insecticide industry.	Vietmeyer, 1996; Adda et al., 2002

Village-level and Trader Storage

Case	Evidence	Source
Village silos	Many governments and NGOs built village silos all throughout Africa. Over the years, most have fallen into disrepair. Many could be retrofitted and used again.	
Warehouse Receipt Programs	Private traders have been to form warehouse receipt programs where farmers can rent space for crops, and obtain extension services	
Controlled Atmosphere (CA)	The Australian Centre for International Agricultural Research (ACIAR) grain storage project used controlled atmospheric storage technology (CAST) to fumigate bagged grain with carbon dioxide.	Goletti & Samman, 1999).

Aggregation and Structured Demand

Case	Evidence	Source
Cereal fairs, Mali	Afrique Verte has worked to organize "cereal fairs" to help farmers access markets. Farmers bring samples of their grains and form contracts with buyers with the NGO as middleman.	Film transcript of *Grain Exchange Fairs in Mali*
Cereal banks, throughout Africa, especially in Sahelian zone	Developed by NGOs and governments in the 1970s, cereal banks formed to help farmers avoid overselling crops at low prices and then buying back at high prices. Most consider them a failure due to inefficiencies and susceptibility to corruption.	Shepherd, 2009; Kent, 1998
Seed Fairs, Eastern and Southern Africa	Several NGOs have run seed fairs, often with voucher systems, that link seed surplus farmers and traders with seed deficit farmers. Seed fairs have been run successfully in Kenya, Tanzania, Mozambique, Uganda and Zimbabwe. Key NGOs involved are CRS, ICRISAT, Practical Action (formerly ITDG), and Save the Children.	Gumbo, 2009; Orinid and Ochieng, 2005; Leonardo, 2001.

Farmer/Retailer, Nyabyumba United Farmers Group, Uganda	The Nyabyumba United Farmers Group is a cooperative of potato farmers. Directly negotiated with Nando, a Ugandan fast food chain, to become the company's potato supplier.	Aliguma et al., 2007
SPPOs, Soja Nyo, Togo	A Togolese company, Soja Nyo, in collaboration with an NGO formed service provider/producer organizations (SPPOs). This organizational structure links farmers to markets, and establishes a level of cooperation between the private sector and smallholders.	Pernot du Breil, 2007
AMPATH, HAART and Harvest Initiative, Kenya	This initiative, a collaborative effort between Indiana University and Moi University, Kenya, is part of the "food by prescription" program. This program uses local farmers to provide nutritious food to HIV/AIDS patients in Kenya.	Fran Quigley, 2009
Midday Meals (MDM), India	Started in 1995, MDM operates through the Food Corporation of India (FCI) where it procured food locally and then distributes it to stores throughout the country that then distribute it to schools. Local procurement from smallholders has been difficult due to irregular flow of funds.	Espejo et al., WFP 2009
Fome Zero, Brazil	In 1998, the government of Brazil mandated a universal school-feeding program. Brazil is currently enacting a law that will mandate that at least 30 percent of the food used by the school feeding programs be procured locally.	Espejo et al., WFP 2009
Ghana School Feeding Program & ;School Feeding Initiative Ghana-Netherland (SIGN), Ghana	Ghana's school feeding program incorporates support from the Dutch government, private sector, and academia with Ghana's expenditures. The Dutch government has committed financing until 2011 on the condition that 80 percent of the food is procured locally. To date it appears that less than 20% of food is procured locally.	Espejo et al., WFP 2009; IRIN 2008; Ghana School Feeding Program Website
Programa Alimentación Escolar (PAE), Junta Nacional de Auxilio	Following a natural disaster in 2001, the government of Chile decided to	Espejo et al., WFP, 2009; Bundy et al, 2009.

Escolar y Becas (JUNEAUB), National Agricultural Promotion Agency, Chile	support the Chilean agricultural sector. Chile's Programa Alimentación Escolar now received almost all of its vegetables from local farmers through the National Agricultural Promotion Agency.	
Njaa Marufuku Kenya, Home Grown School Feeding Program	The program provides small grants and trainined to community-driven food security projects to improve capacity to produce and market. The government provides grants to schools to purchase food produced locally.	Espejo et al., WFP, 2009
Farmer/Retailer, Farmer associations, Tanzania	USAID assisted farmers in the Mgeta region of Tanzania in forming several farmer associations and provided extension services. The association was able to negotiate with Shoprite, a South African grocery chain, to become a supplier of quality produce.	USAID, "Africa Stories," 2006
Farmer/exporter, National Association of Smallholder Farmers of Malawi (NASFAM), Malawi	NASFAM began in 1997. The organization provided free fertilizer and seed and the appropriate extension services. The organization then purchases the farmers' surplus produce and sells it on the market, guaranteeing a buyer.	USAID,"Africa Stories," 2006
Farmer/retailer, Regional Potato and Sweet Potato Improvement Network in Eastern and Southern Africa (PRAPACE), Uganda	The PRAPACE program matched sweet potato farmers with buyers/markets to promote marketing of the vegetables regionally.	USAID, "Africa Stories," 2005
Mara Smallholder Horticultural Project, Tanzania	Farmers' associations coordinate to supply safari lodges with fresh produce.	Mafuru, et al, 2007
SPAR Supermarket Chain, local procurement	Rurally-based franchise supermarket procures fresh produce from local farmers	Benienabe and Vermulen, 2007