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Demand Characteristics for Improved Rice, Cowpea, and Maize Seeds in Nigeria: Policy Implications and Knowledge Gaps

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THE NIGERIA STRATEGY SUPPORT PROGRAM (NSSP)

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Introduction

Despite recent studies on improved seed varieties estimating the adoption rates of maize in 1998 at 40 percent (Manyong et al. 2000) and rice at 60 percent (Larsson 2005), true adoption rates appear to be unknown. This knowledge gap exists due to the ambiguity surrounding what constitutes “improved varieties” in Nigeria, because they become mixed with traditional varieties once they are adopted and start being traded in the informal seed sector.

Given existing evidence and the above caveat, it may be concluded that the rate at which the newly improved varieties of rice, cowpea, and maize are spread among farmers in Nigeria is significantly lower than expected. This slow adoption rate can be attributed to constraints on both the supply and demand sides. Supply side constraints have often been analyzed at various stages, including seed production, distribution, and certification. On the other hand, the constraints on the demand side have not been sufficiently analyzed and there is little systematic understanding of such constraints.

Seed demand in Sub-Saharan Africa (SSA) exhibits distinctive characteristics which differ from the demand in the rest of the world. Diversity in seed demand behavior across farmers is particularly prominent in SSA. This diversity is due to (1) the large number of farmers using seed relative to the aggregate quantity of seed demanded; (2) farmers’ inability to overcome their specific agro ecological and socioeconomic environments; and (3) poorly integrated markets. One key goal in characterizing Nigerian farmers’ seed demand is improving the public sector’s ability to predict which of them are likely to adopt new and improved varieties in the foreseeable future given their agro ecological and socioeconomic situations.

This review focuses primarily on the demand for improved seeds of rice, cowpea, and maize. The key research questions addressed in this review are: (1) how has seed demand in SSA been generally characterized, (2) how does such characterization apply to Nigeria, (3) what are the knowledge gaps that, when filled, will allow the public sector to better target the farmers who are likely to adopt improved seeds in Nigeria in the foreseeable future?

To that end, this review first describes determinant factors and diversity patterns of farmers’ seed demand observed in Eastern and Southern Africa and reported by Minot et al (2007). The study then reviews relevant studies in Nigeria to assess (1) whether any empirical studies on Nigeria report evidence that the same patterns apply to Nigeria; and 2) how such characteristics lead to the demand for specific forms of support from the public sector. This review also discusses some of the unique characteristics of rice, cowpea, and maize, as well as the unique characteristics of Nigerian socioeconomic conditions relevant to the seed sector, in order to highlight how such uniqueness relates to country- and crop-specific characteristics of seed demand in Nigeria.

This review contributes to the literature in two ways. First, it brings together the main studies in Nigeria which analyze farmers’ seed demand behaviors and identifies the key knowledge gaps that should be filled by future empirical studies in Nigeria. Second, the review provides further evidence from Nigeria on the general characteristics of SSA farmers’ seed demand compiled by Minot et al (2007) in Eastern and Southern Africa. Reported evidence generally supports the proposition that farmers’ demand for seed is highly diverse, and is affected significantly by agro-ecological and socio-economic conditions. Such evidence suggests the need for a more systematic understanding of farmers’ demand to assist seed sector policy formulation.

Evolution of seed sector activities in Nigeria

The evolution of Nigeria's seed supply mechanism can be roughly characterized by describing how the activities for production, marketing, and regulation of seeds and the administration of the seed sector have been delegated to specialized institutions and bodies.

Over the past four decades, the government of Nigeria has assigned the production of seeds (breeder, foundation, and certified seeds) to different seed-related institutions. Breeder seed in the formal seed sector has been and continues to be produced solely through Nigeria's National Agricultural Research Institute (NARI). In 1975, the former National Seed Service (NSS) was mandated to produce foundation and certified seeds. Later,, the Agricultural Development Program's (ADP) seed multiplication units joined NSS in producing foundation seeds, and distributed them through the farm-service centers of the Federal Ministry of Agricultural and Rural Development (FMARD) and ADP (Adejobi, Omolayo, and Williams 2005). More recently, private companies have been increasingly involved in the production of foundation seeds and distribution of certified seeds to farmers, with the number of registered private companies growing by more than 20 in 2010. Supply has also been bolstered by private companies contracting outgrowers to produce foundation seed as well as public sector production through the ADP and National Agricultural Seed Council (formally NSS) (Omonona 2006). With the growing role of the private sector and the escalating involvement of outgrowers in seed production it is expected that the capacity of the seed sector to develop suitable seeds for diverse agro-ecological environments will also increase.

In the meantime, Nigeria has been organizing and institutionalizing its seed sector administration, Seed policy was given a legal status with the enactment of the Agricultural Seed Decree No 72 of 1992 (Kormawa, Okorji, and Okechukwu 2002). The regulatory functions such as the control and registration of released varieties, testing, and certification of seeds were assigned to the National Agricultural Seed Council (NASC) which was established by the Seed Decree. The Decree also established various institutions such as theCrop Variety Registration and Release Committee, the Seed Standards Committee, the Seed Industry and Skill Development Committee, and the Department of Training, Information and Seed Extension, to streamline the implementation of each regulatory function both at the national level and state level.

However, the seed supply sector continues to face numerous challenges in raising farmers' adoption of improved seeds. Seed policy has remained a decree enacted during the military era, but not yet supported by evidence-based policy guidelines. The NASC is currently in the process of drafting a seed policy document. The capacity for many public institutions to implement their operations has been limited due to constraints including insufficient funding and its irregular release.

Seed Demand Characteristics in Nigeria and Knowledge Gaps

According to Minot et al. (2007), SSA farmers generally demand seed from off-farm sources for only three reasons: seed replacement, variety change, and emergency response;, and based on five types of factors: agro-ecological, natural and man-made disasters, uneven market development, farmers' preferences about channels and timing of seed distributions, and farmers' level of awareness about improved seeds. This can generally explain the differences among farmers in their decisions as to when they demand seed, which varieties they prefer, and at what quantities.

Little empirical evidence currently exists in Nigeria regarding these three reasons and five factors, creating knowledge gaps (Table 1). However, each of the three reasons and five types of factors leads to key questions which can help the public sector improve the predictability of farmers' demand for improved varieties

Overall, information is relatively lacking in Nigeria regarding how to predict which farmers are, in the near future, likely to replace seed of the same variety, change variety, or supplement the depleted stock of seed at home.

There have been some studies on the factors leading to diversity in seed demand; however in general, the key question of how these many factors affect the demand for seed in Nigeria has not been fully analyzed using empirical data.

Among the factors leading to diversity in seed demand, the varieties needed in each agroecological zone have been relatively well studied, as have other important factors such as weather (temperature, rainfall, humidity), soil (fertility, temperature, moisture, nutrient, soil age, and the like), length of growing period, pests, diseases, and weeds. The effect of natural and man-made disasters has not been well studied in Nigeria, although the common types of disasters are generally recognized as wild fire, bush burning, sudden breakdown of resistance to pests, and theft. The diversity of market development is an important factor that is measured by a range of indicators such as the price of seeds, grains, and complementary inputs; their variety and availability; and the quality certification or each farmer's level of market participation.

The timing and channels through which farmers can access improved seeds are recognized as important factors. There is, however, limited empirical evidence about whether and to what extent these factors affect the demand for improved varieties of seed. The awareness of improved seed varieties has been relatively widely studied in Nigeria (Alene and Manyong 2007; Horna, Smale, and von Oppen 2007; Oladele and Somorin 2008; Oladele and Fawole 2007; Ozowa 1995; Saka et al. 2005). In particular, several studies imply that the farmers' awareness of improved rice varieties may be low and that their demand for more exposure to extension activities is generally high. The awareness of cowpea and maize is less studied, and still mixed.

The following sections explain in more detail what empirical evidence has or has not been reported in Nigeria for rice, cowpea, and maize for each category listed in Table 1. The unique characteristics of rice, cowpea, and maize, as well as the unique characteristics of Nigeria relative to the other SSA countries, partly determine how the general characteristics of seed demand observed in SSA apply to the producers of each of these crops in Nigeria. Therefore, we briefly discuss these unique aspects, summarize the key factors found important in SSA outside Nigeria, and describes the outcome of the empirical studies on the determining factors of farmers' seed demand in Nigeria.

Table 1. Level of knowledge available on seed demand[a]

Categories	Issues and key questions	Evidence in Nigeria		
		Rice	Cow-pea	Maize
Reasons for seed demand				
Seed replacement	How can we predict the frequency of seed recycling? How does the recycling frequency relate to observable characteristics of the farmer?			
Variety change	How can we predict when a farmer changes variety in the foreseeable future? How does the change relate to observable characteristics of the farmer?			
Emergency response	Which farmers are experiencing unexpected depletion in their seed stock and thus need seed from outside sources?			
Factors influencing demand levels				
Agroecological	What are the key agroecological factors for rice, cowpea, and maize production in Nigeria and how sensitive is the demand for seeds to such factors?	××	××	××
Natural and man-made disaster	SSA farmers outside of Nigeria prefer to grow many varieties in small quantities, and prefer to obtain seed at the time of planting as stored seed may be stolen or damaged through civil conflict, wild fire, or bush burning. Is this the case in Nigeria?			
Market development	Due to the varying degree of development and low level of integration among markets, does the price of seed andother complementary inputs and outputs vary significantly? Does the potential and effective demand for particular varieties of seed vary across farmers in Nigeria?	×	×	×
Channels and timing	Due to the weak certification mechanism, do farmers prefer to buy seed through established channels? Do farmers also prefer to buy seed immediately before the planting dates, as a result of a lack of confidence in their ability to preserve improved varieties of seed?	×	×	
Awareness	Farmers may not demand improved seed because 1) they are not aware of it; 2) they do not know where to obtain it although they want to buy, and 3) they prefer local varieties although they know about the improved seed and where to get it. What is the situation in Nigeria?	××	×	×

[a]The three rightmost columns indicate the amount of empirical information that addresses key questions in each category. The amount of empirical information is indicated by the following;

Blank = no empirical results were found so far:
× = some relevant empirical data but not as main focus of the report
×× = relevant empirical data and some reports address the questions as their main focuses)

Country and Crop-Specific Characteristics Relevant to Seed Demand

Each crop differs in biological traits, which results in the variety of methods farmers use to handle their seeds (Table 2). Rice and cowpea are self-pollinating, which usually encourages farmers to recycle their seeds across several production seasons. In contrast, maize is open-pollinating, making it difficult for farmers to recycle maize seeds without losing their important attributes. These differences also affect the likelihood that a farmer will demand improved seeds from off-farm sources at a particular point in time. In addition, seeding and multiplication rates differ across rice, maize, and cowpea, which influences how fast the loss in seed stock in a particular season can be recovered through production in subsequent years. Moreover, production practices differ among these crops. For example, cowpea is a catch-crop grown alongside rice and maize, so its seed needs are additionally affected by the production environments for rice and maize .

The markets for these crops in West Africa and Nigeria seem to differ from the markets in the rest of SSA. For example, Nigeria is one of the largest importers of rice in the world and the international rice price has a significant impact on the domestic rice price and thus the demand for rice seed. This has implications for Nigerian farmers' demand for rice seed, and helps explain why it may differ from the rest of SSA.

Table 2 shows how the demand for rice, cowpea, and maize seeds in Nigeria can broadly differ from that of the rest of SSA and from the demand for other crop seeds.. The farmer-specific demand for seeds in SSA is, however, more complex, as it is affected by differing agroecological and socioeconomic conditions. The differing capacity among famers to overcome these constraints is also an important factor.. It is therefore important to assess the same seed characteristics among Nigerian farmers, as discussed in the next section.

Table 2. Crop-, Country-, and Region-specific characteristics relevant to the seed sector

Aspects	Rice	Cowpea	Maize
Crop specific	• Self-pollinating • Low seeding rate, high multiplication rate • Relatively more labor-intensive crops in SSA (due to constraints in access to machinery)	• Self-pollinating • Significant loss in storage, particularly in low-humid tropics • High seeding rate, low multiplication rate • Less sensitive to the availability of fertilizer • Catch-crop: factors that affect rice and maize will also affect cowpea • Planting timing: growing seasons for rain-fed rice	• Open-pollinating • Low seeding rate, high multiplication rate
Region specific (West Africa)	• Nigeria is one of the largest importer of rice • Depending on the level of market integration, the high rice price may affect the demand for rice seed • While upland rice is the majority in West Africa (Ekeleme et al 2009), most rice grown in Nigeria is low-land rice.	• Cowpea residue is more valued as fodder in Nigeria than in East Africa • Cowpea is ideal for semi-arid areas of West Africa, where soils are sandy and low in fertility (Minot et al. 2007) • Cowpea production is mostly limited to the north including the central region, and grown in mixed cropping except in the Savannah agroecological zone (Oladele 2005)	• Maize residue is less valued as fodder in Nigeria than in East Africa • 60% of maize in Nigeria is from high rain-forest zones (Shuaib, Aliyu, and Bakshi 1997)
Country specific	• Large enough size of market – private company can realize scale of economy from Nigeria alone • Aging of farmers, urbanization, increasing costs of labor => varieties with less labor requirements may be adopted more		

Farmers' reasons to demand new seed

Seed demand in Sub-Saharan Africa is often thought to derive from the following needs: 1) seed replacement; 2) variety change; and 3) depletion of seed stock (Minot et al. 2007).

Seed replacement

Farmers' demand for a specific variety of seeds from off-farm sources in a particular year is generally low because they often recycle seeds every season for use in the next season. Farmers recycle most seeds from grain crops. The seed from self-pollinating crops such as rice tends to maintain most of its desirable attributes over many production seasons, while open-pollinating crops like maize lose such attributes more quickly. Farmers thus tend to recycle rice seed over a long period of time and only occasionally demand new seed from outside to *replace* their seed. This low seed-replacement rate for certain crops discourages private firms from developing improved varieties for such crops (Nagarajan et al. 2007).

Some seeds are difficult to harvest or do not store well, implying that it is necessary (or merely economical) to purchase new seed every year. This is the case for many vegetables and some legume crops (beans) including cowpea (Boeke et al. 2004). The typical replacement period for cowpea is no more than three years, which is shorter than other self-pollinating crops. In Nigeria, the proportions of farmers who recycle seeds are high: around 70 percent for rice and maize, and 90 percent for peas (Figure 1). In addition, farmers typically save 10 percent of their harvest of rice or maize and 3 percent of cowpeas as seeds for the next production season, and almost 80 percent of farmers do not purchase seeds of rice, cowpeas, and maize (National Living Standard Survey in Nigeria, 2004). This indicates that the proportion of farmers who replace seed every year is low in Nigeria. However, low-income households are less seed secure and thus have a higher demand for off-farm sources of seed, since they tend to eat or sell all the grains they produce and have limited stock (David and Sperling 1999). Empirical information is still lacking in Nigeria on farmer-specific recycling patterns, such as how many years ago the seed was replaced by a particular producer and how many years the producer had recycled the seed, as well as how such information can be incorporated to enhance the predictability of seed demand from off-farm sources.

Variety change

Seed attributes and traits are important determinants in a farmer's decision to change varieties. Seed attributes can be categorized into 1) agronomic, 2) morphological, and 3) grain quality for rice, cowpea, and maize (Table 3). Agronomic attributes and grain quality are relatively well known, while morphological attributes are not as well known but equally important. When examining improved varieties as potential seeds, farmers often consider many of the attributes listed in Table 3.

Studies in Nigeria generally address the diversity of attributes farmers look for in improved seeds. However, few studies have addressed all of the attributes in Table 3 and so more systematic empirical information is needed on which attributes are important to different types of farmers. For example, commercial farmers place more importance on potential yield of the seeds while the palatability may be more important for subsistence farmers. More information is also needed about the quantitative aspects of how each farmer's demand for seed varieties changes based on each attribute, for example, the potential yield and size of grains. Such empirical information is essential for incorporating Nigerian farmers' decisionmaking into the prediction of future demand for particular varieties of improved seeds.

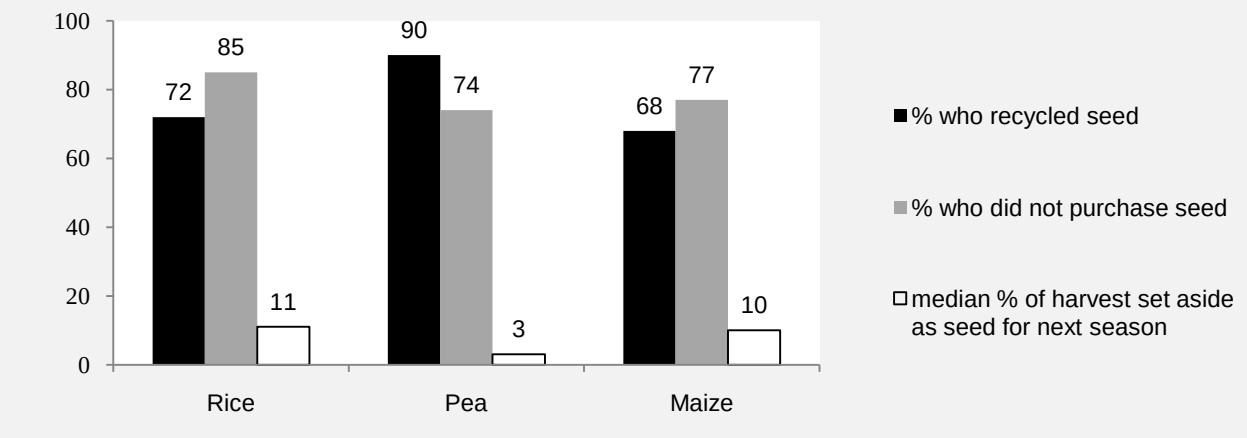
Emergency response

Seed demand as a *response to an emergency*, seems to result from two different types of losses: 1) loss of grain harvest and 2) loss of means to access and exchange seeds due to various causes such as sudden drop in income or breakdown of transportation infrastructure (David and Sperling 1999; Sperling and Longley 2002). In SSA, risks are high for both of these types of losses because farmers generally lack the means to mitigate significant risks in grain harvests due to death, illness, and crop failures and also lack the financial capacity to compensate for such losses. The ways in which SSA farmers are vulnerable to the second type of loss needs to be studied more thoroughly. This is especially true now because the informal seed sector in rural areas is expected to significantly reduce farmers' risk of losing their means to access and exchange local seeds.

As we discuss in a later section, empirical data on Nigerian farmers' demand for seed in response to urgent depletion of home seed stock is scarce. Information is also limited as to how frequently they face such risks, at what intensity, and where they are likely to obtain seed to fill

the depletion. More empirical studies are needed to incorporate the pattern of farmers' emergency response into the prediction of their future demand for improved seed.

Figure 1. Percentage of producers who either recycled or did not purchase seed in 2004[ab]



[a]Source: National Living Standard Survey in Nigeria, 2004

[b]In theory, farmers should obtain seed through either recycling or purchasing (with cash or in kind) and the share of farmers recycling seed should not be lower than the share of those not purchasing seed. There is, however, the possibility that farmers obtained seed as alternative means such as gifts, and thus the former is lower than the latter for rice and maize. The overall implication that most farmers recycle seeds and do not purchase, however, still remains.

Table 3. Important attributes of rice, cowpea, and maize seed in Nigeria[ab]

Height (R)	Leaf architecture (R)	Grain size (R)
Seedling vigor (R)	Panicle structure (R)	Grain shape (R)
Tillering ability (R)		Grain color (R)
Yield potential (RCM)		Particle size (C)
Cycle		
Weed tolerance (RM)		Particle shape (C)
Pest resistance (M)		
Fertility (R)		Particle color (C)
Early maturity (M)		
Pod length (C)		Composite-Taste (R)
Yield (R)		Threshing ability (R)
Yield (dry matter) (C)		Milling recovery (R)
Seeds per pod (C)		Processing quality (M)
Seeds per plant (C)		Soaking time (C)
		Flavors of starch (M)
		Seed coat color (C)

[a]R = rice, C = cowpea, M = maize

[b]Sources: Dalton (2003), Ekeleme et al. (2009) for rice, Lawal et al. (2005), Daniel and Adetumbi (2006), Oyekale and Idjesa (2009) for maize and Nwofia, Ene-Obong, and Okocha (2006), Langyintuo et al. (2003) for cowpea.

Diversity in seed demand

As discussed in Table 1, the factors determining SSA farmers' seed demand can generally be categorized into five groups. The following sections add more explanation to the level of evidence outlined in Table 1 by examining in detail each category for rice, cowpea, and maize in Nigeria and the types (examples) of constraints associated with each, as well as the associated knowledge gaps.

Agroclimatic conditions

Agroclimatic conditions are diverse within Nigeria. Their effects on the diversity of seed demand are multiplied by the fact that many farmers are susceptible to those conditions due to their lack of capacity to overcome them. For example, even when seed is distributed through farmer-to-farmer diffusion systems, the yields of early adopters and late adopters vary considerably for cowpea (Alene and Manyong 2006).

Although not all studies are shown in Table 4, it is clear that agroclimatic conditions are the most extensively studied in Nigeria among the five factors mentioned above. Some of the key knowledge gaps include 1) how the combination of agroclimatic factors (for example weather and soil) affect the performance of improved seeds which address only one of them (drought tolerance or suitability to poor soil quality) and how a drought tolerant variety performs under different soil conditions and vice-versa; and 2) identification of agroecological constraints that can best be overcome by seed technology instead of other inputs such as fertilizer, irrigation, or agrochemicals. Additional knowledge about the first set of questions posed is crucial particularly for Nigeria, which covers a wider geographical area and production environment than many other SSA countries. Information about the second set of questions is important to the government for prioritizing seed research into particular focus areas where seed technology has comparative advantages relative to other production inputs. Such knowledge gaps can be partly filled by more involvement from producers in various production environments from the variety development stage through foundation seed production stage.

Natural and man-made disasters

Many parts of SSA are frequently affected by both natural disasters (drought, flood at the regional level, outbreak of pests, and wild fires at the farm level) and manmade disasters (civil conflict, policy inconsistency at the regional level, and thefts of seed stock at the farm level). In addition to their direct effects on the seed market, these disasters often lead to a large inflow of aid in the form of seed distribution to the disaster-effected regions and their neighbors. While the overall benefits of such aid have been significant, the aid sometimes leads to disruptions of regular seed market functions, mainly by saturating the local seed markets with seeds from external sources (Sperling 2002). In SSA the frequency and intensity of natural and man-made disasters are high, and farmers lack the capacity to overcome them. For example, farmers cannot mitigate the impacts of local-level market disruptions by accessing distant unaffected seed markets.. These types of natural and manmade disasters therefore highly influence farmers' seed demand in SSA.

In Nigeria, however, natural and manmade disasters seem to be less studied than other factors (Table 5). Although seed sector stakeholders in Nigeria seem aware of the various manmade and natural disasters that can affect a farmer's seed storage, such as thefts, breakdown of pest resistance, bush-burning, or wild fire, very little empirical evidence exists in Nigeria that can indicate the frequency, prevalence, and impacts of such incidents. Nor is there substantial data regarding how such impacts differ based on farmers' agroecological and socioeconomic characteristics. The effects of such disasters can also vary across crops with different seeding and multiplication rates (such as rice and cowpea). For example, crops with high seeding rates and low multiplication rates may take more years to replenish the initial seed stock.

More empirical studies are needed on the ability of the local informal seed sector to meet the demand of farmers affected by such disasters in Nigeria. This variable affects whether farmers demand traditional seed from the informal sector or more improved seeds from the formal sector after such disasters. Whether the local informal seed sector can meet the demands of disaster-

stricken farmers depends on 1) the spread of the disaster (whether it hits only particular farmers within the local informal seed sector or the whole sector and 2) how effective the local informal seed sector is in general. Very few empirical analyses currently exist on the effectiveness of the informal seed sector.

Table 4. Reported evidence in Nigeria for Demand Factor 1: agroclimatic conditions affecting rice, cowpea, and maize seed demand

Category	Conditions in Nigeria		
	Rice	Maize	Cowpea

Weather-related
Temperature
Rainfall
Humidity
	• Three recognizable rice-growing zones in Nigeria (NASC 2009)
	  ○ Shallow swamp
	  ○ Deep flooding valleys
	  ○ Upland
		• Drought
		• Extreme heat, intense sunlight (NASC 2009)
			• Erratic rainfall lowers its productivity (Adekalu et al. 2009)

Soil Soil fertility Soil temperature Soil moisture Soil nutrient Soil age	• Well drained soil[a] • Appropriate Iron level (Olaleye, Ogunkunle, and Akinbola 2008)	• Sufficient Nitrogen level in the soil (NASC 2009)	
Pests, diseases, weed	• Rice blast[a] • Stem borers (Amaugo and Emosairue 2005) • Weeds for upland rice (Ekeleme et al 2009)	• Whiteflies • Mildew • Leaf strike virus • Striga (parasitic weed) • Storage weevil (Manyong et al. 2000)	• Brown-blotch, cercospora leaf spot diseases—south western Nigeria (Akande 2007) Striga (Emechebe et al. 2005)

[a] Nigeria seed stakeholder workshop

Degree of market development

Farmers select seeds based on their attributes and their output prices (both expected prices and their variations) as well as on the prices of complementary inputs (fertilizer, agrochemicals, harvesting tools, water, land, credit and so on), all of which have their respective markets. Seed demand is therefore affected by the conditions in each of these markets. In SSA, because of the generally poor level of market integration, there are huge variations in the level of market development across regions. For this reason there are also huge variations in the price, quantities, and quality of goods handled in each market. The prediction of farmers' seed demand may need to factor in information about the conditions of relevant markets for these farmers. It may also need to take into account how such conditions affect the seed demand for each farmer—an assessment that requires significant empirical evidence.

Some of the empirical studies of the market conditions relevant to farmers' seed demand are presented in Table 6. In addition, Figure 2 and Figure 3 present the variation of prices (Naira / kg) for improved maize and rice seeds in 2006 derived from the Fadama II survey dataset. Although the sample size is small, these figures indicate that the prices for improved rice and maize seeds seem to vary significantly across states. This variance supports the hypothesis that the seed market conditions are quite diverse. Moreover, some states like Taraba generally exhibit higher seed prices for maize and rice. This indicates that variation in seed prices may be partly explained by the location and helps us predict the expected prices of seeds in the future.

There are a number of knowledge gaps suggested by the conditions summarized in Table 6 and Figures 2 and 3 regarding the effect of market development levels on farmers' seed demand.

First, more empirical information is needed about which farmers access each output and input market for different crops (such as the share of farmers selling rice or maize to the market). Second, more empirical information is needed about how such market participation behaviors relate to their observed characteristics, such as the distance to market place. The information about farmers' access to each market tells us how their demand for particular varieties of seeds may or may not be affected by the conditions in those markets. While the dearth of links to certain markets reduces the impact of those market conditions on farmers' seed demand, it may also increase the impact of other markets. For example, as in Horna et al. (2007), rice farmers without harvesting machines or low-cost labor prefer taller varieties due to the ease of harvesting (Table 6). This makes farmers more susceptible to the market conditions for the taller varieties, and so the farmers' demand for seed for that variety may be less predictable. Third, more empirical information about the degree of integration between markets would be useful for assessing the level of development among markets, and thus the diversity in farmers' seed demands, as a low level of market integration generally indicates more uneven development across markets. Seed-related policy interventions affecting markets must be made at each market level, rather than based on key major markets in their entirety. Analyzing the market integration in both seed markets and output markets requires data on seed prices and output prices at the local market level, including multiple locations within each state, which are unavailable in Nigeria. Fourth, while diverse market conditions are expected to make farmers' seed demand diverse, more empirical studies are needed to assess the exact scale of such an effect. This is necessary to allow public policymakers to better predict how farmers' seed demands respond to the changes in certain market conditions as a result of policy interventions aimed at those markets.

Table 5. Reported evidence in Nigeria for Demand Factor 2: human activities and natural disasters affecting rice, cowpea, and maize seed demand

Category	General	Rice	Maize	Cowpea
Natural disaster	• Sudden breakdown of resistance to pests[a] • Bush-burning[a] • Wild fire[a]	• Low seeding rate, high seed-to-grain multiplication rate leads to shorter effect of emergency shock • Positive impact of planted area on adoption and intensity (Saka et al. 2005)		• High seeding rate, low seed-to-grain multiplication rate indicating longer effect of emergency shock
Human Activity	Riots / civil conflicts / thefts	• Potential effect of conflicts in the Delta-region	• Higher risk of theft during off-season when grain price increases	• Higher risk of theft during off-season when grain price increases

[a]Nigeria Seed Stakeholder Workshop

Timing and channels preferences

Farmers' timing and channel preferences regarding improved seed varieties are another factor affecting farmers' seed demand in SSA. However, the degree and underlying patterns are unclear.

Seed availability for farmers means that a sufficient quantity of seed exists within reasonable proximity and in time for sowing (Sperling and Longley 2002). Farmers in SSA often lack the capacity to preserve the seeds in storage and are inflexible about changing the timing of their sowing, so have strong preferences about when to buy seeds. As for channels, farmers in some African countries often receive seeds through specified channels either because they trust these

channels to deliver high-quality seeds, can buy seeds in small quantities instead of bulk, or can obtain credit, or other additional benefits (David and Sperling 1999).

In Nigeria, several studies report various constraints associated with seed storage (Table 7). They also report potential variations in the timing of planting across regions. Studies indicate that the most important channel of seed acquisition is through other farmers. .

Information (awareness)

Farmers' adoption of improved seeds can be limited because they have no knowledge about such varieties, are unaware of their existence, or do not regard those varieties as significantly more useful than the traditional varieties, even when they have good information about the improvements. Appropriate seed supply policies depend on which of the above is applicable. Thus it is important to assess farmers' awareness and knowledge about the improved varieties that are available to them.

Nigerian farmers' awareness of the attributes, availability, and accessibility of improved varieties is reported to vary for rice, cowpea, and maize (Table 8). Farmers' awareness of improved seeds is assessed relatively widely in Nigeria using various methodologies, from descriptive statistics to econometric analysis. The findings are mixed regarding how much farmers are aware of and knowledgeable about the attributes of improved varieties, as well as about where and when to access them.

Gaps in key knowledge about channels, timing, and farmer awareness, and the ways in which these affect seed demand, include the lack of empirical studies on:

1. channels and timing, to enable the public sector to improve its predictions about which types of farmers are likely to prefer buying improved seeds, through which channels, and when; as well as farmers' willingness to pay for access to improved seeds through specific channels;
2. farmers' preferences on when to purchase seeds; and
3. farmers' reasons for obtaining seed predominantly from other farmers (because of, for example, trust, because they have no other access, or another reason).

Such information can help assess whether private companies can deliver seeds at the farmers' preferred timing or through channels with minimal financial support from the public sector, as mentioned above.

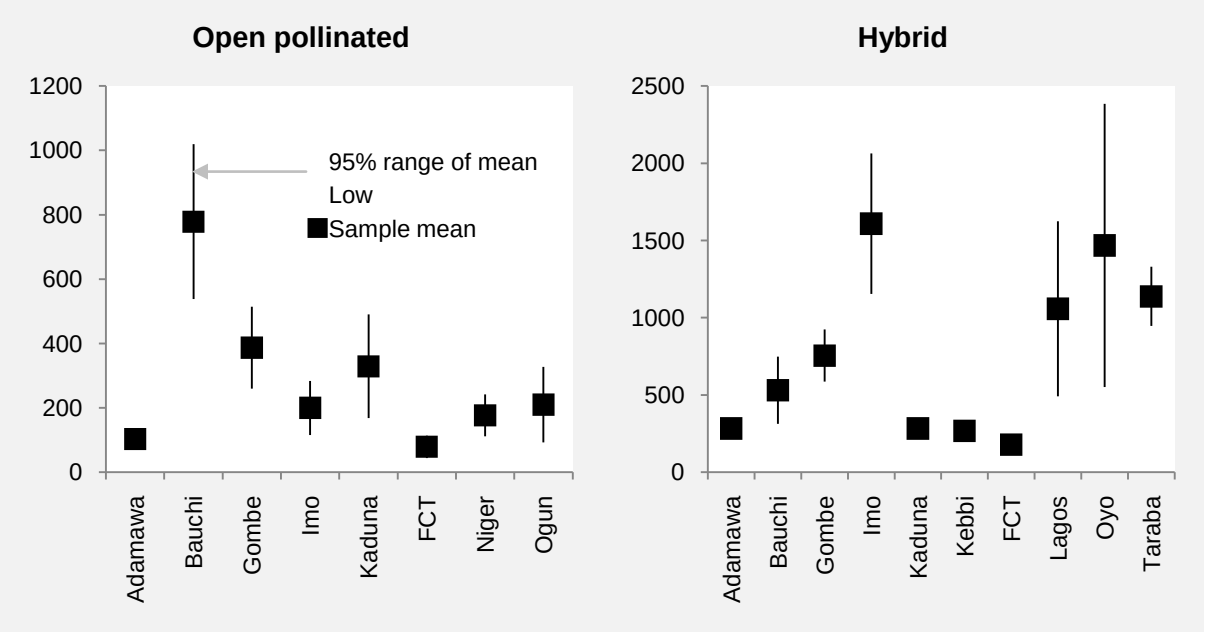
Regarding seed-related information in Nigeria, more studies assessing farmers' awareness of improved seeds are needed. The studies should be conducted in different geographical locations using the same methodologies to enable comparison of the levels of awareness and knowledge across regions and farmers. Also, more studies are needed to assess farmers' knowledge about different types of seed-related information, such as attributes visible at the production stage (*agronomic* or *morphological* characteristics as in Table 3) and those visible only after the harvest (*grain quality* in Table 3). Such information is important for identifying how the public sector can help reduce the cost to farmers. Gathering such information requires an understanding of how the farmer-to-farmer network functions in sharing seed-related information.

Table 6. Reported evidence in Nigeria on Demand Factor 3: Market conditions affecting demand for rice, cowpea, and maize seed

Category	Reported conditions in Nigeria		
	Rice	Maize	Cowpea
Seed market	• Low percentage of improved seed dealers except in the Southwest (Adejobi, Omolayo, and Williams 2005)	• Limited information on the geographical, temporal variation of seed prices across markets	• Potential premium for *Bt* cowpea (Coulibaly et al 2008)
Key complementary inputs	• Water • Labor: High labor intensiveness in Nigeria (Adejobi, Omolayo, and Williams 2005) • Lack of harvesting machine and herbicide, leading to a preference for taller plants which farmers do not have to bend to harvest or kill weeds[a] (Horna, Smale, and von Oppen 2007)	• Fertilizer and labor for weeding	• Fewer fertilizer requirements (nitrogen fixation) • Expensive pesticide (Kormawa, Chianu and Manyong, 2002)
Output markets	• Nuanced impacts of output markets on rice seed demand due to relatively high percentage of autarkic rice producers in Nigeria (almost 30 percent in NLSS dataset) , albeit with variations across state	• Lower value of maize residues in West Africa than in East Africa • Nuanced impacts of output markets on rice seed demand due to relatively high percentage of autarkic rice producers in Nigeria(almost 40 percent in NLSS dataset) , albeit with variations across state	• Higher popularity in the production of cowpea for both grain and fodder (residue) in West Africa (Lenné and Thomas 2006) • High price variation across cities (Langyintuo et al 2003)
General conditions (all crops)	Less private sector interest in rural-remote area compared to urban areas (Adejobi, Omolayo, and Williams 2005)		

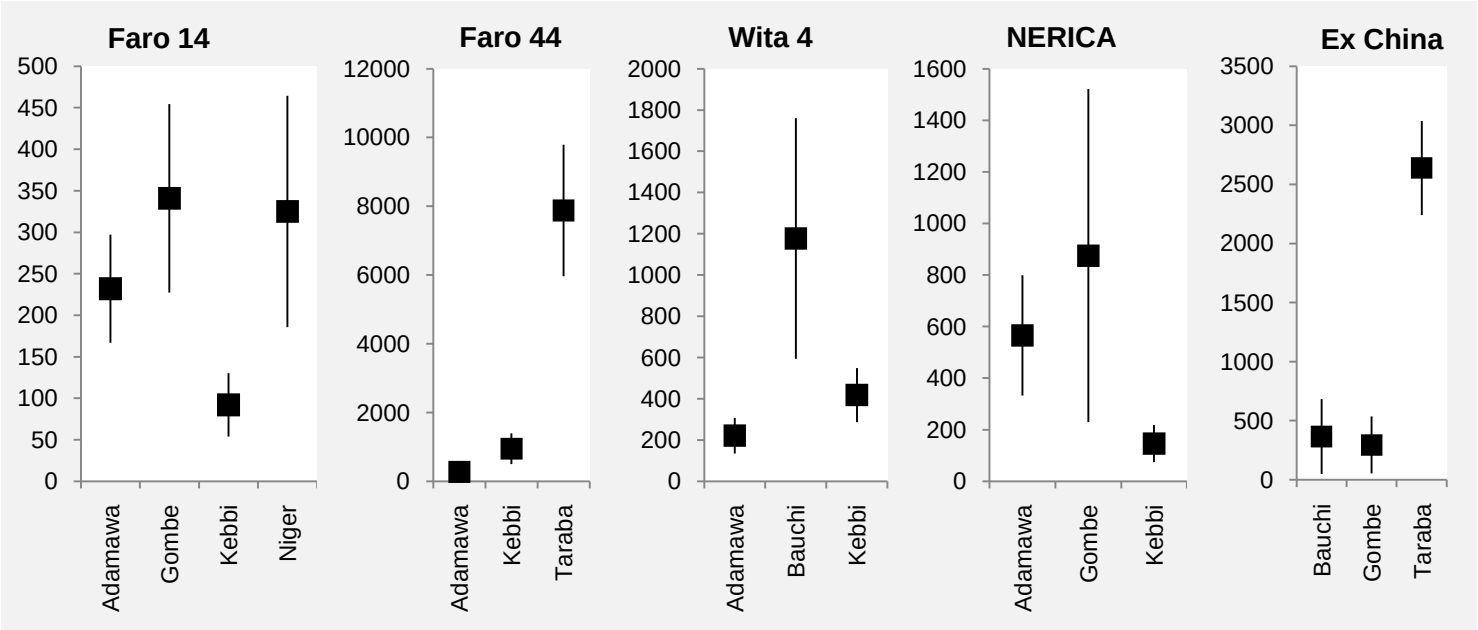
[a]Proceedings from NSSP/APSF research seminar held on June 3, 2010.

Figure 2. State-average price (Naira per kg) of open pollinated maize and hybrid maize in 2006



Source: Calculated by the author from Fadama II dataset

Figure 3. State level average prices (Naira per kg) of improved rice seeds in 2006



Source: Calculated by the author from Fadama II dataset

Table 7. Reported evidence in Nigeria on Demand Factor 4: Timing and channel preferences affecting seed demand

Category	General	Rice	Maize	Cowpea
Timing of purchase	• Significant effect of timing of planting on yield • Farmers' aversions for purchasing seed significantly ahead of planting time due to lack of confidence in their own seed-handling skills[a] • Positive of roles of farmer-to-farmer networks facilitating the acquisition of seeds at planting times	• Significant effect of planting timing on susceptibility of rice varieties to certain pests such as false smut in Edo state (Ahonsi et al. 2000)	• Common use of fumigation particularly in Nigeria's Savannah region (Adejumo and Raji 2007), reducing the loss of seed during storage (Olakojo and Akinlosotu 2004)	• Significant storage loss, particularly in low-humid tropics (Taiwo 1998) • High cost of chemicals to protect stored seed from pests in Nigeria (Williams 1975)
Channels of seed purchase	• Better quality of farmers-sellers or local merchants in terms of physical sorting (to remove undesirable seed affected by disease, mold, weevils, etc.), storage condition, age of seeds than large town merchants (David and Sperling 1999) despite the lack of sufficient quantity for sales by farmers-sellers is not • Potential effects of household characteristics on the selection of channels[a] • Higher trust in sources other than government institutions in some areas	• Generally strong preference on other farmers as the channel[a]	• Reversion of farmers who once purchased improved seed from formal sector to informal sector as the subsequent source of the same seed (Daniel and Adetumbi 2006)	• Generally strong preference on other farmers as the sources in Kano and Kaduna (Tipilda et al. 2006) • Loss of information about production practice appropriate for seeds during farmer-to-farmer diffusion, resulting in a significantly lower cowpea yield for some farmers relying on such channels (Alene and Manyong 2006).

[a]**Nigeria seed stakeholder workshop**

Table 8. Reported evidence in Nigeria on Demand Factor 5: Availability and awareness of seed-related information among farmers

General	Rice	Maize	Cowpea
• Significant need for extension services for providing technical advice on the use of improved varieties, than the availability of such varieties (Lanteri and Quagliotti 1997) • Potentially high demand for obtaining information not only on improved seeds but on other inputs packages at the same time from extension staff (Osun State (Okunade 2007)) • Limitation for farmers in learning new varieties due to lower literacy (Ozowa 1995), despite the presence of strong farmer-to-farmer networks. Potential importance of airing the agricultural program on the radio in the evening when farmers can listen in (Okwu, Kuku, and Aba 2007), and improved reception quality as well as area coverage of radio program (Ozowa 1995)	• Inaccuracy in farmers' knowledge about seed viability and sources for viable seeds relative to extension staff, compared to other production practices (fertilizer application, weeding, etc) (Oladele and Somorin 2008) • Higher willingness to pay for extension activities involving on-farm trial, albeit insufficient to encourage private sector participation into similar extension services (Horna, Smale, and von Oppen 2007) • Positive effect of frequency of extension contacts on the adoption of improved varieties in southwest (Saka et al. 2005)	• High awareness but with perceptions of seeds as irrelevant in some regions (Oladele and Fawole 2007)	• High awareness but with perceptions of seeds as irrelevant in some regions (Oladele and Fawole 2007) • Positive effects of farmers' education levels for adjusting to production environment based on the improved cowpea seeds and achieving higher productivity (Alene and Manyong 2007)

Key Implications for Seed Sector Policy and Further Research

The primary purpose of this literature review is to assess the amount of evidence on farmers' demand for seed in Nigeria to identify knowledge gaps. The reviewed literature and data indicate substantial diversity in Nigerian farmers' demand for improved seeds for rice, cowpea, and maize, in terms of which varieties are demanded when, at what quantities, and at what prices. A high proportion of farmers in Nigeria recycle their own seed from crops from their harvest and only a fraction of farmers purchase these seeds from other sources. Indentifying farmers who are likely to purchase seeds in a given year is important to increase the use of improved seeds in Nigeria.

Climatic conditions, soil quality, and pests affect the productivity of many varieties of these crops, indicating that the development of varieties overcoming these conditions continues to be important in Nigeria. In addition, farmers are resource constrained and their demand for certain seeds vary as much as agro-climatic conditions. The formal seed sector has seen some success in raising adoption of various improved varieties such as stress-tolerant varieties, early and extra-early varieties, or N_2-efficient varieties, raising the hope that varieties appropriately addressing constraints in agro-climatic conditions can reach farmers quickly.

In addition to the diversity in agro-climatic conditions, the current set of evidence in Nigeria also indicates that the demand for certain seeds varies significantly among farmers due to diversity in socio-economic factors. Farmers' seeds tend to be damaged by man-made and natural disasters, such as thefts, breakdown of pest resistance, bush-burning or wild fire. Both the intensity of these disasters and farmers' capacities to protect their seeds against these disasters are thought to vary significantly. The prices paid for improved seeds seem to vary significantly across regions as well, indicating that either the cost of supplying seeds or farmers' demand for these seeds varies. Farmers' access to key complementary inputs such as labor, machinery, fertilizer, and pesticides also appears to vary significantly, and affects farmers' demand for certain varieties in complex ways. The conditions in the relevant output markets, though not influential on farmers who do not sell their harvests, vary across market-oriented farmers and make their demand for seeds more diverse. Nigerian farmers face significant risks in seed loss during storage, particularly for cowpea, and thus they may generally prefer to purchase seed at the planting time, although how their preferences vary will depend on individual household characteristics. Similarly, the level of awareness for availability and accessibility of improved seeds may vary significantly across farmers and crops.

Overall, literature in Nigeria supports the findings in other SSA countries that farmers' demand for seeds varies significantly. Two important future directions are therefore identified in this review as the following for both research and seed sector implementation.

1) Empirical information for predicting farmers' demand for seeds: Current evidence summarized above is suggestive, implying only that farmers' seed demand is affected by various factors. Further empirical research is needed that would allow the seed supply sector to predict the quantity of seed for particular varieties demanded by different farmers. As listed in Table 9, further empirical research can focus on analyzing how the actual purchase behavior of certain varieties can be predicted by each factor presented in this review. The empirical information currently available should also be incorporated into more quantitative analysis predicting farmers' demand for certain seeds. Such quantitative information can be particularly useful in determining the level of public support needed for the seed sector to increase its adoption of improved varieties.

2) Each stage of seed sector activities should have clear principles for serving the diverse nature of farmers' seed demand and the viability of required policies must be assessed by further research: The seed sector involves activities at distinct stages with different objectives, and policy is often designed at each stage, rather than for the whole seed supply chain. Important principles must be set at each stage of seed sector activities, as in Table 10. In particular, increased farmers' participation, including those in outgrower schemes, is needed from the development to the seed production stage to guarantee farmers' needs are reflected in attributes of seeds. More discussion also is needed among the seed sector stakeholders on whether seed certification should be voluntary instead of mandatory in Nigeria, based on further research assessing the impact of relaxing certification requirements on the increased availability of varieties (in terms of number of varieties and speed of release). In addition, various seed sector activities, particularly in the areas of seed marketing and information dissemination, may need to be modified so that appropriate seeds can be distributed to farmers with diverse characteristics. Further research is needed to assess the required resource levels to meet the key principles for seed marketing and information dissemination in Table 10, and the appropriate support mechanisms of support forboth public institutions and private companies in the seed sector.

Conclusions

Farmers' seed demand behavior is complex in Nigeria, and a good understanding of its nature is crucial for increasing farmers' adoption of improved seed varieties. Knowledge gaps are still considerable for an effective seed sector in Nigeria, and must be filled by future research. This sector review suggests two key areas of knowledge gaps that are important for Nigeria. First, currently available empirical information needs to be fully used and more empirical information needs to be collected to predict farmers' seed demand behavior, which will allow the government to target farmers with a higher likelihood of adopting improved seeds. Second, further research should assess the viability of various seed-related policies designed to serve the diverse nature of farmers' seed demand.

Table 9. Identified gaps in research

Seed replacement	Analysis to improve predictability of what types of farmers are likely to replace seed and at what price, given their observed characteristics
Variety change	Analysis to improve predictability of what type of farmers are likely to change the varieties, given the improved varieties available
Emergency response	Analysis to improve predictability as to which regions' farmers are likely to need emergency seed at subsidized prices and public sector involvement in its distribution
Agro-climatic conditions	Identification of factors that are best overcome by seed technology
Natural and man-made disaster	Assessment of frequency and intensity of disasters, and their effects on farmers' seed demand behavior
Market development	Assessment of the degree of diversity in market conditions through empirical information, such as geographical and temporal variations in prices of seeds, and complementary inputs and outputs
Channels and timing	Assessment of whether farmers obtain their seed through certain channels because they prefer them or trust them or because of constraints, such as no access to other channels Assessment of whether farmers prefer to obtain seed at specific times, and how much they are willing to pay to be able to do so
Level of awareness	Analysis of whether farmers may not demand improved seed because (1) they are not aware of it, or (2) they do not know where to obtain it although they want to buy, or (3) they prefer local varieties although they know of the improved seed and where to buy it

Table 10. Key principles of effective policy for each activity in formal seed sector (activity and actions are based on Kormawa, Okorji, and Okechukwu 2002)

Categories	Related activities	Key principles
Variety Development Variety testing On–farm testing	Selection against biotic stresses Facilitation of introduction and testing of new varieties Multi-location trial in all agroecological zones Decision about appropriate packages and protocols for the on-farm trial	• Increase farmer participation • Increase capacity to incorporate farmers into diverse production environment • Expand current trend of more involvement of contract growers
Variety release	Preparation of release documents for presentation to the appropriate board	Enhance capacity to release varieties faster
Variety registration	Consideration of registration by technical subcommittees Development of concept of provisional and final registration	• Simplify the registration process as it is difficult to test each variety based on each farmer's preference since these are very complex in Africa
Seed production Seed processing and storage	Production of breeder seed Varietal maintenance Facilitation of foundation seed production Field inspection Seed certification, collection, and distribution Identification of contract growers Facilitation of certified seed production Provision of market for contract growers	• Increase farmer participation • Enhance capacity to incorporate not only farmers' diverse production environments, but also their production, harvesting and post-harvest marketing practices • Expand current trend of more involvement of contract growers
Seed marketing	Fixing of prices to recover cost. (Government and private seed companies) Negotiation of price by seed dealers with ADPs Sales of seed to private farmers and public establishment	• Identify appropriate timing and establish a system to enable timely distribution to farmers • Identify appropriate channels and establish a system to enable distribution through the right channels • Promote seed sales in smaller packages so more famers can afford them • Extend current coordination with National Emergency Management Agency, Meteorological Station, National Space Agency, which are in charge of monitoring natural disasters
Information dissemination	Diffusion of variety test reports Diffusion of information on the available improved seed	• Identify key leaders in village, community • Disseminate information using the local language when farmers are less busy • Improve infrastructure for radio coverage and reception in rural areas • Identify farmers/regions with high urgent demand for seed due to emergencies (natural disaster, outbreak of pests, civil conflict) and share with them the information on available varieties and accessibility • Increase support for and collaboration with farmers' groups or NGOs which demonstrate improved seeds

Table 10. Key principles of effective policy for each activity in formal seed sector (activity and actions are based on Kormawa, Okorji, and Okechukwu 2002)

Categories	Related activities	Key principles
		• Support collective actions by farmers to reduce individual transaction costs • Raise farmers' literacy level
Seed quality control / certification	Regional law enforcement to follow guidelines	• Discuss the possibility of voluntary certification as farmers' preferences are very complex in Africa and it is difficult to certify seed in ways that meet farmers' demands for such information (certification may work if it is possible to certify every attribute African farmers seek from seed)
Workshop & training	Training of farmers, extension staffs	• Increase substantial support to extension activities
Monitoring seed program activities	Monitor seed production in all states Evaluation of seed projects and advising to Government	• Increase support to the research and project evaluations • Strengthen local research institutions' capacity • Increase research in areas identified in Table 9

References

Adejobi, A.O., F.O. Omolayo, and S.B.Williams. 2005. Expanding the improved seed market in Nigeria: An imperative for increased rice production. In Rice policy and food security in Sub-Saharan Africa, ed. P. Kormawa and A. Ali Touré Proceedings of a workshop held by Africa Rice Center, November 7–9 , 2005 in Cotonou, Benin. Cotonou, Benin: Africa Rice Center.

Adejumo, B.A., and A.O. Raji. 2007. Technical appraisal of grain storage systems in the Nigerian Sudan Savanna. Agricultural Engineering International: The CIGR EJournal 9 (11): 1–12.

Adekalu, K.O., J.A. Balogun O.B. Aluko D.A. Okunade. J.W. Gowing, and M.O. Faborode.2009. Runoff water harvesting for dry spell mitigation for cowpea in the Savannah belt of Nigeria. Agricultural Water Management 96: 1502–1508.

Ahonsi, M.O., A.A. Adeoti, I.D. Erinle,M.D. Alegbejo, B.N. Singh, and A.A. Sy. 2000. Effect of variety and sowing date on false smut incidence in upland rice in Edo State, Nigeria. International Rice Research Notes 25 (1): 14–21.

Akande, S.R. 2007. Genotype by environment interaction for cowpea seed yield and disease reactions in the forest and derived savanna agroecologies of southwest Nigeria. American-Eurasian Journal of Agricultural & Environmental Science 2: 163–168.

Alene, A.D. and V.M. Manyong. 2006. Farmer-to-farmer technology diffusion and yield variation among adopters: The case of improved cowpea in northern Nigeria. Agricultural Economics 35 (2): 203–211.

_____. 2007. The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: An endogenous switching regression analysis. Empirical Economics 32 (1): 141–159.

Amaugo, G.O., and S.O. Emosairue. 2005. Effect of neem seed kernel extracts on stem borer damage and yield of upland rice in southeastern Nigeria. International Rice Research Notes 30 (1): 24–25.

Boeke, S.J., D.K. Kossou., A. Van Huis, J.J. A. Van Loon, and M. Dicke. 2004. Field trials with plant products to protect stored cowpea against insect damage. International Journal of Pest Management 50 (1): 1–9.

Coulibaly O., C. Aitchedji, S. Gbegbelegbe, H. Mignouna, and J. Lowenberg-DeBoer.2008. Baseline study for impact assessment of high quality insect resistant cowpea in West Africa. Nairobi: African Agricultural Technology Foundation.

Dalton, T.J. 2003. A hedonic model of rice traits: Economic values from farmers in West Africa. Paper presented at the 25th International Conference of Agricultural Economists, Durban, South Africa.

Daniel, I.O,, and J.A. Adetumbi. 2006. Maize seed supply systems and implications for seed sector development in southwestern Nigeria. Journal of Sustainable Agriculture 28 (2): 25–40.

David, S., and L. Sperling. 1999. Improving technology delivery mechanisms: Lessons from bean seed systems research in eastern and central Africa. Agricultural and Human Values 16: 381–388.

Dialité, L. A. Sidibé, M. Smale, and M. Grum. 2008. Seed value chains for sorghum and millet in Mali: A state-based system in transition. IFPRI Discussion Paper 00749. Washington, D.C.: International Food Policy Research Institute.

Ekeleme, F. A. Kamara, S. Oikeh, L. Omoigui , P. Amaza, T. Abdoulaye, and D. Chikoye . 2009. Response of upland rice cultivars to weed competition in the savannas of West Africa. Crop Protection 28 (1): 90–96.

Emechebe, A.M., J. Ellis-Jones, S. Schulz, D. Chikoye, B. Douthwaite, I. Kureh, G. Tarawali, M.A. Hussaini, P. Kormawa , and A. Sanni. 2004. Farmers' perception of the Striga problem and its control in northern Nigeria. Experimental Agriculture 40 (02): 215–232.

Horna, D., M. Smale, and M. von Oppen. 2007. Farmer willingness to pay for seed-related information: Rice varieties in Nigeria and Benin. Environmental and Development Economics 12: 799–825.

Kormawa P,, E. Okorji and R. Okechukwu. 2002. Assessment of seed subsector policy in Nigeria. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Computer disk.

Kormawa P., J.N. Chianu, and V. M. Manyong. 2002. Cowpea demand and supply patterns in West Africa: The case of Nigeria. In Challenges and opportunities for enhancing sustainable Cowpea production, ed. C.A. Fatokun , S.A. Tarawali , B.B. Singh, P.M. Kormawa, and M. Tamo Ibadan, Nigeria: International Institute of Tropical Agriculture.

Langyintuo, A.S., J. Lowerberg-DeBoer, M. Faye, D. Lambert, G. Ibro, B. Moussa, A. Kergna, S. Kushwaha, S. Musa, and G. Ntoukam. 2003. Cowpea supply and demand in West and Central Africa. Field Crops Research 82 (2-3): 215–231.

Lanteri, S and L.Quagliotti. 1997. Problems related to seed production in the African region. Euphytica 96: 173–183.

Larsson,R.2005. Crisis and potential in smallholder food production-evidence from micro level. In The African food crisis: lessons from the Asian Green Revolution, ed. G Djurfeldt, H Holmen, M Jirstroml and R Larsson. Wallingford, UK: Cambridge, Massachusetts: CABI Publishing.

Lawal, B.O., J.O. Saka, A. Oyegbami, and I.O. Akintayo. 2005. Adoption and performance assessment of improved maize varieties among smallholder farmers in southwest Nigeria. Journal of Agricultural & Food Information 6 (1): 35–47.

Lenné, J.M., and D. Thomas. 2006. Integrating crop livestock research and development in Sub-Saharan Africa: Option, imperative or impossible? Outlook on Agriculture 35 (3): 167–175.

Manyong, V.M., J. Kling, K. Makinde, S. Ajala , and A. Aenkir. 2000. Impact of IITA-improved germplasm on maize production in West and Central Africa.: Ibadan, Nigeria: International Institute of Tropical Agriculture (IITA).

Minot, N., M. Smale, C. Eicher, T. Jayne, J. Kling, D. Horna, and R. Myers. 2007. Seed development programs in Sub-Saharan Africa: A review of experiences. Prepared for the Rockefeller Foundation. Washington, D.C.: International Food Policy Research Institute. Computer disk.

Nagarajan L., P. Audi, R. Jones, and M. Smale. 2007. Seed provision and dryland crops in the semiarid regions of eastern Kenya. Environment and Production Technology Discussion Paper 00738. Washington, D.C.: International Food Policy Research Institute.

National Agricultural Seed Council of Nigeria (NASC). 2009. Seed sector policy for rice, cowpea, and maize in Nigeria. Abuja, Nigeria: National Agricultural Seed Council of Nigeria. Computer disk.

Nwofia, G.E., E.E. Ene-Obong, and P.I. Okocha. 2006. Genotypic and phenotypic variability in cowpea grown in a humid environment in Nigeria. Tropical Science 46 (2): 82–86.

Okunade, E.O. 2007. Effectiveness of extension teaching methods in acquiring knowledge, skill, and attitude by women farmers in Osun State. Journal of Applied Sciences Research 3 (4): 282–286.

Okwu, O.J., A.A. Kuku, and J.I. Aba. 2007. An assessment of use of radio in agricultural information dissemination: a case study of Radio Benue in Nigeria. African Journal of Agricultural Research 2 (1): 14–18.

Oladele, O.I. 2005. A Tobit analysis of propensity to discontinue adoption of agricultural technology among farmers in southwestern Nigeria. Journal of Central European Agriculture 6 (3): 249–254.

Oladele, O.I., and O.P. Fawole. 2007. Farmers' perception of the relevance of agriculture technologies in southwestern Nigeria. Journal of Human Ecology 21 (3): 191–194.

Oladele , O.I., and A.B Somorin. 2008. Technology and extension gaps among rice farmers in Ogun State, Nigeria. Agricultura Tropica et Subtropica 41 (4): 160–164.

Olakojo, S.A., and T.A. Akinlosotu. 2004. Comparative study of storage methods of maize grains in southwestern Nigeria. African Journal of Biotechnology 3 (7): 362–365.

Olaleye, A.O., G.E. Akinbola, V.M. Marake, S.F. Molete, and B. Mapheshoane. 2008. Soil in suitability evaluation for irrigated lowland rice culture in southwestern Nigeria: Management implications for sustainability. Communications in Soil Science and Plant Analysis 39 (19): 2920–2938.

Olaleye, A.O., A.O. Ogunkunle, and G.E. Akinbola. 2008. Dynamics of iron oxides in two benchmark inland valley soils and rice grain yields in Nigeria. Communications in Soil Science and Plant Analysis, 39 (19–20): 2939–2949.

Omonona BT. 2006. Cost and returns to contract seed production in Nigeria: Evidence from Osun State. Journal of Central European Agriculture 7 (3): 475-478.

Oyekale, A.S. 2009. Climatic variability and its impacts on agricultural income and households' welfare in southern and northern Nigeria. Electronic Journal of Environmental, Agricultural and Food Chemistry 8 (1): 13–34.

Oyekale, A.S., and E. Idjesa. 2009. Adoption of improved maize seeds and production efficiency in Rivers State, Nigeria. Academic Journal of Plant Sciences 2 (1): 44–50.

Ozowa, V.N. 1995. Information needs of small- scale farmers in Africa: The Nigerian example. Quarterly Bulletin of the International Association of Agricultural Information Specialists 40 (1): 1–14.

Remington, T., J. Maroko, S. Walsh, P. Omanga, and E. Charles. 2002. Getting off the seeds-and-tools treadmill with CRS seed vouchers and fairs. Disasters 26 (4): 316–328.

Saka, J.O., V.O. Okoruwa, B.O. Lawal, and S. Ajijola. 2005. Adoption of improved rice varieties among small-holder farmers in south-western Nigeria. World Journal of Agricultural Sciences 1 (1): 42–49.

Shuaib, B., A. Aliyu, and J.S. Bakshi. 1997. Nigeria national agricultural strategic plan 1996–2010. Department of Agricultural Sciences. Federal Ministry of Agriculture and Natural Resources,(FMANR) Abuja, Nigeria: . FMANR

Sperling, L. 2002. Emergency seed aid in Kenya: Some case study insights on lessons learned during the 1990s. Disasters 26 (4): 329–342.

Sperling, L., and C. Longley. 2002. Editorial: Beyond seeds and tools: Effective support to farmers in emergencies. Disasters 26 (4): 283–287.

Taiwo, K.A. 1998. The potential of cowpea as human food in Nigeria. Technovation 18 (6-7): 469–481.

Tipilda, A., A.D. Alene, V.M. Manyong, and B.B. Singh. 2006. Intrahousehold impact of improved dual-purpose cowpea on women in northern Nigeria. In New avenues in impact assessment of participatory research and gender analysis, ed. N. Lilja, J. Dixon, G. Manners, R. La Rovere, J. Hellin, and HS Feldstein. Summary proceedings of the Impact Assessment Workshop held by the International Maize and Wheat Improvement Center in Texcoco, Mexico.

Williams, R.J. 1975. Diseases of cowpea (Vigna unguiculata (L.) Walp.) in Nigeria. International Journal of Pest Management 21 (3): 253–267.