RTB Working Paper

The cassava seed system in Nigeria: Opportunities and challenges for policy and regulatory reform

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Abstract

In many African countries south of the Sahara, farmers depend on the cultivation of vegetatively propagated crops (VPCs) for both consumption and commercial purposes. Yet yields for these crops remain at low levels due, in part, to seed market imperfections that constrain farmers' access to improved varieties and high-quality planting material. Efforts to improve the quality of planting material exchanged in markets or through other channels are often hampered by the unique biological and economic characteristics of vegetative propagation—characteristics that distinguish VPCs from the major cereal crops that drive and shape the policy and investment choices made in many of these countries. This suggests that continued investment in new technologies and systems to produce, package, and distribute VPC planting materials will require customized policies and policy support if these systems are to supply farmers with quality planting material at any significant and sustained scale. This paper explores these issues in the context of the cassava seed system in Nigeria by drawing on (1) prior research, public policy documents, and government statistics; (2) key informant interviews and focus group discussions with seed system actors; and (3) a unique dataset from the 2015 Cassava Monitoring Survey of Nigeria (CMS). The paper examines the production and supply of cassava planting material, the influence of various quality assurance systems on production and supply, and the implications for smallholder farmers in Nigeria. We describe the market, non-market, and regulatory systems that shape the cassava seed market in Nigeria, focusing on effectiveness, influence, and reach. We then explore the ground realities—how farmers actually acquire and use cassava planting material—given the (weak) state of markets and regulation. This is followed by a discussion of alternative policy and regulatory approaches to managing and expanding the cassava seed system, emphasizing a more decentralized approach that prioritizes investment in innovative capacity at the community and enterprise levels.

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The cassava seed system in Nigeria: Opportunities and challenges for policy and regulatory reform

1. INTRODUCTION

Vegetatively propagated crops—roots, tubers, and bananas—are central to both agricultural production systems and consumption choices throughout much of Africa south of the Sahara. Africa is the world's largest producer of two important vegetatively propagated crops (VPCs): cassava and yam, accounting for about 54 percent and 96 percent of global production, respectively. Other VPCs such as potato, sweetpotato, banana, and plantain are also key food security crops in the continent. But yields for these crops in Africa lag well behind global averages. A well-established path towards yield improvement is increasing the availability of improved genetic traits and quality planting material for VPCs (Almekinders et al., 2019; Andrade-Piedra et al., 2016; Jeffery et al., 2020). Yet seed systems and markets for VPCs in many African countries south of the Sahara face many challenges, contributing to low use-rates of improved varieties and quality seed, low yields, and low yield growth rates relative to other countries.[1]

The low productivity of VPCs in Africa is partly attributed to market imperfections that constrain farmers' access to improved varieties (Bold et al., 2017; Wossen et al. 2019a). But even when improved varieties are available, limited access to high-quality seed (i.e., planting materials that are superior in physical, physiological and health quality, irrespective of genetics), is often a serious constraint (Almekinders et al., 2019). There are several well-established explanations for these market imperfections that resonate with VPCs throughout the world (Fuglie et al., 2006). First and foremost, VPC seed is often bulky, perishable, costly to store, highly susceptible to pests and diseases, and difficult to certify (Kapinga, 2013; Gibson et al. 2009). These characteristics constrain the time and space over which seed can be exchanged, as well as the feasible sizes of the exchanges.

Second, VPCs are typically exchanged in markets that embody many of the classic failures observed in other seed markets: asymmetric information between seller (who may know the genetic and physical potential of the seed product) and farmer (who cannot assess quality prior to cultivation) (Jack, 2011); and non-appropriability of the gains from innovation (i.e., breeding and crop improvement) (Kloppenburg, 2010; Spielman & Ma, 2016). Third, returns to the use of quality VPC seed are often low and variable in low-input and nominally commercialized production systems, which is often the reality of smallholders throughout much of Africa. To provide a sense of scale, consider the fact that while the yield gains associated with replacing low-quality or adulterated hybrid maize seed with authentic, first-generation (F1) hybrid seed in Uganda can reach 80 percent (Bold et al., 2017), similar replacement

[1] Throughout this paper, we refer to "seed systems" as a generic phrase to describe any system in which planting material is produced, exchanges, and used. This system covers true biological seed as well as asexually, clonally, or vegetatively propagated materials such as cuttings and buddings. In the case of cassava, "seed" as used in this paper refers specifically to stems, which are the primary form of planting material for cassava.

of stems for disease-resistant cassava varieties in neighboring Tanzania reach between 8 and 20 percent (MEDA, 2016).[2]

Finally, VPC seed production is often uneconomical in many situations. Low seed multiplication rates plus the costs of storage and losses in storage result in high costs of seed production for VPCs relative to most cereal crops (Kapinga, 2013; Almekinders et al., 2019). Combined with the perishability and bulkiness problems mentioned earlier, plus the availability of viable substitutes in the form of farmer-saved seed, VPC seed production is a challenging business proposition even for the best entrepreneur.

In the presence of such market failures, farmers often utilize the information available in local markets to form subjective beliefs about quality. However, farmers may misperceive quality when such information reveals quality inaccurately, thus limiting their ability to use high-quality seed effectively. When quality is difficult to observe in market exchanges, government intervention can be used to address the underlying market failure and improve overall market efficiency. Such interventions may include public investment in R&D to make up for the absence of private innovation incentives; regulatory systems that impose quality standards on seed traded in formal markets; or subsidy and tax incentives to lower the costs of seed production and stimulate demand for quality seed. Considerable evidence on remedies to market imperfections exists in the literature (e.g., Spielman and Smale, 2017; Pal and Tripp, 2002; Tripp and Rohrbach, 2001; Morris, 1998; Tripp, 1997; Tripp and Louwaars, 1997). However, such studies generally focus on major cereal crops—rice, wheat, and especially maize—where issues of quality, costs, and returns are less acute for both seed producers and farmers.

Against this backdrop, this paper attempts to highlight the importance of not only genetic improvement, but also the importance of developing more functional and sustainable seed systems and markets that account for the uniqueness of VPCs. We explore the cassava seed system in Nigeria to illustrate this point. Nigeria is the world's largest producer of cassava, accounting for roughly 20 percent of the global cassava production. Yet cassava yields in the country range between 11 and 14 tonnes per hectare, far below the global average, and only a third of the yields achieved by other major cassava-producing countries such as Thailand and Vietnam (FAOSTAT, 2016; Wossen et al., 2019a). Cassava seed quality—the quality of the stems used as planting material—can significantly affect both the yield and quality of the tuberous cassava roots that is ultimately produced, consumed, and sold (MEDA, 2016).[3] Yet recycled stems are used widely among Nigerian cassava farmers, contributing to the transmission of seed-borne pests and diseases from one generation to the next that ultimately affect yields (Kapinga, 2013; Rabbi et al., 2015; Gibson et al. 2009).

This paper attempts to address the following three questions with illustrations from Nigeria's cassava seed system. First, what are the public policies and regulations that govern a cassava seed system, and how do these policies and regulations influence the availability and affordability of quality seed? Second, what types of quality assurance regimes and mechanisms might be effective in increasing the supply of quality seed at scale in a sustained and cost-effective manner? Third, what types of public policies and regulations might help advance the introduction of these quality assurance mechanisms on a sustained basis? We examine the above issues drawing on key informant

[2] Planting stems infected by cassava brown streak disease (CBSD) may result in a significant yield reduction.
[3] In Tanzania, MEDA(2016) reported a yield gain of 8% by using Mumba sourced from certified cassava seed and 20% gain by using Kiroba sourced from certified seed as compared to the same varieties sourced locally from farmers.

interviews (KIIs) and focus group discussions (FGDs) with seed system actors, data from a nationally representative household survey, and prior research studies, public policy documents, and government statistics.

Cassava in Nigeria offers a useful contrast to the prevailing narratives on cereal seed systems in Africa not least because Nigeria is host to a poorly functional VPC seed system within an economy that is significantly fueled by cassava, and is in search of new and innovative solutions to problems facing the crop's cultivation and use. Cassava represents the largest crop by area and production volume in Nigeria. The crop is largely produced by farm households as a staple food crop and is fast becoming a major source of cash income as well as an important contributor to agro-industrial development (Dixon et al., 2011; Alene et al., 2012; Wossen et al., 2017b). Despite the importance of the crop for livelihood, the seed system remains largely informal throughout Nigeria due partly to the intrinsic characteristics described earlier, and in part due to public under-investment in innovative production, marketing, and quality control mechanisms. For instance, while about 60 percent of farmers in Nigeria cultivate improved cassava varieties, almost all rely on the informal system (i.e., own-saved stems, and exchange with friends, relatives, or neighbors) to obtain planting material for improved varieties (Wossen et al. 2017a).

Our key findings are summarized as follows. Although there are well established legal and regulatory frameworks governing the cassava seed system in Nigeria, the existing system mandating seed certification is more stringent than warranted. Quality assurance standards are not consistently adhered to in the inspection process; inspections are mostly visual, with little or no field sample collection or laboratory testing; and the inspection regime covers an infinitesimally small share of the overall exchange of cassava seed exchanges. The existing certification system is also prohibitively costly to implement, monitor, and enforce at any reasonably effective scale. In addition, previous public investments in breeding for host resistance and distributing improved varieties on a massive scale were conducted without commensurate investments in building quality assurance capacity. This has further weakened the reach and credibility of the legal and regulatory frameworks, further constraining implementation, monitoring, and enforcement. In the simplest terms, no certification may be better than ineffective certification, in terms of accelerating varietal turnover, improving the availability of quality stems and providing profitable opportunities to seed producers.

Further, our findings suggest that efforts to increase access to improved varieties and accelerate varietal turnover might be a more viable investment option than improving access to quality cassava seed for varieties that farmers already plant, given the low adoption rate of improved varieties and slow varietal turnover rate in the country. In terms of regulatory reforms, we propose a low-cost, decentralized quality assurance system that relies on the multiplication and distribution of clean stems by village and individual seed entrepreneurs with mandatory starter stem replacement schedules and stewardship for trueness to type. This "light-touch" system may be more effective in accelerating varietal turnover and improving the availability of quality stems relative to the existing quality assurance system.

The remainder of the paper is organized as follows. Section 2 presents an analytical framework on quality assurance and the supply of quality seed. Section 3 describes the data and data sources used in the analysis. Section 4 provides an overview of the cassava seed system of Nigeria, drawing on our data and focusing on key seed system actors and the legal and regulatory frameworks under which they operate. Section 5 discusses the main findings, followed by a discussion of policy and regulatory reform options for Nigeria's cassava seed system in Section 6. Section 7 concludes with summary reflections and policy recommendations.

2. QUALITY SEED EXCHANGES IN THE PRESENCE OF MARKET AND REGULATORY FRICTIONS

In this section, we develop an analytical framework to demonstrate how the level and type of quality assurance system, public investment in the mass distribution of improved varieties, and breeding for host-resistant varieties affect the demand and supply of quality stems. We then explore alternative quality assurance mechanisms that might be more effective in increasing access and availability of quality stems to farmers.

2.1 QUALITY ASSURANCE AND SUPPLY OF QUALITY STEMS

We begin by considering the level and type of quality assurance, on the one hand, and the supply of quality seed, as an inherent trade-off in any given seed system. Following Auriol and Schilizzi (2015), Li and Veld (2015), and Fischer and Lyon (2019), our analytical framework builds on the experience or credence nature of seed quality, i.e., seed buyers can only learn about its quality after purchasing and planting it.[4] We start by considering the behavior of the three key actors in the market: regulators, seed producers, and seed consumers (i.e., farmers). All else being equal, seed producers maximize profit from the sale of quality seed, seed consumers maximize utility from the use of quality seed, and regulators maximize public welfare, i.e., minimizing pest and disease pressure. We denote the quality of cassava stems as θ^n.

Quality is vertically differentiated such that higher-quality stems are always preferred to lower-quality stems at the same price. We define three levels of quality, differentiated by the quality assurance regime applied to their production.[5] We define these regimes with respect to the application (or absence) of external and internal inspections of seed production and the resultant materials, i.e., stem quality. External inspections are officially sanctioned inspections conducted in reference to established quality standards, procedures, and protocols that are conducted by a public regulator or its designee. Internal inspections are based on positive selection practices and the seed producer's own established authority, credibility, and capacity to assess quality, though this may be done without reference to established quality standards, procedures, and protocols.

We denote a "high" quality assurance regime as one that relies on the application of (a) external inspections and (b) internal inspections. We denote a "light-touch" quality assurance regime as one that does not rely on (a) external inspections but does rely on (b) internal inspections. And we denote the absence of a quality assurance regime as the state in which neither (a) external inspections nor (b) internal inspections are conducted, i.e., the application of traditional or conventional practice only.[6]

This translates directly into three levels of seed quality (θ^n): high-quality seed (θ^H); medium-quality seed (θ^M); and ordinary farmer saved seed $(\underline{\theta})$. Alternatively, we can define these three stems as (a) certified seed, which is a class of seed that meets the minimum official certification requirements for genetic purity, thresholds for physiological

[4] Note that the term "purchasing" does not imply that exchanges of seed take place only in formal markets where transactions are conducted in cash. It is equally feasible for exchanges to take place as bartering or gifting between family members, neighbors, traders, or other seed system actors. This does not affect the insights derived from this analytical framework.

[5] See Gildemacher et al. (2017) for more on external and internal seed quality assurance mechanisms for VPCs.

[6] Of course, we acknowledge that traditional or conventional farmer practices—including the use of indigenous knowledge—applied to farmer selection and production of cassava planting may result in higher-quality stems than the other categories described here. We introduce this ranking only for convenience, noting that results remain consistent with alternative definitions of quality level and quality assurance system.

and health attributes; (b) uncertified clean seed, which is, notionally, an alternative class of seed that may meet some thresholds for genetic purity as well as physiological and health attributes, but does not fulfil the minimum requirements for official certification; and (c) ordinary farmer saved seed, which does not meet any requirements. Although the threats of pest and disease are higher for uncertified clean seed relative to certified seed, it does potentially reduce such threats compared to ordinary farmer saved seeds. Irrespective of the definitions chosen, we order quality such that $\theta^H \geq \theta^M > \underline{\theta}$.

2.1.1 SEED DEMAND

Demand for quality seed originates from N seed buyers, i.e., mostly cassava farmers. On the demand side of this hypothetical seed market, farmers' demand for quality seed is, all else being equal, a function of their preferences for quality (ψ_i). Specifically, ψ_i represents farmers' heterogeneous preferences for quality and implicitly measures their willingness to pay (WTP). Since seed is a key input to the crop production process, we assume the following relationship to hold: $\frac{\partial \theta^n}{\partial \psi_i} > 0$. This implies that farmers' decision to acquire high-quality seed is an increasing function of their marginal utility for quality. Let the private benefit farmers derive from the use of quality stem and the corresponding price premium they are willing to pay be $f(\theta^n)$ and p^n, respectively. In our context, $f(\theta^n)$ can be interpreted as the yield gains associated with quality seed relative to $\underline{\theta}$. Demand for stem quality, implicitly the stringency of quality standards, is represented by the following utility function:

$$\mathcal{W}^n = \psi_i f(\theta^n) - p^n \qquad 1$$

The incentive compatibility condition for seed buyers, i.e., the condition that makes them indifferent between acquiring θ^H or θ^M; and θ^M or $\underline{\theta}$, respectively is given by:

$$\psi_i[f(\theta^H) - f(\theta^M)] = [p^H - p^M]$$
$$\psi_i[f(\theta^M)] = [p^M] \qquad 2$$

Equation (2) implies that farmers with a low (high) preference for quality acquire $\theta^M(\theta^H)$, respectively. Figure 1 portrays demand for seed based on the above incentive compatibility condition. Along the WTP scale, demand for quality seed is zero (i.e., only $\underline{\theta}$ seed types are demanded) when $f(\theta^M) < p^M$. When $\psi_i([f(\theta^H) - f(\theta^M)]$ $(\leq)$ $[p^H - p^M] \geq p^M$ farmers demand θ^M. Finally, in the D^H region, only θ^H will be demanded by farmers.

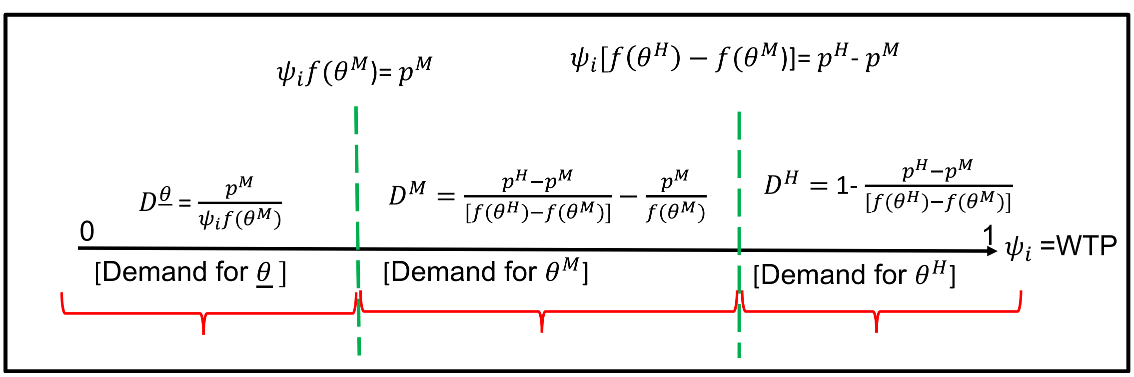

Figure 1: Demand (WTP) for quality seed

2.1.2 SEED SUPPLY

On the supply side, we consider a market with N seed producers. Following Li and Veld (2015), quality is explicitly incorporated in the cost of seed production. Let the quality specific cost of seed production and the cost of external inspections be α and ϕ, respectively. Hence the quality-specific cost of production is represented as:

$$\mathcal{C}(\theta^n) = (\alpha)\theta^n + \phi \qquad 3$$

Given the above cost structures, the seed producer obtains the following quality specific unit profit (π^n):

$$\pi^n = p^n - (\alpha)\theta^n - \phi \qquad 4$$

The incentive compatibility condition for seed producers imply a non-negative profit, $\pi^n \geq 0$.

2.1.3 EQUILIBRIUM ANALYSIS

At the equilibrium, demand equals supply. Hence, by combining equation (1) and equation (3), the optimal quality and price premium becomes:

$$\psi_i f(\theta^n) = p^n \rightarrow \psi_i f(\theta^n) - (\alpha)\theta^n - \phi = 0 \qquad 5$$

The above condition implies that at the equilibrium, the quality-specific marginal benefit must be equal to the price premium paid by buyers. However, in the presence of imperfect/weak regulatory capacity to monitor and enforce quality standards, seed buyers are unlikely to pay a premium (i.e., p^n). In this case, the corner solution would always be supplying $\underline{\theta}$, everyone uses the minimum quality stem that can be grown (this is the classic lemon-market problem described by Ackerlof 1970).

2.2 ACCOUNTING FOR UNOBSERVABLE QUALITY

When quality is not observable, the quality assurance regime and the credibility of the signal emitted from that regime influences seed demand, supply, and ultimately, the structure of the seed system and market. Following Starbird (2005), we address the role of quality assurance and quality signaling by focusing on external and internal seed inspection regimes described above and by Gildemacher et al. (2017). Suppose that the minimum quality threshold set by a regulator is θ. For now, we consider a quality assurance regime that only allows for the production and sale of high-quality seed (θ^H). Given the different levels of seed quality introduced above, let p^H and p^M denote the price premium paid by seed buyers for θ^H and θ^M quality levels. Let ω denote the probability of passing external inspection for non-θ^H seed producers at the quality threshold level of θ. Since quality is vertically differentiated, $\theta^H \geq \theta^M$, high-quality seed producers will have at least ω probability of passing external inspection and hence $p^M = \omega p^H$. Since $\underline{\theta}$ is ordinary recycled seed from own production, neither external nor internal inspection apply. Given a non-zero probability of rejection, the incentive compatibility condition of seed producers, i.e., making the seed entrepreneur indifferent between producing and supplying θ^H and θ^M in the market is given by:

$$p^H - (\alpha)\theta^H - \phi \geq \omega p^H - (\alpha)\theta^M$$
$$= [p^H - \omega p^H] \geq (\alpha)[\theta^H - \theta^M] + \phi \qquad 6$$

Quality assurance through inspection will only be informative if ω is very small/zero at or above θ. If $p^H - \omega p^H = 0$ at or above θ, quality assurance through inspection is uninformative as medium-quality seed have at least the same chance of passing inspection as high-quality stems. In this case, the informativeness of the quality assurance regime can be improved by investing in inspection capacity. If $p^H - \omega p^H = 0$ below θ, increasing the minimum quality standard will improve the informativeness of the quality assurance process (the single-binary standard region in Figure 2). The above insights imply that the accuracy or precision of the inspection process determines the quality of seed supplied to the market.

Moreover, regulation may also introduce a quality-quantity trade-off in the market for seed. For example, an exceedingly high minimum quality standard may pose a barrier to entry for prospective seed producers that, in turn, creates the conditions for a highly concentrated or monopolistic structure in the market for high-quality seed, resulting in a lower quantity of θ^H seed supplied to the market at a higher price or, in the extreme, no entry of seed producers and thus no quantity of θ^H seed in the market at any price. Alternatively, a weak or absent quality assurance regime in a market where product quality is unobservable at the point of exchange may cause producers of lower-quality seed $(\theta^M, \underline{\theta})$ to crowd into the market, driving out high-quality θ^H seed in an illustration of the classic "lemons" market (Akerlof, 1970).

Co-existence of quality levels

What then would be the first-best quality assurance regime under which an optimal quantity and quality of seed is supplied to the market? In other words, what level of regulation overcomes the quality-quantity trade-off described above? Figure 2 illustrates the trade-off between the level of regulation and the supply of quality seed, with θ^* denoting the optimal quality threshold to be set by a regulator. Moving along the x-axis to the left from θ^* toward or past θ^0, the quality threshold is increasingly lower, leading to an increasingly lower quantity of high-quality θ^H seed in the market. In this case, increasing the minimum quality standard to a more ambitious level will improve the overall supply of θ^H seed in the market. Moving along the x-axis to the right from θ^* toward or past θ^1, the quality threshold is increasingly higher, again leading to an increasingly lower quantity of high-quality θ^H seed in the market. In this case, introducing a lower quality standard through a graded labelling system will allow for the co-existence of different quality levels, resulting in higher supply of quality seed in the market.

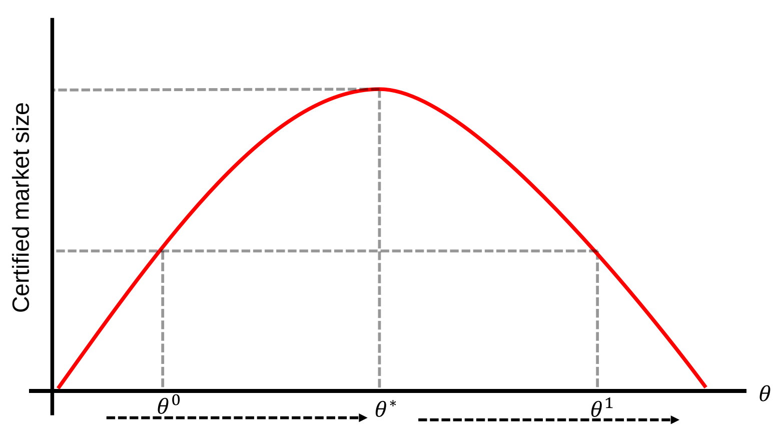

Figure 2: An illustration of "optimal" quality regulation in seed markets

Instead of a strict quality assurance regime, consider the solutions obtained from a less stringent regime that still supplies some level and quantity of quality seed $\theta^M > \underline{\theta}$ to the market Let θ^H and θ^M denote the minimum quality standards for high-quality and medium-quality seed producers, respectively. Also, let $q^H$and q^M denote the respective market shares of high-quality and medium-quality seed producers. An equilibrium which makes seed producers indifferent to adopt θ^H or θ^M seed types is given by:

$$p^H - p^M = (\alpha)\theta^H - (\alpha)\theta^M + \phi \quad 7$$

The above relationship suggests that the overall market share of certified seed (i.e., price premium) and the cost of quality assurance determines the welfare-maximizing standards. Hence, introducing graded standards instead of a single-binary standard allows for the coexistence of multiple seed quality levels (θ^H, θ^M) and provides an explicit channel for quality seed production and replacement (if managed properly), and reduces the costs of a quality assurance regime that are otherwise prohibitive. The optimality of this approach depends on the trade-offs between (a) yield loss/changes in private benefits due to quality degeneration (i.e., $f(\theta^H) - f(\theta^M)$, (b) cost savings from reliance only on internal inspection rather than external inspection (i.e., ϕ), (c) the price premium that buyers would be willing to offer $(p^H - p^H){\sim}\phi$, and (d) a practical recognition that a stringent regime is prohibitively costly to implement, monitor, and enforce.

Following Li and Veld (2015) and Zilberman et al. (2018), we illustrate the welfare implications of a graded labelling system in Figure 3. The green line denotes the demand for high-quality seed while the blue line represents the demand for medium-quality seeds.[7] As discussed above, in the absence of a quality assurance regime, the price premium approaches to zero (p^0) and only $\underline{\theta}$ quality is supplied, resulting in a market for lemons.

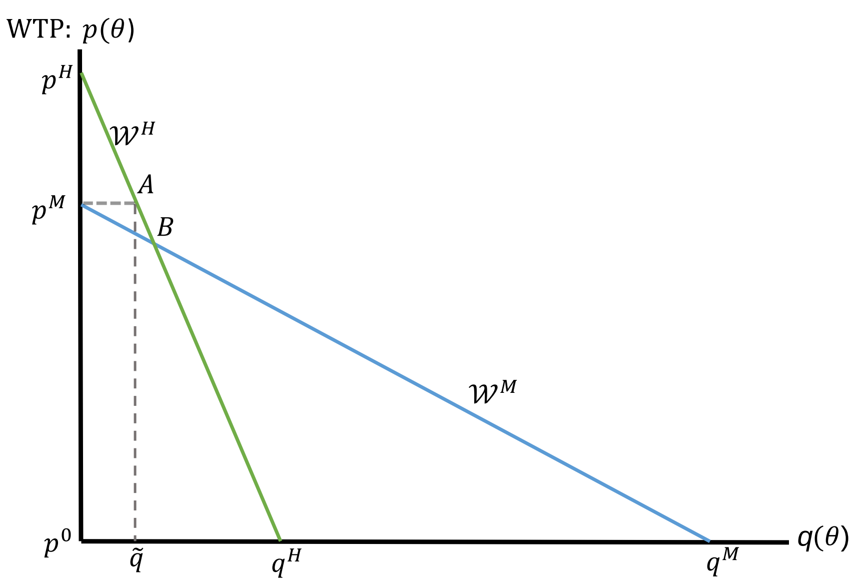

Figure 3: Welfare implication of a graded labeling system

[7] The demand for θ^M is assumed to be more elastic than the demand for θ^Hdue to better availability of substitutes.

Next, consider a quality assurance regime that only allows for the production and sale of high-quality seed and forbids the production of θ^M seed. Since such regulation introduces a barrier to entry, it creates the opportunity for non-competitive market behavior described above. Under this scenario, the price premium ranges from p^0 to p^H, depending on farmers heterogenous preferences for quality (ψ_i) which determines their WTP. As shown in Figure 3, the welfare gains to farmers who are willing to pay above p^0 is denoted by the area $p^0q^Hp^H$. However, by recognizing the production of θ^M through a graded labeling system, the overall supply of quality seed can be increased to q^M, generating welfare given by the area $p^0p^Mq^M$. Hence, by failing to recognize θ^M, the welfare loss of those with a willingness to pay between p^0 and p^H is denoted by area $p^Mp^0q^M - q^Hp^Hp^0 = Bq^Hq^M - Ap^Mp^H > 0$.

2.3 QUALITY ASSURANCE AND BREEDING FOR HOST RESISTANCE

Finally, we account for breeding for host resistance in our characterization of the market for seed. For many VPCs (and, indeed, all crops), breeding for pest or disease resistance provides a near-perfect substitute for quality (pest- and disease-free) seed, although this may not fully address soil- and seed-borne pathogens and or disease vectors such as insects, which require, *inter alia,* better crop management practices. The breeding-for-host-resistance approach is analogous to internalizing the minimum quality threshold (θ^0) into the variety itself. The availability of pest- or disease-resistant varieties directly affects the cost incurred to meet the minimum quality threshold as well as the supply of quality seed. At any quality threshold θ, the cost of quality assurance for disease-resistant varieties ($\boldsymbol{\mathcal{R}}$) is expected to be lower than non-resistant varieties ($\boldsymbol{\mathcal{N}}$). Specifically, although certain fixed costs such as inspection fees and record-keeping may not vary by variety, the inputs, labor, and management required to produce pest- and disease-free seed of disease-resistant varieties are likely to be lower than non-resistant varieties. Moreover, since disease-resistant varieties are bred to withstand biotic pressures, they are likely to achieve higher multiplication rates in seed production and degenerate more slowly than non-resistant varieties, thereby reducing the per-unit cost of seed production.

Figure 4 illustrates the relationship between regulatory costs quality thresholds (θ^1 for low, θ^* for optimal, and θ^1 for high-quality thresholds, respectively) and the size of the market for quality seed. The optimal regulation level for resistant and non-resistant varieties is shown at points R^* and N^*, respectively. Any quality threshold (θ) set higher than θ^* results in a reduction in the supply of quality seed for non-resistant varieties but is meaningless in increasing or reducing the supply of quality seed for disease-resistant varieties. This is because any quality threshold (θ) set higher than θ^* is unlikely to increase the marginal cost of quality for disease-resistant varieties. Since, maximum quality can be achieved at point N^*, seed producers are able to comply with any level of θ set higher than θ^* without incurring additional costs. This is analogous to a "tariff on water" or a "binding overhang" that captures the extent to which the applied quality threshold by regulators exceeds the required quality threshold. As such, reducing the quality threshold from θ^1 to θ^0 increases the overall supply of quality seed of disease-resistant varieties.

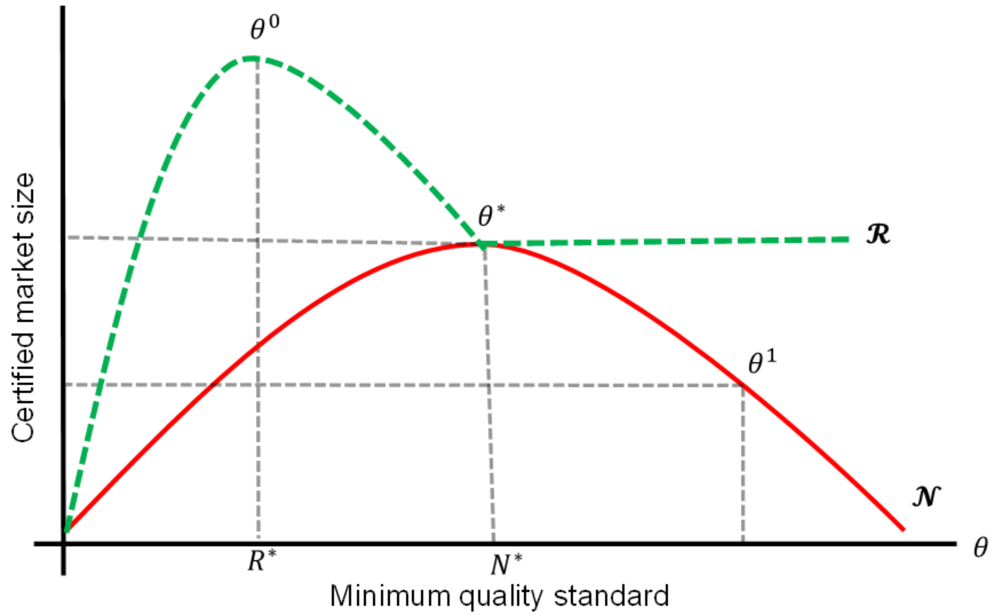

Figure 4: Quality assurance for disease-resistant varieties

2.4 PRODUCER AND CONSUMER SUBSIDIES

So what might the cassava seed system with a graded labeling regulation actually look like? The answer to that question depends acutely on the strategic use of producer and consumer subsidies as a second-best solution to inherent failures (or, more appropriately, the inherent frictions) in the cassava seed market and the regulatory system designed to address those failures. At the highest level, strong external and internal inspections are applied to the production of high-quality θ^H seed at quantities required to replace seed used as an input by producers of medium-quality $\theta^M \equiv \gamma\theta^H$ seed at a rate commensurate with the rate of quality degeneration or in response to emergent pest and disease threats. While marginal production costs of this high-quality seed may exceed the willingness to pay for θ^H among farmers, this price is likely to be closer to the willingness to pay of θ^M seed, and can be further reduced with strategic public investment in land and capital. Medium quality (θ^M) seed producers, in turn, receive public support in the form of producer subsidies. Such subsidies can take the form of technical advice and training on quality seed production, internal inspection practices, and marketing; or may take the form of subsidized credit or preferential, low-cost access to early generation materials from research centers, land, and irrigation equipment for seed production, or other inputs to production. These seed producers then supply medium-quality seed at prices that are likely to be closer to the willingness to pay of farmers themselves, thereby reducing the share of farmers relying on ordinary recycled seed ($\underline{\theta}$) that has been retained beyond recommended durations. Consumer subsidies at this point in the system may take the form of free or low-cost seed provision, extension and advisory services, or subsidized complementary inputs such as fertilizer.

Ultimately, the economic feasibility of strategic public investments—including both public spending on research and extension and producer and consumer subsidies—required to reduce market and regulatory frictions requires a keen understanding of the long-term costs and benefits involved (Jayne and Rashid, 2013; Jayne et al., 2018). While strategic public investments in agriculture and agricultural subsidy programs are a potential means of kick-starting cassava seed markets and improving cassava yields and profitability, they are not benign uses of scarce public resources. Rather, they are the subject of politics as much as they are of economics, necessitating careful analysis of the political economy factors that drive their design and application (see, e.g., Resnick, 2012; Jerven, 2014; Mason et al., 2017).

Still, the conceptual framework provided above formalizes our understanding of the trade-offs involved by different quality assurance regimes for seed—particularly VPC planting material—and their implications for market size and value, producer and farmer welfare, and market structure. This opens the door to some difficult questions about what type of quality assurance system is most appropriate to the situations where regulators have limited capacity to implement, monitor, or enforce quality assurance regimes and external inspections effectively; and where seed producers themselves have limited capacity to conduct internal inspections or signal seed quality in the market effectively. We examine these issues in the context of Nigeria's seed system in the next section.

3. DATA AND DATA SOURCES

We draw on data from three distinct sources: (1) secondary data and analysis, including prior research studies, public policy documents, government statistics, and project documents; (2) key informant interviews and focus group discussions; and (3) the 2015/16 Cassava Monitoring Survey of Nigeria (Wossen et al., 2017a). Each is described in detail below.

Secondary data and analysis on Nigeria's cassava seed system is relatively limited. Although a relatively large body of work exists on the correlates of the adoption of improved cassava varieties (Alene et al., 2012; Abdoulaye et al., 2014; Awotide et al., 2015), few studies directly address the structure and performance of the seed system itself. Studies such as USAID (2016) and Kuhlmann et al. (2018) attempt to address some of the salient features of the cassava seed system in Nigeria, focusing on regional harmonization of seed system regulations and the production and distribution of early generation seed, respectively. We draw on the insights provided from these studies to contextualize and validate our own findings, analysis, and recommendations. For similar purposes, we draw on government documents including national agriculture sector development strategies, cassava sector development strategies, and seed regulatory directives, statutes, rules, guidelines, and standards. Finally, we used secondary sources such as the government's own economic and agricultural statistics, and project descriptions from development partners, international development organizations, and non-governmental organizations to provide further descriptive insights into Nigeria's cassava seed system.

The second data source is a series of KIIs and FGDs conducted with seed systems actors. The KIIs and FGDs were conducted between June and December 2017 in Nigeria using semi-structured interview guides that were developed for each category of actor as part of a larger project on seed systems and markets for VPCs.[8] The interview guides covered topics that ranged from seed production, marketing, and distribution to the regulations and guidelines that govern seed inspection, certification, and trade.

[8] Data collection using KIIs and FGDs was done under the auspices of a cross-country study conducted by IFPRI, CIP, IITA, and CIAT, and supported by the CGIAR Research Program on Policies, Institutions and Markets (PIM) and the CGIAR Research Program on Roots, Tubers and Bananas (RTB). Individuals recruited for participation in the KIIs and FGDs described above were introduced to the study through a spoken script to obtain their verbal consent to participate in the interview. The study was approved by the IFPRI Institutional Review Board (IRB application no. 2017-06-06; IRB no. 00007490; FWA no. 00005121). Survey materials are accessible online at: https://doi.org/10.7910/DVN/MSIMRE.

Table 1: Actors, locations, and number of individuals interviewed

Actor category	Location	No. of Organizations	No. of Individuals
Policymakers, advisors, and regulators	Abuja, Ibadan, Nasarawa, Oyo	4	28
Public research agencies, institutes, centers, and stations	Abuja, Ibadan, Kaduna, Nasarawa, Niger, Ogun, Oyo, Umudike	5	22
Public extension services and development programs	Abuja, Ibadan, Kaduna, Nasarawa, Niger, Ogun, Oyo	2	35
Individual and small-scale seed entrepreneurs	Abuja, Ibadan, Kaduna, Nasarawa, Niger, Ogun, Oyo	41	41
Total		**52**	**126**

Source: Authors

Where just one or several participants were present, discussions were conducted as KIIs; where multiple participants were present, they were conducted as FGDs. The difference pertains primarily to how the discussion was managed and how information was presented, discussed, validated, refuted, and revised by participants and the interviewer, with FGDs often allowing for more iterative processes and KIIs allowing for greater depth of inquiry on specific topics. A total of 126 individuals were interviewed through the KII or FGD format (Table 1).

The third data source is the 2015 Cassava Monitoring Survey (CMS) of Nigeria (Wossen et al., 2017a).[9] CMS is a nationally representative survey that contains information about cassava production from 16 major cassava producing states of the country (Fig. 5). Specifically, the CMS provides data on varietal choice and turnover, source of planting material, stem recycling practices, trait preferences, yield, and other key socioeconomic characteristics from a nationally representative sample of approximately 2500 cassava growers in Nigeria.

[9] The full CMS report is available online here: https://cgspace.cgiar.org/handle/10568/80706

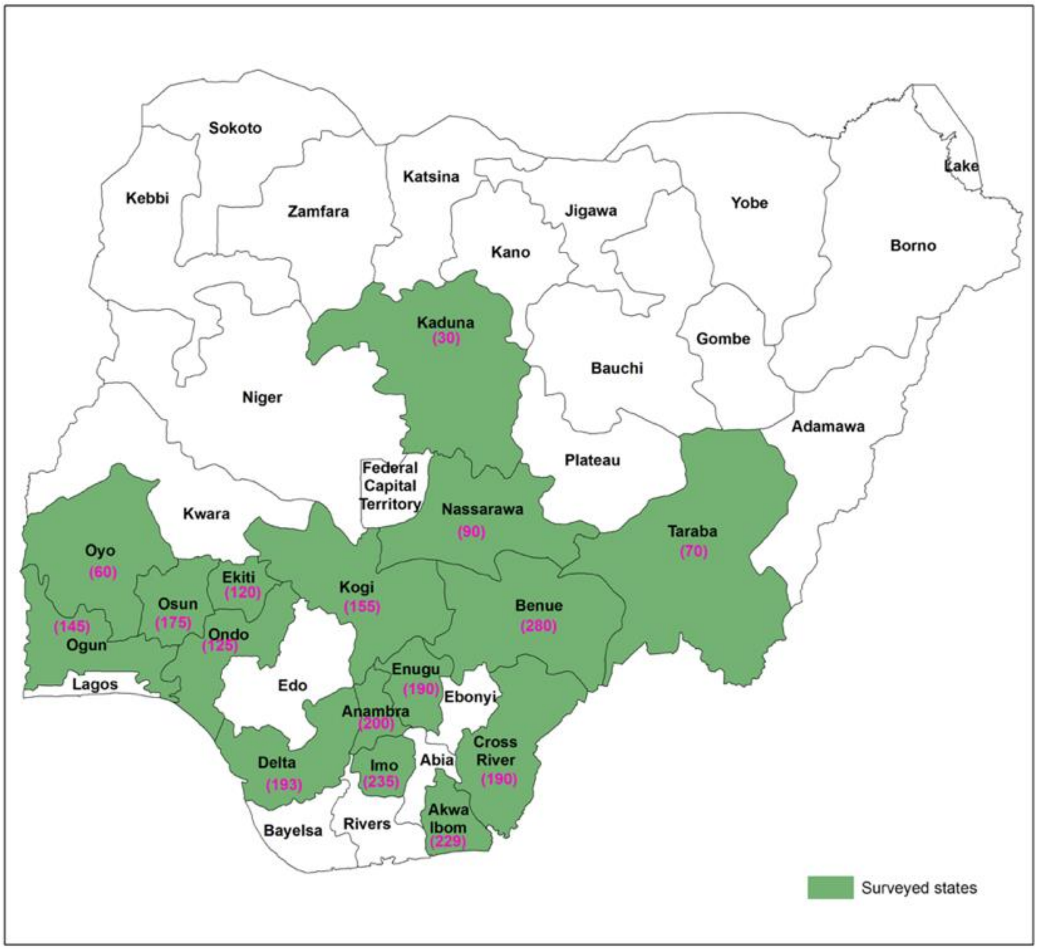

Figure 5: Study area for the Cassava Monitoring Survey of Nigeria

4. A BRIEF HISTORY OF NIGERIA'S CASSAVA SEED SECTOR

4.1. CASSAVA PRODUCTION IN NIGERIA

Cassava figures significantly in Nigeria's economy. It is produced by smallholder farm households in many parts of the country and provides an important source of income and nutrition for farmers and consumers alike (Alene et al., 2012; Wossen et al., 2017b). Due to its resilience to drought and its adaptability to a range of agro-climatic and soil conditions, it is viewed as a traditional food security crop, a principal crop in farm diversification strategies, and an essential input to Nigeria's growing agri-food system. According to data from the 2015 Cassava Monitoring Survey, about 53 percent of the cassava production in Nigeria is marketed while 38 percent is used for home consumption in the form of fresh roots or processed products such as *garri* and *fufu* (Wossen et al., 2017a). The remaining 9 percent is used for feed and industrial purposes such as starch, alcohol, and ethanol production. CMS data also suggest that more than 30 percent of cassava farmers derive about 75 percent of their income from cassava (Wossen et al., 2017a).

Given its importance to the economy, the Government of Nigeria has prioritized cassava in its R&D investment and agricultural development strategies. Since 1984, more than 46 improved cassava varieties have been released and disseminated to farmers, yet adoption rates of these improved varieties are still relatively low. For instance, while approximately 60 percent of the farmers in Nigeria report that they are cultivating improved cassava varieties, only 38 percent of the cassava-cultivated area is under improved varieties (Wossen et al., 2017a; Thiele et al., 2020). Not surprisingly, cassava yields in the country are only about 10.6 t/ha, far below the global average, and only a third of yields in other major cassava producing countries such as Thailand (FAOSTAT, 2016).

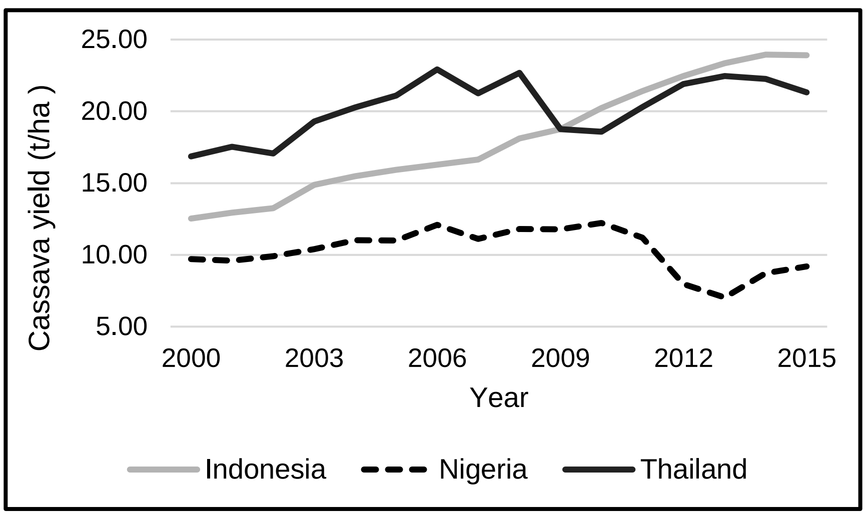

Figure 6: Comparison of cassava yields

Source: FAO, 2016

Data from the CMS also suggest that few farmers had access to improved varieties prior to the 2000s, when significant public investments and initiatives were made to multiply and disseminate improved varieties to farmers. In fact, only 22 percent of respondents in the CMS survey reported growing improved varieties prior to 2001.

However, most of those who did adopt improved varieties are still growing varieties that were released almost 30 years ago. To provide a broader perspective on varietal turnover, we estimate the weighted average varietal age (WAVA) of improved cassava varieties from the CMS data following the approach of Brennan and Byerlee (1991) and using the area under cultivation by variety as weights, where

$$WAVA = \sum_{i=1}^{N} T_i \, p_i \qquad 8$$

where T is the time period (in years) since variety i was released (calculated as 2016 minus the year of release); and p is the proportion of area allocated to variety i. In the CMS sample, the area-weighted average age of improved varieties is about 22 years. This result suggests that, on average, it takes about 22 years for a given variety to be replaced by another variety.

Almost all cassava-cultivating farmers rely on the informal system to obtain planting material. According to the CMS data, own-saved stems and stems obtained from friends, relatives, or neighbors are the primary sources of planting materials for about 70 percent of all cassava farmers (Wossen et al. 2017a). And an additional 6 percent of farmers obtained stems from local markets. Only about 17 percent of farmers obtained cassava stems from semi-formal and formal sources such as government extension services, research institutions, and processors. Note that these latter sources do not necessarily indicate that such seed was certified. Farmers typically recycle their stems as seed. The CMS data indicate that only 6 percent of farmers replaced their planting material at an average rate of once every nine years and travel an average of just 3 km to do so (Wossen et al., 2017a).

4.2 KEY ACTORS IN THE CASSAVA SEED SYSTEM

The cassava seed system in Nigeria is a constellation of many actors, some of which interact in closely integrated sub-systems and others that move in distinct and separate orbits. In this sub-section, we examine the key actors in cassava research and variety development, regulation, early generation seed production, and stem distribution. The first row of Table 2 shows the key actors involved in the seed sector, including legally mandated actors for variety development, early generation and certified seed production to quality regulations. Focusing on cassava, the second row reports the key actors currently involved in variety development, early generation seed production, certified stem production as well as in the multiplication, distribution, and marketing of stems in the formal system.

Table 2: Roles of key stakeholders in the formal seed sector

Key actors	*Variety development*	*Variety release & registration*	*Breeder seed production*	*Foundation seed production*	*Certified seed production*	*Quality assurance & regulations*
Mandated institutions for all crops	National Agricultural Research Institutes (NARIs) International Agricultural Research Centers(IARCs)-CGIAR Private Seed Companies	National Variety Release Committee (NVRC) National Centre for Genetic Resources and Biotechnology (NACGRAB)	NARIs IARCs-CGIAR Private Seed Companies	NARIs IARCs-CGIAR Private Seed Companies	Private Seed Companies	National Agricultural Seed Council (NASC) National Agricultural Quarantine Service (NAQS)
Mandated institutions for Cassava	National Root Crops Research Institute (NRCRI) International Institute of Tropical Agriculture (IITA)	NVRC NACGRAB	IITA NRCRI	IITA NRCRI	Root and Tuber Expansion Program (RTEP) Village Seed Entrepreneurs (VSE)	NASC NAQS

Source: authors based on NESG (2020)

As early as 1966—just six years after independence—the Federal Ministry of Agriculture and Natural Resources (FMANR) was mandated to promote seed industry development in Nigeria. But the introduction of the requisite policies and agencies took longer to develop, first with the establishment of the National Seed Service (NSS) within FMANR in 1975, which was mandated to manage the country's nascent seed industry through various programs and projects. In 1987, the National Crop Varieties and Livestock Breeds Act was introduced and the National Crop Varieties and Livestock Breeds Registration and Release Committee (NVRC) was established to oversee the variety release and registration process (Decree no. 33 of 1987; Kuhlmann et al., 2018*).* However, only in 1992 did Nigeria enact a broader and more structured law governing the seed system: The National Agricultural Seed Act (Decree no. 72 of 1992), which established the legal framework for a national seed system along with the key organizations required to govern and manage this system.[10] Importantly, the law led to the creation of the National Agricultural Seed Council (NASC) under the Ministry, which was charged with implementing and coordinating the Seed Act's implementation (USAID, 2016).

The key objectives of NASC include: promoting and stimulating seed industry development, regulating and controlling the registration of released varieties, facilitating the production and marketing of high quality seed, protecting farmers from the sales of poor quality seeds and providing legal backing for official testing, certification, sales, importation, exportation and use of seed (NESG, 2020). To accelerate the implementation of the seed act, the

[10] Note that, this act was amended and is replaced by the new Seed Act 2019 since May 2020. This work was conducted before the Seed Act 2019 was passed. In the 2019 seed act, basic details remain the same as the 1992 act. The major changes in the 2019 act include: recognition of 3rd party certification, increased penalties for counterfeiting, recognition of propagation materials as "seed" for certification of VPCs.

following departments were established within NASC: the National Seed Service Unit, the National Crop Variety Registration and Release Committee (NVRC), the Seeds Standards Committee, the Seed Industry and Skill Development Committee, and the Department of Training, Information, and Seed Extension.

Two research institutes are largely responsible for cassava research and varietal development: the National Root Crops Research Institute (NRCRI) and the International Institute of Tropical Agriculture (IITA). NRCRI holds the national mandate for varietal development and breeding and works closely with IITA, which started its cassava breeding program in the early 1970s with a focus on developing improved varieties with multiple disease resistance and high yield potential. In 1977, IITA developed the first wave of cassava mosaic virus disease (CMD) and cassava bacterial blight resistant (CBB-resistant) Tropical Manihot Selection (TMS) varieties such as TMS 50395, TMS 63397, TMS 30555, TMS 4(2)1425, and TMS 30572 (Nweke et al., 2002). Another breakthrough in the breeding program was the pyramiding of new sources of resistance to CMD, identified from West African landraces, within the earlier TMS varieties, thereby providing greater and more durable resistance. This second generation of improved cassava germplasm ultimately combined enhanced CMD resistance with improved postharvest qualities, resistance to multiple pests and diseases, and wider agroecological adaptations (Nweke et al., 2002). NRCRI has been a key contributor to the development, testing, release and dissemination of these varieties, and has expanded its work considerably since the 2000s with the introduction of the Presidential Initiative on Cassava, described in detail below.

Although the 1992 Act allows both the private and public sector actors to participate in the production of early generation seed (EGS), there is little private investment in cassava EGS production and marketing. This is not surprising given the issues of appropriability discussed earlier: there is very little profit potential for private EGS producers in the cassava market as it stands today. As a result, IITA and NRCRI are the primary producers of EGS for cassava in Nigeria. EGS production and distribution serve as their primary means of disseminating improved cassava varieties to other seed system actors. Recently, the private sector has also been encouraged into foundation seed production through donor-funded projects.

In Nigeria, the National Centre for Genetic Resources and Biotechnology (NACGRAB) and the NVRC, are the main institutional bodies involved in seed variety release and registration. In particular, the Registrar of NVCR, who is the Director of NACGRAB, plays a key role in variety evaluation, release, and registration (Kuhlmann et al., 2018). The first step in variety release is an application for variety registration and release by individual breeders or research institutions to NACGRAB with the required documentation and fee. As per the 2016 NACGRAB guidelines on release and registration of new crop varieties, the NVRC along with the Registrar of NACGRAB ensure that trials for distinctiveness, uniformity, and stability (DUS) and value for cultivation and use (VCU) are undertaken in collaboration with the appropriate national agricultural research institutes (NARIs) (Kuhlmann et al., 2018). For cassava, the responsible NARI is the National Root Crops Research Institute (NRCRI). Prior to variety release and registration, a crop variety is generally required to undergo a minimum of two years of on-farm testing to determine its adaptability to a particular agroecological zone. Data from DUS, VCU, and on-farm trials form the basis for reviewing and releasing new varieties by the NVRC. The Technical Sub-Committee on Crops of the NVRC plays a key role in the determination of superiority, homogeneity, distinctiveness, and stability of materials to be released; determination of guidelines for testing and describing new crop varieties; and establishment of a variety naming system and recommendation of names for new varieties to the NVRC (Kuhlmann et al., 2018).

As Nigeria's main seed system regulator, NASC aims to ensure and improve the quality of seed distributed to farmers. In particular, NASC seeks to ensure that all seed producers and traders abide by the rules and regulations specified in the 1992 National Agricultural Seeds Act. This includes preventing the production and marketing of non-certified seed: §14(1) of the 1992 Act clearly states that all seed sold in the market by registered seed producers must be inspected and approved and that such certification applies to all seed classes. Inspections are of the field-to-bag type, covering all stages of production. Currently, NASC carries out quality tests at the National Seed Testing Laboratory located in NASC headquarters in Sheda, close to Abuja to verify moisture content, purity, germination, and other disease-related parameters specified in Table 3 (Kuhlmann et al., 2018).[11] For instance, the existing cassava seed quality regulations for pests and diseases established in 2012 are listed in Table 3.

Table 3: NASC standards for pest and disease-related parameters for cassava (2012)

Parameter	Foundation seed (%)	Certified seed (%)
*CMD (mosaic)	10	20
*CAD (Anthracnose)	10	20
*CBB (bacterial blight)	10	20
Scale insects	0	20
CM (mealybug)	10	20
CGM (green mite)	10	20
* Thresholds for plants with mean severity exceeding 3		

Source: NASC (2016)

Current standards cover foundation seed and certified seed categories. Standards for breeder seed category were not established as this particular seed class is authorized for production only by NRCRI and IITA. Specifically, the following three mandatory inspections are undertaken by NASC for cassava seed production. The first is a pre-planting inspection to verify the source of planting material, verify land preparation and isolation distances, and assess the field's history and related information. At this stage of inspection, NASC guidelines recommend a minimum isolation distance of 5 m from fields planted to other cassava varieties, and starter seed replacement after two generations for foundation seed and three generations for certified seed. The second inspection is conducted to assess the incidence of pest and diseases and in-field varietal purity. The third inspection is conducted to evaluate field quality parameters such as the presence of off-types and the incidence of pests and diseases. If the seed field passes inspection, NASC issues tags/labels upon application. The label contains information on germination and purity levels of the seed, the name of the supplier, plant species and variety, and information on lot number, class of seed, and weight.

Currently, NASC follows a per-certification with an area layer inspection cost schedule of ₦1000 for 0–5 ha, ₦2000 for 6–9 ha, and ₦5000 for 10 ha. This is a one-time inspection cost, and standard practice for certification requires three rounds of inspection. This per-hectare cost does not include transport and other inspection-related costs (for example, the cost of shipping samples to the laboratory), which are normally borne by the seed producer. This also does not include business registration fees, which are ₦50,000 for large-scale producers, ₦30,000 for medium-scale

[11] In the 2019 seed act; basic details remain the same, and changes proposed include: 3rd party certification, increased penalties, mention of propagation material to recognize certification of VPCs.

producers, ₦20,000 for small-scale producers, and ₦10,000 for cooperatives. Several key informants suggested that the combined cost of business registration and inspection fees increases the cost of stem production by up to 26 percent. Not surprisingly, the 2018 annual report of NASC shows that the production of certified cassava seed accounts for less than 1 percent of the total area allocated for certified seed production in the country.[12]

To encourage the production of early generation seed (EGS), NASC has approved the engagement of other organizations, including international centers such as IITA, universities, and the private sector since 2017. Considering these changes, NASC has embarked on a revision of quality assurance standards for cassava. A framework for this revision has been proposed, which is currently being revised by NASC for adoption for seed certification starting 2020 season.

In addition to NASC, the National Agricultural Quarantine Service (NAQS) is also involved in enforcing phytosanitary standards on agricultural materials. The mandate of NAQS is to protect crops from emerging pests and diseases through the inspection of germplasm and planting material imported to the country and to ensure that exports meet international standards. NAQS operates UNIDO-accredited testing laboratories in Ibadan, Lagos, Kano, Port-Harcourt, and Maiduguri, and uses other accredited labs. Officially, NAQS has a zero-tolerance policy for planting materials that illegally cross the border, and enforcement—the destruction of the material—is done at the owners' expense. NAQS and NASC jointly facilitate international import or export of commercial seed, whereas NASC is solely responsible for seed produced for domestic use. Unofficially, according to key informants interviewed for our study, NAQS has limited capacity and resources to prevent the flow of material across Nigeria's borders in both directions.

For the most part, cassava stem production, multiplication, and distribution occur with limited reference to the varietal development, EGS production, or regulatory oversight described above. Cassava stems are distributed through the informal practices of farmers themselves, with very small quantities of stems moving through the formal seed multiplication system under the kind of regulatory oversight described above. At least four stylized—and often overlapping—seed systems exist in Nigeria: (a) farmer-to-farmer and farmer-saved seed; (b) exchanges in local markets; (c) public extension programs and projects of non-governmental organizations (NGOs); and (d) more formal, market-based exchanges through commercial channels. Conventional wisdom among key informants interviewed for this study suggests that stem replacement rates—the key to a successful cassava seed system—is lowest in the farmer-to-farmer/farmer-saved seed systems and in local market exchanges (systems a and b), and possibly higher within the distribution programs/projects and commercial channels (systems c and d). Yet these same informants suggest that the volumes of stems moving through the former two systems capture the lion's share of the entire cassava seed market, while the latter two systems are a negligible fraction of that market.

4.3 RECENT POLICY MOMENTS FOR THE CASSAVA SEED SYSTEM

In recent years, the role that these actors play in Nigeria's cassava seed system has been further shaped by several important policy moments (see, Tables 5 and 6 in the Appendix). Most notable are two initiatives that began in the early 2000s: the 2002 Presidential Initiative on Cassava (PIC) and the creation of the Agricultural Transformation Agenda (ATA) in 2011 and its Cassava Transformation Agenda. Overwhelmingly, these initiatives have prioritized the

[12] In 2017, 29989 hectares of land was allocated for the production of certified seed. Of this, only 303 ha was allocated to cassava.

distribution of improved cassava varieties but have also pursued regulatory reforms in the seed system and created incentives to stimulate private investment in cassava processing.

Among the more influential public programs aimed at accelerating the distribution of stems of improved cassava varieties to farmers was the Root and Tuber Expansion Program (RTEP). RTEP was initiated under the Presidential Initiative on Cassava, with the support of the International Fund for Agricultural Development (IFAD) and with counterpart contributions from Federal and participating state governments. Its main objective is to improve the productivity of cassava through the multiplication and dissemination of improved varieties to farmers.

Under the presidential initiative, NRCRI established seed farms on 60 hectares to produce 24,000 bundles of breeder seed while RTEP set up seed farms on 80 hectares to generate 32,000 bundles of foundation stock, with an additional 148 hectares planted by state ADPs to produce 59,000 bundles of certified stock. This was accompanied by the release of five improved varieties, the training of 500 extension agents, and the production of processing machinery such as cassava peelers, chipping machine, and manual harvester (Donkor et al., 2017). RTEP was responsible for the multiplication and distribution of approximately 250 million bundles of improved cassava variety stems to farmers under the presidential initiative (Mogues et al., 2008).

The dissemination of these materials was partly carried out through Nigeria's preexisting extension system, or what is referred to as the Agricultural Development Programs (ADPs). ADPs were set up in the 1980s under the Federal Ministry of Agriculture and Rural Development (FMARD) with World Bank support and were actively involved in the promotion and dissemination of good agricultural practices and improved varieties, especially during the presidential initiative. In recent years, however, the role of both RTEP and the ADPs in improved cassava variety dissemination has diminished with the withdrawal of World Bank support. Interviews conducted for this study suggest that farmer-to-extension agent ratios range from 1200 to as high as 8000 (Table 4). This is a high ratio considering that extension agents under the ADPs are responsible for providing advisory services on a wide range of crop and livestock issues, not just cassava seed production and cassava cultivation.

Table 4: Distribution of extension agents, c. 2017/18

State	Current no. of extension agents	Farmer-to-extension agent ratio
Nasarawa	114	1: 8,000
Kaduna	218	1: 5,000
Niger	327	1: 4,000
Abuja	97	1: 1,200

Source: Authors.

RTEP and the ADPs were followed by other initiatives. For example, the High-Quality Cassava Flour (HQCF) initiative aimed at substituting 10 percent of wheat flour in breadmaking and other value-addition processes with cassava flour, while the Cassava Bread Development Fund supported this initiative by providing funds to help increase demand for quality cassava as a feedstock for agroprocessing, which was expected to accelerate varietal turnover and increase quality seed use (FMARD, 2014; Asante-Pok; 2013). Similarly, the ATA distributed improved cassava varieties to farmers with a subsidy that reached up to 90 percent via the Growth Enhancement Scheme (GES), a targeted input subsidy program, while also advancing its Cassava Transformation Agenda through the promotion of value-added processing for food and fuel, and employment and enterprise development in the value addition of cassava.

These initiatives were preceded—or ran in parallel with, and sometimes in collaboration with—other projects dating back to the late 1980s. These projects were designed, in part or in whole, to distribute stems of improved cassava varieties to farmers. For example, multinational oil companies operating in Nigeria were engaged to fund the multiplication and distribution of TMS varieties to farmers, cooperative societies, women's associations, churches, and schools. Similarly, NGOs such as the Catholic Relief Services (CRS) and international development organizations such as IFAD have also run projects to distribute improved varieties. In effect, these projects attempt to marry the work of cassava breeding programs with efforts to build quality assurance mechanisms and capacity among farmers and farmer groups. In the end, these programs have amounted to one-off initiatives with little impact on the development of sustainable seed systems, and subsequent efforts to integrate the dissemination of improved varieties with quality planting material are still nascent. While providing improved genetics to farmers represents an important contribution to efforts to achieve productivity growth, these programs placed far less emphasis on building mechanisms to provide farmers with quality cassava planting material, irrespective of genetic improvement. In fact, it might be argued that these programs might have hindered the development of formal cassava seed market and subsequent quality assurance mechanisms by promoting and financing the free distribution of stems on such a large scale that no regulatory mechanism could reasonably provide quality assurance service.

More recently, NGOs, IITA and other partners have advanced an alternative model for improved cassava variety distribution in Nigeria: the Village Seed Entrepreneurs (VSE) model led by CRS and fostered through the USAID-funded Unleashing the Power of Cassava (UPoCA) project, and several other donor-funded projects, most notably the SCSS (sustainable cassava seed systems) project led by CRS and funded by the Bill & Melinda Gates Foundation (BMGF) and an ongoing BMGF project "Building an Economically Sustainable Integrated Cassava Seed System" (BASICS).[13] The model aims to address the entry barriers to high-quality seed producers by working with village-based groups, essentially by supplying them with high-quality foundation seed (stems) of improved cassava varieties sourced from IITA and NRCRI, registering them with the NASC, training them in the production and marketing of certified stems, and helping them meet the costs and technical requirements of inspections. In Benue State, for example, more than 104 VSEs are engaged in the production and marketing of certified stems for improved varieties, with each producer allocating an average of 0.5 hectares of land to the production of two or more varieties. In 2017, VSEs allocated a total of 64 hectares to certified cassava seed production and produced 12,326 bundles of certified stems (NASC, 2018).

Another IITA initiative—Cassava Seed Tracker—is a digital platform designed to support cassava seed producers in registering their fields with NASC, providing guidance on seed production standards and protocols, validating seed quality, and making information on quality seed providers available to farmers and the market. Further evaluation is required to determine whether these models are viable in the long term and at a scale sufficient to shift the quality

[13] BASICS is a 4-year project which was led by the CGIAR Research Program on Roots, Tubes and Bananas, with IITA managing components on early generation seed with NRCRI and funded by the Bill and Melinda Gates Foundation that seeks to create a commercially viable private sector cassava seed system in Nigeria that is compliant with improved seed certification standards implemented by NASC. See https://www.iita.org/iita-project/building-an-economically-sustainable-integrated-seed-system-cassava/

of cassava seed production in Nigeria, or whether they will befall the same fate as other non-governmental initiatives.

And ultimately, the success of these formal seed system initiatives and projects depends on their interaction with the informal sector, where most of the exchanges of stems occur. Unfortunately, these exchanges are difficult to quantify or characterize, resulting in insufficient information on the type of variety or quality of stems exchanged. But, as mentioned earlier, key informants to this study generally agree that farmer-to-farmer exchanges are the single most important means of obtaining both improved varieties and quality planting material for cassava in Nigeria. In this informal system, while the trade in cassava stems generally precludes any form of quality assurance, proxies—information about the reputation of the farmer providing or selling stems—play a key role in signaling quality to farmers. This should not be interpreted to suggest that these informal systems are fully detached from the more formal system. Informal seed producers and farmers do find ways of accessing materials from research centers or public extension and distribution programs at rates far higher than what might be conventionally believed. For example, using a DNA-fingerprinting approach, Wossen et al. (2019b) reported that 15 improved varieties had made their way to farmers' fields prior to their official release.

5. FINDINGS

5.1 APPROPRIATENESS OF THE POLICY AND REGULATORY SYSTEM

This extensive description of Nigeria's cassava seed system raises many questions. Possibly the most poignant question is whether the quality assurance system for cassava seed is at all appropriate. Assuming that the first-best line of defense against extant and emergent pests and diseases is host resistance, then the cassava seed system's main challenge is to ensure that farmers have access to stems of improved varieties on a timely basis and at affordable prices. If we assume that replacement schedules for cassava stems extend up to 10 years because of the pest and disease resistance conferred by these newer varieties, then the potential size of the cassava seed market may be quite small; farmers only have to purchase replacement stems every decade.

This replacement schedule reflects a fundamental characteristic of the cassava seed system found throughout our key informant interviews: most extension agents, farmers, and traders (i.e., commodity buyers and aggregators) do not dissociate high-quality cassava stems from improved cassava varieties. And with good reason. Wossen et al. (2019a) suggest yield gains of more than 80 percent are possible simply through varietal turnover, while MEDA (2016) suggest that the use of certified stems (irrespective of variety) offer yield gains of 8 to 20 percent. However, Kulakow et al. (2019) reported no significant difference in root yield and dry matter content resulting from the use of certified and uncertified stems of disease-resistant cassava varieties.

Thus, the costs of building a formal and well-regulated seed market around a market with this unique characteristic may be uneconomical or even impractical. Instead, it may be the case that the informal systems hold a stronger position in this market, suggesting little need for a formal seed system, at least at the farmgate. Still, there remains a question about the speed at which newer varieties—especially varieties with abiotic stress-tolerance traits, resistance traits for emerging pests and diseases to avoid catastrophic dissemination of new pathogen, or nutritional and processing qualities—can be disseminated on a large scale to farmers in the future. And this does require *some* type of seed system. To be sure, the proliferation of TMS varieties in past eras suggests that there is a significant degree of interface between breeding programs, EGS production, stem multiplication, and distribution to farmers. But whether high-quality seed is at the core of this system remains to be seen—improved varieties may be the key driver.

This then gives rise to a discussion on public investment priorities and the regulatory environment governing the seed system. Specifically, what type of public programs and quality assurance systems can (i): increase the overall supply of seed of improved varieties at any quality; (ii) increase demand for such seed among small-scale farmers; and (iii) provide profitable opportunities for seed producers? In this section, we reflect on the enabling policy environment, the functionality of the regulatory system, and alternative quality assurance systems, and relate these to the nature of both quality cassava seed supply and demand and the particular characteristics of cassava itself.

Weak regulatory oversight and implementation

Although there are well-established legal and regulatory frameworks governing the cassava seed system in Nigeria, most key informants—including regulators themselves—recognized that the existing quality assurance system is too stringent, too costly, and ultimately, ineffective in the case of cassava. Yet some key informants still maintain that the rationale behind such as system remains unchanged: that the use of higher-quality planting material will reduce the spread of pest and disease pressure, increase yields and production, and contribute to national food security. Running contrary to this position is the belief of several key informants that the relationship between the quality stems and yield is not straightforward, and that host resistance (e.g., CMD) is a sufficient substitute for quality stems.

At the heart of key informants' criticisms of the regulatory system are observations that NASC rules and guidelines are not consistently adhered to in the inspection process. Stems are inspected visually with little or no sample collection or laboratory testing, and inspections are severely constrained by too few inspectors and facilities, limited technical capacity, long traveling distances between inspection sites, and prioritization of other crops such as maize and rice over cassava. As a result, several key informants suggest that inspections are merely a formality. This reality is the likely reason that many key informants—including several regulators themselves—expressed openness to a less stringent quality assurance regime for cassava.

Unfortunately, this weak seed quality assurance system co-exists with a weak pest and disease surveillance system. Key informants explained that since seed certification considers only known pests and diseases, effective quarantine services are critical to monitor and contain the outbreak of new and emerging pathogens. Currently, NAQS undertakes emerging pathogen prevention at borders and through internal surveillance and global information exchanges with the Food and Agriculture Organization of the United Nations and other global and regional entities. However, the system may be only marginally effective at controlling pathogens in both imported materials and exported materials: NAQS operates checkpoints and posts officers to each of Nigeria's land, sea, and air crossings, but does not have the resources to monitor the country's porous borders.

Devolution and decentralization

Further exacerbating this problem is the sheer size of Nigeria and the importance of devolution to the state level in the country's political, administrative, and regulatory structure. Not surprisingly, regulators interviewed for this study argued that some aspects of the quality assurance system, specifically certification, should be a federal matter and that decentralization of the certification process to the state level would compromise seed quality. Yet other key informants suggested that state-level implementation of the existing seed quality assurance system is entirely feasible with training and guidance from federal agencies—not least because extension agents under the ADPs are directly involved in cassava seed production and inspection, and they fall under the purview of the states. As a result, inspection processes are—in practical terms—already decentralized to the state level in Nigeria, although the ultimate approval of certification remains with NASC at the federal level.

Openness to regulatory reforms

Several regulators interviewed for this study were keen to suggest opportunities for growth in the seed quality assurance system. These included new training in diagnostics, decentralization of the inspection process (but not certification, as noted above), securing facilities for molecular diagnostics, and using information and communications technologies to share data and information with stakeholders. These also included a shift in emphasis on certification to breeder and foundation seed level. NASC is also considering alternatives to reduce the cost of quality assurance following recent legislative developments that have opened the door for accredited third parties to conduct seed inspections. More importantly—and as a result of these recent legislative developments such as the 2019 seed act—the governing body in NASC will also be able to change regulations governing the seed system without parliamentary approval. This may provide the regulatory system with greater flexibility to pursue new opportunities, revise its rules and guidelines, and create a more responsive approach to seed quality assurance.[14]

Concrete efforts to improve the supply of quality seed

Still, many of these new or potential improvements in the regulatory system may just amount to “tinkering at the margins.” The larger issues around the cost of quality cassava seed production and the demand for quality cassava seed remain. This is where Nigeria’s formative experiences with programs such as RTEP, ADPs, and VSEs become important. In the absence of commercial cassava seed producers and a vibrant cassava seed market, extension agents under the ADPs or field staff working with RTEP and VSEs are likely to play a central role in the production of high-quality cassava seed. However, the number of extension agents and their capacity to provide relevant advisory services on cassava seed production is exceedingly limited. For example, individuals engaged in extension and advisory service provision that were interviewed for this study consider “*improved varieties*” as “*quality seed*” to be synonymous, suggesting that at a very fundamental level, the requisite understanding of a cassava seed system is not yet in place. Many of these same interviewees also suggest that they are engaged in the production of only a few selected improved cassava varieties under RTEP and are not given the resources to provide quality assurance in seed production. While RTEP is still actively involved in foundation seed production for a small number of selected cassava varieties, our informants suggested that the program is unlikely to continue playing a major role in the multiplication and dissemination of quality seed of improved varieties to farmers. VSEs may offer an alternative to RTEP and the ADPs. While VSEs are currently small in scale and reach, there is scope for improvement through, for example, the use of irrigation equipment to enable dry-season production, or off-season production to calibrate the supply with periods of peak demand, as suggested by several key informants.

But despite the broad issues of scale and reach, VSEs themselves seem to suggest a degree of professionalization emerging in the cassava seed system. VSE members interviewed for this study seem to have a solid understanding of the issues underlying quality assurance in cassava stem production, for example, isolation distances between varieties, harvesting and postharvest practices, and general farm operations and management. Most VSEs report having written procedures and protocols documented in manuals for stem production, and most reported that they follow the instructions in these manuals. Most VSEs also report having been inspected at least three times per year by NASC and maintain records on key production indicators such as type and timing of fertilizer application; sowing, planting, and harvesting dates; inspection records; harvest quantities; and revenues from sales. While discussions with VSE members suggest that demand is not an issue—they can sell their stems without much difficulty—they are uncertain about future profitability and farmers’ willingness to pay price premiums on quality seed.

These discussions suggest that VSEs have been able to charge relatively low prices—prices below what a considerable share of farmers were willing to pay—because of the implicit subsidy from donor project funding. Several key informants did report that VSEs generally discontinued the production of certified cassava stems when financial and in-kind support from the project ended. Further, there is little indication as to whether the current

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[14] In the 2019 seed act, proposed changes in this regard include: 3rd party certification and increased penalties.

demand for stems produced and marketed by VSEs is driven by the need for quality stems or new varieties. Several key informants suggested that demand for quality stems emanates partly from demand for new varieties. All of these findings raise questions about the long-run feasibility of VSEs.

5.2 PERSISTENT DISTORTIONS

Furthermore, the success of VSEs—or any other commercial venture into cassava seed production and marketing—will have to contend with regular distortions to the market. For instance, seed that would otherwise have not met the NASC standards could be distributed under the discretionary powers of NASC's leadership for food security reasons. At times, this means large public distributions of free seed for emergencies, large program rollouts, or other purposes. While institutional procurement can provide opportunities for emerging seed entrepreneurs, the ability of such institutions to circumvent the regulatory system necessarily distorts the market. For example, according to several key informants, the GES program's demand for certified seed without commensurate investment in production and inspection infrastructure and capabilities led to a situation where non-certified planting materials were regularly distributed to farmers as certified material. Other examples revealed opportunistic behavior by seed producers and traders who procure ordinary stems when government-funded initiatives and subsidy programs are announced for the large-scale multiplication and dissemination of improved varieties. These practices tend to push legitimate seed producers out of the market and away from institutional procurement opportunities and erode farmers' trust in the market for stems altogether.

Finally, many key informants suggested that the seed system is further distorted by corruption and mismanagement. Several key informants indicated that regulators themselves tended to distort the market by participating in the production, multiplication, and marketing of seed, in contravention of the law.[15] Meanwhile, program leakages seem to be non-trivial in Nigeria. For example, in Nigeria's long-standing fertilizer subsidy, an estimated $4.8 billion—$162.5 million per year—was thought to have been lost to corruption over the program's life (GrowAfrica, 2014). Similarly, the GES subsidy program that aimed to supply farmers with certified stems of improved cassava varieties cost Nigeria about $2.5 billion over five years, but without much evidence of reach (Wossen et al., 2018; Wossen et al., 2017a). These types of issues tend to crowd-out existing and potential quality seed producers from the market and render void any reasonable quality assurance system.

5.3 OVERALL FINDINGS

Overall findings suggest that the current policy and regulatory system governing Nigeria's cassava seed system requires significant reforms. At a fundamental level, it is unclear whether the system is geared towards the dissemination of new cassava varieties, or certified cassava stems, or both. Regulators, extension agents, seed producers, and farmers themselves seem to have a mixed view of what the system should be aiming for. If the first-best strategy for combating pests and diseases is host resistance, then the cassava seed system's main challenge is to ensure that farmers have access to stems of improved varieties on a timely basis and at affordable prices. This means that the production and distribution of quality cassava seed to farmers is of less importance than the distribution of stems of improved varieties with trueness to type irrespective of quality. That said, breeders and

[15] This was identified as a major issue particularly for maize. For cassava, this kind of practice was mentioned as common during large-scale initiatives for stem distribution.

regulators argue that at upper levels in the seed system—where breeder and foundation seed are produced and distributed—the quality of planting material needs to be managed carefully, to avoid potentially catastrophic introduction of new pests and diseases for example. This then suggests a different role for NASC and other regulatory entities in Nigeria to focus attention on certification of early generation seed; it also suggests a different role for public programs such as RTEP, extension services such as the ADPs, and enterprise development initiatives such as VSEs.

6. DISCUSSION: TOWARDS SENSIBLE POLICY AND REGULATION

Overall, our findings suggest that there is considerable interest among certain stakeholders in the development of a formal cassava seed system in Nigeria through stronger policy and regulation, and with more effective implementation, monitoring, and enforcement. However, most stakeholders acknowledge that efforts to develop this capacity are likely to be costly and, ultimately, impractical for cassava. But if the supply of high-quality planting material is not the first-order problem in Nigeria, is public investment in stem multiplication and distribution through programs such as the RTEP and GES a viable and sustainable alternative? Experience to date suggests that these programs often amount to one-off initiatives, are susceptible to the distortions discussed above, and are quite limited in their ability to simultaneously accelerate varietal turnover, prevent the spread of pests and diseases, and supply quality stems at scale consistently. But if cassava seed distribution is a fundamentally spatially-constrained activity due to perishability and bulkiness, then some degree of localization—village-based or otherwise—is necessary.

If the existing regulatory system is not practical or cost-effective, is it feasible to rely on a less stringent regulatory system that relies on seed producers to produce and market high-quality stems, *primarily as a mechanism to disseminate improved varieties* that confer biotic stress resistance, abiotic stress tolerance, and nutritional and processing traits? Based on the insights generated from our findings above, we propose a *light-touch* quality assurance system that recognizes the production, multiplication, and marketing of "clean" or medium-quality seed ($\gamma\theta^H \equiv \theta^M > \underline{\theta}$ using our earlier notation) of improved varieties. There is a subtle difference from the existing system that only recognizes the production and marketing of high-quality θ^H seed irrespective of variety and despite the widespread use of recycled $\underline{\theta}$ seed. Below, we discuss the advantage of the light-touch quality assurance system focusing on the supply of quality seed, the cost of quality assurance, and participation by private actors.

The light-touch system depends acutely on a continuous flow of new cassava varieties from the research system—rapid introduction of new and differentiated products that can ultimately provide farmers with a wider choice of agronomic, stress-resistance, nutritional, and processing traits. In the light-touch system, we propose mandatory certification at the level of early generation seed production, relying on the professional capabilities of registered institutional or private EGS producers with proper laboratory and field procedures and accredited in-house staff to manage internal quality assurance. For commercial stem production, we propose that voluntary certification be made available for those seed producers that have cause to obtain certification, e.g., exporters, large commercial farms, or other private sector actors that can valorize certified stems in niche markets. A key requirement of voluntary certification is that these actors invest in internal quality assurance systems and in-house accredited staff to conduct inspections and maintain records for review by NASC and NASQ on a regular or ad hoc basis. This ensures a credible threat of external inspection.

The core of the light-touch system remains the interface between EGS producers, on the one hand, and cooperatives, farmers' organizations, out-growers, contract farmers, and VSEs, on the other hand. The latter group of seed producers would obtain foundation seed from EGS producers to produce clean seed for purchase by farmers. Necessarily, strategic public investment and producer subsidies would be required to develop seed producers' technical capacity, their internal inspection systems, their business planning and marketing skills, and their record-keeping practices. External inspections would be required to ensure adherence to starter seed replacement schedules. But this should not imply the need for consumer subsidies to stimulate demand—ideally, marketing by seed producers would serve this purpose.

Although this component of the light-touch system is partly reflected in current practice throughout Nigeria's cassava seed system, it would nonetheless require a change in the law to provide official recognition. Furthermore, this light-touch system bears similarities to the quality declared seed (QDS) class introduced in Uganda recently. But in terms of practical implementation, minimum quality standards, and cost of regulations, the two systems differ. Specifically, the regulatory costs of ensuring quality in the QDS system are much higher (yearly inspection and certification costs) compared to the proposed light-touch system. Additionally, the light-touch system has the potential to create a vibrant private sector in upstream EGS production, pushed by the continuous release of new varieties and pulled by the growth of demand among downstream seed producers and farmers themselves. Otherwise, there will be only a marginal demand for clean seed.

Such a system would also allow NASC to play a supportive role instead of a policing role, and would encourage decentralization of business registration, inspection, and seed certification. While quality assurance at the breeder and foundation seed level is expected to be performed by NASC or accredited third-party options, adherence to seed replacement schedules (preferably using the cassava seed tracker) can be done in a decentralized manner.

While it is difficult to estimate the cost-effectiveness of the proposed light-touch system given available data, we can generate some suggestive evidence based on our findings and from prior research. First, we note that the cost of cassava seed certification (accounting for both internal and external inspection costs), based on data from VSEs in Nigeria and commercial seed entrepreneurs (CSEs) in Tanzania, is about 36 percent higher than the cost of producing "clean" cassava seed (MEDA, 2016). Second, this suggests that farmers' willingness to pay for certified stems would have to be at least 36 percent higher than their willingness to pay for clean seed (i.e., assurance of true-to-type). However, evidence from Tanzania and Uganda suggests that farmers are only willing to pay a price premium of between 8 and 25 percent for certified stems relative to uncertified stems (MEDA, 2016). The proposed light-touch system fits somewhere within this range, primarily because of a significant reduction in the external quality assurance costs.

7. CONCLUSIONS

This study presented an overview of the cassava seed system in Nigeria and proposes an alternative quality assurance system primarily as a mechanism to disseminate improved varieties. The study draws on prior research, key informant interviews and focus group discussions with seed system actors, and farm-level household data from the CMS as reported by Wossen et al. (2017a). The study documents the key actors, policies, regulations, and public programs that shape Nigeria's cassava seed system and, specifically, their influence on the availability and affordability of quality stems.

Several points emerge from this paper. First, the existing strict quality assurance system is costly, inefficient, and weakly enforced. Second, public programs to distribute improved varieties and distortions caused by public procurement and mismanagement have made the existing quality assurance system ineffective. Third, quality cassava seed and improved cassava varieties are functionally synonymous, implying that the seed system should be viewed almost exclusively as a channel through which to distribute high quality planting materials of improved varieties and, implicitly, not planting material of existing materials.

Based on the insights generated from our findings, we proposed a light-touch regulation system that combines mandatory certification of early generation seed with capacity development and strict adherence to starter stem replacement schedules at the level of clean seed producer. Compared to the existing quality assurance system, this light-touch system may be more efficient in improving the supply of quality seed, addressing trait preference heterogeneity among consumers, and reducing the cost of quality assurance. The success of the light-touch system is, however, contingent on (a) a continuous flow of improved varieties that provide farmers with a menu of desirable traits: biotic stress resistance, abiotic stress tolerance, nutritional qualities, and processing qualities, and (b) public investment in both breeding and technical and enterprise capacity development of seed producers who are the primary interface with farmers.

Finally, priorities for the research agenda moving forward should be to fill the gaps in our knowledge about the cassava seed system in Nigeria and beyond. This includes understanding farmers' willingness to pay for quality cassava seed, the relationship between seed degeneration and yield under farmers' conditions, and the commercial viability of various types of farmer-based cassava seed production enterprises.

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9. APPENDIX

Table 5: Major cassava related policy/regulatory interventions

Timeline (starting year)	Policy/institutional interventions	Major objectives
1972	National Accelerated Food Production Programme (NAFPP)	Increasing the production and productivity of cassava as a key food security crop.
1975	The National Seed Service (NSS)	Establish the legal framework for a national seed system
1976	National Root Crop Research Institute (NRCRI)	Mandated to undertake R&D for root crops, mainly for cassava
1987	National Crop Varieties and Livestock Breeds Act (Decree no. 33 of 1987	Established the Breeds Registration and Release Committee (NVRC) to oversee the variety release and registration process
1985	Agricultural Development Project (ADP)	Provision of extension services for promoting improved varieties.
1992	National Agricultural Seed Act (Decree no. 72 of 1992)	Replaced NSS and updated the legal framework for a national seed system and key public agencies to govern and manage this system.
2002	Presidential Initiative on Cassava (PIC)	Improve cassava productivity, production, export earnings, and value chain development
2002	Root and Tuber Expansion Program (RTEP)	Improve cassava productivity and production through multiplication and dissemination of improved varieties to farmers.
2002	The High-Quality Cassava Flour (HQCF) Initiative and the Cassava Bread Development Fund	Substitute 10 percent of wheat flour with cassava flour in processed goods; fund value chain initiatives.
2004	Presidential Committee on Cassava for Export Promotion	Increased production, processing, packaging, and export of cassava and cassava products.
2011	Cassava Transformation Agenda of the Agricultural Transformation Agenda (ATA)	Improve the value addition of cassava to double productivity, generate employment, and increase farmer incomes from cassava.
2016	Agricultural Promotion Policy (APP)	Improve cassava productivity, production, seed system, and value chain development.

Source: compiled by Authors based on Oparinde *et al*., 2016 and other literature

Table 6: Major cassava related projects

Timeline (starting year)	Policy/institutional interventions	Major objectives
1984	The National Coordinated Research on Cassava Project (NCRCP)	The project coordinates the on-farm adaptive research on cassava by ADPs, research institutes, and universities across Nigeria.
2001	The Rural Sector Enhancement Project (RUSEP)	Increasing the productivity and competitiveness of cassava. Improve and development of market-driven agricultural production to generate employment through the enhancement or creation of rural agricultural enterprises.
2003	The Preemptive Management of Cassava Mosaic Disease Project (CMD)	(a) Mitigate the impact of CMD and prevent its spread throughout Nigeria and West Africa; (b) increase cassava productivity by deploying high yielding cultivars and proven sustainable crop and soil management technologies; (c) promote the adoption of improved and profitable postharvest and processing technologies as well as new product development; (d) improve value addition to cassava through increased private-sector investment in production, processing, storage, and marketing; (e) increase incomes and livelihoods in rural areas by developing increased commercialization and effective and active market information acquisition and dissemination systems and (f) strengthen human and institutional capacity to produce, process, and market cassava efficiently.
2004	Cassava Enterprise Development Project (CEDP)	Value addition to the cassava crop, mechanization, and cassava value chain development. Reduction of CMD through growing of released CMD-resistant varieties. Increased production and productivity of cassava using CMD-resistant varieties. The development and expansion of postharvest processing. CEDP focused on selected communities in eleven states of the southeast (Anambra, Ebonyi, Edo, Enugu, and Imo) and the south-south (Abia, Akwa Ibom, Bayelsa, Cross River, Delta, and Rivers) including the Niger Delta region (NDR).
2006	Cassava Production, Processing and Marketing Project (CAADP)	This project supported expansion and productivity enhancement in cassava through the multiplication of planting material and innovative cassava processing and marketing options.
2007	West African Agricultural Productivity Project (WAAPP)	The objective of WAAPP was to generate and disseminate improved technologies. As part of this project, improved cassava varieties, including vitamin A cassava were multiplied and disseminated in Nigeria
2008	Unleashing the Power of Cassava in Response to Food Price Crisis (UPoCA)	The purpose of the UPoCA project was to provide an adequate supply of cassava products at economically affordable prices through mass propagation of improved and high-yielding cassava varieties; promotion of farm gate and value-adding processing of cassava for food and markets; and training farmers in improved cassava production techniques.
2010	Cassava Adding Value for Africa (C:AVA) project	The objective of this project was developing value chains for High Quality Cassava Flour (HQCF) to improve the livelihoods and incomes of smallholder households and other value chain actors as direct beneficiaries, including women and disadvantaged groups.
2012	Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC)	The project supported new variety development, promoted and disseminated improved cassava varieties, and enhanced the capacity of local institutions and value-chain actors.
2013	Cassava Mechanisation and Agro-processing Project (CAMAP)	The goal of CAMAP is to enhance cassava production and processing technologies for sustainable improvements in food security, incomes, and livelihoods for farmers, processors, and marketers in the cassava sector. In particular, it aims to improve cassava productivity by upgrading and expanding traditional planting, harvesting and processing techniques.
2015	Building an Economically Sustainable, Integrated Seed System for Cassava in Nigeria (BASICS)	The objective of this project is to develop a sustainable cassava seed system that is based on the commercial sale of cassava planting material that is produced with high-quality standards that are certified by the National Agricultural Seed Council (NASC).

Source: compiled by Authors based on Oparinde *et al.*, 2016 and other literature.

RESEARCH PROGRAM ON Roots, Tubers and Bananas

CGIAR

The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is a partnership collaboration led by the International Potato Center implemented jointly with the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), that includes a growing number of research and development partners. RTB brings together research on its mandate crops: bananas and plantains, cassava, potato, sweetpotato, yams, and minor roots and tubers, to improve nutrition and food security and foster greater gender equity especially among some of the world's poorest and most vulnerable populations.

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