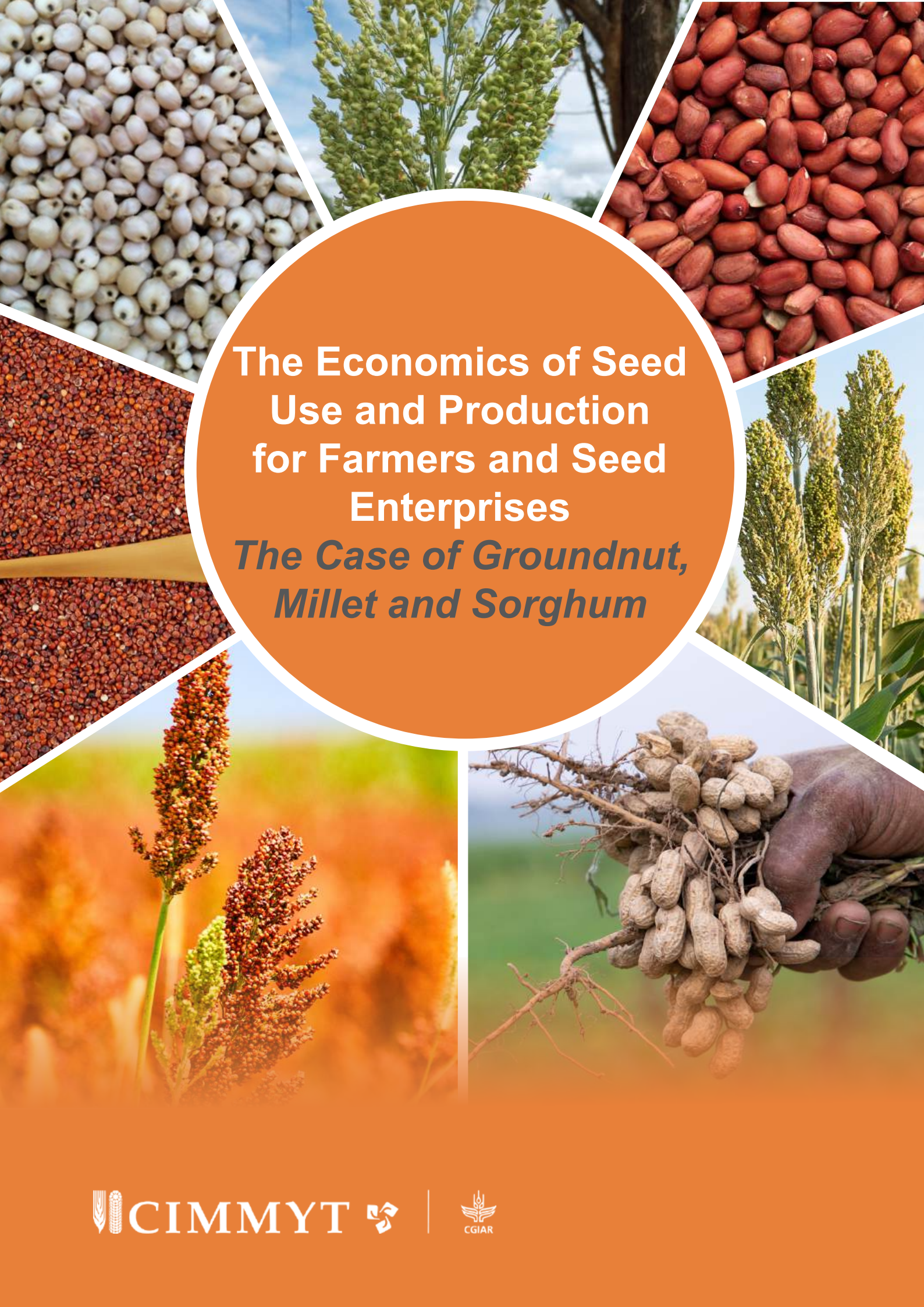

The Economics of Seed Use and Production for Farmers and Seed Enterprises

The Case of Groundnut, Millet and Sorghum

CIMMYT | CGIAR

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ABSTRACT

This report examines the economic viability of seed businesses for dryland crops, with a special focus on sorghum, millet, and groundnut, in sub-Saharan Africa. It explores the profitability and growth potential of seed enterprises (including community-based ones), highlighting key challenges including limited access to quality seeds, low private-sector investment, and insufficient adoption of improved varieties by smallholder farmers. The analysis uses profitability metrics, including the ratio of seed cost to crop value and seed-to-grain increase ratios, to assess the financial sustainability of seed systems across multiple countries. Case studies from East and West Africa provide insights into the profitability of early-generation and certified seed production, demonstrating the importance of integrating private and public sector strategies to enhance economic seed production. The report offers policy recommendations aimed at strengthening seed systems through public-private partnerships, improving seed quality, and encouraging market development to support food security and sustainable agricultural growth in the region.

CITATION

Marenya, P., Narmandakh, D., Kirui, L., Agong, D., Odhong, J., Templer, N., Opie, H., Mchau, D., Gerald, A., Martey, E., Sime, M., Zemedu, L., Bett, C., Compaore, E., Dembele, D., & Abdulsalam, Z. (2024). The economics of seed for farmers and seed enterprises: The case of groundnut, millet and sorghum. CIMMYT.

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ACKNOWLEDGEMENT

This work is part of the Accelerated Varietal Improvement and Seed Systems in Africa (AVISA) project, which aims to enhance the livelihoods of small-scale producers and consumers of sorghum, millet, groundnut, cowpea, and beans. The project partners focus on improving the breeding and seed systems of these crops in key regions across Burkina Faso, Ethiopia, Ghana, Mali, Nigeria, Tanzania, and Uganda. Additional crops receiving increased attention within the project include finger millet, pigeon pea, and chickpea.

We extend our gratitude to all the funders who supported this research through their contributions to the CGIAR Trust Fund: https://www.cgiar.org/funders/. The views expressed in this publication are those of the authors and do not necessarily reflect those of CGIAR or CIMMYT.

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List of Abbreviations and Acronyms

AVISA	Accelerated Varietal Improvement and Seed Systems in Africa project
BCR	Benefit–cost ratio
BMGF	Bill and Melinda Gates Foundation
CAGR	compound annual growth rate
CGIAR	Consultative Group for International Agricultural Research
CGS	Cost of goods sold
CORAF	West and Central African Council for Agricultural Research and Development
DUS	Distinctness, uniformity, and stability
EGS	Early generation seed
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KALRO	Kenya Agricultural & Livestock Research Organization
NARS	National Agricultural Research System
NPM	Net profit margin
NPV	Net present value
OE	Other expenses
OPV	Open-pollinated varieties
PPP	Public–private partnerships
QDS	Quality declared seed
ROI	Return on investment
SSA	Sub-Saharan Africa
TASAI	The African Seed Access Index
TC	Total costs
TR	Total revenue
VCR	Variable cost ratio
VCU	Value for cultivation and use
WAVA	Weighted average variety age

Preface

The growth and development of vibrant seed systems is critical for sustainable development. In this report we examine the potential for growth of dryland seed systems, focusing on sorghum, millet, and groundnut. These crops are essential for the food security and livelihoods of millions of smallholder farmers, yet their potential remains largely untapped due to limited access to quality seeds, low private-sector investment, and underdeveloped market systems. This report represents a collective effort to analyze the viability of seed businesses for these crops, focusing on opportunities for enhancing profitability, seed system efficiency, and market development.

Through comprehensive data analysis and case studies, we explore the financial sustainability of seed enterprises and provide policy recommendations aimed at strengthening seed systems. Our goal is to contribute to the development of strategies that foster stronger public–private partnerships, increase seed adoption, and ultimately improve agricultural outcomes for smallholder farmers.

We are grateful to the researchers, contributors, and stakeholders whose valuable input and collaboration have made this report possible. Their expertise has been invaluable in the creation of this work.



EXECUTIVE SUMMARY

This report analyzes the seed markets for the dryland crops sorghum, millet, and groundnut in the context of global cereal markets and the implications for seed systems. It examines the potential of these seed markets in sub-Saharan Africa, focusing on the size, growth potential, and profitability of seed businesses in dryland agro-ecologies. The analysis highlights the productivity challenges faced by producers of dryland cereals and legumes due to limited access to quality seeds and low private-sector investment.

Maize hybrid seed is the most successful seed system globally (Ter Steeg et al., 2022), followed by soyabeans and vegetables, so this report uses maize as a benchmark for comparison with other (dryland) crops. It explores the incentives for seed companies—crucial for translating breeding investments into practical impacts—and emphasizes their role in making new genetics accessible to farmers. It evaluates key profitability metrics using data for Burkina Faso, Ethiopia, Ghana, Mali, Nigeria, Tanzania, and Uganda, sourced from the Food and Agriculture Organization (FAO), peer-reviewed journals, and government reports. Three key metrics are the ratio of increase from seed to grain; the ratio of seed cost to crop value; and observed seed expenditure relative to profitable seed cost thresholds.

The findings indicate that the market cost of seed often does not meet the profitability threshold, particularly in smallholder settings. For example, maize open-pollinated varieties (OPVs) frequently fail to achieve the suggested profitability threshold of $1 in seed expense for a $10 return in incremental crop value. Groundnut seed shows the weakest business case, while seed expenses for sorghum and millet hybrids range from Marginally (90% within profitable range to twice as profitable as the threshold).

The report also reviews potential seed markets, production, yield, and area covered, with lessons from the global wheat seed, rice seed, and hybrid maize systems. Employing the three key variables provides a scalable way to carry out a "temperature check" on the seed system, potentially providing a traffic light system to guide seed producers on seed costing and pricing to sustain farmer demand. This report provides business analytics to give direction on the business case analysis for identifying a viable seed business.

While current seed market conditions pose profitability challenges, especially for smallholder farmers, adopting advanced business models such as vertical integration models and co-designing and co-development of innovations, could enhance the viability and adoption of improved seed varieties.

[1]Maize hybrids have become dominant in the seed industry due to the successful hybrid breeding system developed in the early 20th century; unique genetic characteristics that allow for effective inbreeding and cross-pollination; and significant economic value. Maize hybrids are adaptable to various environmental conditions, suitable for biofuel production, and offer substantial yield increases due to both genetic improvements and advanced cultivation techniques.



US$2.99 billion
African seed market value in 2024

US$3.99 billion
potential growth by 2030

SEED MARKET SHARE

42% Maize



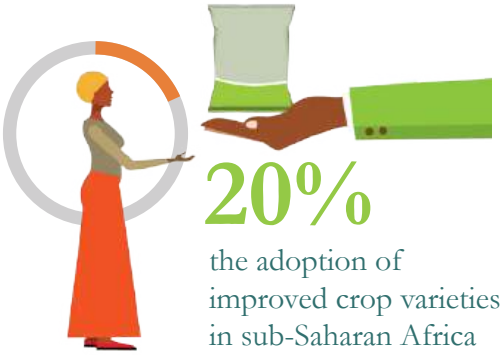
20% vegetables



14% other cereals



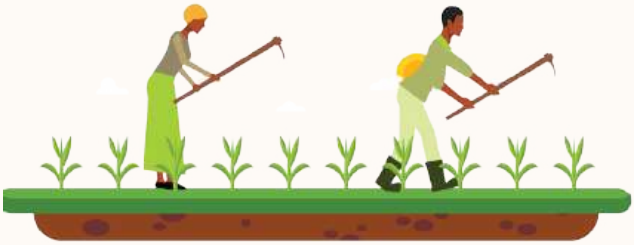
SUB-SAHARAN AFRICA



20%
the adoption of improved crop varieties in sub-Saharan Africa (SSA)

70%
of the population are smallholder subsistence farmers

accounting for **75%+**
of agricultural output in the region



CONTEXT

1.1 The importance of dryland crops

The African seed market has experienced significant growth in recent decades, reaching close to US$2.99 billion in 2024 (Mordor Intelligence 2024). This market predominantly comprises maize (42%), vegetables (20%), and other cereals (14%). Despite this growth, the adoption of improved crop varieties remains low, estimated to be around 20% in sub-Saharan Africa (SSA) (S&P Global 2021). This low adoption rate is particularly notable in smallholder subsistence farming, which constitutes over 70% of the population and accounts for over 75% of agricultural output in the region. The commercial seed market in Africa is expected to continue a growth trend, potentially reaching $3.99 billion in 2030 (Mordor Intelligence 2024).

Dryland cereals and legumes such as sorghum, millet, and groundnut are crucial for food security in for millions of families SSA, and are cultivated on many small farms in challenging environments. Despite their benefits, including nutritional value and drought tolerance, productivity is hampered by limited access to quality seeds (among other bottlenecks). Although many improved varieties exist, their adoption is low due to insufficient private-sector investment (Hambloch et al. 2021; Akpo et al. 2020). Attracting investments into these sectors hinges on factors such as seed demand, production costs, and relevant policies.



Sorghum

Sorghum is a staple crop in many parts of West Africa, covering over 15.8 million hectares in the West and Central Africa region, which constitutes 56% of SSA's total sorghum cultivation area. Major producers include Burkina Faso, Chad, Mali, Niger, and Nigeria, collectively known as the "sorghum belt" (Hodjo and Dalton, 2022) Sorghum production in these areas grew by 1.5% annually from 1999 to 2019, with yield improvements in some regions. Sorghum is highly valued for its drought tolerance and ability to thrive in low-fertility soils, making it a reliable food source in arid conditions (Hossain et al., 2022); however, adoption of improved varieties by farmers is low. Suggesting significant potential for growth, farmers in Tanzania have shown increasing adoption of improved sorghum seeds (from 8% in 2014 to 39% in 2021) (Kalema et al., 2022; Kaliba et al., 2018; Westengen and Brysting, 2014). Despite its imprtance for millions of people, international trade in sorghum remains minimal, primarily involving cross-border exchanges within the major production regions. Continued efforts to improve seed quality, promote the adoption of improved varieties, and strengthen market linkages will be necessary to maximize the benefits of sorghum (Bean et al. 2006). In countries such as Kenya, diversification of sorghum use to the brewing industry, and assurance of the market through contractual arrangements, has gradually increased the use of improved sorghum seeds by Kenya farmers (Njinju et al., 2022).



Millet

Millet, particularly pearl millet, is another crucial crop in the Sahelian zone. Niger is the largest producer, followed by Nigeria, Mali, Burkina Faso, and Chad. Millet is a principal food source in Niger, with annual consumption reaching 124 kg per capita (FAOSTAT, 2023)[2]. Like sorghum, millet is predominantly consumed where it is produced, with negligible international trade (Kane et al., 2024). Millet's resilience to harsh climatic conditions and its ability to grow in poor soils make it an indispensable crop for food security in dryland areas.



Groundnut

Groundnut (or peanut) is utilized as both a food crop and a source of income for farmers in several African countries. Groundnut farming is particularly profitable, with high gross margins reported in countries such as Uganda and Tanzania (Akpo et al., 2020). For instance, groundnut seed production in Uganda showed a gross margin of 29% for breeder seeds and over 225% for foundation seeds (Akpo et al., 2020). This profitability underscores groundnut's economic importance, despite challenges such as high production costs. Akpo et al. (2021) examined issues related to groundnut seed production and distribution in Tanzania, outlining policy measures that could improve the situation. These included grouping farmers for seed production (quality declared seed) to reduce seed costs, implementing seed subsidy programs to attract more investment, and fostering partnerships between the government and private entities for better seed quality control (Lukurugu et al., 2021).

[2]FAOSTAT Database. Rome: Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data/QCL

1.2 The seed industry in sub-Saharan Africa

The seed industry in SSA is a crucial component of the agricultural sector, playing a vital role in the region's economy and food security. Table 1 highlights the production, hectarage, and potential seed markets for the main cereals grown in Africa.

Table 1. Ranking of potential seed markets in Africa

Rank	Crop	Africa production	Average yield	Estimated area	Typical seed rate	Potential seed market	Share of potential seed market[a]	Share of production[b]	Most productive countries in Africa[c]		Africa's largest producers[d]	
		Million MT	MT/ha	Million ha	kg/ha	Thousand MT	%	%	Country	MT/ha	Country	Million MT
1	Maize	71.6	2	35.8	25	895	0.40	0.48	S.Africa	5.5	S. Africa	14.1
2	Sorghum	27.1	1.3	20.8	10	208.5	0.09	0.18	Sudan	2.2	Nigeria	5.2
3	Millet	22.4	1	22.4	10	224	0.10	0.15	Niger	1.4	Nigeria	4.8
4	Groundnut	17.4	0.9	11.2	120	1344	0.13	0.07	Nigeria	1.3	Nigeria	4.3
5	Rice	14.4	2.4	6	50	300	0.13	0.10	Madagascar	4.5	Nigeria	3.7
6	Wheat	13.3	2.2	6	100	600	0.27	0.09	Ethiopia	3.3	Egypt	8.2

Source: Authors' estimates based on FAOSTAT data.

Notes:

a. Total potential seed market represented by the specific crop.

b. Percentage of total crop production in Africa attributed to the specific crop.

c. Countries where the crop achieves the highest yield per hectare.

d. Countries in Africa producing the highest quantities of the crop, measured in million metric tons (MT).

As of 2019, the African seed market was valued at approximately US$1.9 billion with projections indicating potential growth to US$3 billion by 2025 (S&P Global, 2021). This growth is driven mainly by increased demand for improved seed varieties of commercial crops such as maize, which offer higher yields and better resistance to pests and diseases. Maize dominates the market, accounting for 42% of the total value, followed by vegetables at 20% and cereals at 14% (S&P Global, 2021).

Despite its significance, the seed industry in SSA faces numerous challenges that hinder its efficiency and growth. In this region, smallholder farmers constitute over 70% of the agricultural population and produce over 75% of the agricultural output (S&P Global, 2021) thus seed awareness, accessibility, and distribution are challenging. Improved varieties exist for dryland crops (see the example of sorghum in Table 2). However, adoption in SSA is low, estimated at around 20% (S&P Global, 2021), particularly among smallholder farmers. This is due to insufficient private-sector investment (Akpo et al., 2020; Hambloch et al., 2021) and the older average age of varieties, which may not match the current market preferences of farmers, consumers, and the seed industry. For example, a survey by Narmandakh et al. (forthcoming) revealed that the most popular sorghum varieties are Gadam, released in 1994, and Seredo, released in the 1970s.

Table 2. Weighted average variety age (WAVA) of sorghum in selected African countries

Country	WAVA (score)	Number of released varieties
Togo	4.00	4
Uganda	7.61	5
Mozambique	8.00	5
South Sudan	8.38	2
Ethiopia	13.58	16
Tanzania	17.73	5
Kenya	21.78	5
Mali	23.11	5
Ghana	26.89	3
Niger	28.68	4
Chad	31.80	3
Cameroon	39.50	2

Sources: AVISA project dataset and NARS partner datasets (unpublished data); TASAI (2024 data)[3]

Notes:

WAVA calculated as: $\frac{\Sigma(Age\ of\ Variety * Quantity\ or\ Area)}{\Sigma(Quantity\ or\ Area)}$

A higher WAVA score indicates lower varietal turnover, meaning that newer improved varieties are planted on a smaller proportion of the total land area.

The seed industry in SSA is shaped by a complex institutional and policy landscape. Public sector involvement dominates the seed system, especially for dryland crop variety releases and seed delivery for less commercial crops. Private-sector participation is limited, with a few companies playing significant roles through licensing from National Agricultural Research Systems (NARS): multiplying seed, and seed delivery and distribution. Table 3 illustrates the diverse regulatory models adopted by different economies, highlighting the variations in seed company registration, variety registration, and seed certification requirements.

[3]TASAI Country Reports: The African Seed Access Index. https://www.tasai.org/en/products/country-reports/

Table 3. Seed regulatory models

Model	Countries adopting/using the model	
	USA, South Africa, India, Bangladesh, Pakistan, Philippines, Guatemala, Nepal	**European Union, Turkey, Ukraine, most of SSA**
Registration of seed companies, contract farmers	Not required, although individual states may have requirements	Required, but based on minimum criteria
Variety registration	Voluntary	Mandatory: 2 years of VCU and DUS tests for field crops: 1 year of DUS for vegetables
Seed certification	Voluntary, although owner of variety can make certification a requirement	Mandatory for field crops, voluntary for vegetable seed

Sources: USAID (2013); World Bank (2014, 2015).

Notes:

VCU: value for cultivation and use. Where VCU testing is required, new seed varieties must undergo these tests over a period of 2 years to evaluate how well the variety performs under local growing conditions and its potential usefulness to farmers.

DUS: distinctness, uniformity, and stability. Where DUS testing is required, new seed varieties must undergo these tests over a period of 2 years (1 year for vegetables) to assess whether a new variety is distinct from existing varieties, is uniform in its characteristics within a crop, and is stable across successive generations.

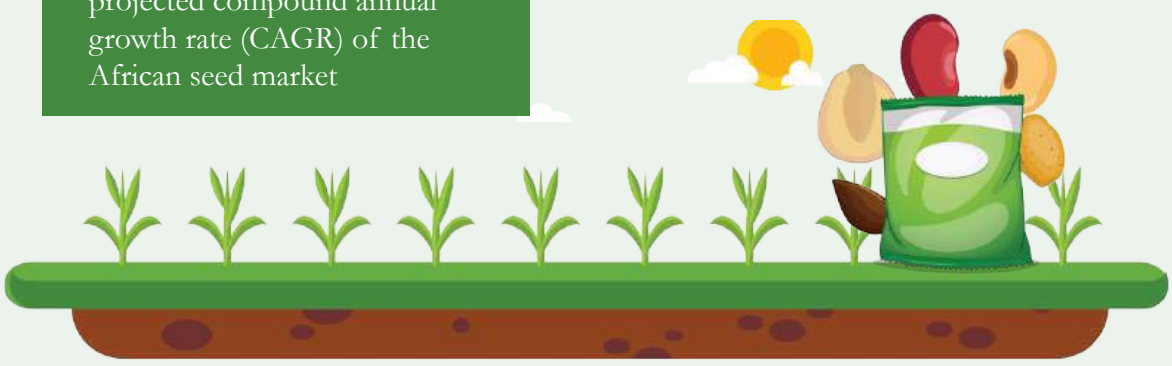
VCU and DUS tests are mandatory in the European Union, Turkey, Ukraine, and most of sub-Saharan Africa.

The future of the African seed market is promising, with a projected compound annual growth rate (CAGR) of 6.5% from 2020 to 2025 (Precision Reports 2024). To sustain or increase this growth, continued investment in research and development, coupled with better market access and supportive policy frameworks, will be key drivers. In SSA specifically, the successful integration of formal and informal seed systems, along with the adoption of innovative business models, can further enhance the sector's resilience and sustainability.

Thus the African seed market is poised for significant growth, driven by increasing demand for improved seed varieties and supportive policy initiatives. Addressing the existing challenges through strategic investments and partnerships will be essential to unlock the full potential of this vital sector.

6.5%

projected compound annual growth rate (CAGR) of the African seed market



1.3 Literature review

This brief, targeted literature review provides an overview of the challenges and opportunities within the seed business, particularly in SSA.

Institutional landscape and seed system development

Research by Guei et al. (2011) in northern Cameroon focused on enhancing smallholder seed enterprises for rice, maize, sorghum, and millet. These FAO-led projects aimed to improve the production of quality seeds by training farmer groups in seed quality management and revolving fund administration. Survey results (although not a formal impact assessment) suggested that farmers could increase rice yields fourfold (from 2 to 8 t/ha) when utilizing quality seeds accompanied by good agronomic practices. This significant yield improvement highlights the importance of quality seeds in agricultural productivity. Regarding incomes, the average income from seed production was reported to be around US$1,700 per season, illustrating the economic benefits of engaging in quality seed enterprises. These FAO projects showed positive impacts on maize, sorghum, and millet production, as well as rice production. For instance, the total certified seed production for maize reached 638,100 kg, while sorghum and millet also saw increases in certified seed production, contributing to the overall supply of these essential dryland crops.

In a review of seed system development strategies in SSA (Kenya, Malawi, Zambia, Zimbabwe), Tripp (2006) studied aspects of demand, local-level provision, commercial sector versus community projects, emergency distribution, policy, and public sector research. The recommendations suggest developing an integrated seed system by interlinking all players with division of labor along the chains, including variety promotion (industry groups); simplifying seed certification and variety registration (policy and public institutions); and covering the full spectrum of seed distribution including formal retail networks for seed companies and humanitarian, NGO, and community projects.

Sperling et al. (2020) highlighted the vital role of informal seed traders for African smallholders, supplying more than 90% of seed for most crops. These grain traders distribute seeds informally even in challenging areas, contributing to seed availability, accessibility, and diversity. Smale et al. (2009) studied the millet and sorghum seed and grain markets in the Malian Sahel. They analyzed data from households and vendors, examining institutional arrangements and genetic diversity. The study found that farmers in areas with higher rainfall risk and smaller markets often buy grain for seed, perhaps suggesting poorly developed markets.

Bidinger et al. (2005) explored the development of topcross pearl millet hybrids in Eastern Africa. Evaluating performance and hybrid vigor, they proposed a participatory approach for developing and disseminating hybrids suited to local conditions and preferences. Mastenbroek and Ntare (2016) analyzed production and delivery of early generation seed (EGS) for various crops in Uganda. Their study identified bottlenecks in EGS provision, and proposed business models

Sperling et al. (2020) **highlighted the vital role of informal seed traders for African smallholders, supplying more than 90% of seed for most crops.** These grain traders distribute seeds informally even in challenging areas, contributing to seed availability, accessibility, and diversity.

and policy interventions to enhance smallholder farmers' access to seed, including strengthening public–private partnerships and building capacity in public research institutions. They highlighted the challenges such as low demand, high costs, and poor quality of seed varying across different crops (perhaps highlighting, in our view, the difficulties of developing the needed integrated seed supply chains).

Akpo et al. (2020) focused on high-quality seed supply for legume crops in Tanzania and Uganda. The study emphasized the importance of affordable and high-quality seeds for smallholder farmers, and proposed practical strategies such as mobilizing farmers into groups, incentivizing them through shared experiences and economies of scale in seed purchases, and implementing seed subsidy programs. Opie et al. (2022) explored business models for EGS production and marketing, emphasizing the importance of planning and product cycle management. They called for capacity building in public research institutions and effective management of breeder seed production. Tasila Konja et al. (2019) compared the profitability of certified groundnut seed production with conventional groundnut production in northern Ghana. Their study found that certified groundnut seed production was more profitable and efficient, conditional on factors such as good access to technical support and extension.

Tripp and Rohrbach (2001) emphasized the need to revise seed policy frameworks in Africa to better support millet seed enterprises, noting that the current systems favor state-run operations and limit market-led innovation. They recommended that agricultural research institutes should increase their efforts to promote crop varieties and encourage commercial seed production. They also suggested building regional strategies that combine public breeding programs with private seed distribution. This is the main model in the current CGIAR maize systems, although maize does have large private-sector involvement (CGIAR, 2024).

Orr and Mwema (2013) investigated business models that aim to include small-scale farmers and women in the sorghum and millet markets. They analyzed the warehouse receipt system and contract farming models in Kenya and Uganda, highlighting the potential for these models to create profitable opportunities for all participants in the seed and grain market. Hambloch et al. (2021) discussed the role of the private sector in developing the sorghum seed market in Eastern Africa, pointing out that private-sector enterprises, even though marginal in most dryland crops, make seeds more available and encourage farmers to adopt new agricultural technologies. Fostering partnerships between governments and private entities was seen as essential to encourage the adoption of new agricultural technologies and help improve the sorghum seed market in East Africa.

Akpo et al. (2021) examined the specific challenges related to groundnut seed production and distribution in Tanzania, outlining policy measures that could improve the situation. They proposed practical strategies such as grouping farmers to reduce seed costs, implementing seed subsidy programs to attract more investment, and fostering partnerships between the government and private entities for better seed quality control.

Seed systems are shaped by complex political and economic factors: the specific nature of crops, the agroecology they are cultivated in, and the

Seed systems are shaped by complex political and economic factors: the specific nature of crops, the agroecology they are cultivated in, and the channels through which farmers obtain seeds (Spielman 2021).

[4]Feed the Future Innovation Lab for Crop Improvement (ILCI): https://ilci.cornell.edu/

channels through which farmers obtain seeds (Spielman, 2021). Seed subsidy programs, like those in Ghana, continue to play a role in stimulating the production and distribution of improved varieties, although their long-term impact on creating a vibrant commercial seed industry remains limited (Spielman, 2021). Initiatives such as the Feed the Future Innovation Lab for Crop Improvement (ILCI) have been working to involve a broader range of stakeholders (including producers) in the breeding process to enhance sustainability in seed systems.[4] The slow registration process for new seed varieties in SSA restricts smallholders' access to improved seeds, highlighting the need for greater regional harmonization in seed policy (Donovan et al., 2021; Syngenta Foundation, 2023).

These studies illustrate the complexity and potential of seed system development in SSA. They highlight the critical roles of both formal and informal seed systems, the importance of public–private partnerships, and the need for supportive policies and innovative business models. Addressing the challenges identified and leveraging the opportunities could possible to enhance the efficiency and effectiveness of seed systems, thereby supporting agricultural productivity and food security in the region.

Farm level economics

Last-mile profitability is critical for sustainable seed demand and thus for production. However, the evidence is mixed, as is the variability in approaches and data for creating sustainable production for dryland crops. In Tanzania, Rohrbach and Kiriwaggulu (2001) examined the commercialization prospects for sorghum and pearl millet. They found that pearl millet had less favorable potential for commercialization than sorghum due to higher price and lower yields and labor productivity, although a niche market for pearl millet-based meals was possible. Orr et al. (2020) presented a business case for research and development investment in sorghum and millets in East and Southern Africa. Their research, a synthesis of ICRISAT studies, analyzed the economic viability of these crops in the region, noting sorghum's alignment with poverty and food security goals, and millet's fit with commercialization strategies, particularly in niche flour markets. In East and Southern Africa, 90% of sorghum and millet is utilized as food within the region. Formal processing sectors handle only a fraction of these grains, with 10% of sorghum and 23% of millet processed (Orr and Choudhary, 2017). In areas such as Ethiopia, Eritrea, Mozambique, and central Tanzania, sorghum largely remains a subsistence crop, with 30% or less being sold from farms. Millets have an even lower market presence in Ethiopia, Eritrea, and Mozambique, with less than 15% entering the market.

In several coutires in West Africa, sorghum and millet are staple crops with significant production. Sorghum covers over 15.8 million hectares in the West and Central African Council for Agricultural Research and Development (CORAF) region, 56% of SSA's total area for the crop. Consumption is high within the sorghum belt countries (Burkina Faso, Chad, Mali, Niger, and Nigeria), exceeding

90%

of sorghum and millet is utilized as food in East and Southern Africa.

Only

10%

of sorghum and

23%

of millet is processed in East and Southern Africa.

Sorghum covers

15.8 million hectares

in West and Central African Council for Agricultural Research and Development (CORAF) region,

50 kg per capita annually (Hodjo and Dalton, 2022). The production to consumption ratio is 1.75, suggesting a surplus (Hodjo and Dalton, 2022). However, international trade in sorghum is minor, mostly confined to cross-border exchanges. Pearl millet thrives in the Sahelian zone, with Niger leading at 6.8 million hectares in 2019, followed by Nigeria, Mali, Burkina Faso, and Chad. In Niger, millet is a principal food, with annual consumption at 124 kg per capita (Kane et al., 2024). Like sorghum, millet is mostly consumed where it is produced, with negligible international trade limited to regional exchanges (Kane et al., 2024).

Ndossi et al. (2021a,b) found that 39% of farmers in their study grew improved sorghum seeds in the dryland sorghum zones of Tanzania, underlining the need for broader use to boost production and market reach. The need for market linkages is frequently mentioned, for example by Rooney (2003), who suggested a focus on processing qualities of sorghum and millet; and Njagi et al. (2019), who recommended stronger links to markets to overcome challenges such as limited credit.

Bakari et al. (2021) argued for more investment in Tanzania's groundnut value chain, citing a 35% adoption rate of better groundnut varieties and predominantly commercial use of the crop. In Nigeria, Audu et al. (2017) found groundnut farming to be profitable despite obstacles such as high costs and capital deficits, and recommended improved storage and seed varieties.

Vertical integration of seed businesses

Our review of the above literature suggests that viable seed businesses and value chains benefit from greater integration, whether through the combination of early generation seed (EGS) and certified seed operations, multi-crop seed enterprises, seed-grain integration, or various combinations of these approaches. We will return to the core analytics later; here, we introduce this concept based on a short review of literature from the early 2000s to the present.

Conceptually, vertical integration involves managing multiple stages of production for a single commodity, from suppliers to retailers, which can be achieved through ownership or contractual arrangements (Rolfe et al., 2022). Companies may pursue backward integration by taking control of upstream supply chain processes, or forward integration by managing downstream activities such as distribution (Luther, 2022). Balanced integration, which combines both upstream and downstream control, can offer greater benefits but is more challenging to execute. Vertical integration is more common in livestock and specialty crop industries than in field crops. Companies tend to integrate when internalizing production stages reduces transaction costs and improves market efficiency, particularly when the costs of using market mechanisms exceed the costs of internal management (Asmussen and Narula, 2022). Different types of vertical integration include full vertical integration, where a company controls all the steps in the supply chain; and quasi-vertical integration, where companies use strategies such as joint ventures or long-term contracts.

Vertical integration is widely used in developed countries, where it accounted for 15% of agricultural output (Ao et al., 2021). In the United States, nearly one-third of the total value of agricultural production was under contract in 2020 (U.S. Department of Agriculture, Economic Research Service, 2022). In the EU, vertical integration through contract farming is encouraged, with 38% of agricultural production in Germany using this method in sectors such as dairy and poultry (Butturini and Marcelis,



2023). Kenya's seed system faced challenges in reaching farmers due to a lack of organized delivery mechanisms, and an integrated system was proposed to help improve seed accessibility by coordinating different stages of production and distribution (Kimani et al., 2014). In addition to these integration efforts, recent studies have highlighted the need for gender-transformative metrics in seed system performance to address systemic inefficiencies and improve seed delivery to smallholder farmers. Nchanji et al. (2024) discuss the importance of these metrics in ensuring equitable outcomes and strengthening both formal and informal seed systems.

The benefits of vertical integration include economies of scale, greater control over variable costs such as logistics, fewer supply chain disruptions, and reduced lead times (Biel, 2021). It also offers faster times to market and improved market insights, helping companies respond to inflation and other market challenges (O'Brien, 2022). Integrated seed systems foster advancements in breeding, ensuring the development of climate-resilient crop varieties (Spielman, 2021), at the same time improving distribution efficiency and reducing market inefficiencies (McEwan et al., 2021). These systems promote agricultural resilience by encouraging the use of diverse seed varieties (Louwaars and Manicad, 2022), empowering smallholder farmers with access to affordable, quality seeds (Adesina et al., 2014). Effective integration requires supportive policies and collaboration among stakeholders all along the seed value chain (Byerlee and Dubin, 2010). A strategic approach involving operational integration, technology adoption, and strong partnerships can help establish vertically integrated agricultural systems (MacRobert, 2009; Collinson and Rugman, 2012).

Overall, the literature reviewed presents a seesaw between, on one hand, the challenges and, on the other, broad recommendations for better seeds, improved varieties, market linkages, and investments in the growth of Africa's agriculture sector. There is limited information on the most binding constraints, the pathway from baselines to impactful outcomes, or a clear articulation of the private and public investments needed to achieve desired impacts, such as higher crop yields, income growth, job creation, poverty reduction, resilience, and sustainability. Notably, there is a lack of basic, publicly accessible business metrics to support decision-making for private and public entities.



2 Profitability analyses

2.1 Methodology

Data sources

This section utilizes data from secondary sources including the Food and Agricultural Organization (FAO), peer-reviewed journal articles, and national statistical reports. Integration of these diverse data sources supports a thorough examination of the seed markets and seed system development in SSA, enabling us to highlight the challenges and opportunities, and make recommendations for actions needed to improve seed systems in the region.

Key metrics and analytical framework

The analytical framework used employs various seed profitability metrics to assess the viability and sustainability of the seed business case for dryland crops. Table 4 provides the key components and metrics used in the analysis.

The application of these metrics across different crops and regions reveals significant variations in profitability. For instance, hybrid varieties generally show higher ratios of increase from seed to grain compared to OPVs, indicating better yield potential. However, actual profitability also depends on market conditions, input prices, and other agronomic factors.

2.2 The business case for farmers

The business case for farmers using improved seeds of dryland crops is provided in four scenarios: ratio of increase (yield potential); seed cost to crop value ratio; farm seed expenditures versus maximum profitable seed cost; and seed price to grain price ratio (Table 2). The following section (2.3) goes on to consider the potential profitability of EGS.

Table 4. Seed profitability metrics for farmers

Seed profitability metric	Formula	High (H) versus low (L) value	Gross or marginal measure (G or M)
Ratio of increase from seed to grain (yield potential)	$\frac{\text{Grain harvested/ha}}{\text{Seed planted/ha}}$	**H:** Indicates greater efficiency in grain production per unit area of seed planted L: Reflects lower efficiency in converting seed into grain	G
Ratio of seed cost to crop value	$\frac{\text{Seed cost expenses/ha}}{\text{Value of grain harvested/ha}}$	**H:** Indicates that a larger proportion of the income generated from selling the crop goes towards covering seed expenses **L:** Reflects a smaller proportion of crop income used to cover seed costs, which can improve profitability by reducing input costs	G
Ratio of seed expenditures to profitable seed cost	$\frac{\text{Seed cost expenses/ha}}{\text{Imputed profitable seed cost/ha}}$	**H:** Implies that the costs associated with seed expenditures, such as purchasing certified or improved seed, are relatively high compared to the profits derived from the seed's productive use **L:** Indicates that costs associated with seed expenditures are proportionally lower compared to profits generated from using the seed, potentially enhancing profitability	M
Ratio of seed price to grain price	$\frac{\text{Seed price/kg}}{\text{Grain price/kg}}$	**H:** Indicates a higher economic cost of seed relative to the price spread between grain and seed L: Reflects a lower economic cost of seed compared to the price spread between grain and seed	M

Ratio of increase (yield potential)

The ratio of increase from seed to grain assesses the efficiency of grain production per unit area of seed planted, which is important for both grain and seed production. Figures 2–5 present data and two profitability measures (ratio of increase, and ratio of seed cost to crop value) for OPVs and hybrid seeds of maize, sorghum, millet, and groundnut for East and West Africa.

For each country and crop, the hybrid variety has a higher ratio of increase from seed to grain than the OPV or line variety.[5] This is not surprising due to the effect of hybrid vigor. Millet hybrid shows the highest ratio of increase from seed to grain across all countries, followed by millet OPV/line variety, sorghum hybrid, sorghum OPV, maize hybrid, and groundnut. However, as noted below, the millet seed rate (a contributing determinant of commercial viability of seed markets (Rattunde et al., 2021), is only around 8 kg/ha, 40% of the seed rate for hybrid maize, which is 20–25 kg/ha depending on agroecology (KALRO 2018a,b). While the ratio of increase is theoretically important because it communicates yield potential, in order to drive farmers' seed choices these technical (theoretical) ratios need to be translated as closely as possible on farmers' fields, for example through improved agronomic practices by growers.

Seed cost to crop value ratio

The seed cost to crop value ratio, based on the ratio of increase, evaluates the relationship between seed costs and the monetary value of crop yield. This ratio provides a measure of the profitability or efficiency of seed investment in terms of monetary benefits. Both maize OPV and hybrids have the lowest ratios of seed cost to crop value across all countries, followed by millet OPV and hybrid, sorghum OPV and hybrid, and lastly groundnut. This suggests that, under the right conditions of input prices, agronomic standards, and grain prices, maize and millet are potentially more profitable crops than sorghum and groundnut in the countries studied. Although groundnut has very low ratios of increase, the market value seems to compensate for this somewhat when viewed from the perspective of seed cost to crop value ratio.

Generally, with a few exceptions (sorghum in Kenya and Uganda, and maize in Ethiopia), hybrids tend to have lower seed cost to crop value ratios than OPVs or line varieties for the same crop. This indicates that hybrids generally have higher yields than OPVs or line varieties, making them more profitable. However, for sorghum in Kenya and Uganda, hybrids have higher ratios of seed cost to crop value than OPVs or line varieties, which could be due to higher seed costs of sorghum hybrids in these countries. For a recent comprehensive treatment of the economic value of hybrids, see Ter Steeg et al. (2022). The lower the seed cost to crop value ratio the better, as a lower ratio indicates that the costs of seed are justified by the returns as measured by the value of the output. However, this is a gross measure; next we discuss a more marginal measure.

[5]OPV specifically refers to varieties that reproduce through open pollination, where pollination occurs naturally by wind, insects, or other mechanisms. Line variety is a broader term referring to self-pollinating crops that have been selected to form a relatively uniform line. In some contexts, "line variety" might imply a greater degree of genetic uniformity than a typical OPV.

Box 1. Which dryland crops are potentially most profitable?

Under the right conditions of input prices, agronomic standards, and grain prices, maize and millet are potentially more profitable crops than sorghum and groundnut, and hybrids are generally more profitable than OPVs or line varieties.

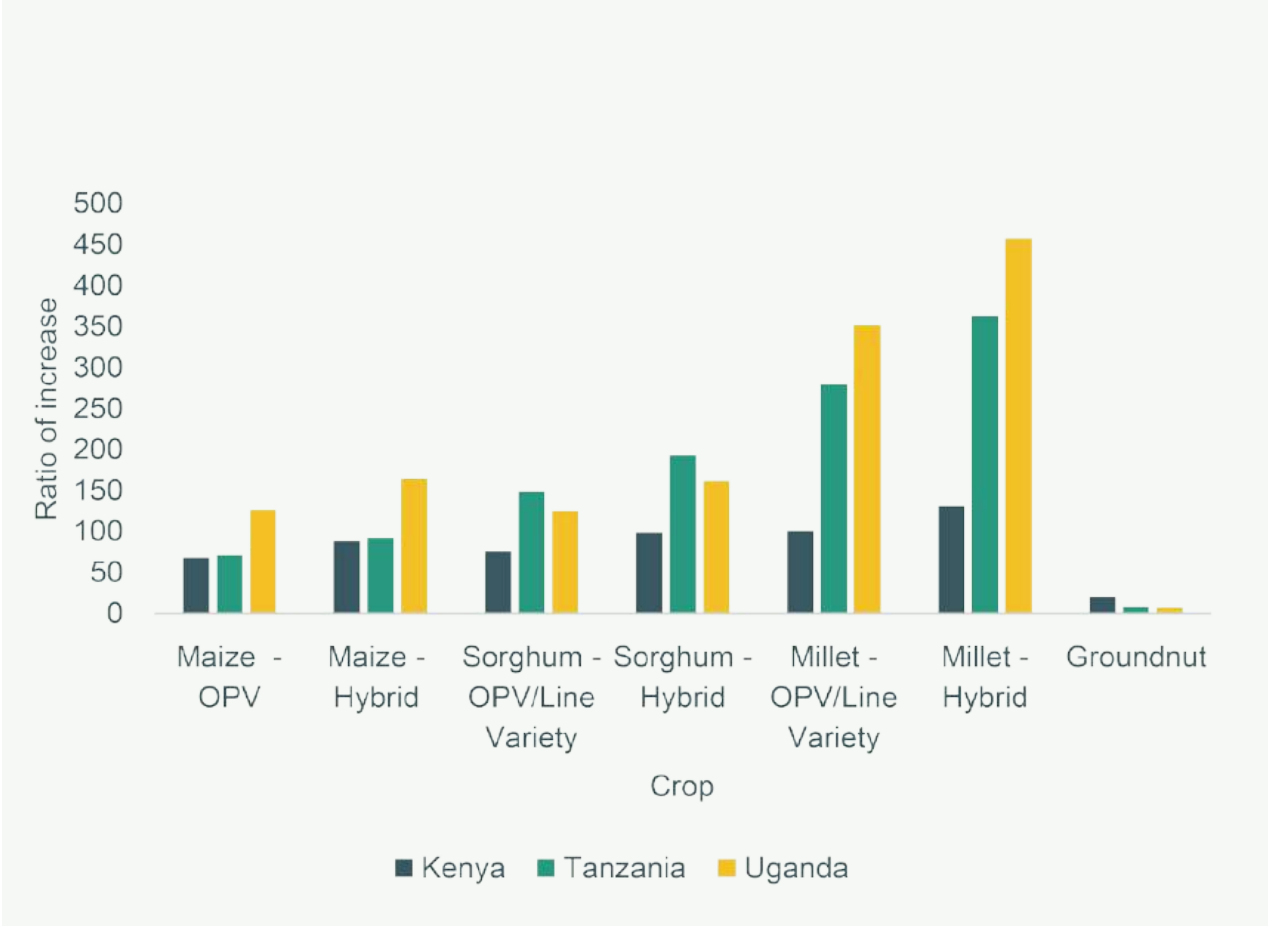


Figure 1. Ratio of increase by crop and country in East Africa

Source: Authors' estimates based on data from FAOSTAT and crop extension manuals (for recommended seed rates per ha).

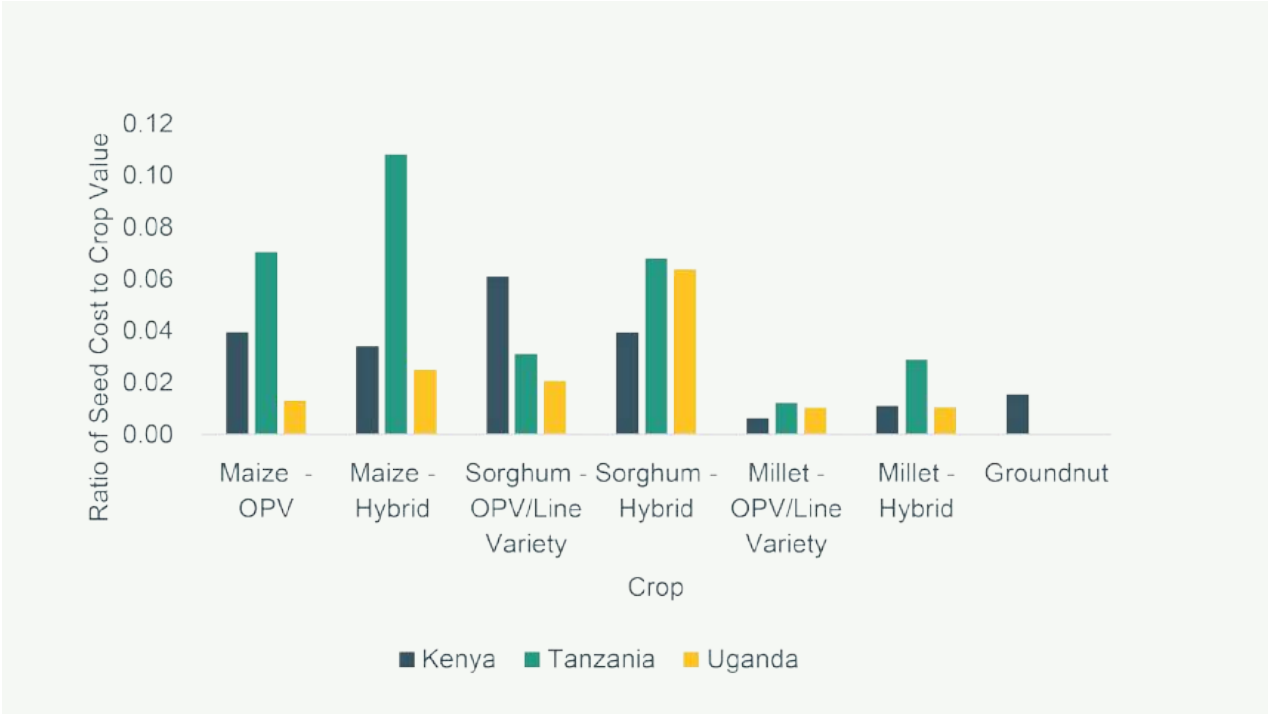


Figure 2. Ratio of seed cost to crop value by crop and country in East Africa

Sources: Authors' estimates based on data from FAOSTAT, TASAI (2024 data) and national statistical reports.

Note: seed cost is seed price multiplied by seed rate per hectare; crop value is grain price multiplied by grain harvested per hectare.

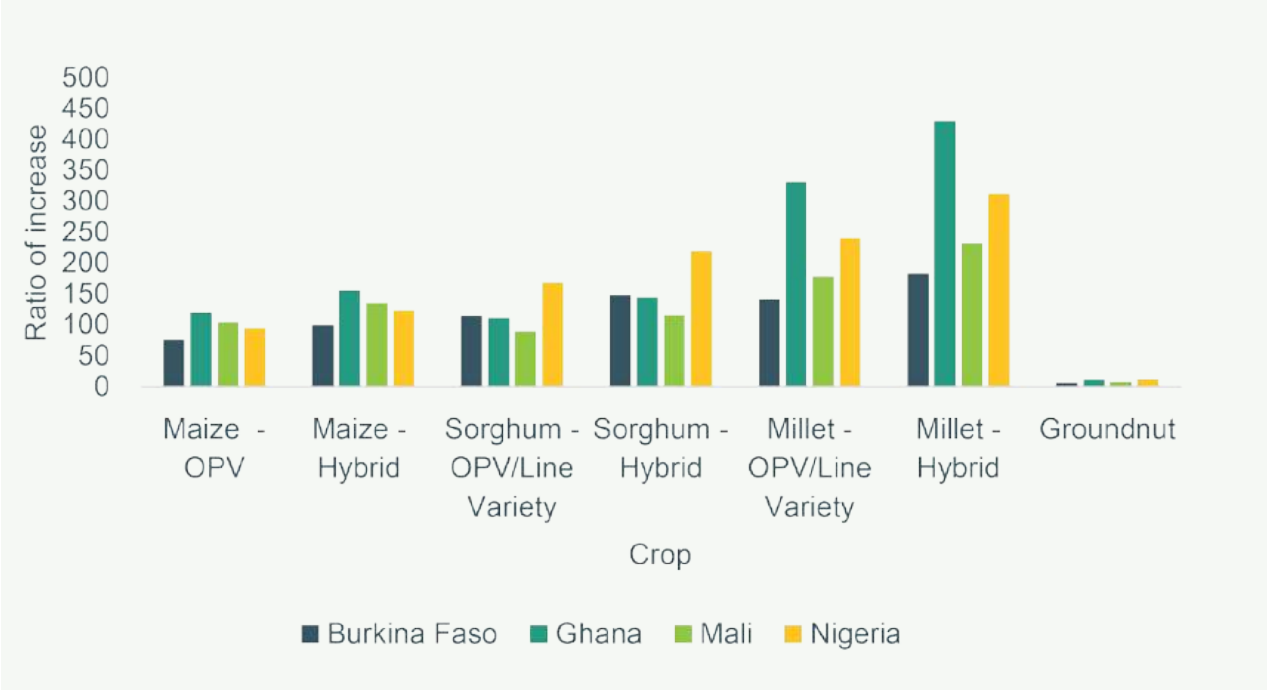


Figure 3. Ratio of increase by crop and country in West Africa

Sources: Authors' estimates based on data from FAOSTAT, extension manuals, TASAI (2024 data) and national statistical reports

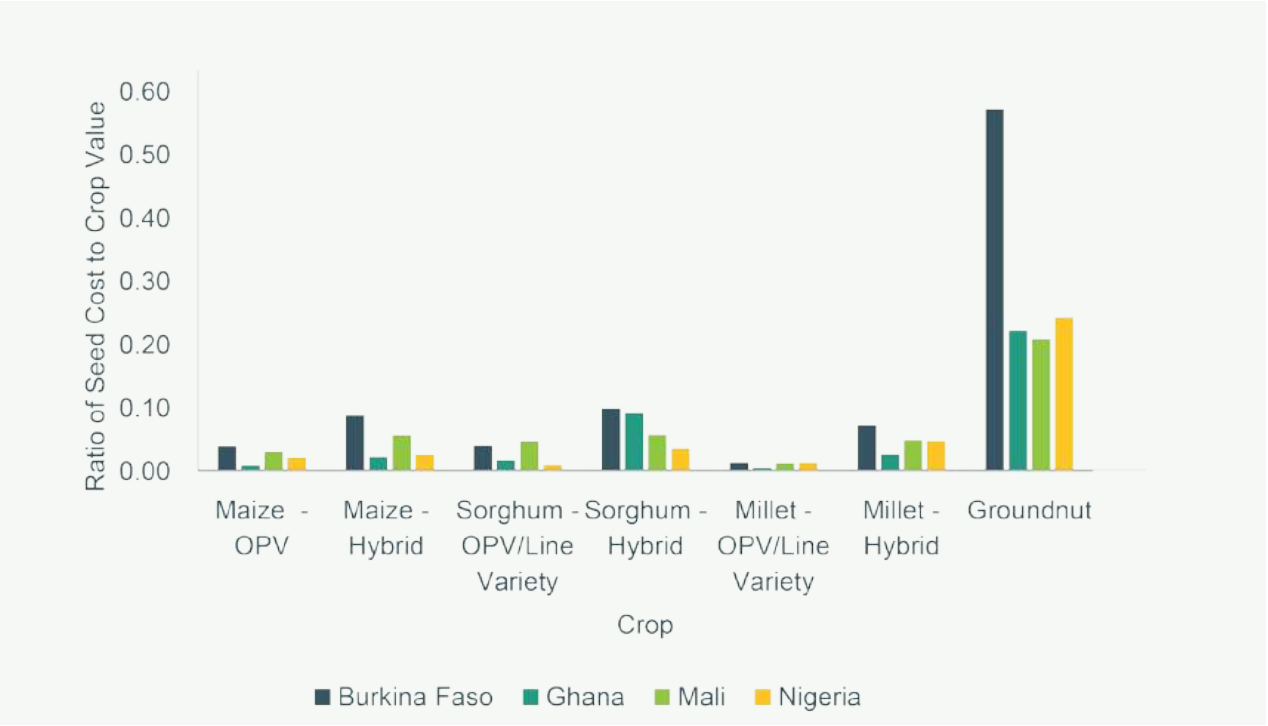


Figure 4. Ratio of seed cost to crop value by crop and country in West Africa

Sources: Authors' estimates based on FAOSTAT (yield data for OPVs); crop extension manuals (recommended seed rates); TASAI (2024 data) and national statistical reports (seed and grain prices).

Note: Yields for hybrids are assumed to be 30% higher than for OPVs, based on the average yield advantage of hybrids over OPVs reported in previous studies.

Farm seed expenditures versus maximum profitable seed cost

The preceding discussions on ratio of increase and seed cost to crop value ratio can be described as gross measures of returns on the use of seeds. We now turn to a marginal measure of seed use profitability for the farmer.

The imputed profitable seed cost is the maximum amount that a farmer should spend on seed to be profitable, based on the expected yield and profit . The market cost of seed is the actual price that a farmer pays to buy improved seed from the market. If the actual expenditure is lower than the imputed profitable seed cost, then the farmer has an incentive to pay more to adopt improved seed, because the expected benefit is greater than the cost. The imputed profitable seed cost is calculated as 10% of the incremental value from using improved seed type or varieties.

The incremental value is the percentage increase in yield from using improved seed compared to local (un-improved) seed. In commercial farming, Chase (1971) showed that farmers are willing to invest $1 in seed for a return of $10 in incremental crop value, and, under low-risk conditions, up to $2 for a $10 return. Given the high-risk conditions of smallholder agriculture, it is likely that farmers may only be willing to spend less than $1 for a $10 increment. The percentage increase in cereal yields[6] (using landraces as a baseline) is assumed to be 15% for OPVs, 30% for hybrids, and 20% for groundnuts.[7] Tables 5 and 6 compare the market cost of seed and the imputed profitable seed cost for different crops and seed types.

[6]These yield advantages are typical values reported in the literature. For example, Rattunde et al. (2021) showed that some millet hybrids in Mali had up to 35% yield advantage under farmers' conditions. Newer hybrids are often cited as having 30–40% advantage over older hybrids under optimal conditions.

[7]There are no OPVs for groundnuts.

Table 5. East Africa: seed market costs compared to profitable expenditures

Country	Crop	Market Cost ($/ha)	Profitable Cost ($/ha)	Market cost as proportion of profitable cost	Warning status	Incentive to adopt improved Seed
Ethiopia	Maize Hybrid	21.92	450.60	0	🟢	Farmers have bigger incentive to adopt improved seed
Ethiopia	Maize OPV	16.83	173.30	0.1	🟢	
Ethiopia	Sorghum OPV	6.26	20.90	0.3	🟢	
Kenya	Millet OPV	3.35	7.76	0.4	🟢	
Kenya	Millet Hybrid	7.45	20.18	0.4	🟢	
Uganda	Millet Hybrid	16.00	44.99	0.4	🟢	
Ethiopia	Sorghum Hybrid	40.50	54.30	0.7	🟡	Farmers have little incentive to adopt improved seed
Ethiopia	Millet Hybrid	21.00	30.30	0.7	🟡	
Uganda	Millet OPV	12.00	17.31	0.7	🟡	
Kenya	Groundnut	36.00	46.44	0.8	🟡	
Tanzania	Millet OPV	12.00	14.41	0.8	🟡	
Uganda	Maize Hybrid	39.60	47.73	0.8	🟡	
Ethiopia	Millet OPV	10.50	11.70	0.9	🟡	
Uganda	Maize OPV	16.20	18.36	0.9	🟡	
Tanzania	Millet Hybrid	36.00	37.45	1	🔴	Farmers have no incentive to adopt improved seed
Kenya	Maize Hybrid	42.98	38.02	1.1	🔴	
Kenya	Sorghum Hybrid	14.40	10.94	1.3	🔴	
Uganda	Sorghum OPV	7.07	5.07	1.4	🔴	
Tanzania	Sorghum OPV	24.50	11.86	2.1	🔴	
Uganda	Sorghum Hybrid	28.00	13.18	2.1	🔴	
Tanzania	Sorghum Hybrid	70.00	30.83	2.3	🔴	
Kenya	Maize OPV	38.48	14.62	2.6	🔴	
Tanzania	Maize Hybrid	58.28	16.17	3.6	🔴	
Kenya	Sorghum OPV	17.10	4.21	4.1	🔴	
Tanzania	Maize OPV	29.25	6.22	4.7	🔴	
Ethiopia	Groundnut	200.00	26.40	7.6	🔴	
Uganda	Groundnut	81.00	10.11	8	🔴	
Tanzania	Groundnut	180.00	10.44	17.2	🔴	

Source: Authors' estimates based on data from FAOSTAT (yield data for OPVs); crop extension manuals (recommended seed rates); and TASAI (2024 data) and national statistical reports (seed and grain prices).

Notes: Market cost of seed calculated as seed prices multiplied by average recommended seed rate per hectare. Imputed profitable seed cost calculated as 10% of incremental value from using improved seed type or varieties.

Table 6. West Africa: seed market costs compared to profitable expenditures

Country	Crop	Market Cost ($/ha)	Profitable Cost ($/ha)	Market cost as proportion of profitable cost	Warning status	Incentive to adopt improved Seed
Ghana	Millet OPV	2.4	5.96	0.4		Farmers have bigger incentive to adopt improved seed
Ghana	Maize OPV	22.79	34.08	0.7		Farmers have little incentive to adopt improved seed
Nigeria	Sorghum OPV	7.28	10.09	0.7		
Ghana	Maize Hybrid	68.36	88.61	0.8		
Burkina Faso	Millet OPV	3.6	3.8	0.9		
Ghana	Millet Hybrid	16	18.07	0.9		
Mali	Millet OPV	2.4	2.68	0.9		
Nigeria	Maize Hybrid	35.33	40.59	0.9		
Nigeria	Millet OPV	4	4.32	0.9		
Ghana	Sorghum OPV	6	5.01	1.2		Farmers have no incentive to adopt improved seed
Nigeria	Sorghum Hybrid	31.5	26.23	1.2		
Nigeria	Maize OPV	22.5	15.61	1.4		
Mali	Millet Hybrid	16	9.77	1.6		
Nigeria	Millet Hybrid	18	11.24	1.6		
Mali	Maize Hybrid	83.48	43.91	1.9		
Mali	Sorghum Hybrid	22.95	11.88	1.9		
Mali	Maize OPV	34.2	16.89	2		
Burkina Faso	Millet Hybrid	24	9.88	2.4		
Ghana	Sorghum Hybrid	40	15.19	2.6		
Burkina Faso	Maize OPV	18.55	6.81	2.7		
Burkina Faso	Sorghum OPV	11.57	4.18	2.8		
Burkina Faso	Maize Hybrid	52.21	17.71	2.9		
Mali	Sorghum OPV	14.58	4.57	3.2		
Burkina Faso	Sorghum Hybrid	36	10.88	3.3		
Ghana	Groundnut Line	180	16.18	11.1		
Nigeria	Groundnut Line	315	25.89	12.2		
Burkina Faso	Groundnut Line	225	7.86	28.6		
Mali	Groundnut Line	180	1.8	100		

Source: Authors' estimates based on data from FAOSTAT (yield data for OPVs); crop extension manuals (recommended seed rates); and TASAI (2024 data) and national statistical reports (seed and grain prices).

Notes: Market cost of seed calculated as seed prices multiplied by average recommended seed rate per hectare. Imputed profitable seed cost calculated as 10% of incremental value from using improved seed type or varieties.

For most crops and countries, seed itself is not profitable, although the seed is not the biggest cost center in production. Even maize OPVs do not appear to fall within the profitability threshold (based on the metric we are using here). Therefore, on its own, seed is not the most profitable item. While this is not a recommendation that farmers should avoid buying seed, it suggests that when they can afford to buy it, it is not the absolute purchase cost per se that drives the use of seed, but the integration of seed with other inputs to achieve synergistic returns not achievable from seed one input alone (whether that is seed, fertilizer, or labor).

Box 2: How would farmers calculate the profitability of seed?

Other factors such as lack of liquidity can also be important. For instance, do farmers perform these calculations (at least mentally)? For illustration, take an average Kenyan maize farmer operating 1 ha of maize. At US$2 per kg, this means a minimum seed spending of $40–50, assuming a seed rate of 20–25 kg/ha. At about 2 t/ha the crop revenue could be $600. The seed itself could easily be 10% of gross revenue (not incremental revenue), suggesting that based on this metric alone, the 1:10 ratio discussed by Chase (1971) would not be met in many cases. This is shown in Tables 5 and 6.



For most crops and countries, seed itself is not profitable, although the seed is not the biggest cost center in production. Even maize OPVs do not appear to fall within the profitability threshold (based on the metric we are using here). Therefore, on its own, seed is not the most profitable item

When Tables 5 and 6 are viewed alongside Figures 2–5, the weakest business case in this analysis relates to groundnut seed, while the best business case is for maize seed. This is unsurprising because maize has one of the highest ratios of increase. While the ratio of increase is important for a positive business case, this suggests the role of complementary agronomic plus other production factors (agronomy being a key driver). The implication is that seed business cases for dryland crop farmers depend on a combination of multiple factors. Seed costs should be monitored to ensure they are no more than 10% of incremental value attributable to new seed. When farmers recycle seed, they typically use about 5% or less of the grain harvest (for sorghum/millet). These "recycling costs" (where seed prices or unit costs are at par with grain price) should be the benchmark for new seed targeted at resource-poor farmers.

Seed price to grain price ratio: benchmarking affordability

Figure 5 shows the ratio of seed price to grain price by country, but does not explicitly show an ideal or profitable ratio. In Ethiopia, the ratios appear lower (Ethiopian seed enterprises that predominate in the seed system are state-run and subsidize the seed). The maize hybrid ratio in Ethiopia was 3.5:1, and the maize OPV ratio was 2.7:1. In Uganda, the ratios were 4.3:1 for maize hybrid and 2:1 for maize OPV. In Tanzania, these ratios were 8.7:1 and 5.2:1, respectively.

The data also indicate that the cost of improved sorghum seed can be between 30% and four times the price of grain. This variation highlights the challenge of producing seeds in a way that minimizes the seed to grain price ratio, thus making seed more affordable for farmers. However, a lower ratio is more beneficial for farmers.

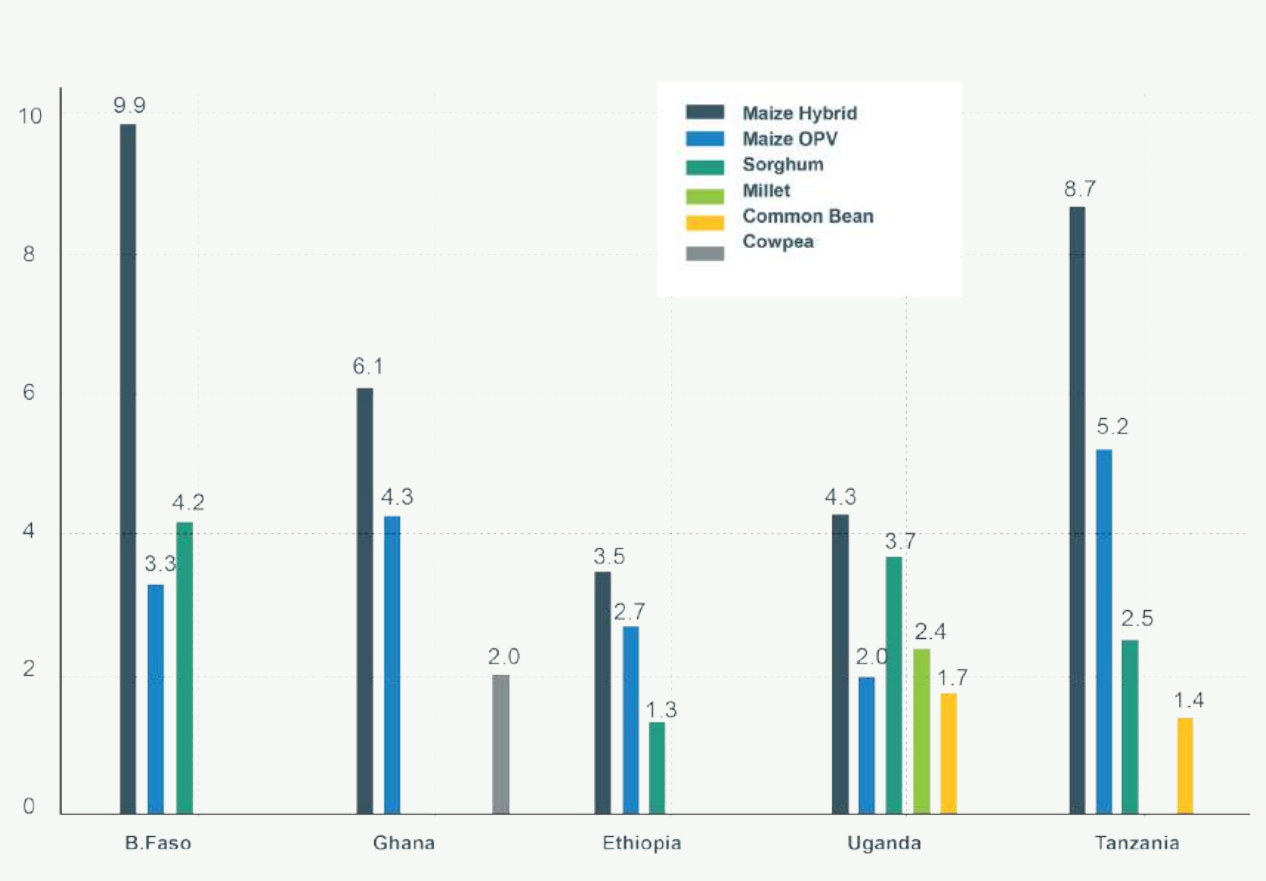


Figure 5. Seed price to grain price ratios by country

Box 3: What is a "good" seed price to grain price ratio for farmers?

Consider that most farmers recycle seeds or purchase grain as seeds, where the ratio is, by definition, 1:1. This suggests that from a farmer's perspective, when nothing else changes and cash is limiting, a profitable ratio would be as close to 1:1 as possible, making seeds affordable and accessible. For those who must sell grain to buy back seed (in effect "bartering" grain for seed), this ratio shows how many units of grain need to be sold to buy one unit of seed. In low-yielding crops such as pearl or finger millet, groundnut, or moderately yielding OPV maize, this can be a major consideration. To illustrate, if a farmer must sell up to nine times the equivalent of grain that can be a challenge if yields are low or the area planted is several hectares (see Fig. 5 for maize hybid seed in Burkina Faso).

As with other inputs, the profitability of seed depends on multiple factors, including the yield potential of the seeds (ratio of increase) and the market price of the grain (seed cost to crop value), compared to the incremental costs associated with growing the crop, including fertilizers, labor, and land (and whether the expenditures are within profitable thresholds). A "profitable ratio" might vary depending on these contextual factors. In general, a lower seed to grain price ratio indicates that the cost to the farmer of acquiring seeds is moderate, making it a more viable and profitable option.

While the 1:1 ratio is a reasonable benchmark, the actual profitable ratio could be slightly higher to account for the value added through seed development and distribution processes. However, how low this ratio should go remains an empirical question.

Box 4. What are the vital signs for seed prices?

We propose that a data gathering and analytics system should be developed, deployed, and scaled, designed to monitor and evaluate seed prices in relation to three "vital signs":

- ratio of increase, which assesses yield potential
- incremental value
- seed price relative to a profitable threshold.

A potential fourth vital sign would be seed to grain price ratio. Where farmers recycle seed this ratio is likely to be 1:1 because the same grain is used as seed.[8]

[8]In some places, traders sell specially selected grain for farmers to use as seed, potentially costing more than ordinary grain.

2.3 The business case for seed companies

The viability of seed companies is a crucial element of the journey from agricultural research to the realization of tangible impacts on the ground. Seed companies serve as a critical link in translating the potential of new crop varieties into widespread agricultural improvement. Innovative varieties developed through research can only achieve their intended impact if they are effectively produced and distributed, and are adopted by farmers. This is where seed companies play a crucial role. Efficient and financially viable seed companies can invest in scaling up production, engaging in effective distribution networks, and providing technical assistance to farmers. Without viable seed companies, the bridge between agricultural research and real-world impact remains incomplete.

To provide an understanding of the decision-making process, Figure 6 illustrates a conceptual framework that could be used for further analysis relating to cost–benefit, break-even, and profitability analyses. This framework helps in systematically evaluating the financial viability of different seed ventures.

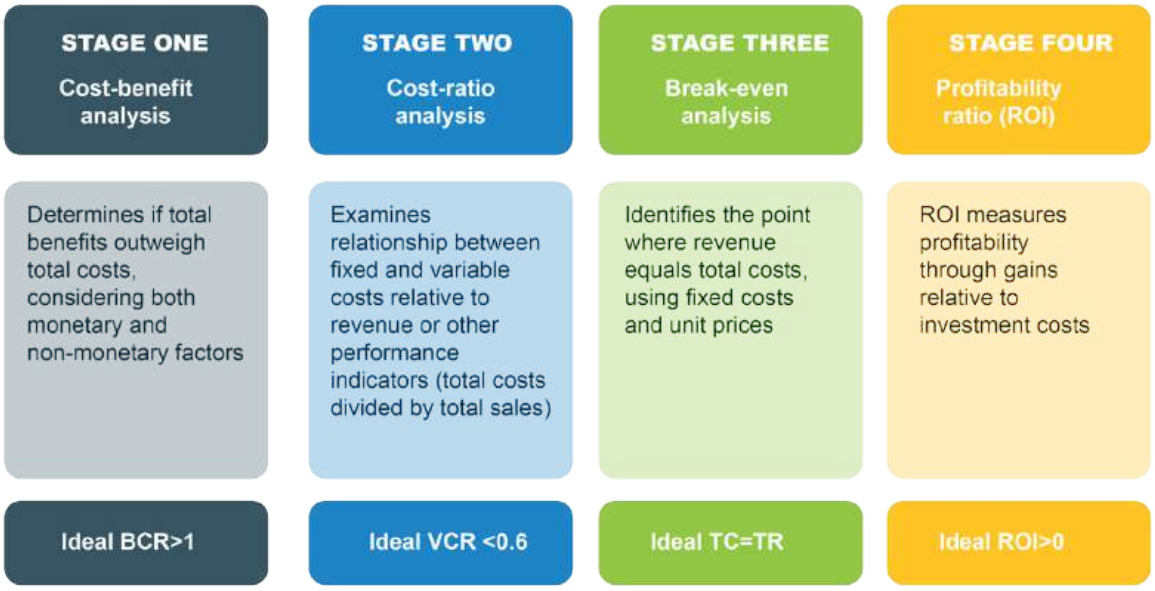


Figure 6. Conceptual framework for seed business analyses

BCR, benefit–cost ratio; VCR, variable cost ratio; TC, total costs; ROI, return on investment.

While not the only factor, the production of EGS[9] plays a pivotal role in the seed supply. EGS is an intermediate input into seed production, and any of the stages of EGS production can obstruct the goal of adequate seed supply. This is especially true if certified seed producers rely on third-party entities for the supply of EGS. In such cases, the production of EGS must be a viable standalone business.

Is production of EGS profitable on its own?

Table 7 gives the gross margins for EGS across several countries for different dryland crops (Prabhala et al. 2015). In Uganda, millet seed production showed modest profitability, with breeder seed showing around a 10% gross margin. Foundation seeds and the quality declared seed (QDS) variety also yielded close to

[9]Early generation seed (EGS) encompasses breeder seed, pre-basic, and basic seed. It is the critical connection between breeding activities and the eventual production and distribution of varieties to farmers.

a 10% gross margin. For groundnut in Uganda, profitability was significantly higher. Breeder seeds had about a 29% margin, foundation seeds over a 225% margin, and quality seeds over a 110% gross margin. In Tanzania, sorghum seed production was highly profitable, especially for certified seeds, which had a gross margin of about 89%. The QDS seeds even surpassed this, with approximately 698% margin. However, in Ethiopia, QDS sorghum seed production was unprofitable, with a negative margin of –2%. Sorghum seed production in Ghana showed moderate profitability: breeder seeds, foundation seeds, and QDS seeds all had around a 10% gross margin.

Groundnut seed production in Tanzania also demonstrated high profitability. Breeder seeds had a gross margin over 517%, foundation seeds around 593%, and QDS around 45%. In Ghana (USAID 2016), groundnut seed production had modest profitability, with all seed types showing around a 10% gross margin.

There are significant variations in the profitability of seed production across crops and countries, often reflected in the gross margin percentages, which provide insights into the economic viability of these agricultural ventures (see Table 7).

These gross margins suggest (though are not necessarily conclusive of) high profitability for groundnut EGS production in Uganda and Tanzania, as well as for sorghum in Tanzania. However, millet in Uganda and sorghum in Ethiopia and Ghana show more modest returns. These variations are likely influenced by market dynamics, input costs, and regional agricultural practices, underscoring the complexities of the seed industry in these countries.

Table 7. Cost of early generation millet, sorghum, and groundnut seed production

Crop	Country	Seed type	Year	Unit	Total cost	Revenue	Gross margin
Millet	Uganda	Breeder	2015	n.a.	20,806.12	22,886.73	2,080.61
		Foundation	2015	n.a.	2,813.55	3,094.91	281.36
		QDS	2015	n.a.	982.59	1,080.85	98.26
Sorghum	Tanzania	Breeder	n.a.	n.a.	n.a.	n.a.	n.a.
		Certified	2020	$/ha	2,566.35 (VC)	4,859.61	2,293.26
		QDS	2020	$/ha	209.63 (VC)	1,676.03	1,466.40
	Ghana	Breeder	2016	$/ha	7,233	7,956	723
		Foundation	2016	$/ha	4,973	5,470	497
		QDS	2016	$/ha	1,458	1,604	146
Groundnut	Uganda	Breeder	2019	$/ha	868	1,121	253
		Foundation	2019	$/ha	421	1,366	945
		QDS	2019	$/ha	221	469	248
	Tanzania	Breeder	2019	$/ha	781	4,828	4,047
		Foundation	2019	$/ha	567	5,074	4,507
		QDS	2019	$/ha	302	960	659
		Certified	2019	$/ha	1,422	2,056	633
	Ghana	Breeder	2016	$/ha	7,828	8,611	783
		Foundation	2016	$/ha	5,018	5,520	502
		QDS	2016	$/ha	922	1,014	92

Sources: Prabhala et al. (2015); AGRA–SSTP (2016); Mastenbroek and Ntare (2016); Akpo et al. (2020); Ndossi et al. (2021a,b).

QDS, quality declared seed; VC, variable cost.

Another viewpoint on EGS: mixed fortunes

Table 8 shows the costs and revenues of multiple crops and seed classes in several countries. For Kenya, for the breeder seed (pre-basic) class, the disparity between maize OPV and maize hybrid is striking. Maize OPV struggles financially, as evidenced by its negative net revenue. With the costs of production at $63 per hectare surpassing the revenue of $39 per hectare, it clearly indicates that this segment is not just unprofitable, but is incurring losses. This could be attributed to various factors, such as higher production costs or lower market demand for this variety. In contrast, maize hybrid in the breeder seed class paints a more optimistic picture. Its positive net revenue, with a total revenue of $237.50 per hectare outweighing the costs of $205.50 per hectare, reflects a modest positive return.

For the foundation (basic) seed class in Kenya, both maize OPV and maize hybrid show profitability, but the extent varies. Maize OPV shows a clear economic advantage, with its total revenue of $39 per hectare exceeding the relatively low production cost of $19 per hectare. This profitability indicates a successful balancing of production expenses against market value. However, maize hybrid in this class reveals a tighter economic situation. Although it remains profitable, the slim margin (with a revenue of $132.50 just over the cost of $131.75 per hectare) suggests that there is little room for error in managing production costs or fluctuations in market price.

In the certified seed (commercial) class, the trend of profitability continues for both maize OPV and maize hybrid. Maize OPV's profitability is evident with its revenue of $37 per hectare against a cost of $19 per hectare, potentially a positive margin. Maize hybrid also maintains its profitable status, albeit with a smaller margin, with a total revenue of $62.50 per hectare and a cost of $56.25 per hectare. These insights into the net revenues across different maize seed classes in Kenya underscore the complexity of the seed production business, highlighting the importance of strategic cost management, market positioning, and understanding the nuances of demand for different seed varieties. While some seed classes show robust profitability, others operate on thin margins or at a loss, emphasizing the need for careful planning and market analysis in the seed industry.

In Ghana, OPV maize and groundnut were found to have negative gross margins per ha for breeder seed, showing losses of $90.70 for maize OPV, $106 for maize hybrid, and $361.70 for groundnut (Table 8). Sorghum had the lowest loss ($33.80). In terms of certified seed, the net revenues are generally more favorable, and all crops (except sorghum) appear to be in the same range of profitability.

This suggests that a standalone business case for EGS was not feasible, primarily due to low volumes. Although the Kenyan data (in Table 8) shows no negative revenues (except for breeder seed maize OPV), the net returns remain modest, with per-kilogram net revenues generally less than a dollar. Returning to Figure 7, based on data from Zambia, indicates that while the business case for EGS is weak, the costs (along with low revenues and negative net returns) can be managed as part of an integrated, end-to-end operation. In the Ethiopian sorghum example (Figure 8), a 60% subsidy sustains the operation; otherwise, commercial seed prices would need to more than double to support a viable business."

Table 8. Costs and revenues of multiple crops and seed classes in Ghana, Nigeria, and Kenya

Seed class	Crop	Price	Cost+ margin	Seed rate	Demand	Total rev.	Total cost	Net rev.	Net rev.
		$/kg	$/kg	kg/ha	MT	$/ha	$/ha	$/ha	$/kg
Ghana									
Breeder seed	Maize OPV	6.15	10.69	20	0.957	123.1	213.1	–90.7	–4.5
	Maize hybrid	8.72	14.02	20	0.1	174.4	280.3	–106.0	–5.3
	Rice	4.1	9.37	50	0.52	205.1	468.6	–263.5	–5.3
	Cowpea	8.21	12.86	25	0.05	205.1	321.4	–116.3	–4.7
	Groundnut	4.1	10.13	60	0.119	246.2	607.8	–361.7	–6.0
	Soyabean	7.18	8.99	40	0.276	287.2	359.6	–72.5	–1.8
	Sorghum	4.62	11.37	5	0.0003	23.1	56.8	–33.8	–6.8
Foundation seed	Maize OPV	3.08	3.79	20	38	61.5	75.9	–14.3	–0.7
	Maize hybrid	4.36	4.76	20	7	87.2	95.2	–8.0	–0.4
	Rice	2.05	1.8	50	10	102.6	90.2	12.3	0.2
	Cowpea	4.1	6.31	25	1.41	102.6	157.7	–55.1	–2.2
	Groundnut	2.05	4.6	60	1.68	123.1	276.0	–152.9	–2.5
	Soyabean	3.59	5.36	40	6.9	214.3	214.3	–70.7	–1.8
	Sorghum	2.31	6.08	5	0.05	30.4	30.4	–18.9	–3.8
Certified seed	Maize OPV	1.54	1.17	22.5	1,913	34.62	26.3	8.32	0.37
	Maize hybrid	2.18	1.53	22.5	542	49.04	34.4	14.7	0.65
	Rice	1.03	0.8	100	525	102.56	80.08	22.48	0.22
	Cowpea	2.05	1.52	25	51	51.28	37.9	13.38	0.54
	Groundnut	1.03	0.81	100	34	102.56	81.14	21.42	0.21
	Soyabean	1.79	1.14	40	207	71.79	45.64	26.16	0.65
	Sorghum	1.15	1.46	5	8	5.77	7.29	–1.52	–0.30
Nigeria									
Breeder seed	Maize OPV	1.51	6.22	20	4.4	30	124	–94	–4.7
	Maize hybrid	2.52	11.56	20	1	50	231	–181	–9.0
Foundation seed	Maize OPV	1.17	0.86	20	287.6	23	17	6	0.3
	Maize hybrid	1.26	0.78	20	151.38	25	16	9.0	0.5
Certified seed	Maize OPV	1.01	0.21	20	28,760	20	4	16	0.80
	Maize hybrid	1.26	0.25	20	22,700	25	5	20	1.01

Kenya									
Breeder seed	Maize OPV	1.57	2.53	25	0.2	39	63	–24.00	–0.96
	Maize hybrid	9.5	8.22	25	45	237.5	205.5	32.00	1.28
Foundation seed	Maize OPV	1.57	0.75	25	19	39	19	20.0	0.82
	Maize hybrid	5.3	5.27		450	132.5	131.75	0.8	0.03
Certified seed	Maize OPV	1.49	0.75	25	1,940	37	19	18.0	0.74
	Maize hybrid	2.5	2.25	25	41,000	62.5	56.25	6.3	0.25

Source: BMGF/USAID (2016).



Figure 7. End-to-end (EGS to certified/quality seed): the business case for maize seed in Zambia

Box 5. Zambia: maize seed business case in 2016

In the Zambian case (Figure 7), seed production was not profitable if fixed costs were taken into account, primarily for capital investment in labs, equipment, and salaries for skilled labor. The variable costs were low, consisting mostly of germplasm royalties. Like breeder seed, foundation seed has high fixed costs due to skilled labor and equipment requirements; and low variable costs due to low volume and transport costs. It is not profitable as a standalone enterprise without achieving large scale.



Certified seed has lower fixed costs (compared to the infrastructure for EGS). Certified seed is frequently produced by large companies with access to credit, or by contract growers. Certified seed sales at US$3,500/MT are profitable enough for private companies to integrate backwards into nonprofitable upstream EGS production, such as breeder and foundation seed production. Breeder seed is highly expensive and not profitable on its own in a low-demand market. Foundation seed, despite being cheaper than breeder seed, requires significant scale due to its high fixed costs. In Ethiopia, the government bears the financial burden of seed production in the interest of food security, selling seeds at about 60%; in the case of sorghum the official price is discounted at 60%, and these seeds are often distributed for free.



Figure 8. End-to-end (EGS to certified/quality seed): the business case for sorghum seed in Ethiopia

Source: Authors' estimates based on BMGF/USAID (2016).

Box 6. Ethiopia: sorghum seed business case (2016)

The business case for sorghum seed in Ethiopia (Figure 8), reveals the economic challenges and viability of EGS production. This example is part of the USAD-BMGF analytical series designed to understand the economics of seed production, identify barriers, and propose potential interventions. Criteria for selecting this case study included its alignment with market archetypes, its relevance to donor priorities, and the quality of data available. The economic model for sorghum in Ethiopia underscores the role of substantial government subsidies, with breeder and foundation seeds incurring high fixed costs, and quality seed production being the primary government expense. The total cost of production significantly exceeds the revenue, resulting in a loss of 75% and requiring seeds to be sold at about 60% below the break-even price. This government support is vital for food security and scaling up production to meet the country's needs, despite the considerable financial loss incurred.



2.4 Analyses

Financial viability of improved seed investment in dryland crops

Profitability metrics such as net present value (NPV) and benefit–cost ratio (BCR), as illustrated in Table 9, show that all crops assessed in this study exhibited a positive NPV over 10 years, with groundnut achieving the highest value. This suggests that, despite high initial costs, the long-term benefits justify the investment in improved seeds for these crops. The BCR supports this conclusion, indicating that the benefits of investing in improved seeds outweigh the costs when analysed in a multi-year, long-term framework.

The importance of maintaining a favorable balance between variable and fixed costs is highlighted in Table 9. For example, crops such as soyabeans exhibit a high variable cost ratio (VCR), indicating that a significant portion of revenue is absorbed by variable costs, thus reducing the amount available to cover fixed costs. On the other hand, maize shows a lower VCR, suggesting a more favorable cost structure conducive to profitability.

Table 9. Cost-benefit analysis

Crop	Investment ('000 $)	Cashflow ('000 $)	Net present value ('000 $)	Benefit–cost ratio ('000 $)
Maize	302.4	426.8	1,232.6	4.1
Sorghum hybrid	111.1	138.9	350.1	3.2
Sorghum OPV	55.5	69.4	175.0	3.2
Pearl millet hybrid	53.4	66.8	168.4	3.2
Pearl millet OPV	26.7	33.4	84.1	3.2
Soyabeans	310.0	387.5	977.1	3.2

Source: BMGF/USAID (2016).

Notes: Due to data unavailability, the price of seed was discounted at 20% to estimate the cost of seed, and uniform area of production assumed. Investments are considered as the injections for the venture. Net present value (NPV) is estimated by cash flow divided by the sum of 1 and the interest (an interest rate of 5% was used for discounting) raised to the period in years (a 10-year period was used), less the initial investment. Benefit–cost ratio (BCR) was generated by NPV/initial investment.

However, for small and medium-sized enterprise (SME) seed companies in African markets, the investment ratios shown in Table. 9, although suggest profitability at large volumes of production, these volumes may be challenging to achieve—or even outright unprofitable—due to constraints in production capacity, high input costs, and limited processing and distribution infrastructure. If seed demand saturates at volumes lower than those outlined in Table 10, the suggested operational levels may be impractical. Additionally, demand for certified seed among smallholder farmers is often inconsistent and highly price-sensitive, making it difficult to justify production at these volumes. While the break-even thresholds provide a theoretical benchmark, many SME seed companies may struggle to meet both the production capacity and market demand needed, underscoring the importance of strategies to improve seed affordability, build farmer awareness, and strengthen distribution networks.

The most impactful innovations in seed supply, particularly for sorghum, millet, and groundnut, are likely to come from small, geographically dispersed enterprises capable of operating at lower lower investment levels than those suggested in Table 9, accompanied by an inherently low fixed-cost model. This combination would enable them to meet localized demand sustainably and affordably. This contrasts with large, capital-intensive operations that aim to serve extensive markets but may struggle with complex distribution logistics and high costs.

Impactful seed supply innovations for sorghum, millet, and groundnut are likely to be driven by small, dispersed enterprises with low fixed costs, enabling sustainable, affordable local demand fulfillment—unlike large, capital-intensive operations challenged by distribution logistics and high costs

Box 7: Simulating Break-even seed production volumes

This analysis, presented in Table 10, examines crops such as maize, sorghum, wheat, cowpea, groundnuts, and soybeans, detailing variable and fixed costs, unit variable cost, unit price, and resulting breakeven volumes in tonnes. Key thresholds to use to support generalized decisionmaking to optimize production and pricing are as follows:

- **Contribution Margin:** Target 25-40% per unit to cover fixed costs comfortably.
- **Contribution Margin Ratio:** Aim for a 30-50% ratio, where this portion of each sale contributes to covering fixed costs and profit.
- **Fixed Costs:** Keep these manageable within projected sales volumes, with stability or reduction as production scales.
- **Variable Costs:** Limit increases to less than 5-10% per additional unit to maintain cost efficiency.
- **Sales Price:** Ensure it remains at least 10-20% above the unit variable cost to secure a viable margin.
- **Breakeven Volume:** Target volumes that not only cover breakeven but also allow for a 20-30% profit cushion.
- **Discounts & Inflation Adjustments:** Limit adjustments to 5-10%, unless specific market conditions require otherwise.



Profitability ratios

Favorable profitability ratios are typically characterized by healthy margins and returns, indicating efficient use of resources. Profit ratios such as net profit margin (NPM) or return on investment (ROI) provide insights into the profitability and financial health of grain-related ventures (Brigham and Ehrhardt 2020). The ROI measures the return generated on an investment relative to its cost. It is calculated as the ratio of net profit to the cost of the investment. A higher ROI indicates a more profitable investment (Aulová et al. 2019; Hilton 2019). It is important to note that the interpretation of these ratios may vary across crops or , nature of the business.

Box 6: Equations for profitability ratio analysis

$$NPM = \left(\frac{R - CGS - OE - I - T}{TR} \right) x100$$

NPM, net profit margin; TR, total revenue; CGS, cost of goods sold; OE, other expenses; I, interest (operationalized as 5% of fixed cost); T, taxes (operationalized as 16% of profit).

$$ROI = \frac{Investment\ net\ profit/loss}{Initial\ cost}$$

ROI, return on investment.

All the integrated chains exhibited a positive ROI (Table 11), with maize the highest at 0.41 over a10-year period, and a 0.04 annual ROI. Due to the nature of the data used, all other crops exhibited a uniform ROI for both time periods, with a 10-year ROI of 0.25 and an annual ROI of 0.02. For a more analytically critical outcome, there is need to collect viable primary data.

Table 10. Profitability ratio analysis

Crop	Variable cost (000' $)	Fixed cost (000' $)	Total cost (000' $)	Profit (000' $)	Net sales	ROI	Annual ROI
Maize	85.7	216.7	302.4	124.4	85.7	0.41	0.04
Sorghum hybrid	80.5	30.6	111.1	27.8	80.5	0.25	0.02
Sorghum variety	40.2	15.3	55.5	13.9	40.2	0.25	0.02
Pearl millet hybrid	36.9	16.6	53.4	13.4	36.9	0.25	0.02\
Pearl millet variety	18.4	8.3	26.7	6.7	18.4	0.25	0.02
Groundnuts	564.4	157.2	721.5	180.4	564.4	0.25	0.02

Source: USAID-BMGF (2015).

Due to data unavailability, the price of seed was discounted by 20% to estimate the cost of seed, and uniform area of production was assumed.

Total cost = cost of goods sold + other expenses.

Return on investment (ROI): a 14% interest rate was applied on the fixed cost; tax at 16% was used and generated from profit. To estimate ROI, investment net profit/loss was divided by initial cost over 10 years. To estimate net profit margin, a difference of revenue, cost of goods sold, other expenses, interests, and taxes was divided by revenue and multiplied by 100.

Given the current grain market size and projections with regard to grain production (estimated harvested area, market value, and yields), there is a strong business case for dryland seed businesses with projections depicting growth. To encourage active participation within the seed sector value chain by players other than government, there is need to reduce bureaucracies and bottlenecks within the research sector for seed development. More advanced and successful seed systems are characterised by relatively free market conditions.

Advanced and effective seed systems are typically characterized by relatively free market conditions.

Data analyzed to establish seed business cases across various crops indicated a favorable cost-benefit outlook (Table 12). Maize, sorghum, and millet met the benchmark cost ratio of 60% or lower. The ROI analysis shows only weak long teem profitability for all grains (except maize which shows clear positive ROI). This initial evidence suggests the viability of dryland seed businesses and underscores the need for a detailed survey of seed value chain actors to gather updated financial data, enhancing future seed business analytics. This is especially identify profitability niches fro the dry land crops seed businesses.

Table 11. Summary analytical framework

Crop	Ideal benefit–cost ratio > 1	Ideal variable cost ratio ≤ 0.6	Ideal total cost = total revenue	Ideal ROI > 0
Maize				
Sorghum hybrid				
Sorghum variety				
Pearl millet hybrid				
Pearl millet variety				
Wheat				
Cowpea				
Groundnuts				
Soyabeans				

Note: Green = proceed; amber = proceed with caution; red = stop.

The ROI analysis shows only weak long teem profitability for all grains (except maize which shows clear psitive ROI).

2.5 Discussion and synthesis

The evaluation of the conomics of seed use by farmers hinges on three key metrics: ratio of increase; incremental value; and seed price relative to a profitable threshold. Typically, seed costs are profitable when at least 10% of the incremental value of production can be attributed to seed, rising to 20–30% in riskier environments. Lower-risk conditions increase willingness to invest in seeds.[10] Groundnut, despite low yields, maintains a seed cost to crop value ratio that is comparable to millet and maize hybrids. Break-even analysis indicates that higher volumes are needed for for pritable production in maize and groundnuts, but smaller volumes for sorghum and millet.

As was discussed this does not mean those lower volumes for millet and sorgum are feasible for seed SMEs (who would be the key players in seed supply). While profitability metrics show a positive NPV for seed business investments over 10 years, EGS production often requires subsidies for viability (as in Ethiopia and Ghana). Long-term investment in improved seeds is feasible with careful cost management (both fixed and variable costs).

Seed profitability in context - input integration and synergies

Even though the marginal returns on seed alone may be low, the synergy between seeds and other complementary inputs increases overall farm productivity, making the whole production package more profitable. Improved seeds often perform better when supported by good agronomic practices, including optimal soil preparation, nutrient management, and pest control. Therefore, farmers are more likely to see higher yields and economic returns when they adopt a comprehensive package of inputs (relatively speaking), rather than just focusing on seed alone. This leads to the profitability of seed being subsumed within the broader system of inputs that collectively improve productivity and returns.

- **Seed as a component of an input bundle.** Seed is not valuable in isolation. Its value is realized when it is combined with other inputs—fertilizer, moisture, and crop protection—and is managed using appropriate practices. This makes it difficult to isolate the profitability of seed alone.
- **Synergistic effects.** The interaction of seed with other inputs can create synergistic effects, where the combined effect is greater than the sum of individual contributions. This means the value of the seed is enhanced within the system, but not necessarily reflected in its individual valuation or price.
- **Quality and traits.** Seed quality—including genetic traits for yield, disease resistance, and other desirable characteristics—significantly impacts its value. However, these traits are often bundled together, making it difficult to price individual components separately.
- **Subsumed value.** The term "subsumed" suggests that the value of the seed is incorporated into the overall value of the crop production system. This means that while seed might not appear highly profitable on its own, its contribution is essential, and its value is captured in the final output.

In essence, the profitability of seed is intertwined with the profitability of the entire input set. In production economics, this phenomenon arises from complementarities, synergies, and economies of scope. Seeds in combination with other inputs (fertilizers, pest control, irrigation) achieve a higher level of productivity than the use of each input in isolation. The synergies created by using these inputs together improve the overall returns. While seed might have a low marginal profit, it is a crucial component that enables the success of other inputs, and ultimately contributes to the overall profitability of the farm.

While seed might have a low marginal profit, it is a crucial component that enables the success of other inputs, and ultimately contributes to the overall profitability of the farm.

[10]As shown by Chase (1971), where $2 is spent for every $10 of incremental value, but risk reduces this by up to 50%.

Farmers are more likely to see higher yields and economic returns when they adopt a comprehensive package of inputs, rather than just focusing on seed alone. This leads to the profitability of seed being "subsumed" within the broader system of inputs that collectively improve productivity and returns.

Macro perspectives on seed business cases

At the grain production level in Africa, the maize seed market has a potential depth of nearly one million metric tons. Maize production accounts for 48% of the combined output of key grains such as sorghum, millet, rice, and wheat. Maize seed markets hold a disproportionate share, representing 42% of the total crop seed market, while other cereals contribute 14%. If maize's share were proportional, it would be only 40% of the cereal market (Table 7). Expanding seed markets for sorghum and millet will require increased adoption of improved varieties. Nevertheless, maize is likely to maintain its dominance due to the prevalence of hybrids and high returns, which are expected to attract disproportionate investments.

Globally, the dominance of hybrid maize is even more pronounced, reflecting the trend seen in Africa. Ter Steeg et al. (2022) highlighted that maize hybrids lead global seed markets, valued at $18 billion in 2018, followed by soybean (around $8 billion) and vegetables (around $6 billion). Rice ranks next at $2 billion, with all other cereals also totaling around $2 billion. Thus, global maize hybrid markets are almost five times larger than those for all other cereals combined (recall from previous paragraph that maize's share of cereal seed markets in Africa is three times that of all other cereals combined). Several factors contribute to this dominance: maize is the most successful hybrid crop, and it is typically grown in favorable environments with better infrastructure and market development. This is evident in predominantly maize-growing regions in Eastern and Southern Africa, such as Kenya, Zimbabwe, Zambia, and Ethiopia, compared to millet-dominant areas in the Sudano-Sahelian countries.

Groundnut seed systems face similar challenges and require a holistic, sector-wide approach. Predominantly subsistence-based seed systems lead to thin groundnut grain markets, limiting investment potential. However, this report

demonstrates that the high value of groundnuts can offset weak seed production economics, suggesting that integrating grain and seed production could make both economic and business sense. This integrated approach could also be applied to sorghum and millet, where weak grain markets currently constrain business opportunities. Linking grain and seed production is not unprecedented; it is a common feature in successful legume programs, even in advanced market economies like the United States (see Box 8 -9).

Box 8: South Dakota Legume EGS System

The South Dakota legume EGS system is an example of an effective public-private partnership (PPP) model. This partnership brings together farmers, a non-profit organization (South Dakota Agricultural Foundation), and a state government agency (South Dakota Department of Agriculture and Natural Resources), with each stakeholder playing a crucial role. Farmers contribute their expertise and practical knowledge of local conditions, routinely implementing legume cover crops and ensuring effective on-farm results. The non-profit organization provides technical knowledge and support, promoting sustainable practices and soil health improvements while helping farmers reduce nitrogen inputs. Additionally, it raises awareness about the benefits of legume cover crops among farmers and the wider community.

The state government agency supplies institutional support, resources, and coordination to facilitate implementation and scaling. This includes funding, policy guidance, and access to additional resources, strengthening the project's credibility and effectiveness. Additionally, legume cover crops contribute to carbon sequestration, aligning with broader sustainability objectives.

The legume EGS system leverages the expertise of multiple stakeholders, enhancing both its success rate and scalability by utilizing a PPP model. The principles and lessons from this model can inform the design of similar EGS initiatives in other regions or for different crops, contributing to sustainable agricultural practices on a larger scale.

Sources: Brown (2020); de Boef et al. (2019); South Dakota State University (2023)



Box 9: Michigan Dry Beans PPP

The Michigan Dry Beans EGS Case is another successful example of a PPP model, where various private and public stakeholders play vital roles as follows:

- **Varietal Development:** The Michigan State University Dry Bean Breeding and Genetics Program develops high-yielding, disease- and stress-resistant cultivars with upright architecture and improved canning quality across 10 commercial seed classes suited to Michigan production.
- **Seed Multiplication:** The Michigan Crop Improvement Association (MCIA) contracts Gen-Tech Seed Company to produce pre-breeder seed. MCIA then contracts private seed companies for foundation seed production, which is either returned to or purchased by these companies for certified seed production.
- **Certified Seed Production:** Certified seed is produced by companies that purchase foundation seed from MCIA, which serves as both the seed certifying body and royalty collection agency. MCIA collects royalties from certified seed growers based on foundation seed purchased, measured on a cwt basis.
- **Farm Production:** Commercial farms purchase certified seed from seed companies to grow commercial beans. Certified seeds are commonly protected by Plant Variety Protection Laws, which restrict the transfer and sale of non-certified seed. Annually, an estimated 4 million cwt of commercial beans are produced from MSU varieties.
- **Industry Advocacy:** The Michigan Bean Commission, representing over 1,100 bean producers and agribusiness partners, supports the industry. The MCIA assists Michigan's seed industry by handling the commercially challenging roles of seed certification and foundation seed production. Additionally, the Michigan Bean Shippers Association advocates for downstream industry stakeholders.
- **Demand Segments:** The main Michigan bean classes (navy and black beans) are in high demand internationally. Michigan dry beans are considered of higher quality than those from other regions. Approximately 85% of Michigan navy beans are canned, while most black beans are sold in the Mexican packaged market.

Sources: Michigan Crop Improvement Association (2023); Michigan Bean Commission (2023); Michigan Bean Shippers Association (2023); USAID (2023)

Table 12: Production, hectarage and potential seed markets for top cereals in Africa

Rank	Crop	Africa Production million MT	Average yield MT/ha	Estimated hectarage million ha	Typical seed rates kg/ha	Potential Seed Market MT	Share of Potential Seed Market	Share of total cereal production	Most productive Countries in Africa		Africa's Largest producers	
									Country	Mt/ ha	Country	million MT
1	Maize	71.6	2	35.8	25	895,000	0.40	0.48	South Africa	5.5	S. Africa	14.1
2	Sorghum	27.1	1.3	20.8	10	208,462	0.09	0.18	Sudan	2.2	Nigeria	5.2
3	Millet	22.4	1	22.4	10	224,000	0.10	0.15	Niger	1.4	Nigeria	4.8
4	Rice	14.4	2.4	6	50	300,000	0.13	0.10	Madagascar	4.5	Nigeria	3.7
5	Wheat	13.3	2.2	6	100	600,000	0.27	0.09	Ethiopia	3.3	Egypt	8.2

3

Policy Recommendations



3.1 Improve agronomic returns and seed replacement rates among farmers

One of the key issues contributing to low seed repurchase and adoption of improved varieties is the low ratio of increase—the amount of grain produced per unit of seed planted. This low ratio often discourages farmers from adopting new seeds, as the agronomic returns do not justify the cost of improved seeds. To address this, dryland agriculture programmes should focus on improving agronomic standards through training and extension services, helping farmers to achieve better yields with improved seed varieties. Through the adoption of best agronomic practices—such as optimal planting density, appropriate fertilizer use, and pest management—farmers can significantly increase their yields, improving the ratio of increase and making seed investments more attractive. Linking seed production with high agronomic investments, for example through offering farmers a bundled package of seeds and inputs, can create a more profitable model: even if the marginal returns on seed alone are low, the overall production package can deliver better profitability. Governments can incentivize adoption by incetivising seed-containing production packages, offering technical support, and promoting the long-term benefits of regular seed replacement.



3.2 Innovate public–private partnerships and pluralistic seed systems

In semi-commercial systems, where the commercial case for upstream seed production (particularly EGS) is weak, PPPs are essential to ensure sustainability. Production of EGS is often not profitable without significant subsidies. PPPs can help absorb the high costs associated with EGS and certified seed production, ensuring a steady supply of high-quality seeds for smallholder farmers by leveraging the strengths of both public research institutions and private-sector capabilities. Examples such as the South Dakota legume EGS system (Chesak Seed House, 2019) demonstrate how such partnerships can effectively integrate public resources, technical expertise, and private-sector efficiency to meet agricultural needs. Public–private partnerships can also help create market linkages and stabilize seed demand by providing institutional support, training, and guaranteed markets for farmers. To further incentivize private-sector engagement, policies should offer tax breaks and financial support to encourage investments in seed production, even in low-return segments such as EGS.

Effective PPPs will hinge on pluralistic seed systems—a diverse mix of formal and informal seed channels to ensure broad access to quality seeds for different types of farmers. Pluralistic systems, which involve the coexistence of commercial seed enterprises, government-supported seed programs, and informal community-based seed networks, help to reach a wider range of farmers, particularly smallholders, who often rely on informal seed systems for their seed needs. Policymakers can create a more resilient seed sector, ensuring that both commercial and non-commercial seed producers are integrated into the value chain by promoting pluralistic seed systems. This approach allows for greater flexibility and diversity in seed distribution, addressing the needs of different farming systems and ensuring food security across regions with varying agricultural contexts.



3.3 Promote integrated commercial seed enterprises (especially SMEs)

Integrated seed enterprises are critical for ensuring the commercial viability of seed production, especially when individual stages, such as EGS or certified seed production, are not profitable as standalone operations. The integration of EGS and certified seed production within a single enterprise allows companies to spread fixed costs, and to benefit from economies of scale. For example, the business case for maize seed production in Zambia showed that certified seed sales, which are profitable, can offset the high costs of producing nonprofitable upstream EGS stages. Linking seed production with grain operations, or combining seed sales with high agronomic investments (such as fertilizers or mechanization) in a bundled package, can significantly enhance profitability. Even when the marginal returns on seed alone are low, these integrated models ensure that seed businesses remain viable by generating additional value from other parts of the agricultural supply chain. As demonstrated in the case of sorghum in Ethiopia, without such integration or subsidies, seed production would struggle to cover its costs.



3.4 Work towards vertical integration of the seed value chain

As noted above, the benefits of vertical integration within the value chain include economies of scale and greater efficiency over fixed and variable costs such as logistics (Biel, 2021; Tripp and Pal, 2001; Almekinders and Louwaars, 2002; O'Brien, 2022). Effective integration requires supportive policies and collaboration among stakeholders all along the seed value chain (Byerlee and Dubin, 2010). A strategic approach involving operational integration, technology adoption, and strong partnerships can help establish vertically integrated agricultural systems (MacRobert, 2009; Collinson and Rugman, 2012).

For the dryland seed value chain, we propose beginning with a quasi-vertical integration, where companies use strategies such as joint ventures or long-term contracts. There is a clear gap within the seed value chains that can be bridged by the creation of information symmetry—a process that can be jump-started by international NGOs. This would allow flow of information along the value chain, and could lead to higher levels of integration in the future.





4 Conclusion

This report presents a comprehensive analysis of seed markets for dryland crops such as sorghum, millet, and groundnut within the broader context of global cereal markets and implications for seed systems in sub-Saharan Africa (SSA). It examines the potential for growth in these markets, evaluating their size, profitability, and growth potential in SSA's dryland agro-ecologies. Key challenges highlighted include limited access to quality seeds, low private-sector investment, and low adoption rates of improved varieties among smallholder farmers.

We explore incentives for farmers, essential for translating breeding investments into impactful agricultural productivity. Key profitability metrics were applied to data from Burkina Faso, Ethiopia, Ghana, Mali, Nigeria, Tanzania, and Uganda, sourced from the FAO, peer-reviewed journals, and government reports. These metrics include the ratio of increase from seed to grain, the ratio of seed cost to crop value, and seed expenditure relative to profitable cost thresholds. Findings indicate that for many smallholders, market-based seed costs fall short of profitability benchmarks, with crops like groundnut showing particularly weak business cases for farmers, while sorghum and millet hybrids sometimes approach profitability under certain in some places.

For seed companies, key metrics in East and West Africa show that maize hybrids consistently achieve the lowest seed cost-to-crop value ratios, with profitability further enhanced by favorable seed price-to-grain price ratios, notably 3.5:1 in Ethiopia, though as high as 8.7:1 in Tanzania. Break-even volumes for crops like maize (318 tonnes), sorghum (78 tonnes), and millet (48 tonnes) suggest that medium-sized seed enterprises can operate profitably. However, achieving this will require innovations that enable decentralized seed production. Positive NPVs across crops, particularly for maize and groundnut (reaching up to $2.27 million and $1.23 million, respectively), underscore the long-term financial viability of seed enterprises, provided these efforts are accompanied by strategies to reduce production costs and foster SME innovations.

To provide actionable insights, we suggest implementing a system for regularly evaluating seed prices against profitability measures, which would function as a "temperature check" for seed system viability. The metrics recommended include the seed-to-grain yield ratio, the seed cost-to-crop value ratio, seed expenditure relative to cost thresholds, and the seed-to-grain price ratio.



The report further emphasizes several key conclusions:

- **Public-private partnerships (PPPs):** PPPs are essential for sustaining the seed supply, particularly for early-generation seeds (EGS), where profitability is often limited. Public and private sector collaboration helps maintain access to high-quality seeds for smallholder farmers.



- **Integrated seed systems:** A pluralistic seed system—combining commercial, community-based, and informal seed networks—is crucial to expanding seed access and ensuring resilience. This integration is especially beneficial for smallholder farmers who rely on informal seed systems.



- **Vertical integration:** Vertical integration within the seed value chain can reduce costs, increase economies of scale, and enhance overall efficiency. Linking stages of seed production and distribution can make upstream seed production more viable and sustainable.



- **Localized seed enterprises:** Small, locally focused seed enterprises are well-suited for dryland crops like sorghum, millet, and groundnut, particularly in dispersed and remote areas. These enterprises can better meet localized demand with lower fixed costs than large-scale operations.



- **Profitability metrics:** Developing a regular system for evaluating seed prices using key metrics—such as seed-to-grain yield ratio, seed cost-to-crop value ratio, and seed expenditure relative to cost thresholds—can help track and guide business decisions for seed producers.



- **Addressing profitability challenges:** Seed market conditions often pose profitability challenges, especially for smallholder farmers. Adopting advanced business models, like vertical integration and innovative public-private strategies, can improve the viability and adoption of improved seed varieties.

Advancing seed business viability for dryland crops in SSA requires coordinated efforts in public-private investment, vertically integrated business models, and support for locally focused small enterprises. We judge that these strategies are fundamental for developing resilient seed systems.

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Appendix: Currency conversion table for seed and grain prices

Country	Currency	Year	Rate (US$)		
			Average (used)	Best	Worst
Ethiopia	Birr	2020	0.0287 US$	0.0316 US$	0.0254 US$
Tanzania	Shilling	2020	2315.0386 TZS	2330.5864 TZS	2290.1925 TZS
Uganda	Shilling	2015	0.0004 US$	0.0003 US$	0.0003 US$
Uganda	Shilling	2021	0.0003 US$	0.0003 US$	0.0003 US$
Kenya	Shilling	2021	0.0091 US$	0.0094 US$	0.0088 US$
Burkina Faso	CFA	2019	0.0017 US$	0.0018 US$	0.0017 US$
Ghana	Cedi	2021	5.9249 GHS	6.1873 GHS	5.7304 GHS
Mali	CFA	2020	0.0017 US$	0.0019 US$	0.0016 US$
Nigeria	Naira	2017	333.7146 NGN	369.0095 NGN	303.4024 NGN
Nigeria	Naira	2021	0.0025 US$	0.0026 US$	0.0024 US$

Sources: *Ghanaian Cedi to US$: www.exchange-rates.org/exchange-rate-history/usd-ghs-2021; all other currencies: https://www.exchangerates.org.uk*

Note: *The Rate (US$) column includes the average exchange rate for the year, which was used for all conversions to ensure consistency, the best rate when the local currency was most valuable compared to the US dollar, and the worst rate when the local currency was weakest relative to the US dollar.*