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The Changing Landscape of Africa's Fertilizer Market: Implications for Research and Policy

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Abstract

This article synthesizes peer-reviewed studies on fertilizer demand and supply in Africa published from 2007 to 2024. This large body of literature is skewed toward fertilizer demand, with little emphasis on critical supply chain challenges such as high costs and logistics, nor does it focus on the rising importance of micro, small, and medium enterprises (e.g., agrodealers), fertilizer production, and blending in Africa. Additionally, most research has focused on a relatively small number of countries and on cereal crops, overlooking Africa's geographic, crop, and dietary diversity. The article advocates for a broader research agenda that recognizes the recent dynamism in African fertilizer markets and challenges posed by climate change, conflict, and other shocks. It emphasizes the critical need for new and better-quality data for this research agenda to be executed and to provide empirical evidence-based guidance for more effective and efficient fertilizer use and, ultimately, enhanced agricultural productivity and sustainability on the continent.

1. INTRODUCTION

This article reviews recent evidence on the nature, growth, and dynamism of the African fertilizer market and its implication for fertilizer use on the continent. Understanding the current landscape of Africa's fertilizer demand and supply is critical for several reasons. First, Africa's recent food production growth has largely been due to agricultural extensification (bringing more land under cultivation) rather than intensification (increased productivity on existing land) (Reardon et al. 1999, Jayne & Sanchez 2021, Jayne et al. 2023). Thus, the drivers of successful agricultural intensification (including the use of modern inputs such as improved seed and fertilizer) are a pertinent issue—and a persistent challenge—for Africa, particularly given the continent's rapidly growing population. Second, Africa is recognized as a key source of current and future fertilizer demand growth globally. Though varying across subregions, the African fertilizer market grew more than 8% per year between the mid-2000s and mid-2010s compared to 1% for Asia and 1% globally (AGRA 2019). Based on FAOSTAT data (FAOSTAT 2024), total nutrient consumption in Africa grew annually by about 4% between 2007 and 2021 (5% between 2007 and 2020 before a drop due to COVID-19 and other shocks). Third, Africa's current and expected fertilizer demand growth has stimulated a dynamic supply response, and, in the last decade, the continent has had the fastest growth of any region in the world in fertilizer production. This expansion in fertilizer supply (primary production and blending) is driven by growth in urea production, which grew from 1.65 million metric tons (MT) in 2006 to 6.1 million MT in 2022. Africa's recent expansion in fertilizer supply has been almost exclusively driven by the private sector, with increasing investment by local firms and multinational corporations in multiple segments of the fertilizer supply chain (AFO 2019, AGRA 2019).

Despite this dynamism, average fertilizer use intensity in Africa, which stood at 21.55 kg per hectare of agricultural land as of 2022 (FAOSTAT 2024), is still significantly lower than the 50 kg/ha target established in the 2006 Abuja Declaration on Fertilizer for the African Green Revolution; it is also well below the levels used in Latin America (94 kg/ha) and Asia (177 kg/ha) (FAOSTAT 2024).

Reflecting on recent empirical evidence can inform important directions for research and policy to support appropriate fertilizer use across Africa (generally), in ways that improve smallholder productivity. This includes understanding the nature and drivers of increased fertilizer demand and supply on the continent, the extent and drivers of farmer engagement with this vibrant market, and how this can be sustained and expanded.

In May 2024, African Union member states declared their commitment to improve access to affordable fertilizer on the continent along with the efficiency, resilience, and sustainability of fertilizer use. This declaration during the Africa Fertilizer and Soil Health Summit (AFSHS) in Nairobi, Kenya has been followed by diverse postsummit efforts to support evidence-based implementation of the associated Africa Fertilizer and Soil Health (AFSH) Action Plan. This creates a unique opportunity for this review to inform key areas for further research to guide these country and regional efforts.

Several prior reviews on fertilizer demand and supply in Africa focused on years prior to the 2006 Africa Fertilizer Summit (AFS) in Abuja, Nigeria (e.g., Bumb & Gregory 2006, Morris et al. 2007). This event, where African leaders met to promote fertilizer use for increased food production, was a pivotal, watershed moment in the African fertilizer debate. The AFS informed subsequent national and regional strategies across Africa, including input subsidy programs. More recent reviews have focused on one aspect of fertilizer use, such as input subsidies (Jayne et al. 2018, Holden 2019), sustainable intensification (Holden 2018), or input quality perceptions (Michelson et al. 2023).

This review focuses on fertilizer-related research in Africa post-2006 to provide an update on the fertilizer landscape in Africa since the AFS. We pay particular attention to the role of the private sector, the main source of fertilizer for most countries and a key player for sustained access to fertilizer on the continent. We critically assess this body of knowledge in relation to long-standing debates about Africa's agricultural and economic transformation and current issues such as climate change and conflict/instability. We also assess the extent to which the current focus of research aligns with the unfolding realities in Africa (e.g., expanding fertilizer supply in response to growing demand and diversified consumption patterns out of starchy staples) as potential leverage points for increasing fertilizer use and productivity.

This review is framed around the economics of fertilizer use and supply in Africa. We reviewed journal articles (in journals indexed in the Web of Science Journal Citation Reports), peer-reviewed studies, and book chapters on this topic from 2007 onward. Given the vast literature on fertilizer subsidy programs and recent reviews by Jayne et al. (2018) and Holden (2019), we only consider fertilizer subsidy studies from 2017 onward. Additionally, we include studies where a particular innovation/intervention is explored as a tool for promoting fertilizer use. We exclude studies based on experimental plots and not farmers' fields.

The article is structured as follows. Section 2 sets the stage with an overview of the African fertilizer market with trends and literature on African fertilizer demand and domestic supply since 2006. We leverage the available data for the review period which includes fertilizer use for all of Africa and fertilizer supply in Sub-Saharan Africa (SSA). Section 3 presents a summary of the reviewed studies to highlight areas of current emphasis. Section 4 presents a critical review of the recent literature loosely grouped into themes related to fertilizer supply and demand, noting areas requiring more attention. Section 5 concludes with thoughts about the Africa fertilizer research agenda going forward.

2. RAPID GROWTH OF THE AFRICAN FERTILIZER MARKET FOLLOWING THE 2006 AFRICA FERTILIZER SUMMIT

2.1. Fertilizer Demand Has Increased Substantially

Fertilizer use per area of cropland in Africa increased by 20% from an average of 16.90 kg/ha in the pre-AFS period (1996–2006) to an average of 20.29 kg/ha post-AFS (2007–2022) (FAOSTAT 2024). Much of the growth in Africa is driven by Central Africa (8% annually), with substantial growth in West Africa (6% annually) and East Africa (5% annually).[1] In the period 2007–2022, six countries accounted for 67.5% of all fertilizer consumption in Africa: Egypt (∼26%), South Africa (∼14.5%), Morocco (∼8%), Ethiopia (∼7.5%), Nigeria (∼7%), and Kenya (∼4.5%) (**Supplemental Tables 1 and 2**; FAOSTAT 2024). However, despite significant variation across subregions and countries, fertilizer consumption growth is taking place much more broadly, with 82% of African countries among the 49 for which there are data recording growth in fertilizer use since 2007 (**Table 1**).

Supplemental Material >

Table 1 and **Supplemental Figures 1–4** provide additional insights into the fertilizer use trends across the aforementioned 49 African countries. Grouping countries by their level of fertilizer use prior to the AFS (1996–2006), the extent of fertilizer demand growth post-AFS (2007–2022) varies significantly, and two key points stand out. First, among countries already categorized as having relatively high fertilizer use intensity (>25 kg/ha) pre-AFS, countries in SSA such as Botswana, Ethiopia, Kenya, Malawi, and Zambia that were at earlier stages of fertilizer

[1] Until 2022, West Africa (9% annually) led Africa's growth, followed by East Africa (6%) and Central Africa (5%).

Table 1 Trends in fertilizer use intensity across Africa

Fertilizer use intensity 1996–2006	Average fertilizer use intensity in 2007–2022 compared to 1996–2006	
	Small/no increase (<30%)	Large increase (>30%)
High (>25 kg/ha)	Egypt (391, +3%) Mauritius (329, −36%) Morocco (45.7, +13%) South Africa (62.4, +26%) Tunisia (27.2, +22%) Zimbabwe (31.1, −3%)	Botswana (50.2, +476%) Eswatini (61.5, +56%) Ethiopia (24.7, +93%) Kenya (39.1, +41%) Malawi (32.4, +35%) Zambia (51.6, +143%)
Low (<25 kg/ha)	Central African Republic (0.2, +13%) Chad (3.4, −6%) Comoros (0.65, −57%) Congo (3.36, −32%) Côte d'Ivoire (3.4, −6%) Eritrea (2.7, −71%) Gambia (3.7, −45%) Libya (22.4, −17%) Senegal (12, +29%) Togo (5.9, +4%)	Algeria (17.2, +56%) Angola (7.6, +362%) Benin (12.2, +282%) Burkina Faso (11.2, +49%) Burundi (10.0, +432%) Cameroon (8.9, +32%) Democratic Republic of the Congo (1.2, +422%) Djibouti (15.8, +386%) Equatorial Guinea (7.1, +142%) Gabon (17.7, +715%) Ghana (18.0, +261%) Guinea (2.1, +150%) Guinea-Bissau (8.2, +115%) Liberia (9.5, +469%) Madagascar (5.9, +118%) Mali (17, +41%) Mauritania (9.5, +216%) Mozambique (6.9, +145%) Namibia (12.4, +844%) Niger (0.5, +57%) Nigeria (9.3, +90%) Rwanda (10.4, +681%) São Tomé and Príncipe (5.2, +151%) Sierra Leone (6.5, +143%) Somalia (0.45, +76%) Uganda (1.7, +90%) Tanzania (9.3, +187%)

Based on calculations from FAOSTAT data on total nutrient use per area of cropland (kg/ha) (FAOSTAT 2024). Numbers in parentheses are the mean fertilizer use intensity (kg/ha) from 2007 to 2022 and the percentage increase in fertilizer use intensity from the pre-Africa Fertilizer Summit (AFS) period (1996–2006) to the post-AFS period (2007–2022).

use growth have experienced notable increases in their fertilizer application rates, with Botswana reporting a staggering 476% increase. This contrasts with lower growth rates in countries such as Egypt, South Africa, and Mauritius that were among the major fertilizer users prior to the AFS and already using the AFS target of 50 kg/ha or more.[2] This upward trend in fertilizer use is attributed in part to policy consistency and successful agricultural policies and programs aimed

[2]Eswatini and Tunisia were interesting deviations from the norm. Fertilizer use in Eswatini continued to increase from a relatively high rate (∼50 kg/ha in 2006 to 61.5), while fertilizer use rates in Tunisia remained around 25 kg/ha for the entire period.

at enhancing farmer input access, use, and productivity (Ariga & Jayne 2009, Sheahan et al. 2013, Ncube et al. 2016).

Second, among countries with low fertilizer use intensity pre-AFS, all except Côte d'Ivoire, Central African Republic (CAR), Chad, Comoros, Congo, Eritrea, Gambia, Libya, Senegal, and Togo have experienced large increases in their fertilizer application rates (>30%), with Namibia and Gabon witnessing the most significant growth at 844% and 715%, respectively. Among those with less than 30% growth over the period, Senegal and CAR still saw increases of 29% and 13%, respectively, while seven countries saw outright declines in fertilizer use: Côte d'Ivoire, Chad, Comoros, Congo, Eritrea, Gambia, and Libya. These declines are partly due to challenges associated with unstable political environments, poor access to essential farming inputs, climate factors, and insufficient support for agricultural development (Boniphace et al. 2015, Ntinyari et al. 2022).

2.2. Inorganic Fertilizer Production in Sub-Saharan Africa Almost Tripled Between 2015 and 2023

Recognition of the large potential fertilizer market has triggered significant investment in fertilizer supply across Africa. This supply is primarily private sector-driven via both local and international investments (AFO 2019). In 2002/2003, global fertilizer production was 146.9 million MT of nutrients (nitrogen, phosphorus, and potassium), with approximately 4% (5.8 million MT) of global production manufactured in Africa (Bumb & Gregory 2006). The majority of Africa's production in 2002/2003 was by North Africa (5 million MT), with South Africa accounting for 600,000 MT and the rest of SSA accounting for 177,000 MT (0.1% of total global production). Fast forward to 2023, and total inorganic fertilizer production in SSA was almost 5.17 million MT, 29 times the amount produced in 2003 and almost triple the production in 2015 (AFO 2024).

Fertilizer production in Africa was historically concentrated in six countries (Egypt, Tunisia, South Africa, Algeria, Nigeria, and Morocco), with only two in SSA. However, there is now significant production in nine countries in SSA apart from South Africa (Nigeria, Ghana, Tanzania, Benin, Mali, Senegal, Burkina Faso, Togo, and Côte D'Ivoire). **Figure 1** shows total inorganic

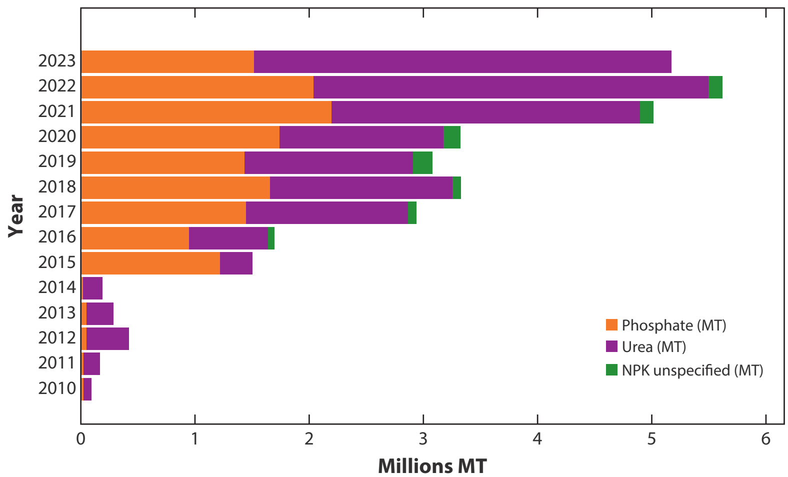

Figure 1

Inorganic fertilizer production in selected Sub-Saharan African countries. Abbreviations: MT, metric tons; NPK, nitrogen, phosphorus, potassium blend.

fertilizer production from these nine countries annually from 2010 to 2023. Overall, fertilizer production in SSA (outside of South Africa) has increased more than tenfold since 2012. This growth is largely driven by Nigeria and Togo, which respectively account for 95% and 72% of total supply of urea and phosphate fertilizer production in SSA excluding South Africa where data are available (AFO 2024). However, production is increasing in other countries as well (e.g., Mali, Tanzania, Senegal, and Burkina Faso) (AFO 2024).

Africa's fertilizer production growth has largely been for nitrogen and in countries with natural gas deposits (AFO 2019). This includes increased urea production in Nigeria (producing more than 2 million MT annually between 2017 and 2020 and more than 3 million MT in 2022 and 2023) (AFO 2019, 2024). Between 2018 and 2019, the number of fertilizer manufacturing and processing plants on the continent grew by 35% (AFO 2019). As of 2019, there were five nitrogen fertilizer manufacturing facilities in SSA (one in Madagascar and two each in Nigeria and Zimbabwe) and seven phosphate fertilizer manufacturing plants (one each in Kenya, Mali, Tanzania, Togo, and Zimbabwe and two in Senegal) (AFO 2019).

Supplemental Material >

Alongside production efforts, there has been significant growth in fertilizer blending plants producing different fertilizer formulations and facilitating farmers' access to balanced nutrients to meet particular needs. The number and capacity of blending plants on the continent have increased approximately fivefold from 21 plants with total capacity of 722 MT/h in 2006 (pre-AFS) to 99 plants with total capacity of 6,102 MT/h in 2023 (**Supplemental Figure 5**; AFO 2024). Several countries with no blending plants pre-AFS, such as Angola, Ethiopia, Guinea, Malawi, Mozambique, Rwanda, Senegal, Tanzania, Togo, and Uganda, have since established plants. Companies such as Saudi Arabia's Ma'aden and Morocco's OCP (the world's leading phosphate fertilizer company) have expanded activities in Africa. OCP created an African subsidiary, OCP-Africa, with a presence in 16 African countries and manufacturing facilities in 12 (AFO 2019). There has also been a strong emergence of organic fertilizer manufacturers, with 12 companies producing organic complements to chemical fertilizers across SSA (AFO 2019, AGRA 2019).

Liberalization and privatization of fertilizer markets since structural adjustment have also supported an expansion of activities further down the supply chain on the continent, largely among distributors and agrodealers. Bumb et al. (2011) estimate up to 10,000 retailers operating in Nigeria alone, and AGRA (2019) notes about 8,000 retailers in Kenya, almost 4,000 in Tanzania, and more than 2,000 in Mali.

Despite these developments, average fertilizer use intensity on the continent remains low. In the next section, we review the post-AFS literature on the drivers and constraints associated with fertilizer demand and supply. We note research gaps and opportunities to support increased fertilizer use to improve productivity and food security on the continent.

3. SUMMARY OF REVIEWED STUDIES

Figure 2 presents a summary of the research publications reviewed for this article. Four key points stand out. First, despite the recent expansion of fertilizer supply across Africa and the rapid growth of investments in entrepreneurial activities along the fertilizer supply chain, relatively little attention is paid to supply-side issues in the literature. Only about 15% of the reviewed studies focused on fertilizer supply (including ∼10% focused on the policy environment). Most of the reviewed studies focused on fertilizer demand, covering topics such as the drivers of and barriers to fertilizer adoption (∼60%), fertilizer profitability issues including crop yield response to fertilizer (∼20%), fertilizer subsidies (∼10%), trends in fertilizer use and prices (∼5%), and/or climate change and shocks (<5%).

Second, the post-AFS literature has focused almost exclusively on cereals (predominately maize), neglecting root and tuber crops and vegetables, despite the importance of roots/tubers

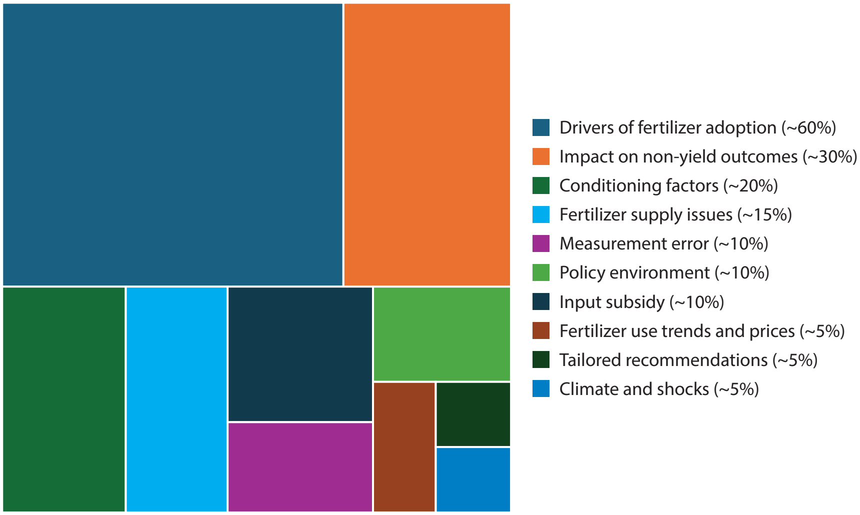

Figure 2

Summary of reviewed studies, by subject matter, covered by this article.

for the African diet and the role of nutrient-rich vegetables in fostering healthy diets.[3] This reveals a gap in the literature: considering the fertilizer yield response potential for roots and tubers (Matsumoto et al. 2021) and vegetables (Amfo & Baba 2021).[4]

Third, we find a huge imbalance in the regions and countries studied. The majority (over 50%) of the reviewed studies were in East Africa; of these, 50% focused on Ethiopia and Kenya. For southern Africa (~30% of reviewed studies), ~65% of studies were for one country: Malawi. In West Africa (25% of the studies), ~90% were focused on two countries: Ghana (50%) and Nigeria (40%). This highlights the need for greater attention to fertilizer issues in a broader set of African countries, particularly those that have seen recent growth in fertilizer demand (see **Table 1**).

Fourth, there continues to be major emphasis on input subsidy programs (ISPs) in the literature. Since the reviews by Jayne et al. (2018) and Holden (2019), the ISP literature has continued to proliferate. We identified nearly 80 peer-reviewed papers on ISPs in SSA published from 2017 through August 2024, of which 19 focus, at least in part, on the impacts of an ISP on fertilizer use or supply.

4. THE STRUCTURE OF AFRICAN FERTILIZER SUPPLY CHAINS

While countries vary in the details of how fertilizer gets to farmers, **Figure 3** presents a stylized depiction of the African fertilizer supply chain structure. Whether moving from a port or domestic producer, there are three main channels through which fertilizer gets to African

[3]A total of 91% of studies focused on cereals, with 74% on maize, 5% on rice, and 2% on sorghum. Roots/tubers and vegetables accounted for 2% and 1% of studies, respectively, and cash crops (coffee, tobacco, tea, and sugarcane) accounted for 5%.

[4]Key informant interviews with International Institute of Tropical Agriculture (IITA) and World Vegetable Center agronomists confirmed that, although needed for higher yields, fertilizer studies on root and tuber crops and vegetables are limited. Key informants note that the low use of inorganic fertilizer is partly due to varying farmer perceptions about their soils, crop mix, and the value of fertilizer use, all of which need further exploration.

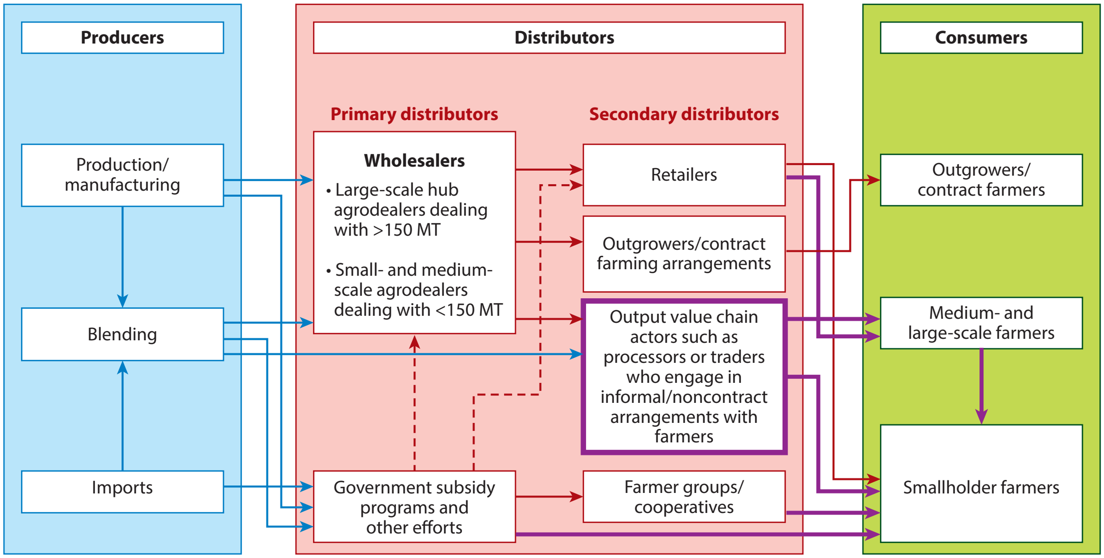

Figure 3

A description of Africa's fertilizer supply chain. Figure adapted from AGRA (2019).

farmers. First is a government intervention/subsidy program supply chain where African governments or agencies have traditionally procured fertilizer directly or from importers and then distributed/sold it to farmers at designated locations at a subsidized price (AGRA 2019). More recently, programs have also worked with agrodealers and private distributors (Ncube et al. 2016, Kaiyatsa et al. 2019, Balana & Fasoranti 2022). Second is a contract farming/outgrower scheme channel where counterparts who will procure output from farmers arrange fertilizer supply to those same farmers. Third is the private fertilizer retail channel, where products typically go from an import/production location to wholesalers/large-scale hub-agrodealers to retailers/small-scale agrodealers or directly to smallholder farmers. This is the primary way that most (often >90%) smallholders acquire fertilizer in Africa (AGRA 2019). Recent evidence highlights the role of farmer groups/cooperatives and noncontract arrangements with value chain actors (e.g., processors, traders, and medium-scale farms), who often provide farmers with complementary inputs and services such as training, credit, or logistical support (Liverpool-Tasie et al. 2020, 2023; Bulte et al. 2024; Grabs et al. 2024).

5. DRIVERS AND CONSTRAINTS TO FERTILIZER SUPPLY

5.1. Limited Empirical Evidence on Fertilizer Supply

Likely owing to data constraints, the highly concentrated nature of the fertilizer production industry, and the small number of actors at some segments of the supply chain (e.g., manufacturers), most of the limited published studies on fertilizer supply in Africa have been descriptive. A few exceptions include Hernandez & Torero (2013), who use a dynamic panel estimation approach with global data from a panel of 38 countries over time (1961–2002) to show how higher levels of competition are associated with lower fertilizer prices. Another exception is Mwatu (2023), who uses a regression discontinuity design to highlight the value of input source diversification during the current Russia–Ukraine war (where Kenya was able to increase fertilizer imports from Russia when Ukraine exports were halted, though at higher costs for freight and insurance). A third paper by Yang et al. (2019) uses global phosphorus fertilizer trade data and multiregional input-output analysis to trace phosphorus fertilizer embodied in trade flows of fertilizer, agricultural and food products, industrial products, and services. They find that despite its relatively high phosphorus use efficiency, Africa uses the least amount of phosphorus fertilizer of any region of the world. This finding (based on 2011 data) was prior to the expansion of phosphate production on the continent (**Figure 1**). Together, these three studies demonstrate the important role of industry structure, trade, and global supply chains for fertilizer supply and prices—topics that remain largely unexplored in the literature.

Within the relatively larger body of descriptive peer-reviewed studies on fertilizer supply, three key themes emerged. The first theme relates to the importance of an enabling environment and competitive fertilizer subsector to encourage and facilitate private sector investment in fertilizer supply (e.g., importation, production/blending, and distribution) (Ariga et al. 2019) and agro-industries more broadly (Christy et al. 2009). This literature shows how fertilizer market liberalization is positively correlated with fertilizer availability for farmers and recommends relatively light (as opposed to onerous) regulatory regimes to improve fertilizer availability (Benson & Mogues 2018; Benson et al. 2012a,b,c; Balana & Fasoranti 2022; Zavale et al. 2020). Relatedly, Ncube et al. (2016) show how demand for fertilizer and other products stimulates greater competition by incentivizing investment and growth in associated services (including transport and logistics), which can reduce the costs of those services and ultimately fertilizer. Other studies explore how remote agrodealers face lower competition and thus stock fewer products and charge higher prices (Rutsaert et al. 2021) or how supply changes correlate with policy and regulatory reform. For example, liberalization policies (e.g., abolishing foreign exchange controls, elimination of fertilizer import quotas, custom duties, value added tax (VAT) or import licensing requirements, and the phasing out of noncommercial fertilizer distribution channels) and government incentives for private sector-led activities allow for more investments in domestic fertilizer supply chains (Ariga & Jayne 2009, Minten et al. 2013, Rashid et al. 2013, Ncube et al. 2016).

The second theme deals with poor infrastructure and high transport costs, identified as some of the biggest barriers to the development of the African fertilizer market (Minten et al. 2013, Ncube et al. 2016, Benson & Mogues 2018). Minten et al. (2013) show how transport costs from fertilizer distribution centers to farmers are roughly twice as high as the expenses incurred to bring fertilizer from the port to remote parts of Ethiopia. Ncube et al. (2016) find that final retail prices are typically more than double the free-on-board (FOB) price, with transport accounting for ~15% of the difference. Although ISPs have been a major source of fertilizer supply in Africa, their cost-effectiveness and impact are often eroded by high transaction and transportation costs (Nhlengethwa et al. 2023). Thus, this literature calls for more investment in infrastructure to reduce input prices and increase output prices in agricultural surplus areas (Ariga & Jayne 2009, Minten et al. 2013, Benson & Mogues 2018). To handle high transportation costs, Ncube et al. (2016) find that increased competition in the trucking industry in Tanzania was associated with a decrease in transport prices over time, while Minten et al. (2013) highlight the role of institutional arrangements (such as cooperative unions and associations) in reducing transportation and transaction costs.

The third theme relates to technical capacity and nontransport costs (e.g., taxes, fees/levies, port charges, and bagging costs) associated with fertilizer supply in Africa that contribute to higher fertilizer retail prices (Ariga & Jayne 2009, Ncube et al. 2016, Benson & Mogues 2018). Ncube et al. (2016) highlight how port charges and bagging/storage accounted for ~15% and 5%, respectively, of the difference between fertilizer FOB and retail prices in their study of three African countries. Another important barrier to value chain actors highlighted in the literature is limited access to credit (Benson et al. 2012a,b,c; Benson & Mogues 2018; Hernandez et al. 2018). An additional constraint is the low technical capacity of many fertilizer supply chain actors, particularly distributors, including a poor understanding of the regulatory frameworks within which they operate (Ncube et al. 2016, Benson & Mogues 2018). Facilitators of improved access to finance underscored by Ariga & Jayne (2009) include lower domestic interest rates or importers' abilities to use international connections to source credit at lower interest and financing costs. They also note the value of mergers or partnerships between local and international firms to support exchange of knowledge and economies of scope to allow for cost savings in local distribution.

5.2. Research Gaps and Areas for Future Work

A notable gap in this literature is analyses that establish the causal effects of policy and regulatory changes on fertilizer supply, as noted by Ariga et al. (2018).[5] One exception is Boulanger et al. (2022), who use a computable general equilibrium model linked with a microsimulation approach to analyze, inter alia, the effects of increasing fertilizer production capacity on domestic fertilizer prices. Motivated by a recent commitment by the Kenyan government to build two fertilizer blending facilities (able to meet 70% of Kenya's current demand), they find that a doubling of fertilizer production in Kenya would reduce fertilizer prices by 20%.

Another research gap is empirical analyses that establish the key drivers and consequences of the nature of growth (e.g., density, growth dynamics, exit/entry rates) of different fertilizer supply chain actors (e.g., producers, transporters, and agrodealers) for fertilizer availability and prices (levels and variability). Limited data (especially panel data) on the activities of actors at various nodes of fertilizer supply chains in different African countries limit the ability to use statistical analysis to understand the determinants and dynamics of value chain actor behavior.

More studies using relatively large samples of agrodealers to understand the drivers of their behavior (and heterogeneity by factors such as gender and age) are needed. Studies on the relationship between agrodealer presence and retail prices (see Rutsaert et al. 2021) or agrodealer behavior (e.g., storage) and outcomes (e.g., fertilizer quality) (see Michelson et al. 2021) are important steps in the right direction. With sufficient data, quasi-experimental impact evaluation methods could be used to estimate the supply-side effects of changes in the fertilizer enabling environment across multiple countries (Ariga et al. 2018). In addition, simulation analyses akin to Boulanger et al. (2022) and economic experiments on/with fertilizer value chain actors are also options (see Liverpool-Tasie et al. 2025, Michelson et al. 2024). These different approaches can provide insights into the drivers of value chain actor decisions and their potential impacts on important outcomes such as fertilizer availability, prices, quality, use, and productivity. Ultimately, more data (and studies) on fertilizer supply chain actors and the policy/legal/regulatory environment are needed across a much broader set of African countries to improve our understanding of the rapid expansion of fertilizer supply on the continent.

6. DRIVERS AND CONSTRAINTS TO FERTILIZER USE

Fertilizer use by African farmers is typically modeled as the solution to a constrained utility maximization problem that yields reduced form specifications of fertilizer that depend on both the economics of fertilizer use (e.g., output/input price ratio and the transportation and transactions costs of inputs) as well as the agronomics of fertilizer use (i.e., yield response) (Singh et al. 1986, Sadoulet & de Janvry 1995, Liverpool-Tasie et al. 2017).

[5] Our discussions of future research in the remainder of the article draw in part from a discussion with a group of experts (Drs. Todd Benson, Jeff Bloem, Bill Burke, Jordan Chamberlin, Manuel Hernandez, and Maria Wanzala) held via Zoom on October 2, 2024.

While the methodological approaches to study fertilizer use in Africa have developed over the last two decades, the research questions posed post-AFS have not differed substantially from those pre-AFS. Four exceptions noted in this review are (*a*) significant growth in the literature on the yield response to and profitability of inorganic fertilizers, (*b*) new work on fertilizer use and climate change, (*c*) work on fertilizer use and shocks such as insecurity and supply chain disruptions, and (*d*) studies related to fertilizer use and farmer perceptions, measurement error, and psychosocial factors. Next, we discuss these four cases, noting the research gaps and areas for future work in each. We then summarize the recent evidence from topics that were common before the AFS, also highlighting remaining gaps given current realities.

6.1. Expansion of Studies on the Yield Response to and Profitability of Fertilizer Use Across Africa

This has been made possible with increased availability of rich household-level panel data, detailed plot-level information, and georeferencing. This literature highlights how low and variable yield response renders fertilizer unprofitable and thus unattractive for farmers in certain contexts (Burke et al. 2017, Liverpool-Tasie et al. 2017, Jayne et al. 2019). The low yield response may be due to low soil organic matter or active carbon (Marenya & Barrett 2009, Chamberlin et al. 2021), high soil acidity (Burke et al. 2017), weeds (Scheiterle et al. 2019, Burke et al. 2020), or late fertilizer application (Ricker-Gilbert 2020), among other factors. One of the frequently suggested measures for tackling the low-yield-response-to-fertilizer constraint in Africa is the promotion of integrated soil fertility management (ISFM) (Marenya & Barrett 2009, Jayne et al. 2019, Chamberlin et al. 2021), which exploits complementarities between organic and inorganic fertilizers, improved crop varieties, and other good agronomic practices (Vanlauwe et al. 2010). Several papers have also underscored the synergies of combining fertilizer with other modern inputs and natural resource management practices under the paradigm of sustainable agricultural intensification (SAI) (e.g., Kassie et al. 2015, Wainaina et al. 2018, Marenya et al. 2020, Kim et al. 2021). High transportation and transaction costs have been identified as another important factor affecting fertilizer profitability and use in Africa (Zerfu & Larson 2010, Minten et al. 2013, Liverpool-Tasie 2017, Liverpool-Tasie et al. 2017), through their effects on farmgate input and output prices and, thus, value/cost ratios. Strategies to lower transportation costs, such as infrastructure investments and encouraging input dealers to operate closer to farmers (Liverpool-Tasie et al. 2025), are therefore vital for improving the returns to fertilizer use in Africa. More research is needed in this area.

Given the critical roles of the private sector in developing technologies and input distribution (often with complementary inputs and services), future research could explore their potential role in promoting ISFM or SAI practices by, for instance, generating improved crop varieties and complementary inputs, developing markets for organic fertilizer, and providing input distribution services and information/training to farmers. Additional research is also needed on mechanisms to incentivize farmer adoption of ISFM/SAI and investments in soil health, given the need for sustained use to realize benefits and the often significant time lag between implementation and realization of benefits. Such studies are also needed to guide domestication and implementation of the AFSH Action Plan associated with the 2024 AFSHS. Notably, much greater emphasis was paid to soil health at this summit than at the 2006 AFS, where the focus was mainly on increasing fertilizer use intensity on the continent. The 2024 summit reflects a growing recognition that raising fertilizer use intensity without improving soil health (and use of improved germplasm) will not be sufficient to sustainably increase agricultural productivity in Africa.

6.2. Fertilizer Use and Climate Change

Africa's predominantly rainfed (95%) agricultural systems make it significantly vulnerable to climate hazards such as rising temperatures, shorter cropping seasons, more frequent and severe drought and floods, and more variable rainfall. At the same time, agricultural practices including the increased application of fertilizer are a source of greenhouse gases that contribute to climate change (Dimkpa et al. 2023). Thus, recent literature highlights how uncertainty created by climate change reduces farmers' incentives to use inorganic fertilizer or to use it at suboptimal levels (Kahan 2008, Holden & Westberg 2010). Other studies show how climate-induced changes increase the demand for fertilizer in Africa by exacerbating soil nutrient depletion, resulting in a greater reliance on mineral fertilizers (Dimkpa et al. 2023). Extremely low fertilizer use in drier agroecological zones is attributed in part to the higher risk and lower profitability of using fertilizer in that context (Holden & Westberg 2010, Asfaw et al. 2016, Theriault et al. 2018, Tefera et al. 2020). Some research suggests that in a country like Malawi, where droughts are frequent, farmers adopt organic fertilizer (Katengeza et al. 2019, Pangapanga-Phiri & Mungatana 2021) or inorganic fertilizer (Makate & Makate 2022) to stabilize and/or reduce the risk of total crop failure under rainfall stress. In Kenya, however, higher temperatures, which increase pest incidence, induce farmers to divert investment from fertilizer to loss-reducing inputs such as pesticides (Jagnani et al. 2021).

Most existing research on climate change and fertilizer use focuses on cereals, neglecting the wide variety of crops grown and consumed on the continent. However, because the impact of climate change on fertilizer use varies greatly by crop and farming systems, an expansion in research scope is critical and will require the development of appropriate crop models for different crops. Relatedly, additional research is needed on the performance of fertilizer when adopted by African farmers under different climate stress conditions.

6.3. Insecurity and Other Supply Chain Disruptions and Shocks

Shocks have been on the rise in Africa since the 2006 AFS. Several studies have documented how insecurity/conflict negatively affect farmer input use, including fertilizer (Adelaja & George 2019, Berman et al. 2021, Sessou & Henning 2023); however, the evidence base is very thin, and the underlying mechanisms have not been unpacked. Even less is known about the impacts of insecurity/conflict on other fertilizer supply chain actors. Studies have shown how lockdowns during COVID-19 sometimes coincided with planting dates, leading to a decrease in the quantity of critical inputs purchased (including fertilizer), labor shortages for fertilizer top-dressing, and reduced cropped acreage, number of crops grown, and crop output (Nchanji et al. 2021, Obayelu et al. 2021, Tripathi et al. 2021, Uyanga et al. 2024). The ongoing Russia–Ukraine war has disrupted global fertilizer markets, causing price hikes for import-dependent African countries (up 73% in 2022 versus 2021) and a surge in fertilizer-cereal price ratios on the continent (up 39% in 2023 compared to 2021) despite global declines in the ratio (Mwatu 2023, AFO 2024, Baffes & Temaj 2024).

Because insecurity and supply chain risks potentially affect all actors along the fertilizer supply chain, additional evidence is needed to understand how countries and different value chain actors (not just farmers) are currently affected by and coping with insecurity and supply chain risks; an understanding of the potential contemporaneous and longer-term impacts of such coping strategies is also needed. Additionally, studies are needed on the effects of government programs on fertilizer market stability to inform interventions to mitigate the effects of shocks and improve the resilience of fertilizer supply chains.

6.4. Farmer Perceptions (About Fertilizer Quality, Soils, Land Size, and Life) and Fertilizer Use

There is a growing body of research on survey data quality including (*a*) mixed evidence regarding the presence (Wollburg et al. 2021) or absence (Beegle et al. 2012) of substantial recall decay bias in survey data on fertilizer; (*b*) farmers' tendency to apply more (less) fertilizer on varieties they believe to be improved (local), and vice versa, with many farmers misidentifying the varieties they grow, leading to fertilizer misallocation (Wineman et al. 2020, Wossen et al. 2022, Bohr et al. 2024); and (*c*) measurement error in land area or crop output data and implications for fertilizer-related variables and estimates. For example, measurement error in plot size influences estimates of plot size effects on fertilizer use (Dillon et al. 2019); measurement error in land size affects estimates of fertilizer use intensity (kg/ha) (Abay et al. 2023b, Burke et al. 2023); farmers' beliefs about land size influence their fertilizer use behavior (Ibid.); and measurement error in land size or crop output can bias estimates of returns to fertilizer (e.g., Abay 2020, Yacoubou Djima & Kilic 2024).

Relatedly, there is a very limited literature on fertilizer quality, focused on a few countries, mostly Tanzania, Uganda, and Ghana. This literature suggests that fertilizers sold in local markets are generally good quality; however, poor observable attributes (e.g., caking and impurities) lead many farmers to perceive the fertilizer to be of low quality, which affects demand (Michelson et al. 2021, Hoel et al. 2024). Information can help: Hoel et al. (2024) find that Tanzanian farmers are willing to pay a 46% premium for fertilizer that has been lab tested and guaranteed to be good quality. The private sector can play a role by addressing storage and transport conditions that cause degradation in physical attributes, but there is also room for labeling or certification schemes that provide credible information on fertilizer quality (Michelson et al. 2021).

Finally, we found three peer-reviewed studies (all in Ethiopia) documenting how psychosocial factors such as aspirations influence farmer adoption of modern agricultural technologies, including fertilizer (Mekonnen & Gerber 2016, Abay et al. 2017, Taffesse & Tadesse 2017). These studies call for more attention to farmers' noncognitive skills.

Additional studies are needed that directly assess the extent and implications of measurement error in inorganic fertilizer purchase or use itself (Abay et al. 2023a) as well as work on when and how to cost-effectively overcome mistaken beliefs and other psychosocial factors to improve the profitability of fertilizer use across different contexts. Empirical evidence-based guidance (beyond the brief discussion in Carletto et al. 2021) on best practices for fertilizer-related survey data collection (to reduce recall decay bias and other data problems) would also be helpful for researchers.

As noted by Michelson et al. (2023), more fertilizer testing studies are needed, including (*a*) focusing on blended fertilizers that are more prone to quality issues and (*b*) conducting testing upstream of the supply chain (e.g., manufacturers), as previous studies have largely focused on testing urea from retail shops. More research on fertilizer storage and handling practices among agrodealers and more fertilizer quality assessments across the continent will help capture contextual variation and document how widespread fertilizer quality issues are.

6.5. Other Drivers of Fertilizer Use

Apart from the aforementioned areas, most of the post-AFS literature reaffirms that the key drivers and constraints to agricultural technology adoption in developing countries highlighted by Feder et al. (1985), Foster & Rosenzweig (2010), and Ruzzante et al. (2021) apply to fertilizer use. These include the following.

1. Farmer organizations, including cooperatives, which provide critical institutional support services, such as access to finance, information, extension, markets, and inputs to smallholder farmers in the Global South (see Bizikova et al. 2020 for a recent review; Verhofstadt & Maertens 2014, Manda et al. 2020, Tabe-Ojong 2023, Bidzakin et al. 2023).
2. Lack of tenure rights (particularly for women) that reduces investment in fertilizer and other productive inputs (Abdulai et al. 2011, Dillon & Voena 2018, Deininger et al. 2021, Mugizi 2022, Donkor et al. 2023, Ngom et al. 2023).
3. Liquidity, credit, and risk constraints (Lambrecht et al. 2014, Koussoubé & Nauges 2017, Lemecha 2023), with new ideas on strategies that can help alleviate these constraints. Examples include offering a small discount on the cost of purchasing fertilizer at harvest time (Duflo et al. 2011); risk-free sales offers in which farmers will pay for fertilizer received only if the value of their increased yields exceeds the cost of the fertilizer (Adong et al. 2020); farmer engagement with large-scale grain traders (Mulwa et al. 2021); mobile money (Batista & Vicente 2020, Abdul-Rahaman & Abdulai 2022); remittances (Veljanoska 2022); bundling credit with index insurance (Mishra et al. 2023); and contract farming arrangements (Konja & Abdulai 2024). Most of these private sector mechanisms have been tested in few single-country studies.
4. The welfare effects of fertilizer use. This literature highlights the value of complementary input use and good agronomic practices for increasing the likelihood of positive welfare effects (Martey 2018, Martey et al. 2019, Tesfay 2020, Jena et al. 2021, Khonje et al. 2022, Bidzakin et al. 2023, Tabe-Ojong et al. 2023, Geffersa 2024, Amankwah & Gwatidzo 2024).
5. Good extension services, particularly for complex and knowledge-intensive technology packages such as ISFM (e.g., Donkor et al. 2016, Lambrecht et al. 2016, Hörner et al. 2022). Given the weaknesses of traditional agricultural extension services in Africa (Aker 2011), the current literature has focused on assessing the impact and cost-effectiveness of using alternative in-person and digital extension methods (e.g., via radio, video, and mobile phones), and combinations of these information delivery channels (Voss et al. 2021, Hörner et al. 2022, Maertens et al. 2023).
6. The need for cost-effective and better targeted ISPs. Recent studies on ISPs find mixed results in terms of impacts on fertilizer use. There continues to be substantial evidence of contemporaneous crowding out of commercial fertilizer purchases by subsidized fertilizer [e.g., Mather & Jayne (2018) for Kenya, Ricker-Gilbert & Jayne (2017) for Malawi, Kijima (2022) for Nigeria, and Ricome et al. (2024) for Senegal]. However, there is evidence of enduring positive effects on fertilizer use after subsidy programs end in some contexts (Carter et al. 2021, Fishman et al. 2022). In addition, Ricker-Gilbert & Jayne (2017) find crowding in of commercial fertilizer demand in the longer run despite evidence of contemporaneous crowding out in Malawi. Relatedly, Giné et al. (2022) find that crowding out is less likely in villages where subsidized fertilizer vouchers were distributed to recipients selected by a village voucher committee compared to a lottery approach; they attribute this to the village voucher committees selecting liquidity-constrained, productive farmers that used the fertilizer on their crops, whereas lottery-based selection resulted in some unproductive farmers receiving the vouchers and subsequently selling the vouchers or fertilizer. And randomized controlled trial (RCT) results from Tanzania suggest that subsidized fertilizer vouchers increase fertilizer use more when combined with tailored fertilizer recommendations based on soil tests (Harou et al. 2022).

This recent literature on other drivers and constraints to fertilizer use reveals several potential future research areas. First is more research using experimental, quasi-experimental, or panel data methods to provide rigorous causal evidence on the effectiveness of value chain actors (e.g., cooperatives, aggregators, processors, wholesalers, agrodealers) and private extension (growing quickly on the continent) in promoting fertilizer use, as most existing studies in this area rely on cross-sectional data. The rise of soil testing services across the continent (though often expensive) creates opportunities to better understand farmers' willingness to pay for such services and how/where soil test information influences farmer decisions on the types and quantities of fertilizers used as well as the benefits thereof. Second, as a follow-on to the call above for more supply-side research, there is a need for research exploring if and how the expansion of fertilizer supply/blending plants as well as agrodealer networks (e.g., in terms of their density, scale, and activities) is affecting farmers' use of fertilizer overall and of more appropriate fertilizers given their soils and crops. Third, although the ISP literature is vast overall, supply-side evidence on the effects of ISPs is extremely thin. Thus, we recommend the supply-side effects of ISPs as a focus going forward. Additional studies are needed to identify cost-effective means of improving ISP targeting (to reduce crowding out of commercial fertilizer demand and increase their effects on fertilizer use) along with research on politically feasible, cost-effective alternatives to ISPs.

7. CONCLUSIONS AND LOOKING AHEAD

Africa's fertilizer market has expanded rapidly over the past two decades. A critical review of more than 180 peer-reviewed studies reveals that the literature is skewed toward fertilizer demand issues, often neglecting critical supply chain challenges such as high costs and logistics. We find an overwhelming focus on cereals and on a few countries despite Africa's diversity, growing fertilizer use in many (largely unexplored) countries, and the food security relevance of noncereal crops that could benefit from improved fertilizer use and/or use efficiency but are understudied.

This review advocates for a broader research agenda that reflects the complexity of the African continent to support ongoing efforts to increase the appropriate use of fertilizer by African farmers. With the recent commitment by African Union member states during the 2024 AFSHS to enhance access to affordable fertilizer and promote its efficient and sustainable application, there is a critical need for targeted research. We highlight some key areas where credible evidence is needed to guide country and regional efforts to facilitate the responsible and sustainable use of fertilizers, ultimately improving agricultural productivity and food security across Africa.

There is much scope for better understanding the recent growth and dynamism of the African fertilizer market. This includes more studies on African countries that have seen rapid growth in fertilizer demand (e.g., Botswana, Zambia, Namibia, and Rwanda) and supply (e.g., Togo, Mali, Tanzania, and Senegal), which could identify important drivers of growth to scale up/out. More research is needed on the different segments of the African fertilizer supply chain, recognizing that fertilizer production is not likely a reasonable or desirable goal for many countries. However, leveraging regional and continental trade options alongside efforts for local blending and distribution are important considerations for countries to identify the most cost-efficient way to supply their farmers with nutrients to meet the needs of their crops and soils.

Rigorous evidence on strategies to support a sustainable Africa fertilizer market requires more and better-quality data. For example, panel data on fertilizer supply chain actors (such as agrodealers and manufacturers) and the environments in which they operate (e.g., markets and policies) can support analyses of the drivers of their decisions and the effect of those decisions on fertilizer supply, fertilizer prices (levels and variability), and fertilizer use. Industrial organization tools can be leveraged to model and estimate the drivers and impacts of fertilizer subsector structure, supported with spatial data linking farmer fertilizer use to input market characteristics (Hernandez & Torero 2018, Hernandez et al. 2018, Rutsaert et al. 2021).

Notably, there are ongoing efforts in some countries to collect data on agrodealers, which is encouraging. We propose a medium-term goal to establish representative panel or repeated cross-section data on agrodealers across several countries (akin to a Living Standards Measurement Study–Integrated Surveys on Agriculture-like survey data collection effort, but for agrodealers). Such data would provide valuable insights into the roles of these intermediaries, enable more rigorous causal analyses, inform policy, and improve market efficiency.

In the short term, rigorous descriptive studies on midstream and downstream actors in the fertilizer supply chain (e.g., agrodealers and blending plants) can begin to fill existing knowledge gaps. This foundational research is essential for mapping out the dynamics of the fertilizer market, which can ultimately help reduce costs and increase access to affordable fertilizers for farmers. Both immediate descriptive analyses and longer-term data collection efforts are needed to create a robust evidence base to support improved African fertilizer markets and use.

On the fertilizer demand side, there is still scope to use experimental, quasi-experimental, and panel data methods to provide rigorous causal evidence on the effectiveness of cooperatives and other value chain actors in promoting appropriate fertilizer use. Also needed is more research on the agronomics and economics of fertilizer use (*a*) for diverse crops produced and consumed on the continent and (*b*) to incentivize farmer investment in soil health to increase productivity and to increase crop yield response to fertilizer.

Finally, insecurity, climate change, and other supply chain disruptions are global concerns that must be better understood in the fertilizer subsector across Africa. They can affect the entire fertilizer supply chain from input supply to farmers as well as output markets that condition fertilizer demand. The current evidence base is thin and studies to learn about the impacts of these shocks—as well as the existing and potential strategies for value chain actors to deal with these shocks—are critical for government, donors, development practitioners, and value chain actors themselves. By addressing these gaps, research can contribute to ongoing efforts to promote more effective and efficient fertilizer use in Africa for improved agricultural productivity and welfare as well as sustainability on the continent.

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