Chapter 8

AGRICULTURAL INPUTS IN KENYA: DEMAND, SUPPLY, AND THE POLICY ENVIRONMENT

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Agricultural inputs, including fertilizers, seeds, breeding stock, crop protection chemicals, machinery, irrigation, and knowledge, are key to innovation and productivity improvement, and are the backbone of any agricultural revolution. They are an integral part of the food supply chain, which comprises the production and distribution of food, and as such a key component of the food system (HLPE 2017). The food supply chain involves various actors at different stages of the chain but this chapter focuses only on agricultural inputs, including both farm inputs and agricultural advisory services.

Agricultural inputs play a critical role in supporting the farming sector and contributing to the productivity of the food system. They complement other components of the food system to enable the efficient and sustainable production of sufficient, safe, and nutritious food for diverse groups of a growing population. Hence, they are part of a support system involving other services like storage, transport, marketing, and processing that work together synergistically toward the modernization and transformation of the agriculture sector (Tiyambe 1991; Nin-Pratt 2016; Gulati et al. 2021).

This chapter presents trends in the supply and use of agricultural inputs and the evolution of policies that have affected these trends. Kenya launched its planned economic development in 1964, immediately after independence. The associated policies were based on Sessional Paper 10 of 1965 (Kenya, Republic of Kenya 1965) and were designed to revolutionize agriculture through land consolidation, extension services and training, and the introduction of modern farming methods (Kamande 2009). In the subsequent decade, the thrust of policy was agricultural intensification practices aimed at replicating the successes of the Asian Green Revolution. The focus was on addressing technical constraints in smallholder production, which included poor access

to farm inputs and credit, and lack of knowledge of agricultural production. Consequently, the government provided key services, including inputs, credit, research, and extension, to smallholders (Argwings-Kodhek 1996; Kelly, Adesina, and Gordon 2003).

In the 1980s and 1990s, structural adjustment programs were introduced to restore resource use efficiency in all sectors of the economy and hence raise the rate of economic growth. This included liberalization of input and output markets, remedying distortions in agricultural markets, and generating "efficiency" in the agriculture sector by transforming state agricultural agencies and parastatals and transferring services provision to the private sector (Kelly, Adesina, and Gordon 2003). During the 1980s, government policies focused on reducing budget deficits and external debt by decreasing government involvement in providing services in agriculture such as extension, research, credit, inputs, price-based support mechanisms, and agricultural subsidies (Ajwang, Atela, and Arora 2019). This is reflected in, for example, the Agricultural Sector Development Strategy (ASDS) of 1997, as implemented through the Agricultural Sector Investment Program (Odhiambo, Nyangito, and Nzuma 2004). While reforms in the liberalization era benefited export-oriented farming, smallholders were affected negatively by the dismantling of state services in marketing and production (Ajwang, Atela, and Arora 2019) in the context of a poorly developed private sector.

Policies in the 2000s have focused on transforming agriculture from subsistence to commercial and market-oriented production. These have included the Strategy for Revitalizing Agriculture (SRA) 2004–2014, the ASDS 2010–2020, and the Agriculture Sector Transformation and Growth Strategy (ASTGS) 2019–2029. They underscore different roles of the private sector and government. Private sector input suppliers have largely replaced parastatals and are increasingly providing diverse agricultural inputs. For instance, the ASTGS recognizes that agricultural transformation requires access to more affordable and higher-quality inputs but embodies a shift in subsidy provision. Under this, provision of inputs is the responsibility of the private sector, and subsidies are targeted only at high-need farming households, which access various inputs from multiple private sector providers through an e-voucher system.

This chapter highlights key agricultural input demand–supply systems, how policy has affected their development, lessons learned, policy implications, and research gaps to fill to ensure the smooth functioning of these systems.

The fertilizer system

Policy and institutional interventions

The fertilizer system in Kenya can be understood in the context of the policy and institutional interventions that have shaped trends and patterns in fertilizer supply and use. These interventions can be organized into three periods, as outlined in Table 8.1 (Ariga and Jayne 2011; Nduati et al. 2015). The pre-1990 period was marked by the government's heavy involvement in agricultural production and marketing activities. Fertilizer trade, including importation and distribution, was restricted to a few state agencies, and fertilizer prices were controlled. The government imported and distributed fertilizers through the Kenya Grain Growers Cooperative Union, Kenya Farmers Association, and Kenya National Trading Corporation. Poor coordination of fertilizer importation led to surpluses and deficits in fertilizer supply in the local market (Ariga and Jayne 2011).

As part of the structural adjustment program during the early to mid-1990s, the fertilizer sector was gradually liberalized. Fertilizer imports, distribution

TABLE 8.1 Evolution of Kenya's fertilizer sector policies, pre-1990–2022

Period	Policy intervention
Pre–1990	Emphasis on government control • Imposition of import licensing quotas • Fertilizer price controls • Fertilizer donations by external donor agencies • Allocation of foreign exchange
1991–2006	Fertilizer market gradually liberalized • Elimination of import licensing quotas • Removal of government price controls • Phasing-out of fertilizer donations by external donor agencies • Liberalization of foreign exchange regime • Private trade in fertilizer (including importation and distribution) permitted • Removal of custom duty and value added tax on fertilizer
2007–2022	Resurgence of government involvement in fertilizer importation and distribution • Targeted fertilizer subsidy through the National Accelerated Agricultural Input Access Programme • Subsidized fertilizer importation and distribution through the National Cereals and Produce Board • Fertilizer subsidies by county governments

Source: Authors using Ariga and Jayne (2011); Nduati et al. (2015).

restrictions, and price controls were eliminated. Private trade in fertilizer was permitted and the import duty and value-added tax were eliminated. The immediate result of relaxing these restrictions was an increase in the number of private traders in fertilizer, estimated at 12 major importers, 500 wholesalers, and 5,000 retailers (Allgood and Kilungo 1996). By 2000, there were 7,000–8,000 fertilizer retailers in Kenya (IFDC 2001).

A newly elected government in 2002 prioritized increasing fertilizer use to improve agricultural productivity and to foster broader economic growth, given the central role of the agriculture sector in Kenya's economy and its dismal performance at that time. Hence, the government developed a three-tiered fertilizer cost reduction strategy, comprising bulk procurement of fertilizer, domestic fertilizer blending and packaging, and establishment of a fertilizer manufacturing plant to meet national/regional fertilizer needs (Kenya, Ministry of State Planning 2007). It also initiated the National Accelerated Agricultural Input Access Program (NAAIAP) in response to the 2006 Abuja Declaration on Fertilizer for the African Green Revolution, in which the African Union Member States resolved to increase fertilizer usage from an average of 8 kg/ha to at least 50 kg/ha by 2015 (African Union 2006).

The NAAIAP had several components, including free provision of fertilizers for maize cultivation to resource-poor farmers in a phased manner. The targeted fertilizer subsidy was distributed through private agrodealers and thus supported private sector trade in fertilizer. The program distributed 50,800 metric tons[1] of fertilizer, valued at KSh 2.73 billion, to about 533,000 smallholder farmers in a span of seven years up to 2015. This subsidy component was terminated in 2017 and re-engineered as a more effective and efficient e-voucher program under the National Value Chain Support Programme (NVSP), discussed at the end of this subsection.

In 2008, high world prices of fertilizer combined with the post-election violence that followed Kenya's disputed presidential elections in December 2007 contributed to a doubling of fertilizer prices in the domestic market. The violence disrupted activities, including transportation and trading, in the local supply chains of goods and services. As a result of these factors, for example, the average retail price of 50 kg of diammonium phosphate (DAP), the most widely applied fertilizer, increased from KSh 2,250 in 2007 to KSh 4,500 in 2008 (Ministry of Agriculture, Livestock, Fisheries, and Cooperatives 2010a).

1 Tons refers to metric tons throughout this volume.

In response, the government introduced a "blanket" fertilizer subsidy program in 2008, referred to as the National Fertilizer Price Stabilization Plan (Kenya, Ministry of State Planning 2008; 2013). This subsidy was different from the NAAIAP in that it aimed at reducing and stabilizing local fertilizer prices to make fertilizers affordable for farmers, and it was not targeted to a specific group of farmers. Importation of the fertilizer was through competitive tendering managed by the National Cereals and Produce Board (NCPB), while distribution was through the latter's depots. Implemented through 2019, this subsidy program procured and distributed 1.27 million tons of fertilizers at a cost of KSh 28 billion over a decade. The distribution of the subsidized fertilizer through the NCPB depots made the subsidized fertilizers inaccessible for farmers who were far away, and at the same time "crowded out" some private trade in fertilizer. It is not clear whether the program was permanently discontinued or whether it was just suspended because of the fiscal constraints imposed by the COVID-19 pandemic. However, the sharp increase in global fertilizer prices in 2022 led the government to allocate money to a fertilizer subsidy for the long rainy season; this, as before, is administered through the NCPB.

In 2013, as part of the devolution of government functions, most agriculture functions were transferred to the county level . The national government has retained the role of policy development for the agriculture sector, while county governments are responsible for implementation of policies and programs. As a result, some county governments have been providing fertilizer subsidies to farmers. However, there is no coordination among the counties concerning these, and they follow no common criteria, since each county prepares its own development plan to guide its investments.

To support greater access of smallholder farmers to agricultural inputs, the national government initiated the NVSP in 2019. This aims to make a wide range of inputs accessible to targeted smallholder farmers through a nationwide e-voucher input subsidy model over the next six years. It seeks to improve the efficiency and effectiveness of delivery of the subsidy and targets 1.4 million *high-need* farming households with a subsidized package of inputs, including fertilizers, agricultural lime, certified seeds, agrochemicals, soil testing services, agricultural insurance services, and livestock and fish feed. The pilot phase began in the 2019/20 cropping year and targeted 309,076 smallholder farmers in 12 pilot counties, focused on coffee, Irish potatoes, maize, and rice. The NVSP is different from the subsidy programs described above, which emphasized fertilizer, but did not have the capacity-building component and did not involve private traders, especially agrodealers, as much.

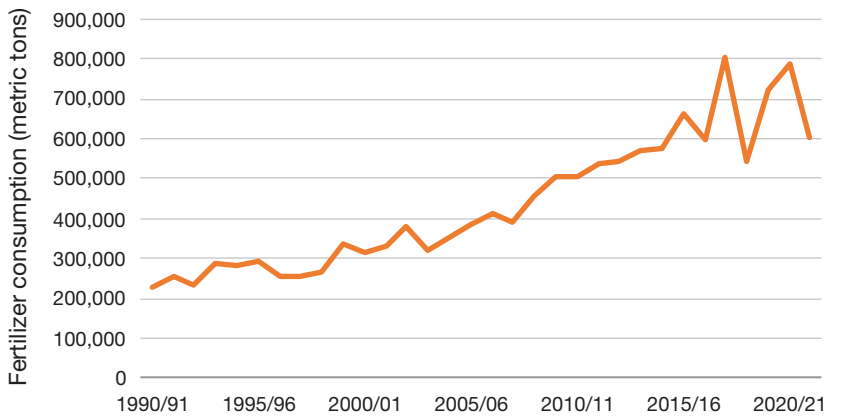
Fertilizer demand

Kenya's aggregate fertilizer consumption has risen steadily over the past three decades (Figure 8.1). Between 1990 and 2006, the period when fertilizer trade was largely in the hands of the private sector, annual growth in aggregate fertilizer consumption averaged 4.3 percent, while between 2007 and 2021, the period when the government intervened in the fertilizer market with subsidies, annual growth averaged 4.1 percent. A dip in fertilizer consumption in 2018/19 reflects a reduction in the national government's fertilizer supply under the "blanket" subsidy program (see Table 8.3).

Available evidence indicates tremendous strides in fertilizer use on farms after the market reforms. Panel household survey data collected by the Tegemeo Institute show a remarkable increase in the percentage of households that applied fertilizer on crops between 2000 and 2010 among both smallholders (cultivating less than 3 ha) and medium- to large-scale farmers (cultivating at least 3 ha) (Table 8.2). The same data also indicate that the average distance a household traveled to a fertilizer retail shop declined by 58 percent, from 8.1 to 3.4 km. However, the fertilizer application rate has remained stable, at 73–78 kg/ha, with smallholders applying at higher rates than medium- and large-scale farmers (Table 8.2).

As such, the increase in fertilizer consumption over the past years is arising more from the increased number of farmers using fertilizers and less from an

FIGURE 8.1 Trends in aggregate fertilizer consumption, 1990/91–2020/21



Source: Authors using data from Ministry of Agriculture and Food Security (2010a), Ministry of Agriculture, Livestock, and Fisheries (2015); AfricaFertilizer (https://vifaakenya.org/#/kenya/use).

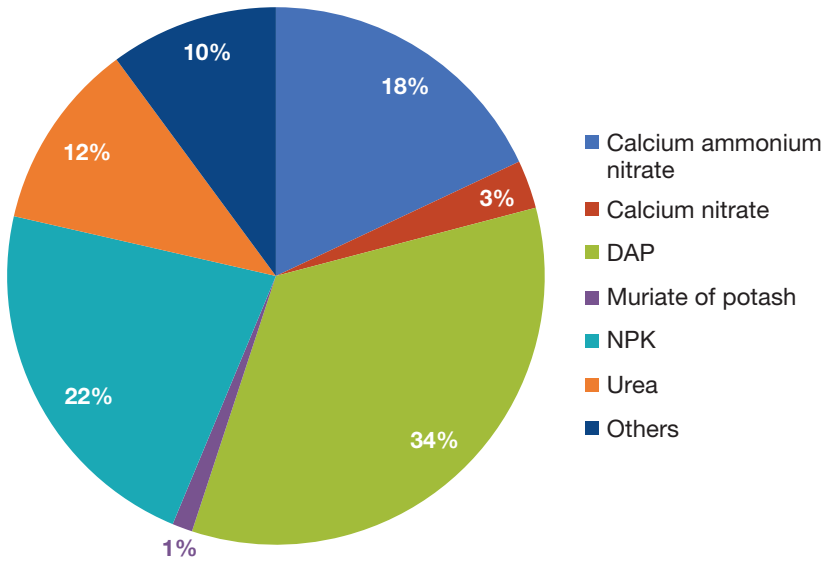
TABLE 8.2 Share of farm households applying fertilizers and average application rate, 2000–2014

Year	Cultivated less than 3 ha			Cultivated 3 ha or more			Whole sample		
	Sample size	% of households applying	Mean application rate (kg/ha)	Sample size	% of households applying	Mean application rate (kg/ha)	Sample size	% of households applying	Mean application rate (kg/ha)
2000	1,315	67.7	78	163	66.9	59	1,478	67.59	75
2004	1,254	71.2	75	143	72.0	59	1,397	71.30	73
2007	1,219	75.4	79	116	85.3	77	1,335	76.25	78
2010	1,224	74.3	75	83	86.7	66	1,307	75.06	74
2014	6,179	66.6	75	114	57.9	63	6,293	66.45	75

Source: Authors using Tegemeo Institute household survey data.

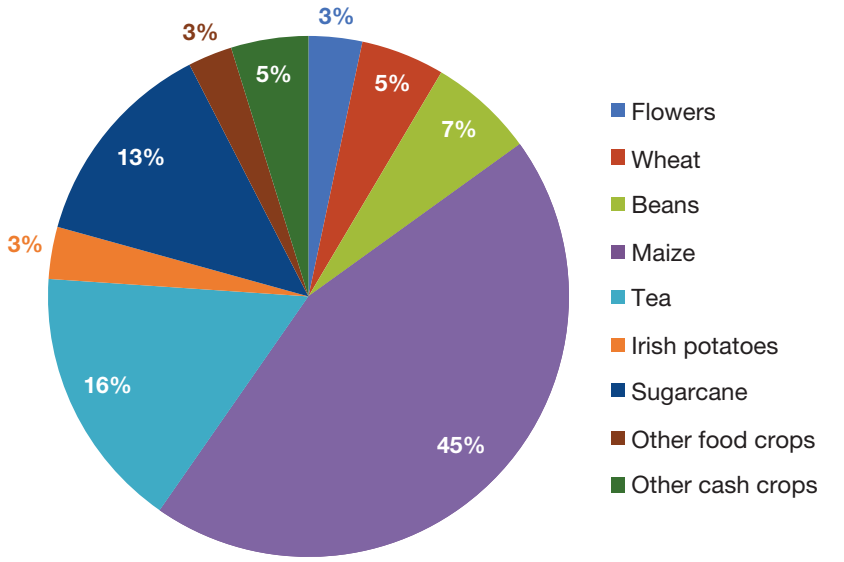
Note: Data for 2000, 2004, 2007, and 2010 are panel data, and the sample was mainly in the high rainfall areas of Kenya. Data for 2014 are cross-sectional and had wider geographical coverage, including in semiarid areas of Kenya.

FIGURE 8.2 Share of main fertilizer types in aggregate fertilizer consumption, average for 2010–2021



Source: Authors using data from AfricaFertilizer (https://vifaakenya.org/#/kenya/use).

FIGURE 8.3 Share of crops in aggregate fertilizer consumption, average for 2011–2016



Source: Authors using data from AfricaFertilizer (https://vifaakenya.org/#/kenya/use).

increased application rate. However, increasing prices of fertilizers in recent years may dampen the gains made in making fertilizers accessible to more farmers, especially smallholders. In addition, Duflo, Kremer, and Robinson (2011) find that providing farmers with information about the benefits of fertilizer use alone is not enough to encourage adoption; but, when coupled with a small incentive, such as a discount on the price of fertilizer, the adoption rate increases substantially.

In terms of the share of various fertilizer types in aggregate consumption, DAP accounts for over one-third of all fertilizer consumed, followed by nitrogen, phosphorous, and potassium (NPK) fertilizers, at 22 percent (Figure 8.2). It is worth noting that most of the NPK fertilizers are applied on tea, which ranks second after maize in terms of the share of crops in aggregate fertilizer consumption (Figure 8.3).

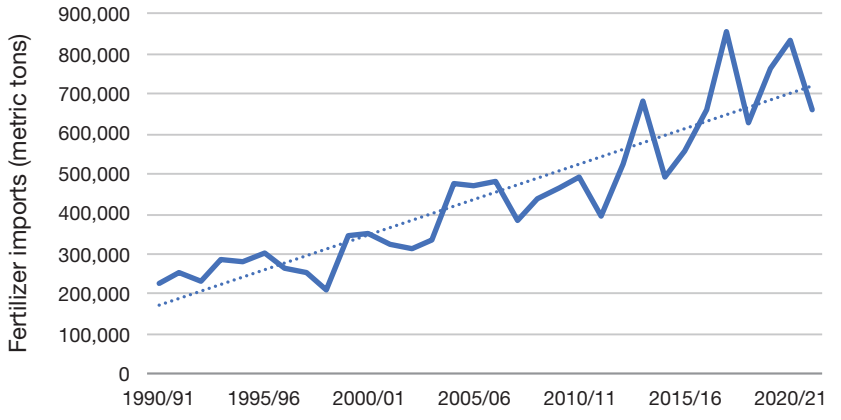
Fertilizer supply and distribution

Kenya relies on imports for virtually all its fertilizer needs. The only fertilizer manufactured in the country is the single super phosphate, while fertilizer blending is currently done by only four companies. In 2012, the government

commissioned a feasibility study to determine the potential for local fertilizer manufacturing. This concluded that, for fertilizer manufacturing to be a viable investment in the country, the required raw materials (natural gas and phosphate rock) had to be available in commercial quantities and the internal rate of return to the investment needed to be above 15 percent. It found that the government would need to invest at least 30 percent in capital expenditure to incentivize a strategic investor in fertilizer manufacturing. Also, it would be cheaper for Kenya to continue importing fertilizers rather than importing raw materials to manufacture the commodity locally. These findings made the government reconsider its position on fertilizer manufacturing in the near term.

Fertilizer imports show a general increasing trend over the three decades and reflect increasing demand (Figure 8.4). Kenya has approximately 18 active fertilizer importers, with the largest 3 accounting for 55.7 percent of the imports (Oseko and Dienya 2015). Fertilizer distribution is through three main channels: the commodity-based interlinked input–credit–output marketing system implemented mainly by the Kenya Tea Development Agency, for tea; a network of private importers, wholesalers, and retailers; and, government distribution through the subsidy programs. The network of private players comprises the 18 active importers, 150 hubs (wholesale agrodealers), and 8,000 retail agrodealers. These private traders are driven by profit rather than an interest in farm development, and thus mainly stock a few fertilizer types that are familiar to farmers and that sell quickly.

FIGURE 8.4 Trends in fertilizer imports, 1990/91–2020/21



Source: Authors using data from Ministry of Agriculture, Livestock, and Fisheries (2010a, 2015); AfricaFertilizer (https://vifaakenya.org/#/kenya/use).

TABLE 8.3 Quantity of fertilizer procured by government vs. total imports, 2008/09–2018/19

Year	Total fertilizer imported (metric tons)	Quantity of fertilizer procured by government (metric tons)	Share of government procurement in total imports (%)
2008/09	440,689	129,746	29.4
2009/10	465,674	16,624	3.6
2010/11	493,567	96,000	19.5
2011/12	395,774	94,155	23.8
2012/13	522,595	66,276	12.7
2013/14	684,448	171,750	25.1
2014/15	494,718	205,955	41.6
2015/16	556,433	147,926	26.6
2016/17	659,834	177,600	26.9
2017/18	855,044	160,900	18.8
2018/19	626,419	44,250	7.1
Total	**6,195,195**	**1,266,931**	**20.5**

Source: Authors using data from Ministry of Agriculture, Livestock, and Fisheries (2010, 2015); AfricaFertilizer (https://vifaak-enya.org/#/kenya/use).

Fertilizer procured by the government between 2008 and 2019 through the National Fertilizer Price Stabilization Plan accounted for 21 percent of Kenya's total fertilizer imports (Table 8.3). This does not include fertilizers procured by county governments for their subsidy programs, which we estimate to be 44,403 tons between 2013 and 2017 (a period of five years) based on the achievement reports contained in the 2018–2022 County Integrated Development Plans for individual counties.[2] The government's share of fertilizer imports has varied with budgetary allocation for the subsidy program, which has not been consistent over time. Major sources of Kenya's fertilizer imports have been the United States and Saudi Arabia (DAP), Russia and Ukraine (urea), and Ukraine and Norway (calcium ammonium nitrate).

Lessons learned and policy considerations for the fertilizer system

- Kenya achieved impressive growth in fertilizer use without government subsidies. Policy reforms and government investments in transport infrastructure have worked synergistically to incentivize private sector investment in fertilizer trade.

2 These are available at Council of Governors (nd).

- While a range of fertilizer types exist in the Kenyan market, farmers have largely stuck to DAP despite soil acidity concerns, which have motivated increased investment in fertilizer blending. There is a need to prioritize farmer learning through more effective extension services. The NVSP, which includes capacity-building for extension staff, farmers, and agrodealers, should be supported.
- Among the challenges encountered in the National Fertilizer Price Stabilization Plan were delayed procurement and delivery of inputs to farmers, poor targeting of beneficiaries, inability of many farmers to reach NCPB depots because of long distances, and inadequate and inconsistent budgetary allocations. These challenges can be addressed to make the NVSP more efficient and effective.
- While some county governments provide fertilizer subsidies, information about targeting, quantity, pricing, fertilizer types, and mode of delivery is not publicly available. Lack of access to such information may hinder proper planning by fertilizer market players.
- Because Kenya relies on imports for its fertilizer needs, and there is considerable instability in fertilizer world prices, fertilizer subsidies will likely continue to be on the government's development policy agenda for the foreseeable future. Therefore, there is a need to ensure that Kenya's gains in expanding private sector trade in fertilizer are sustained.

Seed systems

Seed delivery systems in Kenya are categorized as formal, informal, seed aid, and mixed (CTA 2014). The formal sector refers to the production, processing, packaging, labeling, and marketing of certified seed by registered producers, whereas the informal system denotes production, processing, marketing, and distribution of seed by unregistered seed producers. The formal system started with the establishment of the Kenya Seed Company in 1956 to produce pasture seed for the colonial settlers. Liberalization of the industry in 1996 paved the way for several companies to enter the formal sector, and by 2005 there were 50 registered seed companies (Ministry of Agriculture 2010b). The big companies focused on seeds for cereals (maize, wheat, barley, oats, triticale, and sorghum), oil crops (rapeseed and sunflower), pulses, pastures, horticultural crops, and Irish potatoes. The government provided resources to support the sector to

equip technology incubation centers and train technical services teams on testing, inspection, and certification procedures.

The informal seed sector is the major source of planting material for farmers, though the exact source may not be known and the quality of the seed may be questionable (Ministry of Agriculture 2010b). Informal seed sources include "roadside" nurseries for forest and fruit trees, farm-saved seed, farmer-to-farmer exchange, local markets, nongovernmental organizations (NGOs), and community-based organizations (CBOs). Flower companies are also engaged in the informal seed sector through importation and/or local multiplication of the planting material for their own use and sale to other local growers, although they are not registered as seed dealers.

Additionally, Seed Aid (emergency seed) started as a collaborative program between the government, NGOs, CBOs, farmers, and development agencies to supply seeds to communities facing acute seed shortages following drought-related stress in 1992. Although this program was intended to be a limited, one-time intervention, it has become a regular seed source for affected communities. However, its operations are poorly linked with the formal research system.

The mixed seed system combines elements from the formal and informal systems. It is operated by small seed companies and/or commercially oriented individual seed producers that may or may not be registered, with part of the seed produced locally under a certification scheme or imported and packaged locally. Such producers may provide seed for emergency aid, often by cleaning, dressing, and packaging commodities not intended for seed use. An integrated seed delivery system is proposed to respond to the limitations associated with the current seed delivery systems.

The ASTGS acknowledges that providing quality and affordable seeds is an important entry point in promoting agricultural productivity and resilience among smallholder farmers and pastoral communities in Kenya. However, the seed sector faces challenges including limited adoption of new varieties, erosion of plant genetic resources, inadequate seed security stocks, national seed policies that are based on institutions rather than farmers, lack of a clear seed strategy, inefficient extension services, deficient marketing policies, and limited collaboration within the seed sector (FAO 2001). Seed counterfeit issues have been solved through the implementation of regulations by the Kenya Plant Health Inspectorate Service (KEPHIS).

The trends and patterns of seed and supply vary by the type of seed system in use and the agents involved in the seed supply chain. The major roles in the formal seed sector include research and breeding, variety release and regulation,

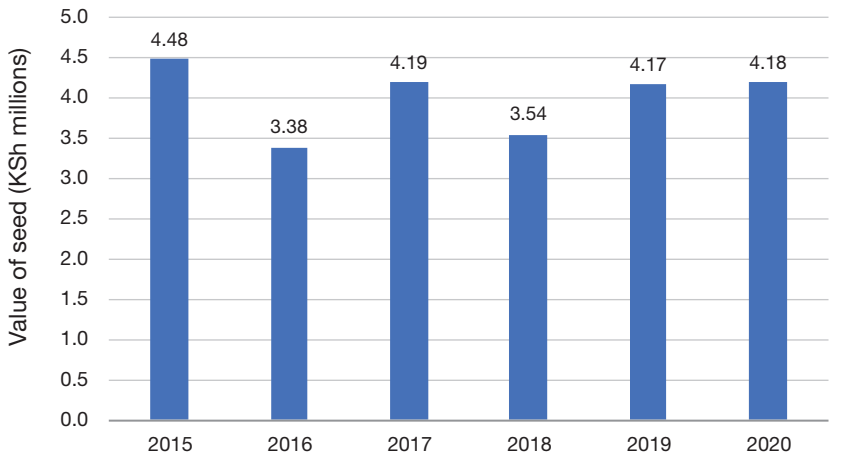
breeder and foundation seed production, seed production, processing and packaging, capacity building, and distribution (Kuhlmann and Zhou 2015).

Trends and patterns in seed usage

The value of seed (mainly certified) demanded in Kenya has been stable over the years (except for in 2016 and 2018), with the highest value recorded in 2015 (Figure 8.5). Official statistics represent seed that is handled by the formal sector and hence is certified seed. There is limited certified seed of pigeon pea, cowpea, sorghum, millet, or green gram produced by private companies, with the demand for such crops often filled by open pollinated varieties. This is because their demand is considered unreliable and insufficient to make a viable business for many seed companies; it is often argued that farmers will buy seeds once and use farm-saved seeds in subsequent seasons.

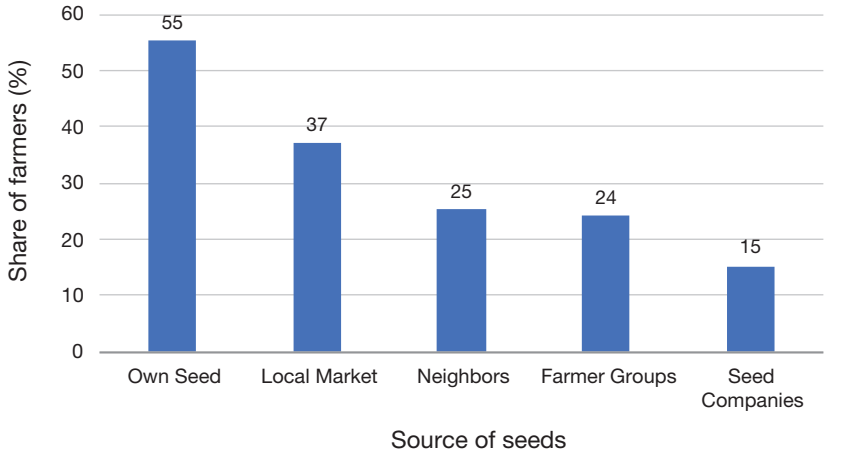
Overall, a substantial percentage of seeds in Kenya comes from the informal sector, with the main sources being "own seed," followed by local market, neighbors, farmer groups, and seed companies (Figure 8.6). Field days and agricultural shows are the most common sources of seed information within the sector, representing 68 percent and 50 percent, respectively.

FIGURE 8.5 Value of seed planted, 2015–2020



Source: KNBS (2021).

FIGURE 8.6 Main sources of seed as per the share of farmers served



Source: Recha and Recha (2018).

Trends and patterns in seed supply

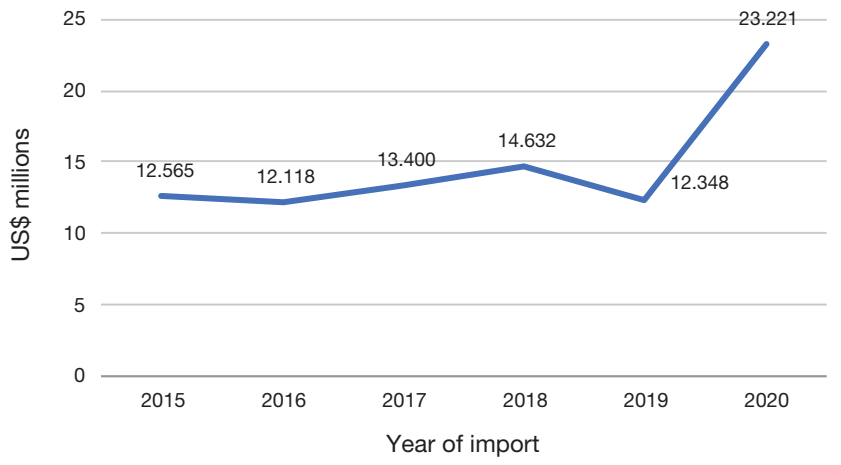
The value of imported seeds has remained stable, except in 2020, when it almost doubled from the previous year (Figure 8.7). This increase is due to the costly and time-consuming exemption of plants, seeds, and seedlings from the Pre-Shipment Verification of Conformity requirement. Vegetable seeds are the most imported seed; their value has increased over time, almost doubling between 2019 and 2020 (Trade Map). This is partly a result of the increasing consumption of vegetables and the use of certified seeds that are imported. The value of imports of seeds for herbaceous plants cultivated mainly for flowers and those for forage plants has also increased (Trade Map).

The major source of seed imports is the United States, accounting for approximately a quarter of the seed (based on the value of the imports) (Figure 8.8). However, in 2020, South Africa and India took a larger share of the market at 18 percent and 17 percent, respectively, while the United States supplied 20 percent of the total value of the imports.

Policies and their effects on seed supply and use

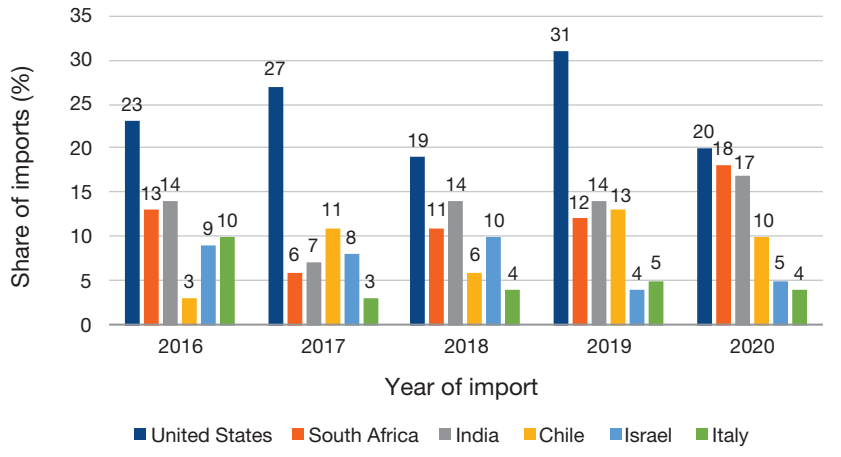
The National Seed Policy of 2010 provides a framework for the seed industry to realize the full potential of improved varieties, facilitate effective regulation of the seed industry, and create an enabling environment for effective public and

FIGURE 8.7 Value of seed imported to Kenya, 2015–2020



Source: Trade Map (https://www.trademap.org/).

FIGURE 8.8 Proportion of imported seed from major source countries, 2016–2020



Source: Trade Map (https://www.trademap.org/).

private sector participation in the production and use of quality seeds. The seed industry is regulated by KEPHIS, while the Seed Traders Association of Kenya brings seed companies together with members of the private and public sectors

(Access to Seeds Foundation nd). In addition to the National Seed Policy, Kenya regulates the seed sector through several legal instruments, including the Seed Act, last amended 2012; the Crops Act 2013; and the Plant Protection Act, enforced under the KPHIS Act 2012. In addition, the Agriculture, Fisheries and Food Authority Act 2013; the Pest Control Products Act, revised in 2012; and those involved in the implementation of the Seed Policy Directives apply related regulations such as the Seed and Varieties Regulations and the Plant Variety Protection Ordinance. Laws and regulations have recently been changed to authorize certain seed certification activities on behalf of the regulator, to include forest tree seeds and other species, including wild plant domestication, and to establish a center for plant genetic resources.

With the entry into force of regional seed protocols through the harmonization of seed regulations within the Common Market for Eastern and Southern Africa (COMESA), the development potential of Kenya's seed system will increase, as will the possibility of challenges in implementing laws and regulations (Kuhlmann and Zhou 2015). Kenya is also a signatory to other international treaties, including the World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights, and has been a member of the International Union for the Protection of New Varieties of Plants since May 1999 and thus has adopted the Seed and Variety Regulations, Subordination to the Seed Act (Cap 326) to grant and protect plant breeders' rights (Kuhlmann and Zhou 2015). However, varied degrees of harmonization between regions can lead to challenges in cross-border trade in terms of quality standards and plant breeders' rights. In addition, data availability constraints limit development and planning in the seed system in Kenya and the region.

Lessons learned and policy considerations for seeds

Availability of and access to high-quality seeds are critical to improved productivity and food security. Over 80 percent of farmers obtain seeds for their main crops (excluding corn) from the informal sector, while infrastructure supporting R&D as well as regulations are aligned with the formal system. The size of the informal system suggests a need to implement an integrated seed system that combines the improved seed technologies in the formal sector and the responsiveness of the informal sector in supplying seeds for rare crops, legumes, native vegetables, and tubers (Munyi and de Jonge 2015). This requires (1) integration of the informal seed system into government investment plans in R&D and (2) development of a policy and regulatory framework responsive to the seed subsector.

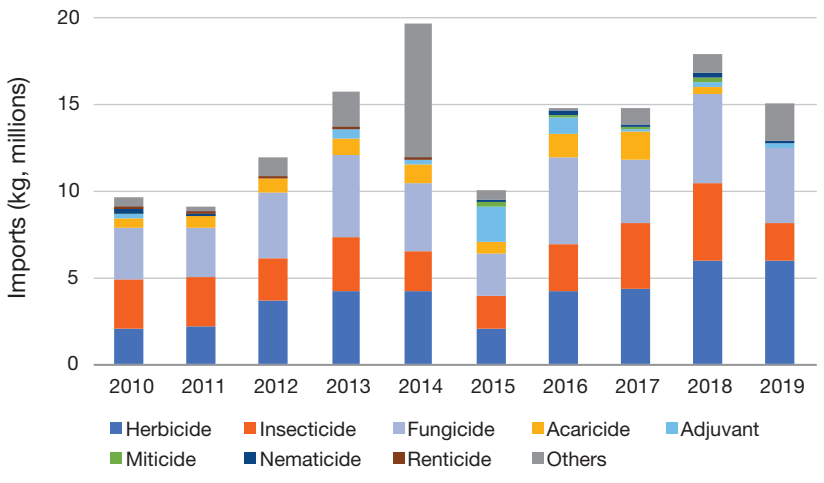
Plant protection inputs

The agriculture sector has faced increasingly frequent pest and disease outbreaks, as a result of climate change, which has made the environment friendlier for some of the vectors, migratory pests, and also increased transboundary trade that makes countries with lax regulations a risk to others (Skendžić et al. 2021). For instance, the fall armyworm was first reported in Western Kenya in 2016 but is now a major pest in the country, leading to a loss of about 33 percent in annual maize production, estimated at about 1 million tons (De Groote et al. 2020). To address these challenges, the use of plant protection products is necessary. This section explains trends in pesticide use and the policy environment governing the use and disposal of pesticides in Kenya.

Trends in pesticide supply and use

Kenya imports about 90 percent of its chemical pesticides (GIZ 2019). The main classes of pesticides imported are herbicides, pesticides, fungicides, acaricides, fumigants, and nematicides. Figure 8.9 shows trends in imported pesticides between 2010 and 2019. Fungicides were the largest class of pesticides imported during this period, accounting for about one-third of the volumes. The other major classes were insecticides and herbicides. These three classes accounted for about 80 percent of the imported volumes (AAK 2021). China

FIGURE 8.9 Imported pesticide volumes, 2010–2019



Source: Data from AAK (2020).

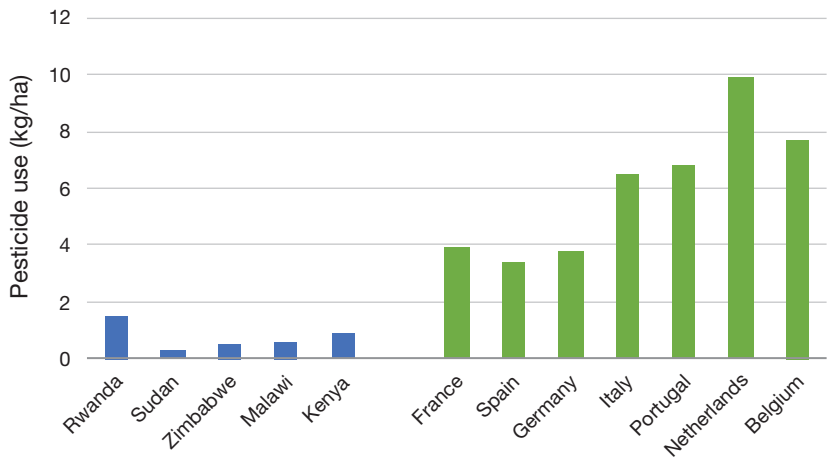
and the European Union are the leading sources of pesticides, at 42 percent and 30 percent, respectively.

As expected, use of agrochemicals has increased significantly in the past five years in direct response to the increased incidence of pests and diseases, particularly maize lethal necrosis disease, fall armyworm, and tomato leaf miner. For key commodities such as coffee, horticultural products, and flowers, pest and disease management continue to be a critical production challenge, hence the need to balance increased productivity and safe use and disposal of pesticides. About 18 percent of pesticides used in Kenya are regarded as counterfeit, mainly imported through Uganda and Tanzania (Sarkar et al. 2021). Also, the current disposal of pesticide products after use, or those that are unsold or expired, raises safety concerns.

Pesticide use patterns

Data availability on pesticide use per hectare is limited, and this remains a key gap in addressing food safety issues. It has been estimated that pesticide use in Kenya is less than 1 kg/ha (Figure 8.10). This is consistent with other sub-Saharan African countries that have very low use, such as Rwanda, Sudan, Zimbabwe, and Malawi (Sharma 2019). Conversely, pesticide use in Europe is significantly higher, ranging from 3.35 kg/ha in Spain to 9.86 kg/ha in the Netherlands. Low

FIGURE 8.10 Per hectare pesticide use in several African and European countries, 2014



Source: Authors using secondary data (WHO 2019).

utilization in Kenya is consistent with the majority of producers being smallholder subsistence farmers. As the country moves toward the commercialization of agriculture, consumption of plant protection products is expected to increase.

Pesticide policy and regulatory framework

The regulatory framework governing pesticide use in Kenya is widely regarded as one of the most rigorous in Africa, and one of the closest to global benchmarks. Several bodies are involved in the regulation of the use of pesticides and agrochemicals. These include the Pest Control Products Board (PCPB), KEPHIS, and the National Environmental Management Agency (NEMA). The industry also has a self-regulatory mechanism under the Agrochemical Association of Kenya (AAK), which by the end of 2020 had 68 members that were small and medium-sized enterprises involved in the packaging and distribution of pesticides. The Ministry of Agriculture and Livestock Development also plays a critical role in shaping policy on agrochemicals.

PCPB is the primary regulator for pesticide products in the country, mainly responsible for the approval and registration of plant protection products. KEPHIS supports the monitoring of pesticide residues in agricultural products and of threats to agricultural production from pests and diseases. NEMA's mandate is to ensure environmental health for the various land uses through monitoring and enforcement of environmental protection laws. The national government, through the Ministry of Agriculture, Livestock, Fisheries, and Cooperatives, leads in policy development for the sector, including policies on the use and disposal of pesticide products. The Ministry of Health plays a vital role in food safety policies, while county governments ensure the safe use and disposal of pesticide products through the extension function.

AAK has made significant investments to promote the safe use and disposal of pesticides. Industry players developed a brand/mark of quality for pesticide products imported by members of the industry association. Association members invest in field days and demonstrations to train farmers on how to safely use and dispose of pesticide products. This includes training of service providers, who are also equipped with protective gear. Other investments by the industry are in compliance with packaging and labeling requirements and in traceability systems, especially for horticulture products.

Altogether, these institutions are expected to ensure the safe use of pesticide products from production and supply chains until they reach consumers. This includes strict compliance with registration requirements, use and disposal of products, and monitoring of residues in agricultural products. The Pest

Control Products Act, revised in 2012, and its regulations govern the use of pesticide products.

Policy challenges affecting the use of pesticides

Implementation of the regulations on pesticides in the country has faced several challenges. Surveillance and monitoring systems for pesticide use and disposal are weak. This stems from weak data collection systems, lack of investment in modern laboratories to undertake pesticide toxicology testing, and limited funding for R&D to support the regulations. Lack of financial resources has hampered staffing capacities for the regulatory bodies and for key functions such as routine monitoring and surveillance. Additionally, knowhow on pesticide use and disposal among users, especially smallholders, is constrained by the collapsed public extension system on which the majority of farmers relied for information on farming practices. Although the country has established a standard, the Kenya Good Agricultural Practice (KenyaGAP)[3] (Carey 2008), its adoption remains low among farmers, and domestic food markets do not incentivize its adoption through the pricing of products.

Significant gaps remain on the regional front. Key among them is that most of the COMESA Member States have underdeveloped capacity to address trade constraints related to pesticide maximum residue limits (MRLs). This poses difficulties in the production of safe food for both domestic and international markets. Often, the absence of MRL assessment results from a lack of residue data for the particular crop/pesticide combination. Also, most COMESA countries cannot generate high-quality data to establish international trade standards. Regional collaboration on the registration of pesticides and the sharing of registration procedures and data are widely reported not to be robust within the COMESA region or greater sub-Saharan Africa (USDA 2016).

Lessons learned and policy considerations for pesticides

Per hectare use of pesticides in Kenya is much lower compared with use in European countries but similar to that for countries within the region. However, per hectare use is likely to rise as the country moves toward the commercialization of agriculture, and as incidence of pests and diseases increases. This will imply the need to balance increased productivity, and safe use and disposal of pesticides. Strategies to attain this balance include adoption of improved management practices such as varieties resistant to specific pests, diseases, and weeds;

3 KenyaGAP is benchmarked to the internationally recognized GLOBALGAP standard for fruit, vegetables, and flowers.

integrated pest and disease management practices; GAPs; climate-smart crop production practices and technologies; crop rotation to break vector reproduction cycles; and biological control of vectors.

Knowledge and information systems

Low productivity in sub-Saharan African agriculture is attributed to many factors (World Bank 2018; Bonilla-Cedrez, Chamberlin, and Hijmans 2021), key among them being low input use. For instance, low yields in potato farming in Kenya have been blamed on a failure to use clean seeds, fertilizers, fungicides, and irrigation (Wang'ombe and van Dijk 2013)—farmers adopting such technology have more than doubled their yields. Low adoption of technologies has been associated with insufficient knowledge on best practices among intended users and insufficient information to assess benefits associated with using a product, as well as on liquidity constraints, access (Simtowe et al. 2021), and the risks associated with the product. This section discusses the importance of information and extension services and their effect on the supply and usage of agricultural inputs, as well as policies that have shaped information systems and extension services over the years.

Agricultural extension and information systems and input supply and usage

Information helps farmers understand the benefits associated with specific product use (Mastenbroek, Sirutyte, and Sparrow 2021). Thus, when lack of knowledge about the product or lack of information is the barrier to adoption (Shiferaw et al. 2015; Shikuku 2019), relevant information can increase the adoption rate. When such knowledge and information remain inaccessible to different stakeholders, or are not packaged in a form suitable for use by farmers, this affects both supply and demand for agricultural inputs. In Kenya, agricultural information has predominantly comprised technical information on production knowhow and agronomic practices; crop varieties or animal breeds; types of fertilizer, feeds, and pesticides; and their application and where to source them. It has also comprised market information, weather forecasts, and weather-informed advisories on pest incidence, control, and management. More recently, sources of information have expanded to include providers of early warning alerts on risks emanating from pests and weather and climate shocks, and agro-advisories based on weather realities. Considering that farmers are generally unwilling to pay for this information, it is predominantly supplied by the public sector, mainly research institutes and government agencies, which

is justified by market failures in the provision of this public good (Anderson and Feder 2004; Maffioli et al. 2011). Regional and international research institutes, the private sector, civil society, and farmer organizations are also important sources of information.

Extension services enable research-to-farm technology diffusion and help overcome the information barrier to adoption by transferring information from research to farmers (Kondylis, Mueller, and Zhu 2017). They also support farmers' decisions on the adoption of technologies by providing information on the advantages, value, or risks associated with a technology (Anderson and Feder 2004; Wanyoike 2019). Extension service providers are also well placed to build capacities of farmers in good agronomic practices (AGRA nd). In some extension models, farmers are linked to other actors in the economy, including input dealers, agro-processors, marketers, and financial institutions (AGRA nd; Farmingtech Solutions nd; Kuza Biashara nd; One Acre Fund nd). Hence, extension service is a critical change agent required to transform smallholder agriculture (Kenya, Agricultural Sector Coordination Unit 2012a). Although proximity to extension service providers is important in the uptake of productivity-enhancing inputs (Muyanga and Jayne 2006), there is now a shift toward digitally enabled extension such as Digital Green and Kuza Biashara. Kenya is a leading agrotechnology hub, with about 60 scalable disruptive agricultural technologies operational in the country (Jeehye et al. 2020).

Policies affecting the agricultural information system and extension services

The government recognizes that transformation of the agriculture sector is knowledge-intensive. However, the nonexistence of appropriate policy and infrastructure for ICT and knowledge management has been a major cause for low technology uptake and the broadening gap between knowledge and application (Kenya, Agricultural Sector Coordination Unit 2012b, 2021). Hence, the expectation is that various public sector-driven information systems will enhance the use of information and the application of technology by various actors.

The National Agricultural Research System Policy (Kenya, Ministry of Agriculture, Livestock, Fisheries and Cooperatives 2021) aims at creating an efficient and effective agricultural knowledge management system by developing an Integrated Agricultural Management Information System as a strategy for improving the processing, storing, and management of knowledge. This is envisioned as a one-stop-shop for all actors, holding all information and knowledge related to agricultural research. To accomplish this, capacities

in brokerage and the deployment of knowledge and technology to end-users will be strengthened, and the development and testing of innovative extension approaches will be encouraged (Kenya, Ministry of Agriculture, Livestock, Fisheries and Cooperatives 2021).

The critical role of extension services in the development of Kenya's agriculture sector was first espoused in Sessional Paper 10 of 1965. Determined to revolutionize agriculture, the government identified extension services and training as key in smallholder production (Kenya, Republic of Kenya 1965). Farmer and pastoralist training centers were established across the country to provide extension services to smallholders. Since then, government policies and strategies have influenced the level and stability of funding for agricultural extension services; methods and approaches to extension service provision; and the role of extension providers.

For instance, the World Bank-supported "training and visit extension approach" was introduced in 1982 to supplement the existing extension (Evanson and Mwabu 1998). This was characterized by frequent and continuous training of extension workers, regular and scheduled visits to farmers' fields, and linkages with research. It was later abandoned for being too demanding on resources and for not allowing farmers to articulate their needs, and hence as unsustainable (Kenya, Agricultural Sector Coordination Unit 2012b, 2021). A "commodity-specialized approach" was also in place, led by agricultural commodity boards and private companies. In subsequent years, the government's emphasis has been on intensification through the use of purchased inputs and the commercialization of agriculture as articulated in the SRA, ASDS and, currently, ASTGS.

For years, the government was the sole supplier of extension services to smallholder farmers. This public extension service was, however, criticized for being unable to serve the demands of a modernizing agriculture sector (Muyanga and Jayne 2006; Anderson and Feder 2004). A subsequent decision to freeze public employment and reduce funding in the early 1990s resulted in a massive reduction in public sector extension staff and facilitation (Evanson and Mwabu 1998; Muyanga and Jayne 2006). This greatly affected coverage by extension services, resulting in ineffective service delivery (Kenya, Agricultural Sector Coordination Unit 2012a; Simtowe et al. 2021). Gaps in public extension services led to the emergence of other extension service providers, including faith-based organizations, CBOs and NGOs, the private sector, and, more recently, start-ups that are revolutionizing extension services through digitalization.

Other notable policies have included the National Agricultural Extension Policy, implemented through the National Agriculture and Livestock Extension Programme, which intended to address the aforementioned challenges by promoting pluralistic, efficient, effective, and demand-driven extension services (Muyanga and Jayne 2006). Implementation of an information service—the National Farmers Information Service—was affected by poor funding.

The National Agricultural Sector Extension Policy was later introduced to provide a plan for information and communication, and directions for improved technology delivery to end-users. The policy aimed to see the agriculture sector served by commercialized extension services, while the government would continue providing subsidized services for non-market enterprises and in disadvantaged communities, or partially charge for the services offered. For quality assurance, registration and licensing for extension service providers was to be instituted, and standards enforced. The government would then promote decentralized extension service in line with the devolved structures, empower farmers to organize themselves, and link them to critical resources. It would also encourage the use of ICT and mass media to enhance information sharing. The ASDS supported this policy by focusing on "strengthening and reforming provision of extension services using coordinated, decentralized, multi-sectoral and multidisciplinary approaches that respond to user demand" (nd). Gradual privatization of extension services and capacity building for other extension service providers were key.

Extension services were devolved in 2013 with the aim at taking services closer to the farmers. Realization of the vision for extension was, however, negatively affected by poor coordination between the two levels of government, and inadequate resourcing for agriculture departments in counties. The National Agricultural and Rural Inclusive Growth Project and the Kenya Climate Smart Agriculture Project are designed to overcome these challenges, through better coordination of extension services and partnering with private service providers within counties to deliver the services.

The ASTGS seeks to reduce the ratio of extension officers to farmers by increasing the number of extension personnel (to 3,000 digitally enabled youth extension officers and 200 transformation leaders) (Kenya, Ministry of Agriculture, Livestock, Fisheries and Irrigation 2019). The NVSP is already deploying digitally enabled extension agents in its e-voucher program.

Lessons learned and policy considerations for knowledge and information systems

- Kenya's policies on knowledge and information systems have been progressive, highly adaptive, and responsive to challenges encountered in the management and dissemination of information. Their full effects on technology adoption in smallholder farms have, however, been curtailed by the partial implementation of these policies as a result of poor coordination and under-resourcing.
- Entry of multiple actors and digitalization have pushed the frontier in extension service provision, with tangible effects on input supply and use on smallholder farms.
- Continual improvement of the information system and extension service necessitates the documentation of impacts of policies, and lessons learned being used to inform subsequent policies and programs.

Conclusion

Kenya's policies on inputs have largely been progressive, and have played a critical role in influencing the dynamics of demand and supply of agriculture inputs. However, the policy environment has faced challenges of an incoherent policy mix and negative effects of some policies. For instance, although agricultural input markets are largely liberalized, the country has continued to use subsidies to reduce the cost of inputs, and these have crowded out private sector investment.

The supply of inputs is hampered by unreliable distribution networks and high costs. Hence, there is a need to improve transport infrastructure and eliminate nontariff barriers (for example, delays at roadblocks and weighbridges) and multiple and burdensome regulations, charges, and taxes. The presence of counterfeit products has affected the quality of inputs. This can be addressed through digitally enabled mechanisms to verify the quality of fertilizers and seeds. To improve crop response to fertilizer, and the profitability of its use, a holistic approach is required that focuses on interventions to enhance soil health rather than just access to inorganic fertilizer. The NVSP e-voucher program will support this, since the subsidy package has lime and soil testing services, among other components that will enhance productivity.

Pesticide use is low but is expected to increase as the country moves toward the commercialization and intensification of agriculture. This needs to be accompanied by the safe use and disposal of pesticides through awareness creation and training through extension systems.

Kenya is a leading agrotechnology hub, which presents an opportunity to use digital solutions to link farmers to input and service providers (extension, agro-weather, and so on) and to scale up these solutions for greater impact.

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