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Evaluating Kenya's National Fertilizer Subsidy Program: Implementation, Crowding-out, and Benefit-Cost Assessment

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Acronyms and Abbreviations

AP	Average Product
APE	Average Partial Effect
BCA	Benefit-Cost Analyses
BCR	Benefit-Cost Ratio
CAN	Calcium Ammonium Nitrate
DAP	Diammonium Phosphate
GOK	Government of Kenya
IPP	Import Parity Price
ISP	Input Subsidy Programs
KES	Kenyan Shilling
KNTC	Kenyan National Trading Corporation
LR	Long Rains
MT	Metric Tonne
NAAIAP	National Accelerated Agricultural Input Access Program
NCPB	National Cereals and Produce Board
NFPSP	National Fertilizer Price Stabilization Plan
NFSP	National Fertilizer Subsidy Programme
NPK	Nitrogen Phosphorous Potassium
NVSP	National Value Chain Support Program
RDD	Random Digit Dialing
SMS	Short Message Service
SR	Short Rains
SRS	Simple Random Sampling
SSA	sub-Saharan Africa
USDA	United States Department of Agriculture
USAID	United States Agency for International Development
USD	United States Dollars

Executive Summary

The current National Fertilizer Subsidy Program (NFSP) in Kenya was introduced in 2023 in response to rising global food and fertilizer prices, with the goal of enhancing food production and improving national food security. This study evaluates the NFSP's effectiveness by examining key outcomes at the farm level and its broader economic impacts.

The program provides subsidized fertilizer to Kenyan farmers through government-run distribution channels, selling it at prices significantly below market rates. However, despite an initial promise of wide availability, only 25% of households acquired the subsidized fertilizer in the long rains season of 2023. The evaluation revealed disparities in access, with larger-scale, wealthier farmers benefitting more than smallholders, raising concerns about equity in program delivery. Furthermore, the untargeted nature of the NFSP limited its effectiveness in reaching resource-constrained farmers who would have otherwise not used fertilizer, reducing the program's overall impact on total fertilizer use and productivity.

Key findings from the analysis include:

1. **Access and Timing:** Though 46% of households registered for the program in 2023, only 32% received an SMS notification and just 19% obtained the subsidized fertilizer. Moreover, the distribution lagged behind the private sector, with NFSP fertilizers being delivered later, although most farmers that received the subsidized fertilizer reported receiving it in time for planting.
2. **Crowding Out of Commercial Fertilizer:** The program caused a 22% crowding-out effect, where subsidized fertilizer displaced commercial purchases. This meant that for every 100 kilograms of subsidized fertilizer distributed by the NFSP, the program only added 78 new kilograms to total fertilizer use because the other 22 kilograms were just displaced commercial fertilizer. This effect was higher among larger-scale farmers, raising questions about the cost-effectiveness of NFSP in increasing total fertilizer use.
3. **Economic Impact:** The benefit-cost ratio (BCR) for NFSP was 1.11, indicating that the benefits outweighed the costs. However, if the private sector had been allowed to manage fertilizer distribution, the BCR would have risen to 1.22, which is both twice as high and would have significantly reduced financial losses for private sector fertilizer supply chain actors. Moreover, the program's returns were significantly lower than other public investment options, such as agricultural research, which across 30 studies from sub-Saharan Africa produced a median BCR of 11.0 – more than 10 times higher than that of NFSP (Pardey et al., 2016). Research from Asia finds that policy reform and investments on agricultural R&D and road infrastructure have higher rates of return than input subsidies (EIU, 2008; Fan et al., 2008).

Recommendation: Based on these findings, the study recommends that future fertilizer subsidies be implemented using private-sector-led distribution of fertilizer subsidy to improve efficiency,

reduce crowding-out effects, and enhance market competition. Additionally, efforts should focus on both targeting small-scale farmers and promotion of better crop and soil management practices to maximize farmers' returns to fertilizer use and facilitate sustainable intensification of crop production in Kenya.

Conclusion: While the NFSP in 2023 met the minimum expectations of a public investment, its untargeted approach and reliance on government-run distribution limited its overall impact. A shift toward private-sector involvement in the fertilizer distribution and targeted subsidy could better enhance agricultural productivity and provide better economic returns for Kenyan farmers and the economy at large.

1. Introduction

The recent international food, fertilizer, and fuel price crisis began in late 2020 as the global economy started recovering from the early effects of the COVID-19 pandemic. The combination of rising global demand for many commodities and pandemic-related supply chain constraints led to significant price increases in food, fuel, and fertilizers in 2021 and 2022 (Mather et al., 2022). Fertilizer prices surged in 2021 due to export restrictions by major exporters, China and Russia, alongside rising oil and natural gas prices, key inputs in fertilizer production. The situation worsened in February 2022 with Russia's invasion of Ukraine, pushing fertilizer prices to levels not seen since the 2007/08 crisis (Laborde, 2022).

As Kenya imports all its oil, fertilizer, and a portion of its maize and wheat, the country experienced significant price increases in these commodities. From January to August 2022, maize retail prices in Kenya rose by 42% (Mather et al., 2022). Similarly, DAP fertilizer prices increased by 76% in 2021, with an additional 10% rise by mid-2022. CAN fertilizer prices also jumped by 102% in 2021, followed by a 56% increase by July 2022 (ibid, 2022).

In response to rising food and fertilizer prices, the Government of Kenya introduced the National Fertilizer Subsidy Programme (NFSP) in April 2022 for the 2021/22 long rains season, with plans to distribute fertilizer through the National Cereals and Produce Board (NCPB). However, the announcement came too late for most farmers. In September 2022, a new government expanded the subsidy for the 2022/23 short rains and future seasons. The Kenyan National Trading Corporation (KNTC) procured the fertilizer, and the NCPB distributed and retailed it to farmers, starting in 12 counties in the 2023 long rains (LR) season before rolling out nationwide. In 2023 LR, NFSP sold subsidized fertilizer for planting at KES 3,500 per 50kg bag, a price that was significantly lower than the prevailing market price for the commonly used planting fertilizer (DAP) that retailed for between KES 5,500-6,000 per 50 kg bag.

Under this initiative, the government procured 472,500 metric tons of fertilizer in late 2022, at an estimated cost of KSh 54.3 billion (approximately $543 million USD). By June 30, 2024, about 175,060 metric tons of subsidized fertilizer had been sold to farmers, with the remaining stock sold over the subsequent 2023/24 short rains (SR) and 2024 LR. The significant government expenditure on NFSP, large scale of the program relative to Kenya's private sector fertilizer demand, use of government parastatals instead of the private sector to distribute and retail program fertilizer, and the high fertilizer prices facing Kenyan farmers in 2023 all merit in-depth assessment of the performance of NFSP.

To date, there have been two assessments of NFSP, the first a rapid evaluation by Opiyo et al. (2023), which relied on key informant interviews with stakeholders, such as government officials and private-sector fertilizer importers, distributors, and retailers, but did not include farmers. The second study assessed NFSP implementation relative to design, and factors associated with farmer participation in the program and estimated the effect of subsidized fertilizer receipt on farmer maize yield (Ayalew et al, 2024). The study finds that a one percent increase in the amount of subsidized fertilizer leads to a 5 to 7 percentage point increase in farmer maize yield, on average (ibid, 2024). The study's descriptive and econometric analysis is based on data from a phone survey of 815 farm households in 5 counties in Western Kenya and the Rift Valley in early 2024, areas with medium to high agroecological potential (Ayalew et al. (2024)).

The present study builds on Opiyo et al. (2023) and Ayalew et al. (2024) in several ways. First, it is based primarily on a phone survey of 1,510 farmers implemented by the authors that is representative of all 38 counties to which NFSP fertilizer was distributed in 2023 LR. This data enables a more comprehensive descriptive and econometric analysis of the characteristics of farmers who purchased subsidized fertilizer from NFSP and the spatial distribution of participation. Second, findings from prior research from Kenya by Mather and Jayne (2018) and Makau et al. (2018) demonstrate that estimating the effect of farmer receipt of subsidized fertilizer on crop productivity requires prior estimation of the extent to which subsidized fertilizer crowds in/out farmers' commercial fertilizer demand. Third, this study includes results from a detailed benefit-cost analysis of NFSP over the 2023 LR, 2023/24 SR, and 2024 LR seasons.

This study addresses the following key questions:

1. What percentage of farmers participated in the NFSP in 2023 LR? How much fertilizer did they acquire? What were their demographic characteristics (e.g., landholding, assets, income, education, and gender)?
2. When did farmers receive subsidized fertilizer and was it in time for maize planting? How did the timing compare to those who bought fertilizer from private-sector agro-dealers?
3. How effectively did the NFSP target farmers who would not have purchased fertilizer from the private sector? Did the NFSP and county programs crowd out or crowd in commercial fertilizer? This is crucial for understanding how much new fertilizer reached farms and how the program contributed to national agricultural productivity.
4. What were the costs for farmers to acquire NFSP fertilizer through government channels, and how did these compare to costs of acquiring fertilizer through the private sector?
5. Which crops received subsidized and commercial fertilizer in 2023?
6. What was the benefit-cost ratio of the NFSP in 2023? How do the benefits, measured as the value of increased maize production, compare with the program's costs to government, participating farmers, and private sector fertilizer distributors and agrodealers? How does the benefit-cost ratio of NFSP compare with estimated returns to a more private sector-friendly program design such as NVSP as well as other potential public investments?

By addressing these six questions, this study offers valuable evidence that can inform policy recommendations to enhance the effectiveness of the NFSP and similar programs in the future.

2. Background

2.1 Evidence of crowding out effects of input subsidy programs on commercial fertilizer demand

Many countries across sub-Saharan Africa have implemented large-scale, targeted input subsidy programs (ISPs) since the international food price food price crisis of 2007/08. The goal of these ISPs has been to induce higher levels of smallholder use of inorganic fertilizer on staple grain or legume crops by subsidizing the price of limited quantities of inorganic fertilizers for targeted farmers. The programs have assumed that increased rates of inorganic fertilizer application will improve smallholder food crop productivity and, subsequently, improve household and national food security (Jayne et al, 2013). However, because farmers who receive subsidized fertilizer may have purchased commercial fertilizer in the absence of an ISP, the degree to which an ISP raises total smallholder fertilizer use (and hence improves food security) depends on the extent to which subsidized fertilizer crowds-out (or crowds-in) farmers' purchases of commercial fertilizer (Ricker-Gilbert et al. 2011).

For instance, if no farmers used commercial fertilizer prior to the NFSP, each 50-kg bag of subsidized fertilizer could be assumed to increase fertilizer use by 50 kg. However, research from 1997-2010 in Kenya found that each additional kilogram of NCPB subsidized fertilizer reduced commercial fertilizer use on maize by 0.398 kg, indicating significant crowding out (Mather and Jayne, 2018). This was especially true in medium to high-potential areas, where 85-95% of maize growers were already using commercial fertilizer before the reintroduction of subsidies (ibid, 2018). [6]

A more recent study from the Rift Valley (2014/15 and 2015/16) found similar results, with each kg of subsidized fertilizer reducing commercial demand by 0.20 kg, implying a net increase in fertilizer use of 0.80 kg (Makau et al., 2018). This crowding out has important implications for the productivity impact of NFSP. Studies in other countries such as Malawi (Ricker-Gilbert et al., 2011) and Zambia (Mason and Jayne, 2013) also found evidence of crowding out, particularly in areas where commercial fertilizer use was already high (Xu et al., 2012; Mason and Jayne, 2013). While two studies have found evidence that receipt of a fertilizer subsidy can "crowd-in" (i.e. increase) farmer demand for commercial fertilizer (Liverpool-Tasie, 2014, in Nigeria; Xu et al., 2012 in Zambia), this result was only found in particular areas of each country with little to no prior use of inorganic fertilizer on food crops and limited to no agrodealer presence. A third study also found evidence of crowding in of commercial fertilizer demand by receipt of an input subsidy (Carter et al, 2021), yet it was from a country (Mozambique) where very few farmers have prior

[6] It is important to note that crowding out of commercial fertilizer demand is not limited to government parastatal subsidy programs like NCPB. Mather and Jayne (2018) found that each additional kilogram of subsidized fertilizer from the NAAIAP program, which was wholesaled and retailed by the private sector in 2010, reduced commercial fertilizer demand by 0.35 kg. However, unlike NCPB, NAAIAP fertilizer was handled by the private sector from the port to agro-dealers, meaning it did not displace private sector fertilizer sales as NCPB distribution did. For more on crowding out in the private sector, see Section 4.6.

experience using inorganic fertilizer at all[7]. By contrast, the vast majority of subsidized fertilizer distributed by NFSP in 2023 and 2024 – as well as by earlier NCPB-led programs -- has gone to counties where between 85 to 97 percent of farmers used inorganic fertilizer on maize in previous years and private sector input supply markets are well developed and agrodealers are closer to farmers than NCPB depots, on average (Mather & Jayne, 2018).

2.2 Evolution of Kenya's Fertilizer Policy and the Role of Input Subsidy Programs

Kenya's expansion of large-scale input subsidy programs (ISPs) in response to rising fertilizer and maize prices in 2022 provides an important context for the government's policy choices in 2023 and beyond. Since independence, Kenya's fertilizer policy has gone through three distinct phases (Kirimi et al., 2023). In the first phase, similar to many sub-Saharan African countries, the government-controlled fertilizer importation and marketing, setting prices and being the sole supplier (Ariga and Jayne, 2011). In the second phase, starting in 1991, Kenya began to liberalize the fertilizer market, allowing the private sector to import, distribute, and sell fertilizer. This was accompanied by related market reforms including liberalization of the foreign exchange regime (Kirimi et al, 2023), phasing down of government control of maize marketing and maize prices, and significant public investment in rural roads. The combination of these related reforms, public investment, and maintenance of a predictable and favorable enabling environment led to significant private sector investments in fertilizer importation, distribution, and retailing that has been deemed a policy reform success story in SSA (Ariga and Jayne, 2011). The benefits of this private sector investment for farmers were observed most directly in a 73% reduction in the average farmer distance to an agro-dealer between 1997 and 2007 in lower potential areas, and a 32% percent reduction in higher potential areas (ibid, 2011).

The third phase began in 2008, triggered by the 2007/08 international food price crisis, regional harvest failures and a subsequent doubling of domestic fertilizer prices and a spike in maize prices. The government responded by scaling up two different types of large-scale ISPs. The first was the National Accelerated Agricultural Input Access Program (NAAIAP), which targeted resource-poor farmers, limited subsidy recipients to two 50kg bags of fertilizer and 10kg of maize seed, and allowed the private sector to import, distribute and retail subsidized inputs on behalf of the program. This program evolved into the National Value Chain Support Program (NVSP) in 2017, incorporating several reforms like e-vouchers, more flexible input options, and using more precise targeting criteria to define "resource poor farmers" – i.e. those with 5 acres or less (Kirimi et al., 2023). "Flexible" e-vouchers allowed farmers to redeem a variety of inputs, including inorganic fertilizer, certified maize or bean seeds, agrochemicals, and/or lime, rather than being limited to just basal (DAP) and top-dressing (NPK) fertilizer and maize seed.

In addition to NAAIAP, the Kenyan government also scaled up a separate large-scale ISP, the National Fertilizer Price Stabilization Plan (NFPSP) (Kenya, Ministry of State Planning 2008).

[7] For example, only 13% of the farmers in the Mozambique study sample from Manica province had used inorganic fertilizer in three or more of the past 10 years, 17% of farmers had used it in 1-2 years, and 67% of farmers had not used it at all. Such low farmer use of inorganic fertilizer is typical of all but one province of Mozambique.

The objectives of NFPSP were to “reduce and stabilize local fertilizer prices” to cushion farmers from price fluctuations across the seasons and to increase fertilizer use among farmers by making fertilizers affordable to farmers who did not use the input due to financial constraints.

There are several key differences between the design and implementation of NFPSP and NAAIAP/NVSP, which remain highly relevant for evaluating Kenya’s current large-scale ISP, the National Fertilizer Subsidy Programme (NFSP). The primary distinction is that NAAIAP/NVSP allowed the private sector to handle the importation, distribution, and retailing of fertilizer, while NFPSP relied on the National Cereals and Produce Board (NCPB) to physically distribute and retail the fertilizer. The NCPB, a state-owned organization responsible for managing Kenya’s national grain reserve, imported fertilizer for NFPSP through competitive tenders to private importers, and then distributed the subsidized fertilizer through its 110 depots, located mostly in medium and high agroecological zones.

This created a dual-channel fertilizer marketing system that displaced, or crowded out, sales and revenue for private sector fertilizer suppliers. Additionally, NCPB depots were typically farther from farmers than local agro-dealers, particularly in areas with lower agroecological potential, leading to higher transportation costs for some farmers, which made accessing the subsidy prohibitive (Mather and Jayne, 2018). Another key difference was that NFPSP had no household-specific targeting criteria, making it available to any maize farmer who registered. The subsidy applied only to inorganic fertilizer and offered a 26% to 46% discount off market prices, depending on the year (Nduati et al., 2015; Mather et al., 2018). The maximum amount of subsidized fertilizer per farmer was capped based on the area planted, with an overall limit of 2,000 kg (or 40 bags of 50 kg each).

In 2018, the Kenyan government ended the untargeted, NCPB-managed NFPSP for various reasons. For example, farmers had long voiced frustrations over the late delivery of subsidized fertilizer, and smaller farmers struggled to access it due to the long distances to NCPB depots, which were primarily located in medium to high-potential zones. Additionally, private sector suppliers complained that the NFSP was crowding out their commercial fertilizer sales. The program faced further criticism when the government publicly admitted that up to one-third of NFPSP fertilizer was being illegally diverted. Reports of fraud revealed that some individuals were purchasing large quantities of subsidized fertilizer and reselling it in the commercial market.

In response to the challenges of NFPSP design and implementation, between 2020 and 2022, the government significantly scaled up the private sector-friendly NVSP, also known at the time as the "e-voucher program." The government expanded the NVSP to 27 counties, with plans to extend it nationwide. However, in April 2022, the Government of Kenya (GoK) re-introduced a government supply chain ISP, the National Fertilizer Support Program (NFSP) – which is very similar in design to the abandoned NFPSP – while continuing to scale up the NVSP. The GoK obtained fertilizer for NFSP from the private sector and from their own direct imports and were once again distributing and retailing it to farmers through NCPB. Unfortunately, most farmers were unable to use the subsidized fertilizer in time for the 2021/22 long rains season (LR) due to delays in delivery.

A new government came to power in September 2022. During its campaign, the new ruling party had promised an input subsidy program for farmers. Rather than scaling up the existing NVSP, the new government decided instead to significantly scale up the National Fertilizer Subsidy Program (NFSP) and while dramatically scaling-down and reducing funding for the NVSP. The government explained its decision to go all in with the NFSP instead of NVSP because (a) NVSP did not yet have enough name recognition; and (b) the number of farmers already registered with the NVSP program was considerably smaller than the number the government hoped to reach with subsidies in 2023 LR. However, these reasons do not seem plausible considering that (a) NFSP was a new program with a new name that had only started one season before, while NVSP had been gradually scaling up since 2017; and (b) the online registration and e-voucher platform used by NFSP beginning with 2023 LR had actually been first developed and piloted by NVSP over several years, and the government engaged in a massive extension effort throughout 2023 to register farmers in this online registration platform. It would seem that the government could have just as easily spent the extension, registration, and public awareness efforts devoted to NFSP to NVSP instead – and could have simply temporarily revised the targeting criteria for NVSP to enable farmers with more than 5 acres to participate as well.

Although both the NVSP and NFSP are designed to provide input subsidies to farmers, they differ significantly in their approach, target beneficiaries, geographic reach, input coverage, and other design elements, as summarized in Table 1.

Table 1: Comparison of design and implementation of NVSP and NFSP

	NVSP (2017-)	NFSP (2023-)	Implications
Private-sector friendly?			
Distribution & retailing of subsidized inputs	Private sector	Government (NCPB depots, KNTC sale points)	NVSP supports development of private sector input supply; NFSP undercuts & crowds it out
Use of e-vouchers?	Yes	Yes	E-vouchers can reduce subsidy leakage to non-eligible farmers
Which farmers benefit?			
Targeting criteria	Smallholders (0.5 - 5 acres)	No targeting: any farmer can benefit	NVSP targets support to smallholders only & most agro-zones. NFSP fertilizer sales are concentrated in high/medium potential areas & relatively costly for smaller farmers & those in lower potential zones to access given distance to NCPB depots
Spatial coverage	Most agro-zones	Most agro-zones	
Retail location of subsidized inputs (mean HH distance[a])	Agrodealers (6.6 km)	NCPB depots (17.8 km[b])	
Benefits for eligible farmers			
Subsidy rate (commercial price discount on inputs)	2022: 40%	2023 LR: 41% 2023/24 SR: 52% 2023 LR: 55%	NFSP large max benefit implies that larger farmers may capture a disprortionately large share of subsidies. NVSP flexible voucher empowers farmers to choose inputs based on their specific preferences, opportunities & constraints. Also enables farmers to obtain inputs that typically provide best performance when used with complementary inputs.
Inputs eligible for subsidy	Inorganic fertilizer; certified seeds; agro-chemicals; and/or lime	Inorganic fertillizer	
Maximum benefit per farmer	KSh 5,000 on eligible inputs	up to 100 50-kg bags of subsidized fertilizer	
Flexible voucher?	Yes	No	

Notes: \a mean distance from household to the nearest agrodealer; to the nearest NCPB depot; \b 17.8 km was the average in 2023 long rains. This average distance likely fell in 2024 long rains as government responded to farmer complaints about the relatively long distances from villages to NCPB depots by adding more NFSP retail locations closer to farmers.

2.3 Implementation of the fertilizer subsidy program in 2023

Under NFSP, the quantity of subsidized fertilizer allowed per farmer depended on the farmer's self-declared cultivated land size. The NFSP was open to all farmers, without targeting specific groups or crops. Farmers registered for the program by providing details,[8] such as the size of their cultivated land. After registration farmers would wait until they received SMS message (electronic

[8] Details farmers were asked during registration included: Name, ID, size of cultivated (prepared) land for planting, and crops grown.

voucher) indicating how many bags of subsidized fertilizer they could purchase from the nearest NCPB depot or KNTC selling point. They then visited the depot to redeem the voucher and buy the specified number of bags.

Alongside the NFSP, some counties in Kenya implemented their own fertilizer subsidy programs in 2023 LR, separate from the NFSP. As a result, farmers could obtain inorganic fertilizer from three sources: (i) the national government's NFSP, (ii) their county government's subsidy program, or (iii) commercial fertilizer from the private sector

3. Data, Method and Sample Description

3.1 Data sources

Our farm household data come from a phone survey conducted in Kenya between September and October 2023, at the end of the long rains season. We surveyed a randomly selected sample of farmers from 38 out of 47 counties in Kenya. The survey targeted adults (18+) from households engaged in crop farming during the long rains season of 2023, who played a role in farm decision-making. Nine counties—six from the northern region (Garissa, Isiolo, Mandera, Marsabit, Turkana, Wajir), one coastal county (Lamu), and two urban counties (Nairobi and Mombasa)—were excluded due to the limited importance of crop farming.

The survey was conducted by GeoPoll, a platform by Mobile Accord, Inc., which specializes in global surveys via mobile phones. Given the high mobile phone penetration in Kenya, this method ensured a representative random sample of farm households. According to DATAREPORTAL (2020), 96% of adults in Kenya had mobile phone access as of 2018–2019. Respondents were randomly selected using Simple Random Sampling (SRS) from GeoPoll’s verified list of mobile subscribers, generated through Random Digit Dialing (RDD) to ensure sample randomization and representativeness. Details are provided in Appendix A.

The survey was conducted in two phases with different sampling frames. In phase 1, we targeted any adult (18+) from a crop-farming household in one of the 38 counties, aiming for 900 farmers. Sampling was done using the probability proportional to size method, where the number of farming households in each county determined the sample size. This phase 1 sample is considered representative of all crop-farming households, and we used it to estimate farmer registration for the NFSP. The SRS method ensured equal probability of surveying adult mobile phone users in the target counties, making the sample highly representative.

In phase 2, we focused on 12 counties where the government had piloted the subsidy program. To capture enough households participating in the NFSP, we surveyed an additional 610 farmers, specifically targeting those who had registered for subsidized fertilizer. The sample distribution by phase and county is shown in Appendix B.

Our analytical sample includes 1,510 farmers—900 from phase 1 and 610 from phase 2. To ensure representativeness of all crop-farming households across the 38 counties, we applied sample weights to adjust for: 1) the distribution of farm households across the counties, and 2) NFSP registration rates in the 12 focus counties based on phase 1 data. All results in the paper are weighted accordingly to reflect the national population of crop-farming households.

3.2 Sample Description

Table 2 provides descriptive statistics (means and standard deviations) for the 1,510 respondent households in our sample. The average land area farmed during the 2023 long rains was 2.62 acres (just over one hectare), with an average household size of just under six members. Twenty-two percent of households were female-headed, and the average household head had just over 10 years of education. The average age of household heads was around 45 years, and they had lived in their villages for nearly 31 years on average.

Table 2: Descriptive statistics of sample households

Household characteristics	**Mean**	**Std. Dev.**
Land area (acres) operated by households in 2023	2.62	3.14
Household size	5.85	2.52
=1 if female-headed household	0.22	0.41
Household head years of schooling	10.17	3.96
Age of household head	44.74	13.64
Years that the head has lived in the village	30.60	17.72
=1 if Household related to the village leader	0.30	0.46
=1 if Household member of community group	0.43	0.49
=1 if the household owns a smartphone	0.81	0.39
Travel time (minutes) to the nearest city/town in wet season	49.89	51.25
Distance (km) from home to nearest agro-dealer	6.59	11.73
Distance (km) from home to nearest NFSP fertilizer sale point	17.82	26.83
Tropical Livestock Unit (TLU) owned	2.56	6.02
Household asset index	0.05	1.71
No. of observations (N)	1,510	

Note: Statistics were calculated using sampling weights as described in section 4.

Thirty percent of households were related to their village leader, and 43% were members of a community group—two proxies for social and political capital, which may have influenced access to the NFSP and county fertilizer programs. Eighty-one percent of households owned a smartphone, while the rest presumably had basic phones, as the survey was conducted by phone. The average travel time to the nearest town during the rainy season was 50 minutes. The average distance to a private-sector agro-dealer selling fertilizer was 6.59 kilometers, while the distance to a government-subsidized fertilizer depot was nearly 19 kilometers, indicating that private-sector dealers were more accessible. In terms of assets, the average household owned 2.56 tropical livestock units, and the household asset index had an average value of 0.05, a normalized index with a mean of zero.

3.3 Data and method for Benefit-Cost Analysis

The aim of NFSP is to improve household and national food security by increasing food production. Its success depends on two key assumptions: (i) subsidizing inorganic fertilizer at 40 to 55% of the commercial price will encourage farmers to use more fertilizer per acre, and (ii) this increased use will boost food crop yields, leading to higher household and national production, ultimately enhancing food security. To address one of the research questions, this study conducted a benefit-cost analysis (BCA) to compare the economic benefits of NFSP – the value of increased maize[9] production attributable to NFSP -- to the program's costs, thereby assessing its overall cost-effectiveness in improving food security in 2023.

BCA is used to evaluate both the financial and economic impact of the NFSP by comparing the benefits and costs in a "with program" scenario to those in a "without program" scenario. Since most NFSP fertilizer was applied to maize during the 2023 long rains, the program's benefits are defined as the value of national maize production during that season. The counterfactual, or "without program" scenario, estimates maize production without the NFSP, and the difference—called "incremental benefits"—represents the additional maize produced due to the program. This BCA also considers the financial losses experienced by private-sector fertilizer suppliers due to the crowding out of commercial fertilizer demand. As subsidized fertilizer reduced the need for farmers to buy from private suppliers, this led to lost revenue for those businesses, which is measured by comparing the reduction in commercial fertilizer sales between the "with" and "without" program scenarios. Details on the method and procedures used to estimate: a) incremental benefits attributable to NFSP provision of subsidized fertilizer; b) incremental national maize production attributable to NFSP; c) farmgate maize price; d) costs of NFSP implementation for government; e) supply-side crowding out of the private sector fertilizer supply chain; and f) Financial losses for private sector fertilizer supply chain actors from crowding out of commercial fertilizer demand and supply, are included in Appendix C.

The same approach is used for costs, which include government and farmer spending on subsidized fertilizer. Incremental costs cover the government's total expenditure, including fertilizer costs, program management, and farmers' contributions (more details provided in Appendix D). The analysis also accounts for private sector financial losses caused by the displacement of commercial fertilizer sales. This includes evaluating the market share of private sector suppliers before and during the program, the price difference between commercial and subsidized fertilizers, and the volume of fertilizer displaced. Fixed costs, such as distribution and infrastructure, borne by private suppliers despite reduced sales, are also considered. These financial losses are factored into the overall cost side of the BCA, allowing for a comprehensive assessment of the NFSP's broader economic impact, including its effect on the private fertilizer market. The benefit-cost ratio (BCR) is then calculated by dividing the incremental benefits by the incremental costs.

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[9] Maize accounts for the largest share of fertilizer consumption in Kenya.

We generate an estimate of financial losses due to foregone profits of fertilizer distributors and agro-dealers for each season using the logic and assumptions detailed in Appendix D, section J.

Data for this BCA come from government (NFSP, Ministry of Agriculture and Livestock Development, and Ministry of Trade), the private sector (Fertilizer Association of Kenya), and international organizations (Africa Fertilizer/IFDC, World Bank). Detailed data sources are noted in the results table and Appendix C. Information on fertilizer quantities, types, and costs purchased by the government through KNTC and distributed by NCPB is primarily drawn from the NFSP report by Opiyo et al. (2023).

4. Results

4.1 Access to fertilizer

During the 2023 long rains season, households accessed fertilizer from three main sources: (i) the national government's NSFP; (ii) county government input subsidy programs; and (iii) commercial purchases from agrodealers (Table 3, first panel). Overall, 76% of households obtained fertilizer from either government or private channels. The average total quantity of fertilizer acquired was 87 kg per household (median of 25 kg) across all 1,510 households, and 116 kg (median of 50 kg) for those who acquired fertilizer.

During the 2023 long rains, households acquired an average of 44 kg of subsidized fertilizer, with 36 kg coming from the NFSP and 6 kg from smaller county government programs. Households participating in the NFSP received an average of 200 kg of subsidized fertilizer. While 46% of households registered for the NFSP, only 32% received an SMS invitation to purchase fertilizer, and 19% actually acquired it from the NFSP. In total, 25% of households received subsidized fertilizer, with 8% obtaining it through county programs.

Additionally, 57% of households purchased commercial fertilizer, averaging 43 kg (median of 50 kg). Those who purchased commercial fertilizer bought an average of 76 kg (median of 40 kg). Overall, subsidized fertilizer accounted for 51% of all fertilizer acquired during the 2023 long rains.

The second panel of Table 3 shows that during the 2022 long rains, 30% of households acquired fertilizer, with only 6% receiving subsidized fertilizer and 27% purchasing it commercially. Subsidized fertilizer made up just 18% of total fertilizer purchases. On average, farmers bought 28 kg of fertilizer from all sources—5 kg from subsidies and 23 kg from commercial purchases. Households that acquired fertilizer from any source acquired an average of 121 kg, slightly less than the 116 kg acquired in 2023. Those receiving subsidized fertilizer in 2022 acquired 151 kg, compared to 180 kg in 2023, while households purchasing commercial fertilizer in 2022 bought an average of 101 kg, more than the 73 kg in 2023.

The comparison between 2022 and 2023 indicates that more households purchased both commercial and subsidized fertilizer in 2023, likely due to higher maize prices, which made fertilizer purchases more profitable. In 2022, the lack of a national fertilizer subsidy during planting, combined with rising commercial fertilizer prices, may have made fertilizer unaffordable for some farmers. For instance, the average price of a 50kg bag of DAP rose from KES 5,391 in January to KES 6,111 in March 2022, compared to KES 3,505 – KES 3,475 during the same period in 2021.

Table 3: Farm household access to fertilizer in 2022 and 2023 long rains, by fertilizer source

2023 Long Rains	Mean	Std. Dev.	Median	N
% (of farmers that) acquired fertilizer (subsidized or commercial)	76	43	-	1,510
Total quantity of fertilizer acquired by HH (kg) (subsidized + commercial), unconditional	87	169	25	1,510
Total quantity of fertilizer acquired by HH (kg) (subsidized + commercial), conditional on acquiring	116	194	50	1,285
% acquired any subsidized fertilizer (NFSP or county government)	25	43	-	1,510
Total quantity of subsidized fertilizer acquired by HH (kg), NFSP + county govt), unconditional	44	125	0	1,510
Total quantity of subsidized fertilizer acquired by HH (kg), NFSP + county govt), conditional on acquiring	180	210	100	634
% registered to receive NFSP subsidy	46	50	-	1,510
% received an SMS notification from NFSP	32	47	-	1,510
% acquired NFSP fertilizer	19	39	-	1,510
Quantity of NFSP fertilizer acquired by HH (kg), unconditional	36	104	0	1,510
Quantity of NFSP fertilizer acquired by HH (kg), conditional on aquiring	200	209	100	555
% acquired county-subsidized fertilizer	8	27	-	1,510
Quantity of county-subsidized fertilizer acquired by HH (kg), unconditional	6	31	0	1,510
Quantity of county-subsidized fertilizer acquired by HH (kg), conditional on acquiring	75	85	50	157
% purchased commercial fertilizer	57	50	-	1,510
Quantity of commercial fertilizer acquired by household (kg), unconditional	43	123	50	1,510
Quantity of commercial fertilizer acquired by household (kg), conditional	76	15	40	803
Average household share of subsidized fertilizer in total fertilizer quantity acquired (%)	51			
2022 Long Rains	Mean	Std. Dev.	Median	N
% (of farmers that) acquired fertilizer (subsidized or commercial)	30	46	-	1,510
Total quantity of fertilizer acquired by HH (kg) (subsidized + commercial), unconditional	28	72	0	1,510
Total quantity of fertilizer acquired by HH (kg) (subsidized + commercial), conditional on acquiring	121	196	50	667
% acquired subsidized fertilizer	6	23	-	1,510
Total quantity of subsidized fertilizer acquired by HH (kg), NFSP + county govt), unconditional	5	28	0	1,510
Total quantity of subsidized fertilizer acquired by HH (kg), NFSP + county govt), conditional on acquiring	151	214	100	125
% purchased commercial fertilizer	27	44	-	1,510
Quantity of commercial fertilizer acquired by household (kg), unconditional	23	62	0	1,510
Quantity of commercial fertilizer acquired by household (kg), conditional	101	170	50	595
Average household share of subsidized fertilizer in total fertilizer quantity acquired (%)	18			

4.2 Dates of Fertilizer Acquisition and Types of Fertilizer Acquired

Table 4 summarizes farm household fertilizer acquisition, and the distance traveled to obtain it in 2023 LR. Column 1 shows means, standard deviations, and medians for NFSP fertilizer, Column 2 for county government-subsidized fertilizer, and Column 3 for commercial fertilizer. Rows i) and ii) reveal that the most common fertilizer provided by the NFSP was NPK 23-23-0, which differed from the DAP fertilizer most farmers preferred for planting. In fact, DAP was the most purchased commercial fertilizer during the 2023 long rains. This aligns with findings from Opiyo et al. (2023), who noted that the government prioritized NPK over DAP in the NFSP due to concerns about soil acidity. However, county government programs predominantly provided the preferred DAP to farmers.

Row iii) shows that farmers traveled farther to obtain NFSP fertilizer, with an average distance of 16 km and a median of 10 km, compared to 11 km (median 5 km) for county-subsidized fertilizer and 9 km (median 3 km) for commercial fertilizer. Row iv) also indicates it took longer to acquire NFSP fertilizer (238 minutes on average) than county government fertilizer (137 minutes) or commercial fertilizer (28 minutes). This is likely due to the fewer and more dispersed NCPB and KNTC depots for NFSP fertilizer, compared to the more accessible local agro-dealers.

Row v) shows that farmers typically acquired NFSP fertilizer in the first week of April 2023, one week later than county-subsidized fertilizer (4th week of March) and two weeks later than commercial fertilizer (3rd week of March). Row vi) reveals that 80% of NFSP recipients received fertilizer in time for planting, slightly

lower than 82% for county-subsidized and 87% for commercial fertilizer. This suggests that the private sector was somewhat more efficient in delivering fertilizer to farmers before planting season.

4.3 Fertilizer costs

Table 5 examines the costs of acquiring fertilizer from different sources during the 2023 long rains. Despite longer travel distances, the per-unit cost of NFSP fertilizer was significantly lower than county government and commercial fertilizer. Row i) highlights the fertilizer purchase price by source, while row ii) includes transportation costs, and row iii) includes other potential costs related to acquiring fertilizer. The mean price of fertilizer per 50-kilogram bag was 3,200 shillings from the NFSP program, while the mean county government price was 3,626 shillings per bag. The mean commercial price was almost double that of the NFSP or county government at 6,190 shillings per bag. The transportation costs were significantly higher for farmers who obtained subsidized fertilizer from the NFSP at 820 shillings per household compared to just 408 shillings per household and 369 per household for commercial fertilizer. The higher transport costs for NFSP fertilizer were likely due to the further distance that farmers had to travel to NCPB depots to acquire the subsidized fertilizer compared to subsidized fertilizer sold by counties and commercial fertilizer sold by local agro-dealers. Results from row iii) suggested that other costs like bribery were not a major issue for NSFP fertilizer as the mean household paid just 33 shillings in other costs to acquire their subsidized fertilizer.

The bottom of Table 5 compares fertilizer prices from the 2022 long rains. The average subsidized price in 2022 for a 50-kilogram bag of fertilizer was 1,692 shillings, which compared to a mean commercial price of 3,762 shillings per bag. The survey did not ask about transportation or other costs in 2022, but it was clear that the costs of both subsidized and commercial fertilizer increased tremendously on average between 2022 and 2023. The percentage discount between the subsidized and commercial fertilizer prices in 2022 was 45% and even with higher prices, the subsidy rate to 52% in 2023. This constituted a tremendous fiscal expenditure for the Government of Kenya when they scaled up the NFSP in 2023.

4.4 Determinants of Household Participation in NFSP in 2023

Table 6 presents the factors influencing whether households acquired subsidized fertilizer and the amount they received from the NFSP during the 2023 long rains. Column 1 shows the factors affecting the likelihood of registering for NFSP fertilizer, Column 2 covers whether households received an SMS notification about how much fertilizer to purchase and where to buy it. Column 3 examines whether households acquired the fertilizer, and Column 4 looks at the amount of fertilizer acquired.

Row 1 (Table 6) indicated a positive relationship between landholding and receipt of NFSP fertilizer in 2023. An additional acre increased the likelihood of registering by 1.4 percentage points, acquiring fertilizer by 1.6 percentage points, and led to an additional 5 kg of fertilizer from the NFSP. Larger households and those with more educated heads were also more likely to participate, suggesting these households had the labor and knowledge to utilize the program or were better connected and informed. Households with longer village tenure, those with connections to the village head, or community group members were also significantly more likely to participate, indicating that social connections played a key role in accessing NFSP fertilizer in 2023.

Households located farther from agro-dealers were less likely to participate in the NFSP, likely due to limited access to fertilizer markets. However, those farther from NCPB or KNTC depots were more likely to register for the program and receive an SMS about fertilizer acquisition, suggesting government efforts to raise awareness in remote areas. Despite this, these households did not acquire more subsidized fertilizer, likely due to the difficulty of accessing the distant depots.

Table 6 also shows that households who acquired subsidized fertilizer in 2022 were 11 percentage points more likely to do so again in 2023 and received 23 kg more fertilizer. Those who bought commercial fertilizer in 2022 were 13 percentage points more likely to register for the NFSP and 14 percentage points more likely to receive an SMS notification. Female-headed households were more likely to receive an SMS, and households with fewer assets were more likely to register, but neither group was more likely to acquire fertilizer, indicating a gap between interest and participation among resource-limited households.

Overall, Table 6 suggests the NFSP was not targeted at resource-limited farmers in 2023. Although this was not the program's goal, the fact that better-connected, larger-scale producers with previous fertilizer use were more likely to participate raises concerns about NFSP crowding out commercial purchases, reducing its effectiveness in increasing total fertilizer use and its cost-efficiency.

Table 4: Average date of fertilizer application and costs for subsidized and commercial fertilizer acquisition during the 2023 long rains

VARIABLES	(1) National government-subsidized fertilizer		(2) County government subsidized fertilizer		(3) Commercial fertilizer	
	Mean (SD)	**Median**	**Mean (SD)**	**Median**	**Mean (SD)**	**Median**
i) The most common type of fertilizer acquired by farmers	NPK 23-23-0	-	DAP	-	N/A	-
ii) The most commonly preferred type of fertilizer by farmers for Maize	DAP	-	DAP	-	DAP	-
iii) Distance traveled to acquire fertilizer, in km	16 (16)	10	11 (14)	5	9 (24)	3
iv) Minutes spent collecting fertilizer	238 (205)	180	137 (130)	120	28 (43)	10
v) Week and month fertilizer was acquired	April, 1st week	April, 1st week	March, 4th week	March, 4th week	March, 3rd week	March, 3rd week
vi) Share of farmers acquiring fertilizer in time for planting during long rains	0.80 (0.40)	-	0.82 (0.38)	-	0.87 (0.34)	-

Table 5: Costs of farmer acquisition of subsidized and commercial fertilizer in 2023 and 2022 long rains

VARIABLES	**(1) National government-subsidized fertilizer**		**(2) County government subsidized fertilizer**		**(3) Commercial fertilizer**	
	Mean (SD)	**Median**	**Mean (SD)**	**Median**	**Mean (SD)**	**Median**
2023						
i) Price of fertilizer per 50-kilogram bag (in Kenyan Shillings)	3,200 (951)	3,500	3,626 (1,596)	3,500	6,190 (1,670)	6,000
ii) Cost to transport fertilizer per household (in Kenyan Shillings)	820 (1,464)	500	408 (666)	250	369 (627)	200
iii) Other costs paid to acquire fertilizer per household (in Kenyan Shillings)	33 (328)	0	N/A	-	N/A	-
No. of observations (N)	555		157		803	
2022	Subsidized fertilizer				Commercial fertilizer	
	Mean (SD)		Median		Mean (SD)	Median
Price of fertilizer per 50-kilogram bag (in Kenyan Shillings)	1,692 (1,455)		1,692		3,762 (2,101)	3,500
No. of observations (N)	125				595	

Note: Descriptive statistics calculated conditional on acquiring the specific types of fertilizer. Statistics were calculated using sampling weights as described in section 4.

Table 5: Factors affecting the probability that a household acquired National Government (NFSP) subsidized fertilizer in 2023

	(1)	(2)	(3)	(4)
VARIABLES	Dependent variable: =1 if the household registered to receive the subsidy	Dependent variable: =1 if the household received an SMS notification	Dependent variable: =1 if the household acquired national-govt. subsidized fertilizer	Dependent variable: kgs of national-govt. subsidized fertilizer the household acquired
Land area (acres) operated by households in 2023	0.014**	0.008	0.016***	5.157***
	(0.006)	(0.006)	(0.005)	(0.916)
Household size	0.019**	0.016**	0.011**	2.466***
	(0.007)	(0.006)	(0.005)	(0.911)
=1 if female-headed household	0.046	0.067*	0.036	5.743
	(0.036)	(0.034)	(0.032)	(5.836)
Household head years of schooling	0.018***	0.017***	0.013***	3.109***
	(0.004)	(0.004)	(0.003)	(0.711)
Age of household head	-0.002	-0.002	-0.000	-0.086
	(0.001)	(0.001)	(0.001)	(0.215)
Years that the head has lived in the village	0.004***	0.004***	0.001	0.250
	(0.001)	(0.001)	(0.001)	(0.179)
=1 if the household was related to the village leader	0.065	0.068*	0.056*	10.001**
	(0.041)	(0.036)	(0.032)	(4.700)
=1 if Household member of community group	0.087**	0.073**	0.016	1.142
	(0.033)	(0.027)	(0.027)	(4.862)
=1 if the household owns a smartphone	-0.011	0.014	0.019	5.301
	(0.047)	(0.035)	(0.029)	(6.794)
Total Livestock Unit (TLU) owned	0.000	-0.001	0.001	0.230
	(0.002)	(0.003)	(0.003)	(0.279)
Household asset index	-0.031**	-0.018	0.001	-0.043
	(0.014)	(0.012)	(0.008)	(1.321)
Distance (km) from home to nearest agro-dealer	-0.003*	-0.004**	-0.003***	-0.954***
	(0.002)	(0.002)	(0.001)	(0.290)
Distance (km) from home to nearest national govt-subsidized fertilizer sale point	0.002**	0.003***	0.000	0.027
	(0.001)	(0.001)	(0.000)	(0.077)
=1 if HH acquired subsidized fertilizer in the previous season (2022)	0.036	0.073	0.110*	23.311***
	(0.062)	(0.048)	(0.059)	(8.898)
=1 if HH used commercial fertilizer in the previous season (2022)	0.127***	0.137***	0.055*	7.407
	(0.033)	(0.036)	(0.028)	(4.867)
R-squared/ Pseudo R-squared	0.136	0.137	0.145	0.059

Note: 1,510 observations in all models; standard errors in parentheses, clustered at the county level; *, **, *** indicates that the corresponding coefficients were statistically significant at the 10, 5, and 1% level respectively; model in columns (1), (2), and (3) estimated by linear probability, model in column (4) estimated by Tobit with marginal effects shown; all models include a constant and province fixed effects; models were estimated using sampling weights as described in section 3.

4.5 Fertilizer Acquisition and Landholding Size: Distribution Patterns in 2023

Figure 1 and the following figures analyze fertilizer use among farmers with varying land sizes during the 2023 long rains. As shown in Figure 1, 62% of farmers in the sample cultivated less than two acres, 27% farmed between two and five acres, and 11% had more than five acres. Notably, the smallest group (under two acres) cultivated only 27% of the total land, with an average farm size of 1.10 acres. The group with two to five acres cultivated 37% of the total land, averaging 3.55 acres, while those with more than five acres worked 36% of the land, with an average of 10.30 acres. This highlights the unequal distribution of land in Kenya, which subsequent tables will explore in relation to fertilizer use in 2023.

Figure 1: Total Household Area Cultivated by farm size group in 2023

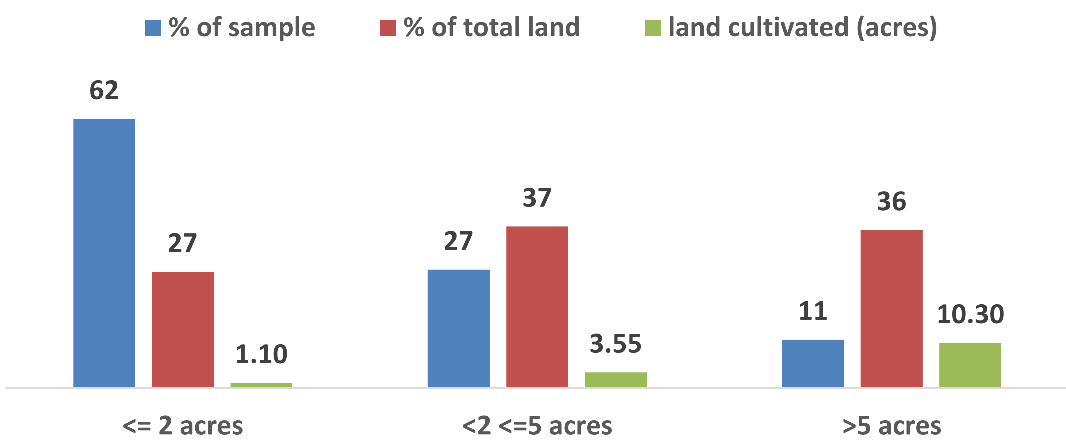
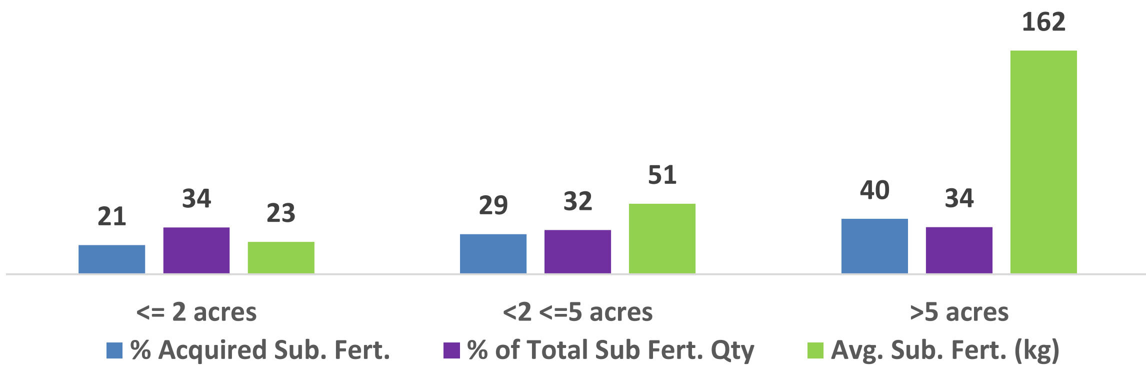


Figure 2 analyzes subsidized fertilizer acquisition during the 2023 long rains by landholding size. It shows that larger landholders received a disproportionate share of NFSP and county subsidies. Only 21% of households with less than two acres obtained subsidized fertilizer, compared to 40% of those with more than five acres. Despite representing 62% of the sample, farmers with less than two acres acquired just 34% of the total subsidized fertilizer that was distributed in 2023, while 11% of farmers with over five acres also received 34% of the fertilizer that was distributed. On average, smallholders (under two acres) acquired 23 kg of subsidized fertilizer, while larger farmers (over five acres) received 162 kg. These findings align with Table 5 , indicating that larger, wealthier farmers benefited most from the untargeted NFSP and county programs in 2023.

Figure 2: Shares of farmers obtaining subsidized fertilizer, fertilizer quantity shares, and average subsidized fertilizer use by farm size group, 2023



4.6 Crowding out of commercial fertilizer at the household level

Table 6 presents the factors influencing how much commercial fertilizer households purchased during the 2023 long rains. Column 1 shows the results for whether or not households purchased commercial fertilizer, while Column 2 shows the amount purchased using a linear model. Column 3 estimates the same model using the non-linear Tobit estimator, which accounted for the fact that 43% of households bought no commercial fertilizer.

Table 6: Factors affecting the probability that a household acquired commercial fertilizer and kilograms acquired during the 2023 long rains

VARIABLES	(1) Dependent variable: =1 if the household acquired commercial fertilizer: Probit marginal effects	(2) Dependent variable: kgs of commercial fertilizer the household acquired: linear model	(3) Dependent variable: kgs of commercial fertilizer the household acquired: Tobit marginal effects
Subsidized fertilizer acquisition in kg, household level	-0.001***	-0.147***	-0.221***
(includes both NFSP and county-level subsidized fertilizer)	(0.000)	(0.028)	(0.043)
Commercial fertilizer price per kg	0.000**	-0.014***	0.002
	(0.000)	(0.004)	(0.002)
Land area operated by household in acres in 2023	0.030***	9.635***	6.867***
	(0.006)	(1.685)	(1.045)
Household size	-0.007	-2.979**	-1.925**
	(0.007)	(1.263)	(0.955)
=1 if female-headed household	-0.020	-5.708	-4.825
	(0.036)	(12.298)	(8.353)
Household head years of schooling	0.007	-1.921	-0.377
	(0.006)	(1.447)	(0.860)
Age of household head	0.001	-0.316	-0.162
	(0.001)	(0.358)	(0.269)
Years that the head has lived in the village	-0.001	-0.048	-0.057
	(0.001)	(0.339)	(0.255)
=1 if Household related to village leader	-0.012	-15.639*	-9.081
	(0.037)	(8.930)	(6.439)
=1 if Household member of community group	-0.036	-9.317	-7.113
	(0.036)	(8.074)	(6.444)
=1 if the household owns a smartphone	-0.031	-2.260	-4.760
	(0.043)	(11.038)	(7.900)
Household asset index	0.028**	8.487**	6.334***
	(0.011)	(3.131)	(2.092)
Total Livestock Unit (TLU) owned	-0.002	0.294	0.197
	(0.002)	(0.935)	(0.592)
Distance (km) from home to nearest agro-dealer	-0.002	0.663	0.260
	(0.001)	(0.417)	(0.276)
Distance (km) from home to nearest national govt subsidized sale point	-0.000	-0.124	-0.091
	(0.001)	(0.088)	(0.076)
R-squared/ Pseudo R-squared	0.159	0.086	0.016

Note: 1,510 observations in all models; standard errors in parentheses, clustered at the county level; *, **, *** indicates that the corresponding coefficients were statistically significant at the 10, 5, and 1% level respectively; the model in column (1), was estimated by Probit with marginal effects; the model in column (3) was estimated by Tobit with marginal effects shown; all models include a constant and province fixed effects; models were estimated using sampling weights as described in section 4.

The key variable of interest across all models is the amount of subsidized fertilizer (from both NFSP and county programs) acquired by each household, which serves as a measure of "crowding out." Column 1 shows that acquiring an additional 100 kg of subsidized fertilizer made households

20 percentage points less likely to purchase any commercial fertilizer. Column 2 reveals that for every 100 kg of subsidized fertilizer acquired, households purchased 14.7 kg less commercial fertilizer on average, indicating a crowding-out rate of nearly 15%. In Column 3, the Tobit model estimate shows that each additional 100 kg of subsidized fertilizer led to households purchasing 22.1 kg less commercial fertilizer, resulting in a crowding-out rate of 22%. This means that for every 100 kg of subsidized fertilizer given to farmers, only 78 kg of new fertilizer was applied to farmers' fields, as 22 kg were just displaced commercial purchases.

Other significant factors include land size and assets, with larger and wealthier households buying more commercial fertilizer, as expected. Households with more members tended to buy less commercial fertilizer, possibly due to other financial priorities or greater engagement in non-farm activities.

Table 8 expands on the crowding-out estimates from Table 7 by breaking them down according to land size and asset levels in 2023. While Table 7 showed an overall crowding-out rate of 22%, Table 8 reveals that this rate increases with larger landholdings and greater assets. For example, in Panel 1, the crowding-out rate is 21% for those cultivating less than two acres, but it rises to 27% for those with over five acres. Similarly, the rate is 20% for households in the lowest asset quintile and increases to 27% for those in the highest quintile. These findings align with other studies (Ricker-Gilbert et al. 2011; Jayne et al. 2014), as wealthier farmers with more land are more likely to purchase commercial fertilizer.

Therefore, when they receive subsidized fertilizer, they reduce their commercial fertilizer purchases more than smaller, resource-limited farmers do.

Table 7: Average partial effect of receipt of subsidized fertilizer on farmer commercial fertilizer demand (i.e. crowding out/in), by area cultivated and quintiles of household assets, 2023

Farm Household Category	**Mean**	**P-value**	**N**
I. Area cultivated			
Less than 2 Acres	-0.21	(0.00)	933
Between 2 and 5 Acres	-0.22	(0.00)	410
Greater than 5 Acres	-0.27	(0.00)	167
II. Asset Quintile			
Poorest 20% of households	-0.20	(0.00)	303
20 - 40%tile	-0.20	(0.00)	281
40 - 60%tile	-0.21	(0.00)	354
60 - 80%tile	-0.22	(0.00)	297
Richest 20% of households	-0.27	(0.00)	275

Notes: Results in this table were derived from tobit model as in Table 6, with average effects disaggregated for different groups: 1,510 observations estimated in all models; p-values in parentheses, clustered at the county level; all models include a constant and province fixed effects; models were estimated using sampling weights as described in section 4.

Figure 3 shows commercial fertilizer purchases during the 2023 long rains, broken down by landholding size. Interestingly, 60% of farmers cultivating less than two acres purchased commercial fertilizer, compared to 52% of those with two to five acres and 54% of those with more than five acres. Despite the higher participation rate, farmers with less than two acres accounted for 52% of all commercial fertilizer purchased, while those with more than five acres accounted for just 20%. However, on average, smaller-scale farmers bought 36 kilograms of fertilizer, while those with over five acres purchased 92 kilograms.

Figure 3: Farmer commercial fertilizer purchases by farm size group, 2023

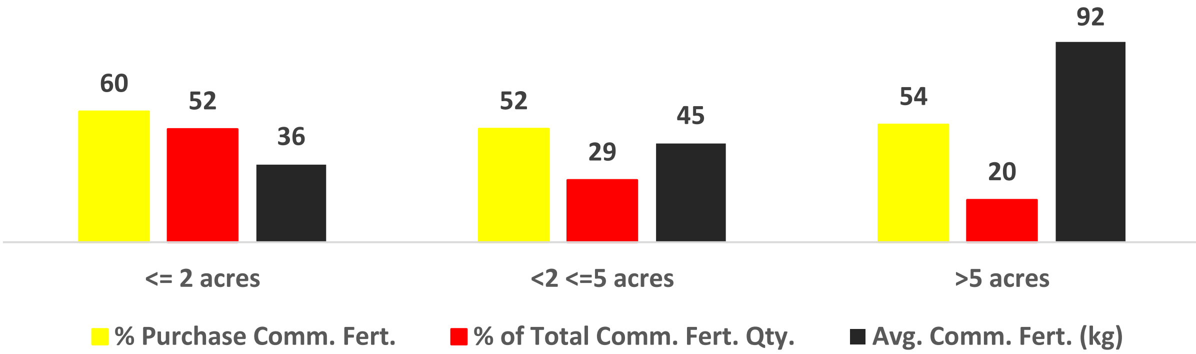
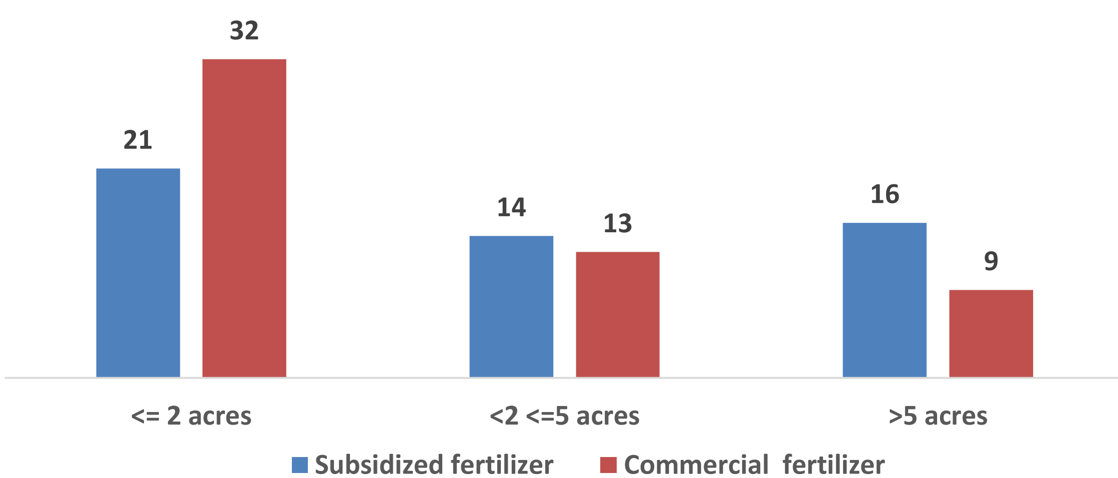


Figure 4 complements the earlier figures by showing both subsidized and commercial fertilizer acquisition by landholding size during the 2023 long rains. A striking finding is that farmers with less than two acres used fertilizer far more intensively than those with larger holdings. Farmers with less than two acres acquired 53 kilograms of fertilizer per acre (21 kg from subsidies and 32 kg from commercial sources). In contrast, those with two to five acres used 27 kilograms per acre (14 kg from subsidies and 13 kg from commercial sources), and those with more than five acres used only 25 kilograms per acre (17 kg from subsidies and nine kg from commercial sources). These results suggest that if the Kenyan government aims to promote intensive crop production, smaller-scale farmers should be prioritized in fertilizer subsidy programs.

Figure 4: Farmer total fertilizer acquisition (kg per acre), by farm size group and source in 2023



4.7 Crops receiving fertilizer

Table 8 shows the percentage of farmers applying fertilizer to different crops during the 2023 long rains, based on where they sourced their fertilizer. Column 1 includes farmers who acquired NFSP fertilizer from the national government, Column 2 covers those using county government-subsidized fertilizer, and Column 3 includes commercial fertilizer users. These categories are not mutually exclusive, as some farmers used fertilizer from multiple sources.

Table 8: Share of farmers who applied fertilizer to each crop in 2023 long rains (%), by fertilizer source

	(1) % of farmers that applied NFSP subsidized fertilizer to the crop		(2) % that applied county government (subsidized) fertilizer to the crop		(3) % that applied commercial fertilizer to the crop	
Crop	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Maize	0.96	0.20	0.84	0.37	0.87	0.33
Beans	0.52	0.50	0.55	0.50	0.45	0.50
Irish Potatoes	0.19	0.39	0.08	0.27	0.14	0.34
Vegetable crops	0.17	0.37	0.20	0.40	0.24	0.42
Millet	0.03	0.16	0.02	0.14	0.01	0.12
Sugarcane	0.03	0.16	0.02	0.13	0.02	0.13
Green gram	0.03	0.16	0.02	0.14	0.03	0.17
Tea or coffee	0.03	0.18	0.06	0.24	0.02	0.14
Sorghum	0.02	0.14	0.03	0.17	0.02	0.15
Rice	0.02	0.14	0.01	0.09	0.02	0.15
Wheat	0.02	0.12	0.01	0.11	0.01	0.07
Sweet potatoes	0.02	0.14	0.02	0.14	0.01	0.08
Pigeon pea	0.02	0.14	0.05	0.21	0.00	0.06
Bananas	0.02	0.12	0.00	0.07	0.01	0.09
Cowpea	0.02	0.14	0.02	0.15	0.01	0.12
Ground nuts	0.01	0.09	0.02	0.13	0.01	0.11
Avocados	0.01	0.11	0.00	0.07	0.00	0.06
Fruits	0.01	0.11	0.00	0.00	0.01	0.09
Soybean	0.00	0.05	0.01	0.09	0.00	0.03
Cassava	0.00	0.05	0.00	0.00	0.00	0.06
Coconut	0.00	0.00	0.00	0.00	0.00	0.00
Tree nuts	0.00	0.05	0.00	0.05	0.00	0.05
Khat [Miraa]	0.00	0.00	0.00	0.00	0.00	0.06
No. of observations (N)	555		157		803	

Note: Statistics were calculated using sampling weights as described in section 4.

The results show that maize was the most fertilized crop across all sources. Nearly all farmers who received NFSP fertilizer applied it to maize (96%), while 84% of county-subsidized fertilizer users and 87% of commercial fertilizer users did the same. The second most fertilized crop was common beans, with 52%, 55%, and 45% of farmers using NFSP, county-subsidized, and commercial fertilizer on beans, respectively. This reflects the common practice of intercropping maize and beans. Irish potatoes and vegetables were also widely fertilized, regardless of fertilizer source. Other crops were fertilized by far fewer farmers, and the top four crops—maize, beans, Irish potatoes, and vegetables—remained consistent across all fertilizer sources in 2023.

4.8 Benefit-Cost Analysis of NFSP

4.8.1 Cost and benefit components of benefit-cost analysis of NFSP

The components of our BCA of NFSP implementation during the 2023 long rains (LR, in short), 2023/24 short rains (SR, in short), and 2024 LR seasons are shown in Rows A through Row O in Table 10. Rows J through O contain the components used to estimate the incremental benefits of NFSP to Kenyan society. For example, in 2023 LR, the incremental national fertilizer use attributable to NFSP (Row L, 114,699 MT of fertilizer) is computed as the quantity of subsidized fertilizer sold by NFSP to farmers that season (Row A, 172,060 MT) multiplied by the estimated average partial effect (APE) of a 1 kg increase in NFSP fertilizer on total household fertilizer use (Row J, 0.655), which accounts for crowding-out of farmers' commercial fertilizer demand and diversion of program fertilizer.

This BCA assumes a crowding-out rate based on the econometric analysis reported in Table 7 above, which indicates that each additional 1 kg of subsidized fertilizer received by a farmer is associated with a decline in his/her commercial fertilizer demand (use) of 0.22 kg on average. This BCA analysis also assumes that 16 percent of NFSP fertilizer is diverted from the government supply chain into the private sector supply chain, which is based on evidence from countries with similar large-scale, government supply chain ISPs (Malawi and Zambia) and from Kenya (see Appendix C, section H). It is important to note that because of crowding out and diversion, the quantity of additional fertilizer utilized on farmers' fields (Row L, 114,699 MT) is considerably less than the total quantity of government-subsidized fertilizer intended for distribution (Row A, 175,060).

The quantity of incremental maize produced in Kenya (Row M, 628,552 MT of maize) is then computed as the quantity of additional fertilizer use (Row L, 114,699 MT of fertilizer) multiplied by the estimated average product of maize (in MT) per additional MT of fertilizer (Row K, 5.48). The value of this additional maize production for financial BCA (Row O.i, $153,846,301) is estimated by multiplying the additional quantity of maize produced in 2023 LR (Row M, 628,552 MT) a given season by the annual average farmgate price of maize ($US per MT), which in 2023 LR was $245 per MT.

Table 9: Benefit-cost estimates for Kenya's NFSP in 2023 LR, 2023/24 SR, & 2024 LR

Estimated program costs to government and farmers:[1]	2023 LR	2023/24 SR	2024 LR	TOTAL
(A) Total quantity of subsidized fertilizer distributed by NFSP (MT)[2]	175,060	124,940	172,500	472,500
(B) Unit cost of NFSP fertilizer at NCPB retail level ($US / MT)[3]	$892.12	$892.12	$892.12	
(C) Total estimated costs of NFSP fertilizer ($US) [A * B]	$156,175,353	$111,462,062	$153,891,513	$421,528,928
(D) Farmer subsidized price for NFSP plus farmer transport costs ($US / MT)[4]	$604.08	$385.71	$354.68	
(E) Total farmer expenditure on incremental fertilizer use as result of NFSP program, accounting for transport, crowding out & diversion [A * D * J]	$69,287,748	$31,574,837	$40,086,621	$140,949,205
(F) Total government expenditure on NFSP fertilizer program	$59,110,685	$60,858,709	$84,025,350	$203,994,745
(F.a) Total government expenditure on NFSP fertilizer [A * (B - D)]	$51,301,918	$55,285,606	$76,330,775	$182,918,298
(F.b) NFSP program administration costs of NFSP fertilizer program (C * 5%)	$7,808,768	$5,573,103	$7,694,576	$21,076,446
Incremental government program costs for economic analysis				
(G) Total government spending on the portion of NFSP fertilizer received by farmers that results in incremental aggregate fertilizer use, accounting for crowding out & diversion (F.a * J)	$33,613,017	$36,223,129	$50,011,924	$119,848,069
(H) Total government spending on NFSP fertilizer that is diverted at wholesale level to commercial channels (F.a * 16% diversion * 90% wholesale share of retail price)	$7,387,476	$7,961,127	$10,991,632	$26,340,235
(I) Total incremental government costs of NFSP fertilizer program, accounting for crowding out & diversion [F.b + G + H]	$48,809,260	$49,757,359	$68,698,131	$167,264,750
Estimated financial losses of private sector fertilizer supply chain actors:				
(J.a) Financial losses from supply-side crowding out in 2023 LR (KNTC imports)	$14,260,284			$14,260,284
(J.b) Financial losses due to demand-side crowding out in 2023 LR	$10,317,429			$10,317,429
(J.c) Financial losses due to foregone profits from fertilizer sales	$6,388,483	$3,363,400	$4,877,556	$14,629,439

Source: Mather et al (2024)

Table 10: Benefit-cost estimates for Kenya's NFSP in 2023 LR, 2023/24 SR, & 2024 LR, continued

Estimated incremental benefits:	2023 LR	2023/24 SR	2024 LR	TOTAL
(J) Estimated average partial effect of a 1 kg increase in NFSP fertilizer on total household fertilizer use, accounting for crowding out & diversion (kg)[5]	0.655	0.655	0.655	
(K) Estimated average product of maize (MT) per additional MT of fertilizer[6]	5.48	5.48	5.48	
(L) Incremental national fertilizer use as a result of NFSP, accounting for crowding out & diversion [A * J] (MT)	114,699	81,861	113,022	309,582
(M) Incremental maize output produced as a result of NFSP, accounting for crowding out & diversion [K * L] (MT)	628,552	448,597	619,361	1,696,509
(N) Maize grain prices ($US / MT):[7]				
(i) Annual average farmgate price of maize ($US / MT), financial analysis[8]	$245	$235	$272	
(ii) Annual average famgate IPP of maize ($US / MT), economic analysis[9]	$321	$334	$386	
(iii) Farmgate maize price at which NFSP breaks even (financial analysis)	$343	$319	$313	
(iv) Farmgate maize price at which NFSP breaks even (economic analysis)	$188	$181	$176	
(O) Value of incremental maize output [M] at prices in N ($US):				
(i) Using annual average farmgate maize price ($US / MT), financial analysis	$153,846,301	$105,481,470	$168,281,570	$427,609,341
(ii) Using annual average farmgate maize IPP ($US / MT), economic analysis	$201,855,308	$150,003,463	$238,865,497	$590,724,268
Benefit-cost ratios of NFSP:				
(P.a) Financial BC ratio of incremental benefits (value of incremental maize output in O.i), to total government program costs [B] + incremental farmer costs [D]	1.198	1.141	1.356	1.240
(P.b) Financial BC ratio of incremental benefits (value of incremental maize output in O.i), to total government program costs [B] + incremental farmer costs [D] + S-side crowding out (J.a & J.c)	1.032	1.101	1.305	1.144
(P.c) Financial BC ratio of incremental benefits (value of incremental maize output in O.i), to total government program costs [B] + incremental farmer costs [D] + S&D-side crowding out (J.ac; J.b)	0.965	1.101	1.305	1.113
(Q) Economic BC ratio of incremental benefits (value of incremental maize output in O.ii, to incremental costs to government [I] and incremental farmer costs [D]	1.709	1.844	2.196	1.917

Notes: All monetary values are in nominal $US. 1) The term incremental refers to the difference between benefits (costs) in a 'with program' and a 'without program' scenario; 2,3,4) adapted from Opiyo et al (2023); 5) See section 7.3.1; 6) Sheahan et al (2013); 7) average farmgate prices for post-harvest months (LR: Nov-Dec; SR: Feb-Mar); 8) Agricultural Market Information System, MoALI; 9) farmgate maize import parity price based on SAFEX white maize price, freight from www.sagis.org.za and cost buildup from IFDC/AfricaFertilizer.

Source: Mather et al (2024)

4.8.2 Benefit-Cost Ratios

Benefit-cost ratios (BCRs) are calculated by dividing the estimated incremental benefits of NFSP (additional maize output) by the total incremental costs to the government, farmers, and private sector fertilizer distributors associated with the program's implementation. Previous BCA assessments of input subsidy programs, such as Jayne et al. (2013), defined incremental costs as those borne by the government and participating farmers. Using this definition, the financial BCR of NFSP over the three-season period was 1.24. However, when financial costs to the private sector from supply- and demand-side crowding out of commercial fertilizer are included, the BCR drops to 1.14. When private sector distributors' foregone profits are also factored in, the BCR further declines to 1.11.

A significant portion of the private sector's financial losses, due to the crowding out of commercial fertilizer sales and lost profits, is attributable to the government's choice to use parastatals (KNTC and NCPB) to retail fertilizer under the NFSP. This contrasts with the more private sector-friendly approach used in the NVSP. Had the private sector been allowed to participate in the subsidized fertilizer distribution, they would likely have maintained or increased sales, with no loss in revenues or profits. However, in practice, not all private sector distributors are selected to participate in subsidy programs, leading to financial losses for those left out due to reduced sales and foregone profits.

In this scenario, we calculate a fourth financial BCR to estimate the return on NFSP if the private sector had been allowed to distribute and retail the subsidized fertilizer. This calculation includes the incremental program costs for the government (Row F), participating farmers (Row E), and private sector distributors and agro-dealers who were excluded from NFSP participation—assumed to be 30% of distributors and 35% of agro-dealers in the program areas. We note that the vast majority of distributors and agro-dealers still would not have been able to participate in the subsidy program even if some were allowed to do so. Under the model where some private sector actors could distribute and sell NFSP fertilizer the financial losses from foregone sales and profits are significantly lower ($4,011,830, Row J.d, Total column) compared to the actual implementation of NFSP, which resulted in higher losses of $14,629,439 (Row J.c, Total column). Additionally, there would have been no financial losses from fertilizer already in stock before the 2023 long rains ($24,567,713, sum of Row J.a and J.b, 2023 LS column). The BCR in this scenario is 1.225 (Row P.d), with returns over 1.0 that are nearly double the BCR of 1.11 (Row P.c) for the NFSP as it was implemented. That scenario included financial losses from supply- and demand-side crowding out, and foregone profits experienced by distributors and agro-dealers excluded from the program.

4.8.3 Sensitivity of results to maize prices

As with most benefit-cost analyses (BCA) of agricultural projects, the results of this BCA for NFSP are highly sensitive to a few key parameters, mainly the prices of key inputs (fertilizer) and outputs (maize), as well as assumptions about how changes in fertilizer application rates impact farmer maize productivity. The variation in farmgate maize prices across the three seasons highlights the sensitivity of the BCRs to output prices. For example, when the farmgate maize price dropped from $245/MT in the post-harvest period of the 2023 long rains (Nov/Dec 2023) to $235/MT in the 2023/24 short rains (Feb/Mar 2024), the BCR fell from 1.198 to 1.141 (Row P.a). Conversely, when the maize price rose to $272/MT in the 2024 long rains post-harvest period (Nov/Dec 2024), the BCR increased to 1.24.

4.8.4 Sensitivity of results to assumptions regarding maize-fertilizer response rates

The BCR is also highly sensitive to assumptions about maize's physical response to inorganic fertilizer, known as the Average Product (AP). In the base scenario, the AP of maize (5.48) is based on empirical estimates from five waves of panel household data in Kenya from 1997 to 2010 (Sheahan et al., 2012). However, anecdotal evidence suggests that soils in key maize-growing regions have become more acidic since 2010, with no significant increase in fallowing rates. This likely means the AP of maize has declined due to worsening soil conditions and lower organic matter. If we assume the AP in 2023-2024 is 10% lower than in 2010, the BCR under cost scenario CS-1 drops from 1.24 to 1.115, and from 1.113 to 1.000 under CS-2 (Table 11). If the AP is assumed to be 20% lower, the BCR falls further to 0.991 under CS-1 and to 0.890 under CS-2. This demonstrates the significant sensitivity of the BCR to changes in the AP parameter.

Table 11: Sensitivity analysis of financial benefit-cost ratios for NFSP implemented over 3 seasons, by cost definition and parameter assumptions

	Financial BCR by cost definition1		
	Parameter value	CD-1: Govt + farmers	CD-2: Govt + farmers + priv sector
Average product of maize (kg) per additional kg of fertilizer			
(i) Baseline scenario AP of maize	5.48	1.240	1.113
(iv) 80% * base scenario AP of maize	4.38	0.991	0.890
(iv) 90% * base scenario AP of maize	4.93	1.115	1.001
(iv) 110% * base scenario AP of maize	6.03	1.364	1.225
(iv) 120% * base scenario AP of maize	6.58	1.488	1.337
(iv) Break-even AP of maize for cost definition CD-1	4.42	1.000	0.898
(iv) Break-even AP of maize for cost definition CD-2	4.93	1.115	1.000
Average partial effect of a 1 kg increase in NFSP subsidized fertilizer on household total fertilizer use (kg), with and without diversion:			
(i) Baseline scenario APE (with 16% diversion of NFSP fertilizer)	0.655	1.240	1.113
(i) Baseline scenario APE (with no diversion of NFSP fertilizer)	0.780	1.369	1.239

Source: Authors' computations using BCA framework shown in Table 10. Note: Govt refers to government expenditures on NFSP; private sector refers to financial losses incurred by private sector fertilizer supply chain actors due to NFSP

In contrast, if future public and private efforts could boost maize's response to fertilizer (AP) by 10%, the BCR would rise from 1.24 to 1.36 under the CD-1 cost scenario, and from 1.11 to 1.22

under CD-2. A 20% increase in maize-fertilizer response would raise the BCR further to 1.48 under CD-1 and 1.33 under CD-2. These results show how much more effective and cost-efficient an input subsidy program can become when paired with efforts to (a) promote farmer adoption of complementary crop and soil management practices to improve soil fertility, (b) help farmers better understand nutrient constraints in their area through tools like low-cost soil testing equipment being piloted in East and Southern Africa, and (c) guide farmers on which fertilizer types or blends are most suitable for their soil conditions.

4.8.5 Sensitivity of results to diversion of program fertilizer

The base scenario BCR uses an assumption that 16 percent of program fertilizer is diverted. If the government were able to reduce diversion to zero, the BCR would increase from 1.24 to 1.37 using the CD-1 cost definition and would increase under the CD-2 cost definition. If one were to assume that the probability of diversion of government-subsidized fertilizer increases by the number of government employees that are in a position to physically access program fertilizer as it moves from the port to inland warehouses to rural retail locations, then the most logical way to reduce diversion of program fertilizer would be to have the private sector import, distribute and retail subsidized fertilizer for the government. This is because actors within each node of the private sector supply chain that participate in a private-sector friendly subsidy program would have a very strong financial incentive to sell 100 percent of the program fertilizer they are allocated because (a) farmers who have the option to purchase a given type of fertilizer at a subsidized or a commercial price will choose the commercial price[10]; and thus b) distributors and agro-dealers should have no problem selling their allocation of subsidized fertilizer.[11]

[10] In practice, this assumes that the subsidy program subsidizes types of fertilizer that farmers prefer. This was not the case with NFSP for some farmers, who prefer to use DAP rather than NPK, and of the two, only NPK was subsidized.

[11] It is important to note that in practice, private sector actors who participate in an ISP in which the private sector imports, distributes and retails subsidized fertilizer may experience unexpected and additional costs of their participation – that would reduce their profits – if the government is not prompt in repaying importers and distributors the government's share of the full cost of the program fertilizer (Mather, 2016).

5. Discussion

This study aimed to address six key research questions posed at the outset. Below, we restate these questions and provide the answers derived from our analysis.

Q1) ***What percentage of farmers participated in the NFSP? How much fertilizer did they acquire? What were their demographic characteristics (e.g., landholding, assets, income, education, and gender)?***

In 2023, nearly 50% of households registered for the NFSP program, and 32% received an SMS with details on where to obtain their fertilizer. However, only 25% of households actually acquired subsidized fertilizer—19% through NFSP and 8% from county government programs. While this marked a significant increase from 2022, when only 6% of households received subsidized fertilizer, the gap between registration and acquisition suggests that many households, especially those with limited resources, faced access issues.

Our analysis also showed that the NFSP did not prioritize reaching limited-resource farmers in 2023, though this was not the program's goal. Larger-scale farmers, who were more educated, well-connected, and had previously used fertilizer, were more likely to participate in the program. This is notable because smaller-scale farmers (those with less than two acres) applied fertilizer more intensively than larger-scale farmers. If the goal is to boost agricultural productivity and intensification, it would be more effective to target smaller-scale producers with the subsidy.

Q2) When did farmers receive subsidized fertilizer and was it in time for maize planting? How did the timing compare to those who bought fertilizer from private-sector agro-dealers?

Our results show that most farmers received their NFSP fertilizer during the first week of April 2023, which was one week later than those who received county-subsidized fertilizer and two weeks later than those who purchased from the private sector. Despite the timing, 80% of farmers reported that the NFSP fertilizer arrived in time for planting, compared to 82% for county fertilizer and 87% for commercial fertilizer.

The NFSP primarily distributed NPK 23-23-0 fertilizer, but most farmers expressed a preference for DAP, which was the main type distributed by counties and purchased from the private sector. According to Opiyo et al. (2023), the government limited the distribution of DAP through the NFSP due to concerns about its reduced effectiveness on acidic soils.

Q3) How effectively did the NFSP target farmers who would not have purchased fertilizer from the private sector? Did the NFSP and county programs crowd out or crowd in commercial fertilizer?

In 2023, 57% of households purchased commercial fertilizer, with an average purchase of 43 kilograms. This was a significant increase from 2022, when only 23% of households bought commercial fertilizer, averaging 23 kilograms. The rise in commercial purchases in 2023 was likely driven by higher maize prices and lower fertilizer prices, making fertilizer use more profitable.

At the household level, we estimated a crowding-out rate of 22%, meaning that for every 100 kilograms of subsidized fertilizer acquired, only 78 kilograms of new fertilizer were applied to fields, with 22 kilograms displacing commercial purchases. The crowding-out rate was 21% for farmers with less than two acres, compared to 27% for those with more than five acres. This aligns with the finding that larger, more well-connected farmers were more likely to access NFSP fertilizer while still purchasing more commercially. These results raise concerns about the cost-effectiveness of the NFSP in increasing total fertilizer use and boosting maize production.

Q4) What were the costs for farmers to acquire NFSP fertilizer through government channels, and how did these compare to costs of acquiring fertilizer through the private sector?

Farmers had to travel farther and spend more time acquiring NFSP fertilizer compared to county-subsidized or commercial fertilizer. However, the significantly lower cost of NFSP fertilizer made it worthwhile for farmers to make the trip, if they were awarded the opportunity to buy the fertilizer at a discounted price. the average cost for a 50-kilogram bag of subsidized fertilizer from NFSP was 3,200 shillings, and the average transport cost was 820 shillings per household. Conversely, the average cost for a 50-kilogram bag of commercially priced fertilizer was 6,190 shillings, and the average transport cost was 369 shillings. These findings further strengthen the recommendation that if NFSP fertilizer was sold through the private sector in agro-dealers' shops, then the transport costs would be lower. Farmers would also benefit from having to make one trip rather than two to buy both subsidized and commercial fertilizer, along with other inputs like seed and chemicals that they need for the season.

Q5) Which crops received subsidized and commercial fertilizer in 2023?

Our results showed that maize was the most fertilized crop in 2023, regardless of where farmers obtained their fertilizer. Nearly all farmers who received NFSP fertilizer applied at least some of it to maize (96%). A slightly lower, but still high percentage, applied county government fertilizer (84%) and commercial fertilizer (87%) to maize. Common beans were the second most fertilized crop, with 52% of farmers using NFSP fertilizer, 55% using county fertilizer, and 45% using commercial fertilizer for beans.

Q6) What was the benefit-cost ratio of the NFSP in 2023? Did the benefits, in terms of increased maize production, justify the program's costs? How does the benefit-cost ratio of NFSP compare with other potential public investments?

The benefit-cost analysis (BCA) in this paper defines the additional benefits of NFSP as the value of the increased maize production in Kenya due to the program's impact on farmer fertilizer use. The benefit-cost ratio (BCR) is calculated by comparing these additional benefits with the extra costs incurred by the government, farmers, and private sector fertilizer suppliers due to NFSP. When considering only government and farmer costs, the financial BCR for NFSP was 1.24 over three seasons. However, when factoring in financial losses experienced by private sector suppliers due to crowding out of commercial fertilizer, the BCR drops to 1.11. If the government had allowed the private sector to handle all subsidized fertilizer distribution and retail, as it did with NVSP from 2017 to 2022, the BCR would have risen to 1.224. This is because private sector distribution would have significantly reduced supply-side crowding out, minimizing the financial losses for private suppliers to just 6% of what they experienced under NFSP.

A benefit-cost ratio (BCR) greater than 1.0 is the minimum expectation for a public investment, indicating that the benefits outweigh the costs. While NFSP's BCR of 1.11 meets this threshold, public investments are usually assessed by comparing them to average BCRs from similar projects in other regions or periods, as well as to alternative public investment options. For instance, had the government allowed the private sector to handle fertilizer distribution and retail over the past three seasons, the BCR would have increased to 1.22. However, studies show that investments in public goods, such as agricultural research and development (R&D), road infrastructure, and policy improvements, typically yield much higher returns than input subsidies. For example, research from Asia highlights that the returns on these types of investments often surpass those of input subsidies (EIU, 2008; Fan et al., 2008). Similarly, a review of 30 studies across sub-Saharan Africa found a median BCR of 11.0 for agricultural R&D, more than 10 times higher than NFSP's BCR (Pardey et al., 2016).

6. Policy Recommendations

To enhance the effectiveness and sustainability of fertilizer subsidy programs in Kenya, we offer several policy recommendations based on our findings. These suggestions aim to improve agricultural productivity, support smallholder farmers, and strengthen the private sector's role in input supply chains. Addressing both immediate and long-term needs, these recommendations provide a roadmap for policymakers to optimize the benefits of subsidies while mitigating potential negative impacts on the economy and farming communities.

Short-Term Recommendations

1. Implement Input Subsidy Programs Exclusively Through the Private Sector. To strengthen existing supply chains and prevent crowding out, input subsidy programs should be delivered solely through the private sector, rather than through government-run distribution systems. While the government may feel pressure to scale up input subsidies during crises, as seen in 2022, distributing subsidies through government supply chains undercuts private sector actors—fertilizer importers, distributors, and agro-dealers—leading to significant financial losses. Prolonging government-led distribution, as in the NFSP, could drive these private businesses out of the market, reducing competition and raising fertilizer prices for farmers in the medium to long term. Moreover, fewer distributors would force farmers to travel farther to access inputs, increasing transportation and transaction costs, and ultimately leading to reduced fertilizer use and lower crop productivity.

1.1 Prevent Long-Term Financial Losses in the Private Sector

Continuing government-led fertilizer distribution would not only hurt private sector businesses but also reduce competition in the fertilizer market. Fewer private sector actors would drive up wholesale and retail prices, increasing costs for farmers. With fewer agro-dealers, farmers in rural areas would need to travel greater distances to access inputs, further increasing their costs and lowering input use. Ultimately, this would lead to reduced crop productivity and reverse the small yield gains achieved since market liberalization.

1.2 Maintain a Favorable Investment Environment

The government must ensure that private sector actors continue to view Kenya as a favorable environment for investment. The abrupt switch from the NFSP model to the more private sector-friendly NVSP in 2017, followed by a sudden return to NFSP, undermines trust in government policy stability. The period between 1996 and 2007, when the government had no direct involvement in fertilizer distribution, saw the largest sustainable increases in farmer access to fertilizer. Returning to private-sector-led distribution would restore confidence and encourage long-term investment.

1.3 Ensure Timely Availability of Inputs

Private sector actors have significantly more experience in the importation, distribution, and retailing of fertilizers than government parastatals like KNTC and NCPB. In 2023, farmers who purchased fertilizer from private sources received it on average two weeks earlier than those relying on NFSP. Ensuring that fertilizers are available when farmers need them is crucial to maximizing their benefits, and the private sector is better equipped to meet this demand in a timely manner.

1.4 Reduce the Risk of Subsidy Diversion

Private sector distribution of fertilizers offers better oversight and reduces the risk of illegal diversion of subsidized inputs. Private companies must carefully track fertilizer as it moves through the supply chain to ensure it is sold, while their participation in input subsidy programs requires verifiable records of farmer redemptions to claim government reimbursements. By contrast, NFSP fertilizer is handled by multiple government officials across regions, with fewer financial incentives to monitor and prevent diversion. Shifting to private sector-led distribution would minimize the risk of misuse and ensure that subsidies reach the intended beneficiaries.

2. Reduce the Maximum Quantity of Subsidized Fertilizer Per Farmer To promote equity and efficiency, the maximum quantity of subsidized fertilizer should be reduced. In times of crisis, the limit could be 24 bags (sufficient for 4 hectares of maize), while in normal conditions, the cap should be reduced to 4 bags (for 2 acres). This ensures that medium and large-scale farmers, who can afford commercial fertilizer, do not disproportionately benefit, allowing smaller farmers, who are more in need of subsidies, to access the fertilizer.

3. Return to a Targeted Subsidy Approach A targeted subsidy approach, such as the one used in NVSP, is more effective in increasing fertilizer use by smallholder farmers who otherwise could not afford it. During stable periods, the program should focus on farmers with 2 hectares or less. In times of crisis, the program could be modified by increasing the e-voucher value and temporarily allowing medium-scale farmers to access subsidies.

Medium- to Long-Term Recommendations

4. Promote Best Practices for Crop and Soil Management. Crop yields depend on more than just fertilizer use and seed variety—soil health and management practices play a critical role. The effectiveness of both inorganic and organic fertilizers is influenced by soil characteristics, which are shaped by a farmer's crop rotation and soil management over time. Research in Kenya shows that soils low in organic matter (SOM) have significantly lower maize yield responses to fertilizer (Marenya and Barrett, 2009). Practices like intercropping with legumes, minimum tillage, cover crops (Lal, 2011), and fallowing can increase SOM and improve fertilizer efficiency. However, rising population pressure and shrinking farm sizes in Kenya have reduced fallowing rates, contributing to soil degradation.

A key shortcoming of large-scale input subsidy programs in Kenya and other SSA countries since 2008 has been the lack of focus on training farmers in complementary crop and soil management practices. To maximize the impact of fertilizer subsidies, these programs must be paired with extension services that promote

5. Increase Funding for Agricultural R&D and Extension Services. Boosting agricultural productivity requires increased investment in research and development (R&D) to develop technologies and management practices that improve crop response to fertilizer and enhance soil fertility. These innovations are essential for maintaining and improving yields over time. In addition, increased funding for public extension services is crucial to ensure that extension agents can reach farmers and provide the education needed to adopt these new technologies and best practices. By strengthening both R&D and extension efforts, Kenya can equip its farmers with the tools and knowledge needed to sustainably increase productivity and improve food security.

6. Invest in Rural Roads and Create a Supportive Environment for Private Sector Input Supply Chains. To sustainably lower the cost of fertilizers and other agricultural inputs, the government should prioritize investments in rural transportation infrastructure to reduce distribution costs. Additionally, establishing a favorable policy and regulatory environment will encourage private sector investment in fertilizer supply chains, including local production and blending. Investments in local fertilizer blending are particularly important, as many Kenyan farms face soil acidity and micronutrient deficiencies (NAAIAP, 2014). By supporting tailored fertilizer blends suited to local soil conditions, the government can improve crop-fertilizer response rates and enhance overall agricultural productivity. This approach, combined with efforts to improve soil management, will strengthen Kenya’s agricultural sector in the long term.

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Appendix A. Sampling methodology and survey procedures

GeoPoll used Random Digit Dialing (RDD) probability sampling which randomly generates a phone number and then automatically confirms if the number represents an active account carried by a mobile network operator. The verified list is then randomized and used by enumerators to reach out to respondents to conduct surveys.

In phase 1, we targeted farmers who had engaged in crop farming in 2023 long rains season (with planting between February and April) and were key decision makers on matters of crop farming. In phase 2, two additional screener questions were added, requiring the farmer to:

1. Be aware of the national fertilizer subsidy program; and
2. Had registered for this program.

The first round of data collection occurred from 29th of September through 19th of October 2023, and the second round of data collection occurred between 23rd of October and 17th of November 2023. Computer Assisted Telephone Interviewing (CATI) was used to collect 1,510 surveys in total in all 38 counties.

RDD Methodology

For random digit dialing, the research team used the best-in-class GeoPoll RDD methodology which consisted of the following three steps:

- Step 1 – Mobile number generation: Using public information, GeoPoll's team identified the most common prefixes for each mobile network operator operating in a market, as well as the percentage share that each mobile network operator represents. The system then randomly generated lists of unique numbers that include numbers from each telecom network.
- Step 2 – Mobile number validation and testing: Once the initial files were generated, GeoPoll conducted a validation process that identifies likely active and inactive numbers and removes numbers that are inactive before proceeding with live testing. GeoPoll's call center teams then conducted testing with the final list of numbers.
- Step 3 – Survey administration: Once GeoPoll had finalized the list of mobile numbers, it was handed off to trained survey interviewers for full survey administration. The GeoPoll CATI Application tracked the outcome of each call, including the percent of phone numbers that are invalid, and the percent of respondents who refuse to take a survey. The survey production statistics is presented in Table 12.

Over the course of the data collection for phase 1, GeoPoll called approximately 18,987 survey invitations to Kenyan residents in 38 counties. Of those, 30% refused to participate in the survey and 24% opted-in, with 5% completing the survey. In phase 2, GeoPoll called approximately 44,027 survey invitations to Kenyan residents in 12 counties. Of those, 13% refused to participate in the survey and 19% opted-in, with 1% completing the survey.

Table 12: Survey production data, Phase 1 and 2

	Phase 1	**Phase 2**
Total calls attempted	18,987	44,027
% Nonresponse	46%	68%
% Refusals	30%	13%
% Opted in	24%	19%
Outcomes of opt-ins		
Ineligible	9%	16%
Dropoffs	11%	2%
Completes	5%	1%

Table 13: Sample size by counties and the two stages of sample selection

County	**Pilot county**	**Phase 1 survey (Random sample of crop farming HHs)**	**Phase 2 survey in selected 12 counties (Additional random sample of eligible NFSP beneficiaries)**	**Total sample**
1 Baringo	No	9	--	9
2 Bomet	Yes	37	45	82
3 Bungoma	Yes	76	80	156
4 Busia	No	13	--	13
5 Elgeyo Marakwet	Yes	19	21	40
6 Embu	No	12	--	12
7 Homa Bay	No	17	--	17
8 Kajiado	No	9	--	9
9 Kakamega	Yes	85	96	181
10 Kericho	Yes	38	43	81
11 Kiambu	No	19	--	19
12 Kilifi	No	15	--	15
13 Kirinyaga	No	13	--	13
14 Kisii	No	21	--	21
15 Kisumu	No	13	--	13
16 Kitui	No	19	--	19
17 Kwale	No	10	--	10
18 Laikipia	No	9	--	9
19 Machakos	No	21	--	21
20 Makueni	No	17	--	17
21 Meru	No	26	--	26
22 Migori	Yes	43	48	91
23 Muranga	No	21	--	21
24 Nakuru	Yes	71	81	152
25 Nandi	Yes	35	43	78
26 Narok	Yes	46	47	93
27 Nyamira	No	10	--	10
28 Nyandarua	No	13	--	13
29 Nyeri	No	15	--	15
30 Samburu	No	8	--	8
31 Siaya	No	18	--	18
32 Taita Taveta	No	7	--	7
33 Tana River	No	7	--	7
34 Tharaka Nithi	No	9	--	9
35 Trans-Nzoia	Yes	35	40	75
36 Uasin Gishu	Yes	37	43	80
37 Vihiga	No	10	--	10
38 West Pokot	Yes	17	23	40
Total		**900**	**610**	**1510**

Appendix B. Details of the Benefit-Cost Analysis of NFSP

This appendix provides further details regarding the figures, parameters, data sources, assumptions and computations used in the BCA of the National Fertilizer Subsidy Program (NFSP) reported in this paper. This section summarizes a more detailed review of the BCA methods, assumptions, and analysis of NFSP found in Mather et al. (2024). Such details are important to document and share as many BCA applications can be quite sensitive to assumptions made regarding key parameters. The authors welcome questions regarding the data, methods and parameters used that may not be addressed by this appendix.

Computing incremental costs of NFSP

(A) Total quantity of NFSP fertilizer distributed to farmers (MT)

During the 2023 Long Rains season, NFSP sold 175,060 MT of subsidized fertilizer (3,501,200 50-kg bags) to farmers through 30 July 2023 (Opiyo et al, 2023). In January 2024, the government stated that NFSP had sold 6 million bags of subsidized fertilizer to farmers in 2023[12]. This implies that NFSP distributed 2,498,800 50 kg bags (124,950 MT) of subsidized fertilizer in the 2023/24 Short Rains season, which is consistent with estimates shared by NFSP with the authors in early December 2024[13]. Based on government statements made in February and May 2024, we assume that NFSP sold the remaining 175,500 MT (of the 472,500 MT purchased by KNTC in late 2022) (3,450,000 50 kg bags) during the 2024 Long Rains season[14]. While it is possible that the government distributed more than this amount in the 2024 LR season, there is currently no official government confirmation yet of the total quantity of subsidized fertilizer in 2024 LR.

(B) Unit cost of NFSP fertilizer at NCPB retail level ($US / MT)

The unit cost of NPK, CAN, and urea fertilizers purchased by the government for NFSP is based on information on fertilizer cost buildups provided by NFSP officials to Opiyo et al (2023). The costs per 50 kg bag of NFSP fertilizer at NCPB retail level range from 5,250 KSh/bag to 5,535 KSh/bag, depending on the specific type of fertilizer (NPK, CAN, Urea), brand, and formulation (Table 14). The full cost per MT of NFSP fertilizer at NCPB retail level in is computed as the weighted average cost of NPK, CAN, and urea fertilizers, using the share of each fertilizer type in

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[12] On 31 Jan 2024, Agricultural Cabinet Secretary Mithika Linturi said that government distributed 6 million bags across the country in 2023. Given that 3.5 million bags were distributed for the 2023 LR season, this implies that 2.5 million were distributed in the 2023/24 Short Rains. https://www.the-star.co.ke/news/2024-01-31-state-to-issue-12-million-bags-of-subsidised-fertiliser-cs-linturi/

[13] In early December 2023, NFSP officials said that NFSP had distributed 111,908 MT of subsidized fertilizer (2,238,160 50kg bags) for the 2023/24 Short Rains by that point (authors' personal communications).

[14] On 13 April 2024, Agriculture Principal Secretary Paul Ronoh said that the government "(had) planned for 7.5. million bags for the (2024) long rains and 5 million bags for the (2024/25) short rains, totaling 12.5 million bags. https://www.kenyanews.go.ke/state-flags-off-fertilisers/ Yet, Agricultural Cabinet Secretary Mithika Linturi announced on 2 May 2024 that, to date, the government had distributed a total of 3.6 million 50kg bags to farmers for use in the 2024 LR season, implying that they may not reach their target of 5 million bags. https://www.kenyanews.go.ke/govt-to-distribute-12-5-million-bags-of-subsidised-fertiliser/

the total quantity as weights. The cost per MT of NFSP fertilizer in Table 10 (Results section) remains constant across the 3 seasons because the 472,500 MT of subsidized fertilizer sold by NFSP in those seasons was all purchased by the government in Nov/Dec 2022.

(C) Estimated total costs of NFSP fertilizer at NCPB retail level

The total costs of NFSP fertilizer at NCPB retail level were computed by season based on available information regarding the quantities of NPK, CAN, and urea fertilizers sold each season multiplied by the full unit cost of each type of fertilizer (Table 15).

Table 14: Fertilizer cost buildup for NFSP fertilizer at NCPB retail level (KSh/50 kg bag), by fertilizer type, 2023

Fertilizer type	Ex-warehouse[1]	Handling & distribution	Landing cost at NCPB	NCPB retail cost	Subsidy price paid by farmers	Share of full cost paid by farmers	Farmer cost including transport[2]
CAN	4,750	750	5,500	5,775	2,875	50%	3,075
UREA	4,700	750	5,450	5,723	3,500	61%	3,700
NPK	4,500	750	5,250	5,513	3,275	59%	3,475
Yara Microp (NPK)	4,650	750	5,400	5,670	3,500	62%	3,700
NPK 23:23:0	4,785	750	5,535	5,812	3,500	60%	3,700
Kynomaizec (NPK)	4,500	750	5,250	5,513	3,500	63%	3,700
KNTC Fomi Kuzia/ Otesha (NPK / Urea)	4,700	750	5,450	5,723	3,500	61%	3,700

Source: Mather et al (2024), adapted from Opiyo et al. (2023). 1) "Ex-warehouse" includes costs of importation and clearing the Mombasa port. 2). The median farmer transport cost to/from NCPB depots in 2023 was 200 KSh/50kg, according to authors' computations using 2023 Farm Household Phone Survey data.

Table 15: Components of the full cost of NFSP fertilizer by season and the government's share of it, 2023 LR, 2023/24 SR, 2024 LR

Season	Fertilizer type	Quantity of NFSP inorganic fertilizer sold[1] MT	Quantity of NFSP inorganic fertilizer sold[1] 50 kg bags	Full cost of NFSP fertilizer per 50 kg bag KSh/50kg	Full cost of NFSP fertilizer (B * C) KSh	Farmer's subsidized price per bag KSh/50kg	Government expenditure per bag (C - D) KSh/50kg	Government expenditure on NFSP fertilizer (B * F) KSh
		(A)	(B)	(C)	(D)	(E)	(F)	(G)
2023 Long Rains	NPK	117,633	2,352,658	5,456	12,835,804,395	3,500	1,956	4,601,500,691
	CAN	36,123	722,470	5,500	3,973,584,127	3,500	2,000	1,444,939,683
	UREA	21,304	426,072	5,450	2,322,092,169	3,500	1,950	830,840,317
	Total	175,060	3,501,200		19,131,480,691			6,877,280,691
2023/24 Short Rains	NPK	83,954	1,679,088	5,456	9,160,889,987	2,500	2,956	4,963,170,410
	CAN	25,781	515,625	5,500	2,835,939,683	2,500	3,000	1,546,876,190
	UREA	15,204	304,087	5,450	1,657,272,910	2,500	2,950	897,055,979
	Total	124,940	2,498,800		13,654,102,579			7,407,102,579
2024 Long Rains	NPK	115,913	2,318,254	5,456	12,648,099,269	2,500	2,956	6,852,464,349
	CAN	35,595	711,905	5,500	3,915,476,190	2,500	3,000	2,135,714,286
	UREA	20,992	419,841	5,450	2,288,134,921	2,500	2,950	1,238,531,746
	Total	172,500	3,450,000		18,851,710,380			10,226,710,380
3-Season Total		472,500	9,450,000		51,637,293,651			24,511,093,651

Source: Mather et al (2024) using data on total fertilizer quantities and costs for NPK, CAN & Urea from Opiyo et al (2023). Notes: 1) Total quantity of fertilizer sold by season based on government statements and assumption that the same share of each fertilizer type was distributed in each season.

(D) Farmer subsidized price for NFSP fertilizer plus farmer transport costs ($US / MT)

The farmer price of NFSP subsidized fertilizer in the 2023 LR was 3,500 KSh per 50-kg bag. According to data from our 2023 phone survey of Kenyan farmers, farmers also spent a median of 200 KSh per 50-kg bag in transportation costs to and from NCPB depots from which they obtained NFSP fertilizer. This implies that the full cost of one 50-kg bag of NFSP fertilizer for participating farmers was 3,700 KSh/bag in 2023 LR. This is equivalent to $US 604 per MT using the average exchange rate of 123 KSh/$US during the 2023 LR planting period.

For the 2023/24 SR and 2024 LR seasons, the government lowered the farmer cost per bag of NFSP subsidized fertilizer to 2,500 KSh/bag. Thus, farmers' total cost per 50kg bag of subsidized fertilizer was 2,700 KSh/bag in those seasons, after adding farmer transport costs. This is equivalent to $US 386 per MT for the 2023/24 SR (exchange rate of 140 KSh/$US), and $US 355 per MT for the 2024 LRS (exchange rate of 152 KSh/$US)

(E) Total farmer expenditure on incremental fertilizer use as result of NFSP program, accounting for transport, crowding out & diversion [A * D * J]

This is computed as the total fertilizer program quantity (A) multiplied by (J), the average partial effect (APE) of 1 kg of subsidized fertilizer on total fertilizer use on maize. As noted in section

7.3.1, this APE is adjusted for *crowding out* of farmer commercial fertilizer demand and *diversion* of NFSP subsidized fertilizer out of the program. The adjusted APE is then multiplied by (D), the farmer's subsidized price per MT of NFSP fertilizer, including transportation costs to/from an NCPB depot.

In both the economic and financial analysis, we assume that neither (i) farmers' cost of purchasing subsidized fertilizer that has displaced commercial fertilizer demand nor (ii) the farmer cost of purchasing diverted fertilizer (via private sector fertilizer supply chain) are included in incremental program costs. The reason is because both of those costs would also be observed in a "without program" scenario.

<u>(F.a) Total government expenditure on NFSP fertilizer [A * (D - B)]</u>
For 2023 LR season, the government expenditure per 50kg bag of NPK fertilizer sold by NFSP is computed as: Total cost per 50kg bag NPK – Farmer cost per 50kg bag NPK = 5,456 KSh/bag – 3,500 KSh/bag = 1,956 KSh/bag of NPK (Table 15, column F). The same approach is used to compute the total government expenditure per 50kg bag of CAN or urea fertilizer sold by NFSP. This means that the government paid for 36 percent of each bag of NPK, CAN, and Urea in the 2023 LR season, while farmers paid the other 64 percent. The total government expenditure on NPK sold to farmers in this season is computed as the quantity of NPK sold by NFSP (2,252,658 50kg bags) multiplied by the government expenditure per bag of NPK (1,956 KSh/50kg bags), resulting in a total of 4,601,500,691 KSh spent by the government for NPK sold by NFSP that season (Table 15, column G).

The government lowered the farmer cost per bag of NFSP subsidized fertilizer to 2,500 KSh/bag for the 2023/24 SR and 2024 LR seasons. Thus, for those seasons, the government expenditure per 50 kg bag of NPK sold by NFSP is computed as 5,456 KSh/bag – 2,500 KSh/bag = 2,950 KSh/bag of NPK (Table 15, Column F). The government paid 54 percent of the cost of NFSP program fertilizer in these two latter seasons, while farmers paid 46 percent.

<u>(F.b) NFSP program administration costs of NFSP fertilizer program (B * 5%)</u>
In addition to the costs associated with importation/procurement, distribution, and retailing of program fertilizer, a program like NFSP cannot be implemented without managerial and administrative support that goes beyond what a private sector fertilizer importer, wholesaler, or agro-dealer would incur[15] – such as: (i) the costs of developing, setting up, promoting, and maintaining a national farmer registration system used by NFSP, costs associated with equipment

[15] While our analysis assumes that NFSP costs of fertilizer procurement, distribution and retail are the same as those of the private sector fertilizer supply chain, it should be noted that this is a conservative (generous) assumption as there are reasons why the public sector is unlikely to be able to achieve this. First, the public sector has considerably less experience with such activities compared with the private sector; and second, private sector actors face strong incentives to control costs given market competition at each level of the fertilizer supply chain – particularly at the retail level. Such incentives that are undoubtedly weaker for staff managing and administering a public sector program.

purchases and NCPB staff training to operate the e-voucher system, time spent in planning and coordination of e-voucher distribution with national and local government officials each season, etc. These additional costs include both staff time as well as additional communication and transportation costs, for example. Subsequently, this analysis assumes that there are NFSP-related management and administrative costs beyond those captured in the cost build up estimates of the retail cost of NFSP fertilizer as reported by Opiyo et al (2023) (Table 14).

We are unaware of any annual program reports from NFSP or Parliamentary reports or studies that provide an accounting of the full costs of NFSP implementation each year – nor for prior years of Kenya's large-scale ISPs including NAAIAP/NVCP and earlier versions of NFSP. Given these data limitations, we rely upon in-depth studies of similar large-scale ISPs run by government parastatals from Malawi (Holden and Lunduka, 2012) and Zambia (as reported in Jayne et al, 2013), which include data on the various components of program-related costs each year, including program administration and management. The average share of administration costs in total program costs in Malawi and Zambia was 5 percent, which is the assumption that we use for NFSP.

(F.c) Total official government expenditure on NFSP

We assume that the total government costs of NFSP per season include (F.a) the government's share of the full financial costs of NFSP fertilizer distributed that season, multiplied by the total cost of that fertilizer; and (F.b) program-related administrative and management costs.

(G) Total government spending on the portion of NFSP fertilizer received by farmers that results in incremental fertilizer use (aggregated to the program level), accounting for crowding out & diversion (F.a * J)

For the computation of the economic BCR, we multiply the government costs of NFSP net of administration costs (F.a) by (J), which is the average partial effect (APE) of 1 kg of subsidized fertilizer on total farmer fertilizer use on maize, adjusted for crowding out and diversion of commercial fertilizer. We do not include government expenditure on NFSP fertilizer that crowds out commercial fertilizer use in the economic analysis because it does not constitute an incremental cost. The reason is that the cost of the NFSP fertilizer that displaces commercial fertilizer is the same as the cost of that same quantity of commercial fertilizer in a "without program" scenario – though in the that scenario, farmers pay this cost.

(H) Total government spending on NFSP fertilizer that is diverted at wholesale level to commercial channels (F.a * 10% diversion)

Studies of the "government supply chain" ISPs in Zambia and Malawi covering 2006/07 to 2010/11 found that an average of 33% of fertilizer purchased by each government for their ISP was not distributed through the ISP retail locations to farmers but rather was "diverted" (i.e. illegally sold) to private sector actors outside of the ISP distribution system. We define "diverted" ISP fertilizer as fertilizer that is physically removed from the ISP distribution system and sold to private sector actors who then physically move it into the private sector fertilizer supply chain. This diverted fertilizer was then likely purchased by farmers at what appeared to be the full prevailing commercial rate for fertilizer in each country, based on survey data of commercial fertilizer prices paid by farmers over time. Due to anecdotal evidence of diversion of NCPB subsidized fertilizer in prior years, we assume a diversion rate of 16 percent for our base scenario. We assume a rate that is half that of Malawi and Zambia given the lack of more rigorous evidence of the extent of diversion of subsidized fertilizer from the NFSP/NCPB government supply chain ISP approach.

We multiply the government expenditure on this diverted fertilizer by 90% because the costs borne by government may not necessarily include the wholesale-to-retail marketing margin, which are included in the unit cost of NFSP fertilizer in (B)[16]. It is important to note that the "handling fee" results in significant economic rents (i.e. illegal earnings) for officials and traders involved in the diversion and resale of program fertilizer. It also represents a financial transfer from Kenyan taxpayers (and any donor partners who may help fund NFSP) to these officials and traders.

<u>(I) Total incremental government costs of NFSP fertilizer program, accounting for crowding out & diversion [F.b + G + H]</u>

In the financial analysis, total incremental costs include the total government costs of the NFSP fertilizer program and farmer's incremental expenditure on their total fertilizer use (commercial and subsidized). In the economic analysis, we do not include government expenditure on NFSP fertilizer that displaces commercial fertilizer purchases by farmers (G), as this is considered to be a transfer from government to farmers (see G above) and economic analysis does not consider such transfers to be a "program cost".

<u>(J) Financial losses for private sector distributors and agro-dealers in 2023 LR from (J.a) demand-side and (J.b) supply-side crowding out</u>

To estimate financial losses of private sector fertilizer supply chain actors from demand-and supply-side crowding out, we first estimate the quantities of fertilizer crowded out from the demand- and supply sides. The quantity of commercial fertilizer crowded out on the demand-side is computed as the average partial effect of 1kg of subsidized fertilizer on farmers' commercial fertilizer demand (-0.22) multiplied by the quantity of NFSP subsidized fertilizer sold in 2023 LR by fertilizer type (Table 15, Column E), which results in 38,513 MT of fertilizer. We assume that 100 percent of the NFSP fertilizer imported directly by KNTC in late 2022 – 50,000 MT -- crowds out private sector fertilizer on the supply side (Table 15, Col F). We further assume that 20 percent of the quantity of fertilizer diverted from NFSP at the distributor level results in supply-side crowding out (Table 16, Col G).

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[16] On the other hand, this wholesale-to-retail margin of diverted fertilizer may indeed be paid for under government contracts to selected fertilizer companies, based on official volumes distributed rather than actual volumes. If this latter scenario is true, then the economic analysis is underestimating the actual costs incurred.

(J.b) Financial losses for private sector distributors and agro-dealers in 2023 LR from supply-side crowding-out related to KNTC imports

The next step in estimating the financial losses of crowding-out incurred by private sector fertilizer supply chain actors in 2023 LR is to multiply the quantities crowded out by the change in the wholesale price of fertilizer[17] in Kenya between the months of fertilizer acquisition (November-December 2022) to months of eventual (assumed) sale of the fertilizer in planting period of 2023/24 SR (August-September 2023), by fertilizer type. For example, the Kenya wholesale cost of NPK fell from $950/MT in Nov/Dec 2022 to $706/MT in Aug-Sept 2023, a change of $-244 / MT. The quantity of fertilizer crowded-out is then multiplied by the estimated cost of additional storage, finance, and physical loss for the 8 months between November 2022 to August 2023, which we assume to be 4 percent of the wholesale price, based on detailed cost buildup information from the Mombasa port to wholesale levels from AfricaFertilizer. These additional costs per MT are then multiplied by the quantities of fertilizer crowded out from the demand- and supply-side (Table 16).

Table 16: Derivation of the quantity of private sector fertilizer crowded-out in 2023 LS by fertilizer type

Fertilizer type	Quantity of fertilizer (MT) purchased for NFSP in late 2022 by source:		Total NFSP fertilizer stock (MT) pre-2023 LR	Quantity NFSP fertilizer sold in 2023 LR	Quantity of private sector fertilizer crowded-out in 2023 LR (MT) from:			
	Priv. sector	KNTC			Demand-side	Supply-side: KNTC imports	Supply-side: Diversion	Total
			(A + B)	(MT)	D * | -0.22 |	B	(D*0.16)*0.2	E + F + G
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
NPK	292,500	25,000	317,500	117,633	25,879	25,000	3,764	54,643
CAN	72,500	25,000	97,500	36,123	7,947	25,000	1,156	34,103
UREA	47,500	0	47,500	21,304	4,687	0	682	5,369
Total	412,500	50,000	462,500	175,060	38,513	50,000	5,602	94,115

Source: Mather et al (2024) using data in columns A to D from Opiyo et al (2023).

(J.c) Financial losses for private sector distributors and agro-dealers due to foregone profits

For this BCA, we compute an estimate of foregone profit from fertilizer sales for distributors with two main assumptions. First, the foregone quantity of fertilizer sales for distributors in a season with NFSP implementation is the quantity of fertilizer sold by NFSP that season. Second, average profit across all distributors is 2 percent. For each season, we compute foregone profit from

[17] Retail price is estimated as the average of the import parity price of each fertilizer type using FOB prices from the World Bank and Africa Fertilizer.

fertilizer sales as the forgone fertilizer sales quantity multiplied by the wholesale fertilizer price multiplied by the assumed 2 percent profit. See Mather et al (2024) for more details.

(J.d) Financial losses for private sector distributors and agro-dealers due to foregone profits, assuming a counterfactual private-sector friendly NFSP design

Here we assume a counterfactual scenario in which the government had decided from the beginning of NFSP (2023 LR) to allow the private sector to import, distribute and retail government subsidized fertilizer. In this scenario, we assume that 30 percent of private sector fertilizer distributors and 35 percent of agro-dealers are either not invited to participate in the government's new ISP or chose not to participate. Unlike distributors and agro-dealers participating in the counterfactual private sector-friendly ISP, the non-participating distributors and agro-dealers would face financial losses from foregone fertilizer sales revenue and profits related to crowding out of their commercial fertilizer sales by subsidized fertilizer.

(J) Estimated average partial effect of a 1 kg increase in NFSP fertilizer on total household fertilizer use, accounting for crowding out & diversion

Based on results from our crowding out analysis (Results Table 7), we assume that the average partial effect of a one-kilogram increase in NFSP fertilizer on total household fertilizer use is -0.22kg. *Diversion* is assumed to be 16 percent as per (H). Following Mason and Jayne (2013)[18], the change in total commercial fertilizer demand given a 1-kg increase in government subsidized fertilizer is computed as: (1 – 0.22)*(1 – 0.16) = 0.655. See Mather et al (2024) for more details.

(K) Estimated average product of maize (MT) per additional MT of fertilizer

Maize response rates to inorganic fertilizer are drawn from research by Sheahan et al (2010), who estimated maize yield response to nitrogen using a large panel household survey dataset from Kenya including five survey waves from 1997 to 2010. They report the average product (AP) of maize (kg) per kg of nitrogen by agroecological zone, as well as the full sample average AP, which is 21 kgs of maize per kg of Nitrogen.

We adjust the Sheahan et al (2010) sample average AP by reweighting their AP results by agrozone. This reweighting is done to reflect the relatively higher concentration of NFSP fertilizer distributed to medium and high potential zones in 2023 LR, compared with the broader spatial distribution of subsidized fertilizer in 2009/10, as observed in the data used by Sheahan et al (2010)[19]. The reweighted sample AP of maize per kg of N is 18.48. This is then multiplied by the

[18] It is important to note that the online version of Mason and Jayne (2013) includes a corrigendum in which the authors made a revision to equation (5), and that equation (5) shown above is taken from this corrigendum – not the original version of the paper.

[19] The data used by Sheahan et al (2010) captured an early year (2009/10) during the reintroduction of fertilizer subsidies to Kenya that began in 2008/09. At that time, the government of Kenya implemented two separate input subsidy programs that had different spatial coverage. One led by NCPB distributed subsidized fertilizer primarily to medium to high potential zones, and the other (NAAIAP) distributed to a wider range of agro-zones.

average N content of NFSP fertilizer in the 2023 survey (0.296), producing an average AP of 5.48 kgs of maize to kg of inorganic fertilizer.

(N) Maize grain prices ($US / MT)

The farmgate maize price used to value incremental maize production is shown in row N.1. The farmgate price of white maize is used instead of the wholesale or retail price because (a) the direct benefit of NFSP's effect on total fertilizer use on maize is an increase in maize production by subsidy recipient farmers; (b) the additional maize production attributable to NFSP is physically and temporally located at the farmgate level of the marketing system, and (c) represent farmers' opportunity cost per kilogram of retaining this maize or selling it is the farmgate maize sale price during the post-harvest period. Unlike a farmgate price, the retail price of a commodity embodies significant additional costs beyond the farm-level related to the spatial and temporal characteristics of a given bag of maize. This includes costs of assembly of surplus maize in rural areas, transport from these rural villages to rural and urban wholesalers, wholesaler costs (finance, storage), and then retailer costs of transporting maize from wholesalers to retail locations along with other retail costs.

Given data limitations, the farmgate price is imputed from data on wholesale market prices of white maize from the Agricultural Market Information System (AMIS)[20] of MoALI using a procedure outlined by Mather et al (2024).

Potential effects of NFSP on maize prices and wages: Our analysis does not include any assumed effects of changes in maize prices or wages resulting from NFSP implementation. The reason is because Kenya has long had a structural maize deficit (Kirimi et al, 2011), thus any additional maize production (such as that from NFSP) simply replaces maize imports and is not large enough to fill the maize deficit. Subsequently, additional maize production in a given season is not likely to affect domestic maize prices or wages in Kenya. Analysis on this issue from two countries with considerably larger-scale ISPs than Kenya – Malawi and Zambia – found that the effects of those ISPs on food prices (Ricker-Gilbert and Mason, 2013) and wages (Ricker-Gilbert, 2014) were quite small in magnitude and/or statistically insignificant.

(O) Value of incremental maize output [M] at prices in N

Because Kenya has long been a net importer of maize, we assume that the incremental maize production attributed to the NFSP programs in Kenya (M) simply displaces imports. An implication of this is that realistic quantities of incremental domestic maize production due to NFSP would not be large enough to close Kenya's maize deficit. Thus, for Kenya, the value of

[20] AMIS collects wholesale market prices of various agricultural commodities at least once a week from 1 to 3 or more markets in nearly every county of Kenya, though markets in some counties do not report wholesale maize prices year-round.

incremental maize output is simply the maize price (N) multiplied by the incremental maize production attributed to the NFSP program (M).

(P) Benefit cost ratios by definition of which costs are included

(P.a) Computes the financial BCR as the ratio of incremental benefits (value of incremental maize output in O.i), to total government program costs [F] + incremental farmer costs [E].

(P.b) Computes the financial BCR of incremental benefits (value of incremental maize output in O.i), to total government program costs [F] + incremental farmer costs [E] + supply-side crowding out due to (J.a) and (J.c).

(P.c) Computes the financial BCR of incremental benefits (value of incremental maize output in O.i), to total government program costs [F] + incremental farmer costs [E] + supply-side crowding out due to (J.a) and (J.c). and (J.b)

(P.d) Computes the financial BCR of incremental benefits (value of incremental maize output in O.i), to total government program costs [F] + incremental farmer costs [E] + foregone profits (J.d).