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# Policy options for fertilizer subsidy reforms in Rwanda

## A simulation-based analysis and synthesis of prior studies

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# ABSTRACT

Agricultural input subsidies are a prominent feature in the 2018-2024 Strategic Plan for Agricultural Transformation (PSTA 4), which is designed and implemented by the Ministry of Agriculture and Animal Resources (MINAGRI). By reducing the cost of improved seed and inorganic fertilizers, subsidies are designed to accelerate the use of these productivity-enhancing inputs, thereby increasing agricultural yields and output, increasing rural incomes while reducing food prices, and improving food security in line with PSTA 4's targets.

However, questions arise about whether the current input subsidy rates and levels are sufficient to increase crop production and meet the PSTA 4 targets, and whether the subsidy system can be expanded in the current economic climate and fiscal situation caused by the COVID-19 pandemic and spike in global fertilizer prices.

This paper examines the impact of an increase in the price of fertilizer in Rwanda using seasonal production data from National Institute of Statistics of Rwanda (NISR) in a microsimulation model aimed at three priority crops—maize, rice, and Irish potato—and the three main fertilizers in use—diammonium phosphate (DAP), urea, and NPK.

The paper also examines recommendations from prior studies that aim to strengthen the input subsidy system through better management, provision of credit and financial services, better targeting, and the introduction of an open market for fertilizer.

The paper's simulation model is used to calculate value-cost ratios (VCR) for each plot in the NISR data and determine changes in yields, output, revenues, and costs as fertilizer subsidy rates are progressively reduced. VCRs capture both a farmer's sensitivity to changes in fertilizer prices and a crop's sensitivity to changes in fertilizer application. Results suggest that as fertilizer prices reach unsubsidized market rates, profitability decreases, thereby decreasing demand for fertilizer. Overall, demand for DAP and urea decreases by up to 13 percent, and demand for NPK decreases by 8 percent when prices increase to the market rates, and when we conservatively assume that farmers are highly price-insensitive.

Necessarily, these increases in fertilizer prices and reductions in fertilizer use lead to reductions in yields and output. Overall simulation results indicate that reductions in fertilizer subsidies lead to reductions in national crop production by up to 3 percent for maize, 3 percent for rice, and 15 percent for Irish potato. These production declines can lead to price increases for all three commodities, in the absence of trade and assuming all else remains equal.

Against these production effects, simulation results indicate that budgetary savings resulting from eliminating fertilizer subsidies range from RWF 10.2 billion to RWF 19.6 billion (depending on the price sensitivity of farmers) for the three focus fertilizers. These figures represent between 8 and 16 percent of the MINAGRI budget. These results raise several important points.

- Reductions in fertilizer use rates can lead to decreases in production and increases in food prices, most notably for Irish potato, but also for maize and rice. In the current economic climate, it is unlikely that either government or consumers will tolerate an increase in food prices. Without being alarmist, the twin threats of slow economic growth and food price inflation could endanger Rwanda's return to its pre-COVID growth trajectory in the short term.

- In the medium term, national efforts to increase fertilizer use rates will remain important. As such, any reductions in the subsidy rate would likely need to be accompanied by commensurate increases in MINAGRI's total budget for subsidies at a level that aligns with the

growth in fertilizer demand. In other words, if MINAGRI opts for a lower subsidy rate, it will still need to increase its subsidy budget to meet increasing demand for fertilizer.

- But recent spikes in global fertilizer prices have required MINAGRI to increase both subsidy rates and the subsidy budget, making any strategy to reduce subsidy rates challenging in the short term.
- In the medium term—if and when international fertilizer prices return to lower, more stable levels—there is still scope to pursue subsidy rate reductions because profitability, production, and price effects differ significantly by crop. Specifically, there may be more scope to reduce subsidies on Irish potato and possibly rice compared to maize, although it is extremely difficult (and often inadvisable) to control what crops farmers actually use the fertilizer for.
- If subsidy targeting by crop is deemed too difficult to implement, then targeting by fertilizer type may be more straightforward. It may be feasible to gradually reduce the relatively low subsidy rate on NPK (currently at 35 percent) since NPK is primarily recommended for use in Irish potato cultivation. The potential reductions in public spending on NPK subsidies for the three focus crops are estimated to be between RWF 6.1 and 9.8 billion, with additional reductions possible if other NPK formulations are included. However, this does not account for the possibility that Irish potato farmers will substitute out of NPK and into other fertilizers, whether recommended or not.

Another way of approaching this issue is to ask what additional investments are needed in order to maintain or increase VCRs if fertilizer demand continues to increase in the medium term. This directs attention to the continued need for greater investment in subsidy management and in complementary investments that increase the efficiency of fertilizer use.

To this end, several recent studies provide detailed recommendations to improve the input subsidy system by (a) improving subsidy management from importation at the port to the point of sale; (b) expanding credit and other financial services for fertilizer purchases; (c) targeting input subsidies to farmers with specific profiles; and (d) transitioning to an open market for fertilizer.

While all of these proposals have merit, they require careful attention to detail in both design and implementation. Significant improvement is required in data systems integration, analytical capacity, and monitoring, evaluation, and audit functions before these systems can be scaled up nationally.

In summary, there are multiple options for reforming Rwanda's fertilizer subsidy system. The analysis provided here highlights the need for cautious, time-bound continuation of input subsidies accompanied by strategic reductions in subsidy rates, increases in the budget allocated to subsidies, and extensive changes to subsidy management, credit provision, targeting, and the open market for inputs.

# INTRODUCTION[1]

Rwanda has invested significant resources in modernizing its agriculture sector. Since 2004, successive Strategic Plans for Agricultural Transformation (PSTAs) have channeled public resources into a range of critical investment areas including land consolidation, hillside terracing, irrigation, erosion control measures, research, extension, and input subsidies. As a result of these strategic plans and associated policy changes and program interventions, the use improved seeds and inorganic fertilizer has grown considerably during the past two decades. This helped fuel agriculture sector growth of approximately 5 percent per annum in the early 2000s, likely contributing to wider economic growth and improvements in food security.

Input subsidies have been a prominent feature in these plans, driven partly by the emergence of favorable—though sometimes controversial—narratives around “smart subsidy” designs and impacts throughout sub-Saharan Africa (Jayne et al. 2018; Jayne and Rashid 2013). These narratives revolve around a straightforward impact pathway, through which subsidies of improved seed and inorganic fertilizers lead to increases in farmers’ use of these productivity-enhancing inputs, thereby increasing crop output, farm incomes, and national food security. This narrative is a key element in the fourth PSTA that runs from 2018 to 2024.

This paper examines the policy options for managing the current input subsidy system in a manner that accelerates farmers’ use of modern inputs to meet the PSTA 4 targets within the fiscal space provided by government. While that space has tightened as a result of the economic uncertainty created by the COVID-19 pandemic and the crisis in Ukraine, input subsidies remain an important part of the effort to realize PSTA 4’s goals. This paper aims to address a key element of this policy challenge: the implications of an increase in fertilizer prices and a reduction in fertilizer subsidies in light of global fertilizer prices and a tightening domestic fiscal space, and alternatives to improve the management of input subsidies that together increase use-efficiency while limiting the fiscal burden.

The paper focuses primarily on fertilizer because it represents the largest share of the input subsidy budget as well as the largest cash outlay for those farmers who use it (Table 1). More specifically, the paper focuses on three crops (maize, rice, and Irish potato) that are prioritized in PSTA 4, and three fertilizers used in their production (DAP, urea, and NPK).[2]

The paper examines the impact of an increase in fertilizer prices on demand for fertilizer, changes in the profitability of its use, and the implications for crop production and public budget resources. The analysis is conducted using a microsimulation model that draws on data from the Seasonal Agriculture Surveys (SASs) of the National Institute of Statistics of Rwanda (NISR). Results are then discussed in the context of findings and recommendations from prior studies on the management of input subsidies in Rwanda. Finally, the paper recommends policy reform options to the current management of input subsidies.

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[1] This paper updates an earlier policy note published in May 2022 as D.J. Spielman, S. Mugabo, G. Rosenbach, S. Ndikumana, G. Benimana, and C. Ingabire (2022), Expected impacts of increases in international prices of fertilizer in Rwanda: Estimates from a microsimulation (Rwanda Strategy Support Program Policy Note no 6 (Kigali/Washington, DC: IFPRI; URL: https://doi.org/10.2499/p15738coll2.135073). The updated analysis in this version pertains mainly to revised budget data and information. The annex contains the graphs from the previous analysis.

[2] Unless otherwise noted, NPK refers to NPK 17:17:17. Other NPK fertilizers such as YARA’s Winner™, Cereal™, or Tracel BZ™ containing essential micronutrients such as Zn, S, and B, are more recent entrants to the market. While they also receive subsidies, they represented just 11 percent of all NPK products distributed in Rwanda in 2020, according to data from MINAGRI (2020), and are often marketed for specialized crops and purposes that are beyond the scope of this paper.

**Table 1. Fertilizer costs as a share of total production costs (conditional on fertilizer use), all seasons 2020 (percent)**

| Farmer type | Plot type | DAP | Urea<br>% | NPK | All fertilizers |
|---|---|---|---|---|---|
| Large-scale farmers | Maize and Irish potato plots | 14 | 10 | 22 | 36 |
| | Maize plots | 20 | 12 | 16 | 30 |
| | Rice plots | 11 | 16 | 44 | 60 |
| | Irish potato plots | 10 | 11 | 23 | 25 |
| Small-scale farmers | Maize plots | 27 | 19 | 33 | 38 |
| | Rice plots | 9 | 10 | 24 | 27 |
| | Irish potato plots | 21 | 13 | 26 | 31 |

Source: Authors, based on data from NISR Seasonal Agriculture Surveys, 2020

Note: All fertilizers refers to the fertilizers that are the focus of this paper: DAP, urea, and NPK only.

The paper is a rapid assessment exercise prepared in response to an articulated request from the Ministry of Agriculture and Animal Resources (MINAGRI). As such, there are several limitations to its analysis. We discuss each of these below.

*Seed subsidies.* First, while the paper does examine patterns and trends in the use of improved seed,[3] it does not address seed subsidies in its simulations. There are several reasons for this.

At a most basic level, we would argue that seed subsidies remain an important means of creating demand for improved varieties and quality seed, especially given the low adoption rates observed in Rwanda. At another level, strategies to reform seed subsidies cannot be approached in the same way fertilizer subsidies can: there are significant differences in how seed is produced and disseminated, how farmers respond to changes in seed prices, and how outcomes from a seed input subsidy program are measured.

Next, these issues are exacerbated by difficulties in measuring the use of "improved seeds" in surveys such as NISR's SASs. A simple question about whether a farmer uses improved seed does not indicate whether the farmer uses seed of an existing or improved variety, whether the seed is of a specific quality (e.g. certified or quality declared), or whether the seed is of an improved variety saved from a previous season. Answers to these questions are critical in determining the genetic gains associated with the use of improved seed, and are very crop-specific (Spielman and Kennedy 2016).

Furthermore, Rwanda has already taken steps toward investing in seed sector development with interventions designed to build domestic capacity for seed production, popularize new varieties and quality seed, and withdraw subsidies on imported seeds. These steps already constitute a set of policy reforms that aim to improve supply and demand for seed and, in the short run, will likely require some level of continued subsidies.

Finally, any discussion of seed subsidies needs to recognize that 85 percent of the seed subsidies in 2020/21 were allocated to just one crop—maize—because hybrid maize seed is among the costliest seed available to farmers. As such, a focus solely on seed subsidies for maize hybrids will distract from the larger focus of this paper.

*Income, welfare, and distributional effects.* Second, the paper relies on a microsimulation model which does not capture the economywide effects of subsidy reductions or crop production shocks on welfare outcomes, including household incomes, income distribution, and poverty.

[3] Technically, the correct terminology here is "quality seed of improved varieties" because the seed subsidies aim at providing farmers with both improved genetic traits in the varieties they cultivate, and better quality planting material that embodies those genetic traits. Unfortunately, convention seems to favor "improved seed" throughout the research and policy literature.

Economywide models of Rwanda that contain detailed agriculture sector components are in use and being updated (see Aragie et al. 2022). However, those models cannot, on their own, provide the resolution on distinct fertilizer products (DAP, urea, and NPK) that is addressed in this paper. It is an aspiration for the immediate future that this economywide model be integrated with the microdata and microsimulations presented here, and with crop models and spatial data to address these high-resolution policy questions in the future.

These income and distributional effects are not addressed in the simulations due to critical limitations in the data. How the effects of subsidy reductions are distributed between poor and non-poor farmers is an important question. However, this cannot be done in a microsimulation without data that integrates farm-level production data with household income and expenditure data. Having said that, we know from data drawn from the Fifth Integrated Household Living Conditions Survey (EICV5) (NISR 2018) that the farm households focused on in this paper—households cultivating maize, rice, or Irish potato—are not significantly different from one another in terms of consumption per adult equivalent (measured in RWF terms) on average. Additional data and analysis on these households is important to understanding their capacity to absorb any changes in the subsidy system and the price of fertilizer, and remains a topic for further investigation.

This paper proceeds as follows. Section 2 discusses the background to input subsidies in Rwanda and highlights patterns and trends associated with input use. Section 3 provides details on the data and data sources used in the paper. Section 4 describes the microsimulation model, followed by results in Section 5. Section 6 discusses these results in the context of prior studies on the management of input subsidies in Rwanda, and with specific reference to reform options in the context of Rwanda's COVID-19 recovery efforts. The paper concludes in Section 7 with options that highlight the need for cautious, time-bound continuation of input subsidies accompanied by extensive changes to delivery and targeting.

# BACKGROUND AND CONTEXT

In Rwanda, the flagship intervention involving input subsidies has been the Crop Intensification Program (CIP), which was piloted in 2007 and scaled nationally in 2010. Following on a series of land policy reforms, the CIP scaled up efforts to consolidate land, develop marshland, and terrace hillsides, and was accompanied by subsidies on fertilizer and seed targeted especially to high-potential areas (Clay and King 2019). The CIP's positive effects on modern input use, yields, and output have been studies in some detail. Periodic MINAGRI reporting shows substantial growth in land allocated to the CIP's priority crops and multifold increases in production of those crops, with more in-depth studies examining the often difficult-to-establish relationship between the CIP and outcomes such as commercialization and farmer incomes (Nsabimana et al. 2021; Weatherspoon et al. 2021).

Pia (2019) finds a positive association between land use consolidation under the CIP and crop yields, but only for farmers with landholdings greater than 1 ha, which exceeds the mean farm size of 0.66 ha found in the study's sample. However, many of the analyses of CIP's impacts have tended to concentrate on overall average effects and not the distributional effects, unanticipated consequences, or interactions between multiple public policies and programs (Weatherspoon et al. 2021; Clay and King 2019; De Frahan et al. 2018).

Since this initial period, the quantity of subsidized seed and fertilizer distributed to farmers has continued to grow, approaching the PSTA 4 target for at least 75 percent of farmers using improved seeds and applying at least 75kg/ha of inorganic fertilizer on land use consolidation sites by 2024 (Table 2). At the national level, MINAGRI data indicate that the overall quantity of all fertilizers distributed to farmers between 2017/18 and 2021/22 increased by 111 percent (MINAGRI 2022).

**Table 2. Quantities of subsidized DAP, urea, and NPK fertilizer distributed in Rwanda, 2014–22 (metric tons)**

| Year | DAP | Urea | NPK | Total |
|---|---|---|---|---|
| | | (metric tons) | | |
| 2014/15 | 13,063 | 7,472 | 11,408 | 31,943 |
| 2015/16 | 10,716 | 6,697 | 14,707 | 32,120 |
| 2016/17 | 9,530 | 6,666 | 13,774 | 29,979 |
| 2017/18 | 9,595 | 6,492 | 14,276 | 30,363 |
| 2018/19 | 15,883 | 9,572 | 17,633 | 43,088 |
| 2019/20 | 16,099 | 9,691 | 16,870 | 42,660 |
| 2020/21 | 18,774 | 11,784 | 15,608 | 46,166 |
| 2021/22 | 32,371 | 23,376 | 20,505 | 76,252 |

Source: MINAGRI (2022)

Note: NPK refers to all NPK products including, but not limited to, NPK 17:17:17

At the household level, it is important to note that subsidized fertilizer is likely used by farmers with landholding both inside and outside of the land use consolidation (LUC) sites established under the CIP. For households cultivating maize, rice, and Irish potato, between 38 and 57 percent of households that do not have any land in a LUC site *do* still use fertilizer, according to data drawn from the EICV 5 (NISR 2018). And for those households that do cultivate some share of their landholdings on LUC sites, EICV data do not indicate whether the fertilizer is being applied to crops grown on the LUC sites or on other landholdings belonging to the household. This suggests that (1) the subsidy system is not extensively targeted, and (2) there is latent demand that may be constrained by fertilizer price, inter alia. This highlights the tradeoff between the fertilizer market's growth potential and farmers' sensitivity to fertilizer prices and other factors.

**Table 3. Share of households using fertilizer by land use consolidation (LUC) site and crop**

| Household cultivation sites | Maize | Rice | Irish |
|---|---|---|---|
| | | (percent) | |
| Household does not cultivate land on LUC site | 40 | 57 | 38 |
| Household cultivates land on LUC site* | 64 | 76 | 62 |

Source: Authors' based on data from NISR EICV5, 2017.

Note: * Indicates that the households may cultivate all or a fraction of its landholdings on LUC sites.

At the plot level, data from the NISR SASs indicate that the share of small-scale farmer plots using DAP and urea grew consistently from 2017 to 2020, increasing by 17 and 12 percentage points respectively, while the share of the same types of plots using NPK decreased by 2 percentage points during the same period. The same trend is also observed for large-scale farmer plots during the same period. As defined by NISR, these large-scale farmers are farmers with 10 ha or more of land, representing just 2 percent of cultivated land area in Rwanda, while small-scale farmers are defined as farmers with less than 10 ha of land, representing 98 percent of cultivated land area (NISR 2020).

### Table 4. Share of plots using improved seeds and fertilizers, and fertilizer application rates (2017-2020)

| Crop/plot | Farm/farmer type | Year | Share using improved seeds (any season) % | Share using inorganic fertilizer(s) (any season)* % | Fertilizer application rates (kg/ha) for those who used fertilizer (averaged across seasons)* (kg/ha) | N (number of plots) |
|---|---|---|---|---|---|---|
| Maize plots | Small-scale farmers (<10 ha) | 2017 | 20 | 17 | 129 | 9,980 |
| | | 2018 | 28 | 25 | 115 | 7,214 |
| | | 2019 | 30 | 30 | 92 | 10,561 |
| | | 2020 | 47 | 39 | 99 | 11,229 |
| | Large-scale farmers (>=10 ha) | 2017 | 63 | 51 | 119 | 345 |
| | | 2018 | 76 | 58 | 117 | 550 |
| | | 2019 | 66 | 50 | 131 | 323 |
| | | 2020 | 76 | 57 | 118 | 419 |
| Rice plots | Small-scale farmers (<10 ha) | 2017 | 50 | 89 | 233 | 936 |
| | | 2018 | 64 | 92 | 236 | 817 |
| | | 2019 | 16 | 74 | 160 | 293 |
| | | 2020 | 27 | 76 | 148 | 59 |
| | Large-scale farmers (>=10 ha) | 2017 | 63 | 95 | 273 | 172 |
| | | 2018 | 73 | 99 | 159 | 184 |
| | | 2019 | 69 | 92 | 207 | 197 |
| | | 2020 | 69 | 89 | 202 | 212 |
| Irish potato plots | Small-scale farmers (<10 ha) | 2017 | 2 | 53 | 241 | 2,878 |
| | | 2018 | 4 | 61 | 228 | 2,234 |
| | | 2019 | 2 | 59 | 175 | 3,999 |
| | | 2020 | 3 | 69 | 219 | 2,965 |
| | Large-scale farmers (>=10 ha) | 2017 | 28 | 63 | 191 | 64 |
| | | 2018 | 22 | 54 | 173 | 105 |
| | | 2019 | 23 | 58 | 220 | 77 |
| | | 2020 | 49 | 75 | 167 | 75 |

Source: Authors, based on data from NISR Seasonal Agriculture Surveys, 2017-20

Note: * Fertilizer use and application refer to the fertilizers focused on in this paper: DAP, urea, and NPK only.

When looking at fertilizer and improved seed use by crop, Table 4 shows the same trends: more small-scale farmers are using fertilizer each year, but the trend is more variable for large-scale farmers. Additionally, as the percent of small-scale farmers using the target fertilizers increases, the average amount of target fertilizers applied per hectare declines, suggesting that new entrants into the fertilizer market may be using smaller—and possibly sub-optimal—quantities. For example, the percent of maize plots cultivated by small-scale farmers that used one of the three target fertilizers increased from 19 to 40 percent from 2017-2020, however the average amount of one of the three target fertilizers applied decreased during that same period from 129 to 99 kg/ha. These trends are not as consistent for large-scale farmers: the percent of maize plots cultivated by large-scale farmers using any of the target fertilizers fluctuated between 50 and 58 percent from 2017-2020, while the average amount applied also fluctuated over that same period (between 117 and 131 kg/ha).

Rwanda has also experienced a slight deceleration in the growth in yields and output in recent years. This may be an early indication that while a growing share of farmers are using fertilizer, this growth may be concentrated among an increasing number of small-scale farmers using fertilizer at relatively low application rates, i.e., growth that is primarily on the extensive margin. Growth on the intensive margin—higher use-intensity rates per ha—seems to be more concentrated among large farmers.

Irrespective of growth on either the extensive or intensive margins, it is likely that aggregate demand for fertilizer will continue to increase in Rwanda and, with growing demand, public spending on subsidies. Fertilizer subsidies alone totaled an estimated RWF 4.9 billion (in constant (2017) terms) in 2019/20 and increased to 8.6 billion in 2020/21, with a significant increase projected in 2021/22 (Table 5).

**Table 5. Estimates of input subsidy expenditures in Rwanda, 2014/15 to 2020/21**

| | Fertilizer subsidy | | Fertilizer subsidies as a share of total MINAGRI budget | Fertilizer subsidies as a share of the earmarked transfers to Districts |
|---|---|---|---|---|
| Year | Nominal RWF (mill.) | Constant (2017) RWF (mill.) | % | % |
| 2016/17 | 4,546 | 4,923 | 4.10 | 21.70 |
| 2017/18 | 4,487 | 4,487 | 3.48 | 22.76 |
| 2018/19 | 5,770 | 5,788 | 4.74 | 29.02 |
| 2019/20 | 10,247 | 9,946 | 6.97 | 25.11 |
| 2020/21 | 9,682 | 8,555 | 8.03 | 36.34 |
| 2021/22 | 15,967 | 14,485 | 9.91 | 40.98 |
| 2022/23* | 30,840 | 27,357 | 18.78 | 64.25 |

Source: Authors, based on MINAGRI (2020, 2022) data and NISR's consumer price index for conversion to constant (2017 RWF) terms. Updated October 2022.

Note: MINAGRI budget is inclusive of MINAGRI Central, RAB, NAEB, and earmarked transfers to Districts. Figures refer to all fertilizer subsidies, including the three main fertilizers that are the focus of this paper.

Note: * Indicates provisional figures only, subject to revision.

While the subsidy bill is growing, fertilizer subsidy rates in Rwanda remained constant from 2015, at least until the recent international fertilizer price shock. Subsidy rates prior to the price shock for DAP, urea, and NPK were at 35, 30, and 15 percent of market price, respectively.

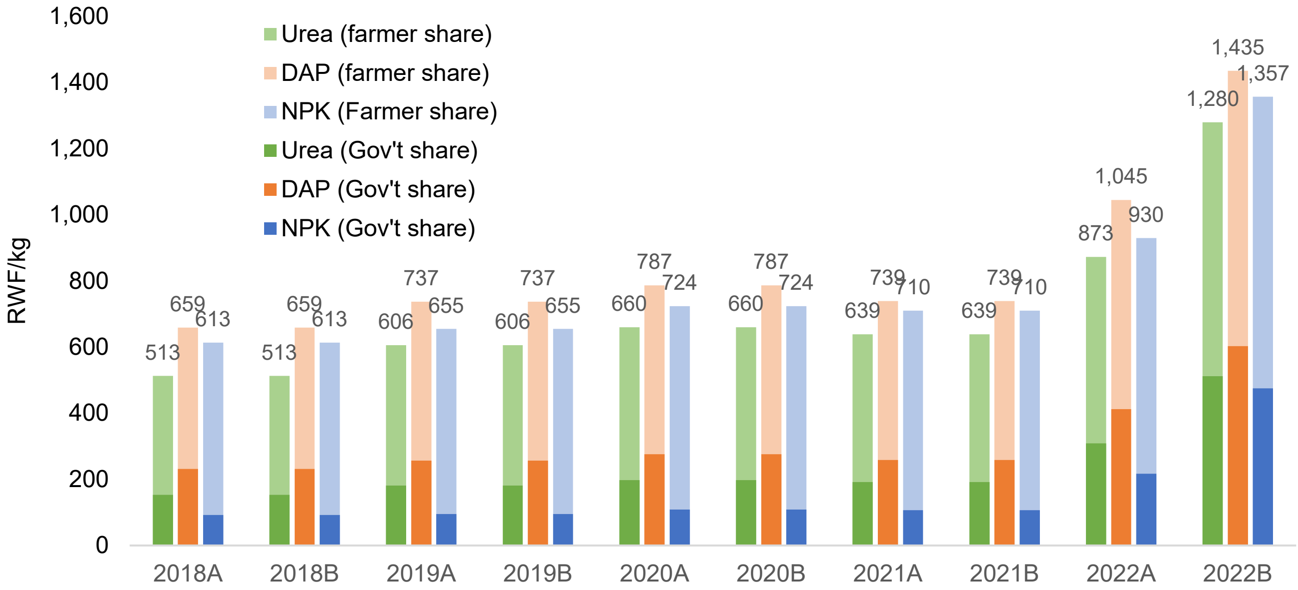
To fully appreciate how the subsidy rate has recently changed and how fertilizer costs are distributed between farmers and the Government of Rwanda, it is important to understand how fertilizer market policy is implemented in the country. Since 2015, fertilizer has been distributed to Rwandan farmers under a subsidized price scheme with little or no variation in prices at the farm or market level. Typically, market and subsidized prices are announced by MINAGRI at the beginning of each fiscal year, which begins on July 1, just prior to Season A. These discrete (rather than continuous) changes in fertilizer prices and subsidies follow from the fact Rwanda procures fertilizer at relatively fixed points in time before each season, while international prices have shown relatively little variation between seasons.

In 2021, fertilizer prices were announced as usual, and reflected both rising international fertilizer prices and an increase in the subsidy (Figure 1). This was followed by an unprecedented mid-year announcement in January 2022 of another round of price and subsidy increases. In both rounds, the Government of Rwanda effectively split the cost of the change in fertilizer prices equally with farmers, although this split changed slightly in the second round with the Government absorbing 60 percent of the increase in NPK prices and farmers absorbing 40 percent.

The initial subsidy rates placed Rwanda on the low end of the continuum in sub-Saharan Africa, where fertilizer subsidy rates are as high as 85 percent in Malawi, 50-70 percent in Mozambique, and 40-50 percent in Mali (FAO 2020), and where input subsidies account for anywhere between 6 and 70 percent of public spending on agriculture (Jayne and Rashid 2013). As a share of the agriculture sector budget,[4] these subsidies have grown from 4.10 percent in 2016/17 to 9.91 percent in 2021/22, and may increase to 18.78 percent in 2022/23.

[4] The agriculture sector budget is defined here as public spending on MINAGRI, the Rwanda Agriculture and Animal Resources Development Board (RAB), the National Agricultural Export Development Board (NAEB), and earmarked transfers to districts for agriculture-related spending.

**Figure 1. Market and subsidized prices for fertilizer, by year and season, 2018A to 2022B**




Source: Authors, based on MINAGRI (2022) data.

The decentralized administration of fertilizer subsidies presents its own, somewhat unique budgetary challenge. Districts consistently distribute subsidized fertilizer in response to farmers' demands but in excess of MINAGRI's budget allocation. This had led to the accumulation of arrears that reached RWF 6.33 billion in FY 2020/21 (MINAGRI 2022).

Taken together, these points indicate that Rwanda needs to accelerate not only the uptake of inorganic fertilizer, but also to increase use-intensity, while simultaneously managing the budgetary impact of a growing subsidy bill and accumulating arrears in the midst of a national and global crisis resulting from the COVID-19 pandemic and international fertilizer price shock. The analysis that follows attempts to address these issues.

# DATA AND METHODOLOGY

The analysis presented in this paper relies on data from several sources. Data on input distribution, prices, and subsidy levels and rates are drawn from documents provided by MINAGRI and the Rwanda Agriculture and Animal Resource Board (RAB), which is charged with the management of input subsidies. Microdata on plot use of fertilizer is drawn from NISR's Seasonal Agricultural Surveys (SAS) for Seasons A, B, and C in 2017-20. A total of 76,182 plots from the SAS dataset are used in this exercise.

Information and analysis on the management and administration of the input subsidies is drawn from consultancy reports by Palladium Group et al. (2020), 2AGSolutions (2020), IRDP (2020), and FAO (2020). Additional data, information, and analysis on input subsidies are drawn from the current draft of the 2019 Public Expenditure Review, prepared by Policy Associates (2020) for the World Bank, and from the FAO (2021) Monitoring and Analysing Food and Agricultural Policies (MAFAP) program.

The microsimulation model used in this paper examines the effect of reductions in fertilizer subsidy rates on farmers' demand for fertilizer, the profitability of fertilizer use, crop production, and public expenditures. The model, illustrated in Figure 2, closely follows Rashid et al. (2013), with several limitations imposed by the nature and structure of the SAS data. It is important to note that the model assumes all else remains equal (e.g., variety and seed type, irrigation, crop management practices, and other such variables), and so the results could be mitigated by programs that focus on improving yields through the promotion of other inputs, technologies, or practices.

From a conceptual point, the potential profitability of fertilizer is determined by crop response to fertilizer, the price of fertilizer, prices of other inputs that substitute for or complement fertilizer, and the crop (output) price (Morris et al. 2007). Crop response to fertilizer is, in turn, influenced by factors such as soil type, terrain type, irrigation, and a range of other environmental factors, as well as farmer management practices.

For this model, data on fertilizer use, fertilizer prices, plot areas, plot types, main crop grown on each plot, and farmgate prices are extracted from seasonal rounds of the SAS between 2017 and 2019 on a crop by plot basis. These data are used to calculate value-cost ratios (VCRs) at the crop-by-plot level according to the combinations of fertilizer products used. VCRs are a measure of the profitability of fertilizer use that captures both farmers' sensitivity to changes in fertilizer prices and the crop's responsiveness to changes in fertilizer application. Formally, a VCR measures the change in crop revenue attributable to fertilizer use relative to the cost of fertilizer use, or

$$VCR = \frac{(\Delta y \cdot p)}{Cf}$$

Where $\Delta y$ denotes the crop's incremental yield gains per hectare resulting from the use of fertilizer, $p$ denotes the crop output price per kilogram, and $Cf$ denotes the cost of fertilizer per kilogram. Value-cost ratios greater than 2 are generally considered a profitable use of fertilizer, although this threshold is more of a rule of thumb, with values ranging from 1.5 to 4 depending on the crop and context (Jayne and Rashid 2013; Morris et al. 2007; Kelly and Murekezi 2000). Importantly, VCRs are typically less noisy than calculations of production costs drawn from large-scale surveys such as the SAS. As such we refer to VCRs > 2 throughout this paper as a shorthand term "profitable use of fertilizer," although we acknowledge that this does not account for the marginal costs of other complementary inputs or other variables.

Next, simulated VCRs are calculated for each observation in the SAS data using (a) fertilizer prices that reflect the incremental removal of subsidies, and (b) a range of price elasticities of fertilizer demand that reflect farmers' sensitivities to changes in fertilizer prices. These calculations are made for maize and rice in Seasons A and B, and for Irish potato in Seasons A, B, and C. See Figure 2 for an illustration of the model, which highlights how on-farm profitability, rather than yield maximization, drives the model: although Rwandan farmers may be able to achieve higher yields with greater fertilizer use, it might not make good economic sense for them to do so (Bonilla-Cedrez et al. 2021; Burke et al. 2017; Sheahan et al. 2013).

To simulate a change in the fertilizer subsidy policy, the simulation relies on a schedule of subsidy rate reductions of 25, 50, 75, and 100 percent. Using 2022 fertilizer prices from MINAGRI (2022), this translates into the simulated fertilizer prices paid by farmers shown in Table 6. In all simulations, the farmgate price for each commodity was estimated by using the January 2022 breads and cereals component of the consumer price index (CPI) to scale up farmgate prices reported in the 2020 SAS.[5]

[5] The average breads and cereals CPI across September 2019-September 2020 was used as the base CPI since this is the time period when the SAS 2020 data was collected. These estimates were then triangulated with the eSoko market price data generated by MINAGRI, which was slightly higher than the CPI-scaled SAS prices due to the additional cost build-up between farmgate and market prices (e.g. transport, aggregation, and trader fees).

**Table 6. Simulated subsidy rate reductions and resulting fertilizer prices paid by farmers, January 2022**

| Subsidy rate reduction (%) | Fertilizer price paid by farmers (FWR) | | |
|---|---|---|---|
| | DAP | Urea | NPK |
| 0% subsidy rate reduction (current subsidized price as of 2022 Season B) | 832 | 768 | 882 |
| 25% subsidy reduction | 983 | 896 | 1,001 |
| 50% subsidy reduction | 1,134 | 1,024 | 1,120 |
| 75% subsidy reduction | 1,284 | 1,152 | 1,238 |
| 100% subsidy reduction (market price as of 2022 Season B) | 1,435 | 1,280 | 1,357 |

Source: IFPRI simulations

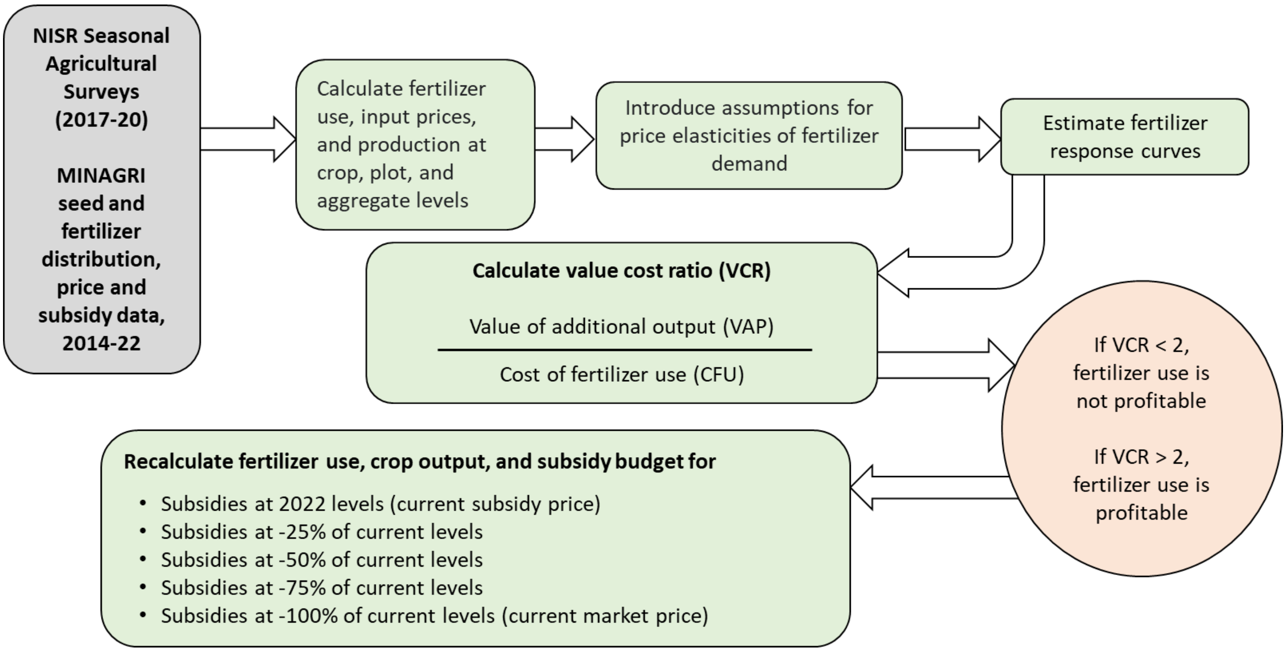
To capture farmers' sensitivity to these changes in prices, we assume the following price elasticities of fertilizer demand: −0.1 (price insensitive), −0.5 (moderately price sensitive), and −0.9 (price sensitive). Note that price elasticities of fertilizer demand cannot be estimated empirically as in Rashid et al. (2013) because the SAS data do not contain household data that are used to predict the correlates of fertilizer use, quantities of fertilizer purchased, and sensitivity to price.[6] Alternative data sources such as the EICV 5 and the Comprehensive Food Security and Vulnerability Analysis (CFSVA) from NISR contain the required household data, but do not contain fertilizer price and quantity data—for fertilizer in general or by product—that are necessary to estimate the elasticities in question. The 2017 Agricultural Household Survey (AHS) contains these data points and much of the requisite household data, but does not include plot sizes which are necessary to normalize the amount of fertilizer demanded per hectare. Nonetheless, the assumed elasticities are consistent with estimates from other countries and crops in the region (Komarek et al. 2017; Rashid et al. 2013). Specifically, they correspond to expected elasticities in a country characterized by low fertilizer use and application rates, limited land and resource endowments, and low agronomic efficiency of nitrogen, but the potential for growth (see, e.g., Jayne et al. 2019; Chianu et al. 2008). Fertilizer response functions are derived directly from the SAS plot-level data. These response functions are generally lower than, but still consistent with, response curves estimated in agronomic trials, including trials conducted in Rwanda (Nabahungu 2020; Cyamweshi et al. 2017; Kelly and Murekezi 2000). The simulation relies on SAS estimates of fertilizer responses because they represent a better estimate of the variation in ground realities facing Rwandan farmers than agronomic trials that are conducted under controlled research conditions. However, these data are fairly noisy, requiring a careful approach to dealing with outliers. To account for potential outliers, the top 1 percent of values of yields and fertilizer use by hectare were assigned to the median. With these assumed fertilizer price elasticities and the estimated fertilizer response curves, the model simulates first how the increased price may impact demand for fertilizer and the amount of fertilizer used on each plot, and then how this reduced amount of fertilizer per plot may affect crop production.

Note that the simulation model relies on several simplifying assumptions. First, fertilizer supply is assumed to be exogenous and determined by negotiated prices and quantities between government and international suppliers, implying that a change in fertilizer demand by farmers does not elicit a supply response from producers. Second, seed subsidies remain unchanged as a matter of policy and, in any case, are relevant primarily to maize only. Third, although farmers using fertilizer in our simulations may have VCRs less than 2, we assume that they continue to purchase fertilizer even though it may not be economically efficient to do so. The exception to this

[6] Along these lines, Ricker-Gilbert et al. (2017) use a double-hurdle model to estimate the crowding out effect of subsidized fertilizer on the purchase of fertilizer at market rates.

assumption is for farmers using less than 1 kg of fertilizer total, who are assumed to be priced out of the market and therefore are not considered to be fertilizer users. Finally, land use is fixed in the short run such that farmers do not change their crop cultivation patterns in response to changes in fertilizer prices and profitability.

**Figure 2. A microsimulation model of the effects of fertilizer subsidy reductions on fertilizer use, crop output, and budget costs**



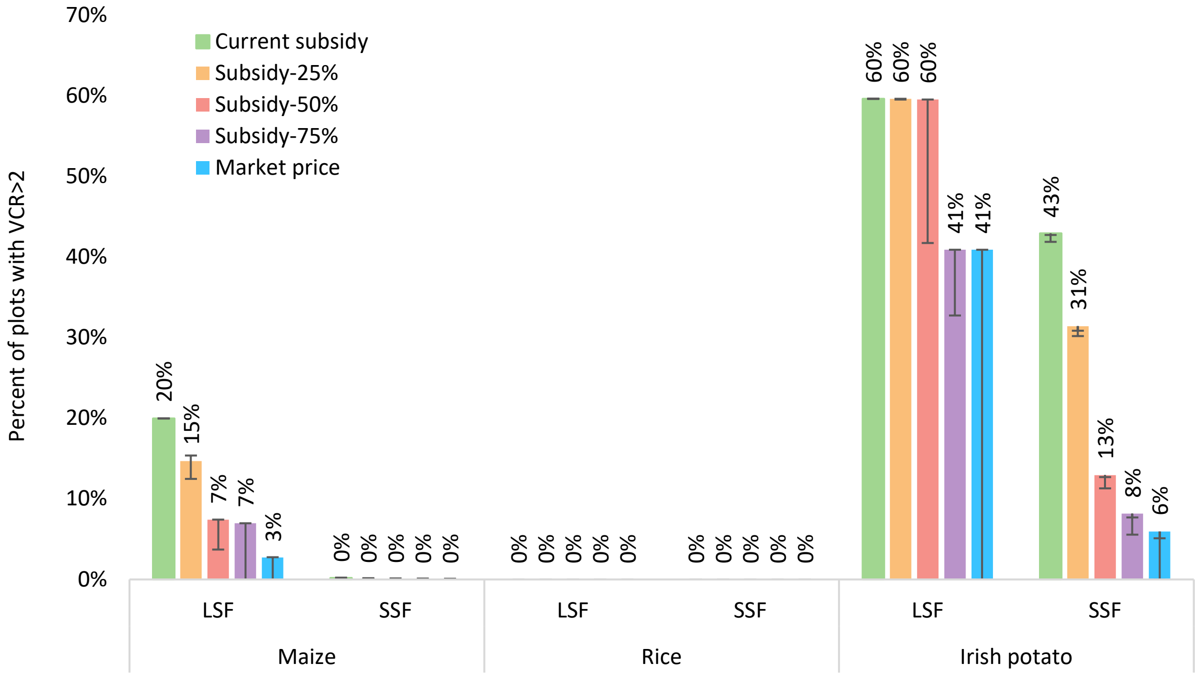

Source: Authors.

# REDUCING FERTILIZER SUBSIDIES SLIGHTLY REDUCES FERTILIZER DEMAND AND PRODUCTION

Figure 3 shows the share of plots in Season A that are profitable across a simulated phase-out of the fertilizer subsidy, which may also be interpreted as a simulated increase in fertilizer prices. Results are disaggregated by crop and between small-scale farmers (those operating plots of less than 10 ha) and large-scale farmers (those operating plots greater than or equal to 10 ha).

Results indicate that as fertilizer subsidies are reduced, farmers' fertilizer costs increase, and the share of profitable plots decreases. The January 2022 subsidy rate regime discussed earlier (referred to as the "current subsidy") leads to a larger share of plots with VCRs greater than 2 for both large- and small-scale farmers in Season A when compared to the subsidy phase-out (Subsidy -25%, -50%, and -75%) and eventual removal ("market price"). Similar results are obtained for Seasons B and C.

**Figure 3. Simulated share of plots with value-cost ratios greater than 2 in Season A, by farm size and crop**

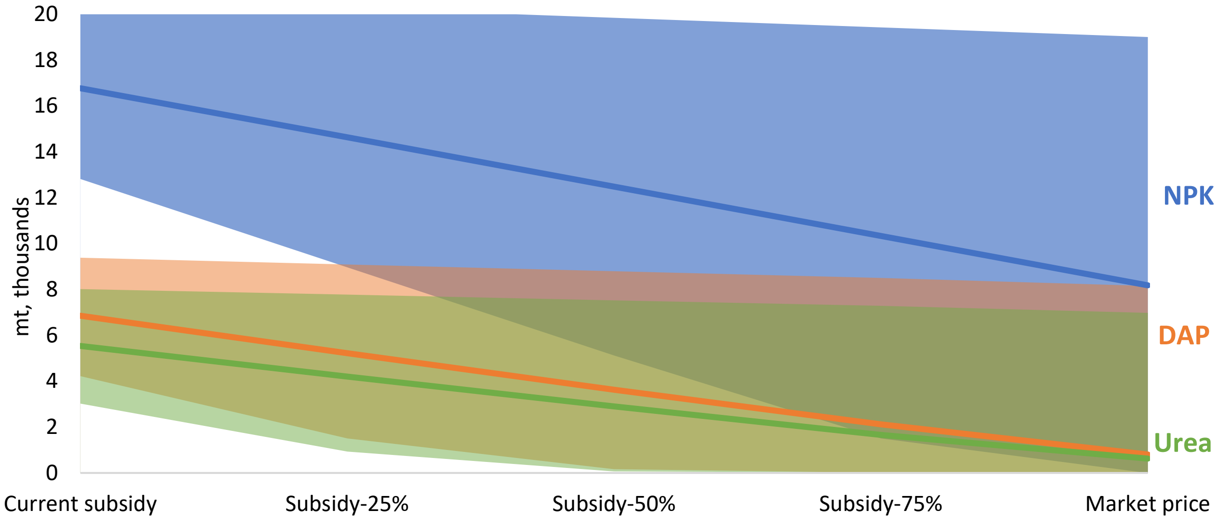



Source: Authors' calculations using 2020 Seasonal Agriculture Survey (NISR).
Note: Error bars indicate the range of simulated fertilizer demand based on varying assumptions about farmers' sensitivity to fertilizer prices. LSF=large-scale farmers (>10ha plots); SSF=small-scale farmers (<10ha plots); VCR=value-cost ratio.

Having calculated changes in plot-level VCRs, we then simulate the effect of fertilizer prices and subsidies on total demand for fertilizer. We use a range of assumptions about farmers' sensitivity to changes in fertilizer prices (i.e., the price elasticity of fertilizer demand).

Assuming that farmers are highly price-sensitive, results indicate that demand for all three fertilizers may drop to zero as the subsidy is removed. This drop is shown along the bottom border of each shaded region in Figure 4. If farmers are highly price-insensitive, the removal of all subsidies leads to a 13 percent decrease in demand for DAP and urea and an 8 percent decrease in demand for NPK compared to demand at the current subsidy rate. This is shown along the top border of the shaded regions in Figure 4.

**Figure 4. Simulated yearly national fertilizer quantities demanded, in thousands of metric tons**



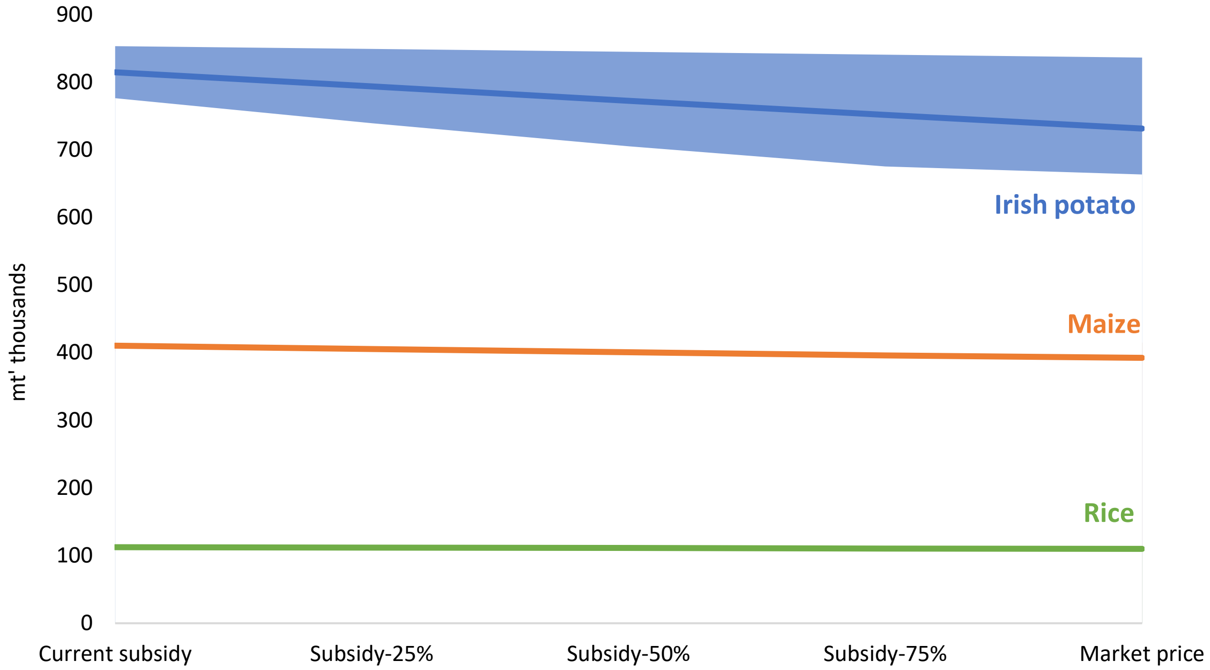

Source: Authors' calculations using 2020 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated fertilizer demand based on varying assumptions about farmers' sensitivity to fertilizer prices.

Next, we turn our attention to the impact of fertilizer prices and subsidies on crop output (Figure 5). When comparing the current subsidy regime and the market price, national production for all seasons does not drop by more than 4, 3, and 15 percent for maize, rice, and Irish potato, respectively. In fact, more conservative estimates that assume farmers are relatively price insensitive result in annual production losses of just 0.9 percent for maize, 0.4 for rice, and 2.0 for Irish potato. Although these decreases in output may have a negative effect on prices facing consumers, trade can potentially mitigate these effects.

Necessarily, there are limitations to this simulation model. For example, because the simulations rely on data from the 2020 SAS, we only capture data on those plots that are cultivating the three selected crops, and cannot account for changes in cropping patterns or exogenous shocks such as weather events. Our assessment of the SAS data in prior years suggests that cropping patterns have not changed to any significant extent. However, economic shocks associated with the COVID-19 pandemic and climate shocks may have been significant during this period and may explain the difference between simulated and actual production levels for maize, in particular., Specifically, climate shocks may result in downward biased results for maize production in our simulations. A preliminary version of this analysis was completed prior to the release of the 2020 SAS microdata, and these results using the 2019 SAS (pre-COVID) are shown in the annex.[7]

[7] A detailed discussion of these results can be found in D.J. Spielman, S. Mugabo, G. Rosenbach, S. Ndikumana, G. Benimana, and C. Ingabire (022), *Expected Impacts of Increases in International Prices of Fertilizer in Rwanda: Estimates from a Microsimulation,* Rwanda SSP Policy Note no. 6 ( Washington, DC: IFPRI).

**Figure 5. Simulated yearly national production, in thousands of metric tons**



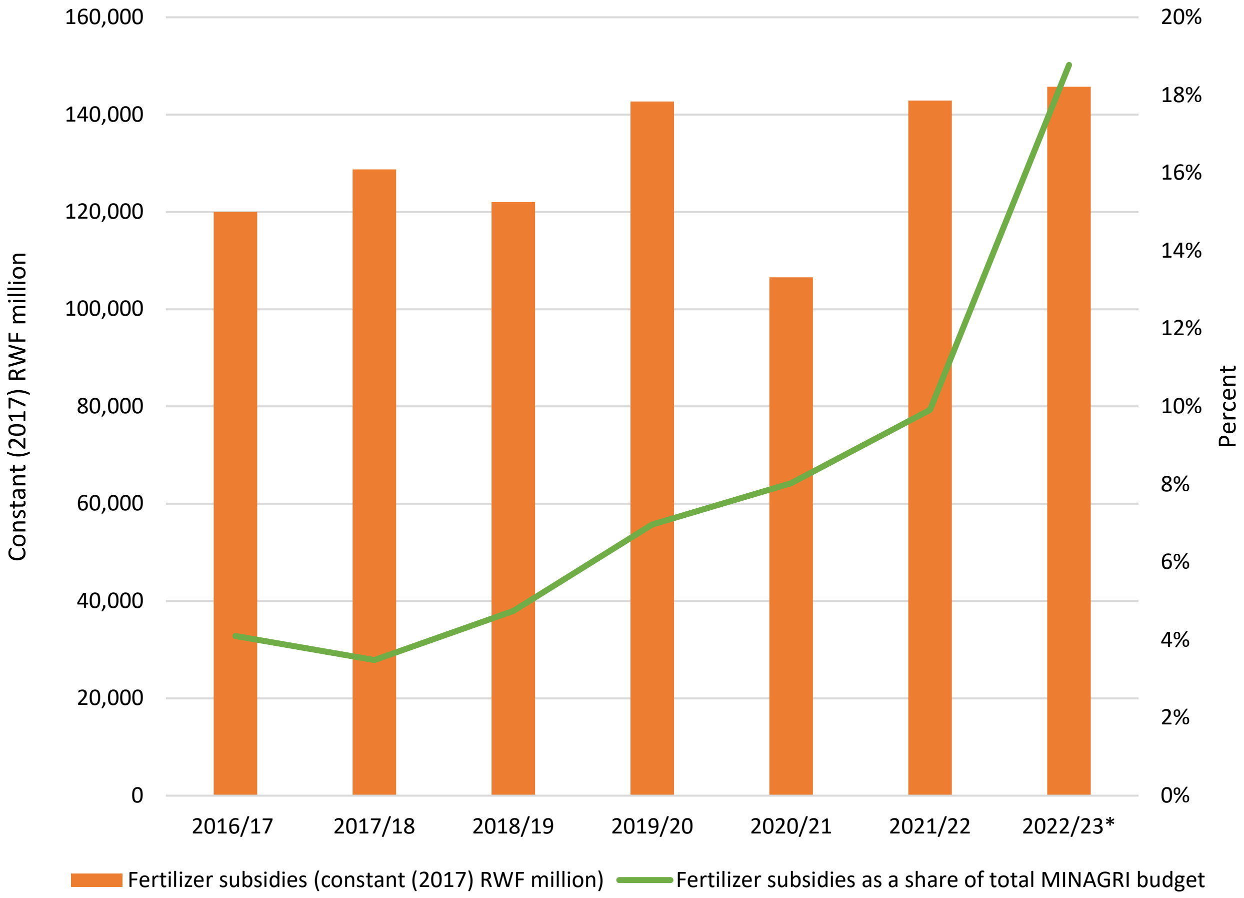

Source: Authors' calculations using 2020 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated national production based on varying assumptions about farmers' sensitivity to fertilizer prices; mt=metric tons.

# BUDGET IMPLICATIONS

The effects on fertilizer demand and crop production described above should also be considered in light of MINAGRI's budget. In this analysis, we consider the MINAGRI budget as the total of budgets for MINAGRI central, RAB, NAEB, and earmarks for districts, and convert the budget to constant (2017) RWF to account for inflation. We also note that fertilizer subsidies are actually budgeted under and disbursed through the earmarks for districts. As such, any budget revisions made during the fiscal year to accommodate MINAGRI's announced changes in fertilizer prices will show up as revisions to the earmarked budget for districts.

In 2019/20, fertilizer subsidies accounted for 6.97 percent of the MINAGRI budget and increased to 8.03 percent in 2020/21. The current subsidy regime increases this share by about 1.9 percentage points in 2021/22 to 9.91 percent (Figure 6). In 2021/22, fertilizer and seed subsidies accounted for 65 percent of the MINAGRI budget earmarked for districts, indicating that the majority of MINAGRI-funded activities administered by district governments now revolve around subsidized input distribution and management

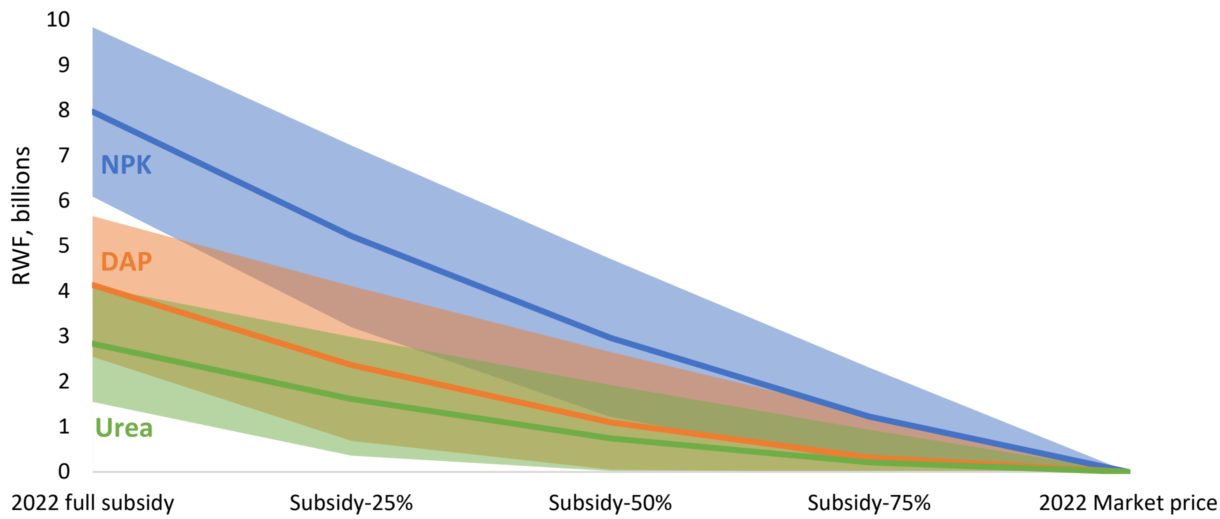
**Figure 6. Fertilizer subsidies in constant (2017) RWF millions and as a share of the MINAGRI budget, FY 2016/17 to 2021/22**




Source: Authors, based on MINAGRI data; updated October 2022.
Note: Constant RWF figures are based on CPI data from NISR. Note that the CPI used to calculate FY 2021/22 is the provision, based only on the CPI as of December 2021 reported by NISR. RWF=Rwandan francs. MINAGRI=Ministry of Agriculture and Animal Resources. Figures for the fiscal year 2022/23 are provisional and subject to revision.

Based on the simulation results discussed above, the estimated total subsidy bill for all three seasons and all three fertilizer products under the current market price and subsidy regime is between RWF 10.2 and RWF 19.6 billion, These figures represent between 8 and 16 percent of the MINAGRI budget. The upper-bound estimate of RWF 19.6 billion assumes that farmers are highly price insensitive and therefore will continue purchasing similar quantities of fertilizer as they did before the change in fertilizer prices, whereas the lower-bound estimate of RWF 10.2 billion assumes that farmers are very price sensitive and therefore demand significantly less fertilizer in response to a change in prices. The total subsidy bill per fertilizer product is shown in Figure 7 and is calculated by multiplying the current subsidy rates by the total fertilizer demand.

**Figure 7. Simulated yearly national fertilizer subsidy bill, billions RWF**




Source: Authors' calculations using 2020 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated national production based on varying assumptions about farmers' sensitivity to fertilizer prices.

# POLICY OPTIONS TO MITIGATE IMPACTS OF SUBSIDY REDUCTIONS

An alternative approach to the simulations conducted above may be to ask what additional investments are needed in order to maintain or increase VCRs if fertilizer demand continues to increase. This directs attention to the continued need for greater investment in subsidy management and in complementary investments that increase the efficiency of fertilizer use, for example, an expansion of credit facilities for fertilizer purchases, market reforms, improved extension and advisory services, new varieties and quality seed, irrigation, terracing, post-harvest handling, higher farmgate prices for crops, and other agriculture and rural infrastructures.

Several recent studies specifically address the need for greater investment in subsidy management and complementary expenditures. These studies reference as their starting point the PSTA 4 objective to increase the delivery and use of modern inputs to farmers through voucher schemes and targeted subsidies within the context of market liberalization. This directly translates into at least four issues should be addressed: subsidy management, credit and other financial services, subsidy targeting, and transitioning to an open market for fertilizer. We examine each issue below.

Note that we do not discuss critically important options such as strengthening agricultural extension and advisory services. There are important issues pertaining to RAB fertilizer recommendations, sector and district agronomists' communication of those recommendations, and farmers' uptake of those recommendations in their crop management practices. However, those issues receive detailed treatment elsewhere and are not within the immediate scope of this paper.

## Subsidy management

Prior studies suggest scope for reforms to reduce the time and cost of managing fertilizer distribution and fertilizer subsidies. Relevant reforms include the following.

1. *Reduce the regulatory requirements pertaining to inspections and testing of imported fertilizers at port.* IRDP (2020) suggest that there are potential cost savings to be realized at the very head of the supply chain—portside in Dar es Salaam where fertilizer bound for Rwanda reaches the continent. They point to delays caused by testing and inspection as a significant

area for improvement. While quality testing may be a regulatory necessity, there is sufficient evidence to suggest that counterfeiting of urea is highly unlikely due to the low returns to such behavior, whether portside or at other points along the supply chain (Michelson et al. 2021). And while testing may be required for other higher-value fertilizers, there may be scope to reduce the costs and delays associated with imported fertilizer inspections by the relevant governmental authority.

2. *Reduce the costs of APTC's fraud-monitoring operations in the fertilizer supply chain.* Agro Processing Trust Corporation (APTC)'s role in the supply chain expanded in 2016/17 in response to findings of fraud among importers and agro-dealers (2AGSolutions 2020). Assuming that this role remains relevant, there may still be scope to reduce these costs and improve APTC performance by linking payments to APTC with timely and accurate distribution of fertilizer (Palladium et al. 2020).

3. *Increase the cost-effectiveness of subsidized fertilizer delivery with an electronic voucher system integrated into the Smart Nkunganire System (SNS).* The SNS is used to provide eligible farmers with subsidized fertilizers from agro-dealers through a mobile-phone based messaging system, subject approval by the sector agronomist. Palladium et al. (2020) argue that an electronic voucher system would allow MINAGRI to link access to subsidized inputs with targeting criteria such as crop, land area, and input requirements. An e-voucher system would then link farmers to agro-dealers and credit providers, thereby encouraging private sector participation in the input market while also providing MINAGRI and local government with valuable monitoring data on fertilizer use and farmers. But, as Mason et al. (2020) find in their analysis of Zambia's e-voucher program for agricultural inputs, these mechanisms are not a panacea to the wider issue of input subsidy management.

## Credit and other financial services

Credit provision has been a central feature in efforts to increase fertilizer demand and use in most industrialized and developing countries. In Rwanda, there is evidence to suggest that demand for fertilizer is strongest among those producing commercial surpluses. 2AGSolutions (2020) find that having received a loan from the Rural Investment Facility (RIF) is associated with a 39 percent higher probability of using inorganic fertilizer.[8] As such, public investments designed to extend credit and other financial services to farmers should be considered essential to increasing fertilizer use and realizing the goals of PSTA 4.

The question is what types of financial services are most appropriate to the Rwandan context. Palladium et al. (2020) float several broad recommendations around integrating credit and insurance with the intended use of the fertilizer though the SNS system. These include mechanisms to: (a) track farmers' prior performance in input use and loan repayments as a prerequisite for obtaining credit or as a targeting tool; (b) use payment platforms linked directly to the purchase of inputs to prevent misuse of loan proceeds; (c) provide farmers with an option to purchase inputs at both subsidized and non-subsidized rates; and (d) integrate insurance with credit provision. Indeed, there is also prior work on targeting based on farmer typologies and One Acre Fund's activities in the country that could be put to use (Hammond et al. 2020). But while these proposals have merit, they require careful attention to detail in both design and implementation.

[8] 2AGSolutions analyzes EICV data to arrive at these estimates. While their methodological approach requires further validation, their findings suggest opportunity for further analysis.

## Targeting input subsidies

Recommendations from prior studies all steer towards one common point: input subsidies need to be targeted rather than disbursed through a blanket/universal subsidy system. Two questions arise from this rather broad recommendation. First, should subsidies be targeted to resource-poor, food-insecure, or otherwise vulnerable households, or should they be targeted to farmers that are likely to be produce commercial surpluses profitably? Clearly, this highlights the equity-efficiency tradeoff in subsidy targeting (De Frahan et al. 2018).[9]

Subsidy targeting is a difficult task under the best circumstances in which governments have full information on farmers. That information is critical in directing subsidized inputs to the "right" households, farms, or plots, at least from the perspective of a public administrator or policymaker. But how do we define "right"? Unfortunately, neither the technical or economic efficiency of a given farmer nor his/her household's income or wealth status can be directly observed by individuals or organizations charged with distributing input subsidies.

To remedy this problem, administrators often use proxy indicators and typologies to identify farmers that might qualify for subsidies according to some predetermined criteria set. Unfortunately, such targeting mechanism have produced mixed results, even in this more recent period of "smart" subsidy programs (Jayne et al. 2018; Holden 2019). Multiple studies show that a substantial share of input subsidies do not reach their intended farmers—typically resource-poor farmers—because of targeting problems (Lunduka et al. 2013; Chibwana et al. 2014; Holden and Lunduka 2012; Ricker-Gilbert et al. 2011).

However, input subsidy targeting faces several fundamental challenges, even when the targeting criteria are as simple as landholding size. These challenges include (1) the identification of a credible population that requires input subsidies, (2) the development of clear criteria to target that population, and (3) the creation of a system to select and reach members of that population. In the next section, we review the evidence on targeting, targeting criteria, and targeting tools used in the region and their applicability to Rwanda.

Palladium et al. (2020) and 2AGSolutions (2020) provide a compelling strategy for targeting these "potentially profitable" farmers, or farmers who cannot afford the optimum amount of fertilizer but still have the potential to be self-sufficient through increased productivity. In some cases, these potentially profitable farmers can be readily identified by their landholding sizes, presence in a land use consolidation site, membership in a cooperative, cropping system of the mix of crops they cultivate, the potential of their agro-ecology and geography, their proximity to markets and market infrastructure, or their individual educational achievements or entrepreneurial prowess.

The Palladium et al. (2020) and 2AGSolutions (2020) strategy is highlighted by (a) the design of a clear targeting framework, i.e., targeting criteria such as *Ubudehe* category, land type, cropping system, cooperative membership, or combinations of these variables that effectively map to the attributes of "potentially profitable" farmers and their farms, (b) proxy means testing that is integrated into LODA's social profiling to establish a farmer's eligibility according to these criteria as well as the expected value-cost ratios for input fertilizer use, and (c) mechanisms to address targeting errors and changes in a farmer's circumstances over time.

There is considerable merit in any effort to improve targeting and replace the blanket/universal subsidy that may result in larger farmers benefiting from subsidies when they may not need such

[9] To illustrate this point, Frahan et al. (2018) use an empirical modelling approach to assess the income and welfare effects of input subsidies across heterogeneous agricultural household types, under competitive and monopolistic input market structures. Their findings show that irrespective of market structure, about 51 percent of Rwanda's input subsidy transfers are absorbed by farmers with more than 1 ha of land who account for 50 percent of Rwanda's arable land.

support. There is also merit in taking a data-driven approach to targeting. With an understanding that targeted characteristics may both *explain and be explained by* the use of subsidized inputs, a cautious but steady approach to developing this system may be warranted. Significant improvement in data integration systems and analytical capacity would be pre-requisites to the introduction of this system. Significant investment in auditing this system would also be required to prevent farmer typologies and targeting criteria from being used as an instrument of discrimination, intentional or otherwise.

Of course, targeting along these lines seeks to address the efficiency dimension of the efficiency/equity tradeoff by investing in farmers with commercial potential. But what becomes of resource-poor households that do not use modern inputs but could potentially benefit from increased production? The World Bank-commissioned public expenditure review (2019) emphatically emphasizes that input subsidy programs should not be a mechanism for social protection but rather an investment in the productive capacity of agriculture. But the empirical literature suggests that synergies between agriculture and social protection are important: social protection impacts agricultural production while agricultural interventions reduce household risks and vulnerability (Tirivayi et al. 2016). So simply abandoning the poorest or most vulnerable farmers is not necessarily an advisable option.

With small quantities of improved seed and inorganic fertilizer, many of these households may be able to increase production to a level that enhances their own consumption or generates income that allows them to purchase additional food staples, medicines, or services essential to their well-being. A targeting strategy based solely on commercial potential is likely to miss these households. This argues for continued investment in an input subsidy approach along the lines of small starter kits to popularize modern inputs and encourage greater investment in on-farm production.

Approaches to targeting in Rwanda have received a fair amount of attention in recent years. We can classify these targeting approaches into three categories: (1) geographic criteria; (2) landholding and crop criteria; (3) income and poverty proxies; and (4) farmer typologies.

1. *Landholding size criteria.* As illustrated above, a simple targeting approach to subsidy input provision based on landholding size can be appealing. Landholdings vary in Rwanda, and may seem like a useful criterion for targeting. Unfortunately, landholding sizes are distributed among Rwandan households within a very narrow band: farmers holding less than 10 ha of land account for 98 percent of Rwanda's cultivated land area. And while poverty *does* correlate with landholding size, the fact that average landholding sizes are so small throughout Rwanda means that the correlation is not particularly useful in targeting subsidies (see World Bank 2015).

2. *Geographic targeting criteria.* Geographic targeting is used to identify and target farmers in a specific agroecological, administrative, or livelihood zone. For this targeting approach to be effective, a significant share of the farming population residing in the zone should fit the overarching inclusion criteria for the system, e.g., farmers who are likely able to use inputs in an efficient and productive manner, but who might otherwise not do so without subsidies due to resource constraints they face. In the Rwandan context, the potential for geographic targeting may be limited: with 10 agro-ecological zones and many more land-use zones, livelihood zones, and agri-potential zones—none of which map perfectly to provincial, district, or sector boundaries—the administration of these targeting criteria might be challenging.

3. *Income and poverty proxies.* There are several ways to use income or poverty measurements to identify resource-poor farmers. These include classification of a household by *Ubudehe* category, other forms of proxy means testing, or community-based identification. Unfortunately,

the relationship between poverty and farm-based livelihoods is complex such that the likelihood of excluding a qualifying household from the subsidy system is probably as serious as including a non-qualifying household.

4. *Farmer typologies.* This multi-attribute targeting approach is similar to the use of actionable farmer typologies. Drawing on data from One Acre Fund, Hammond et al. (2020) describe an approach that relies on rapid data collection and analysis tools to classify farm households and their readiness to adopt new agricultural technologies and practices. The key variables used to typologize farmers include their baseline adoption and use of recommended technologies and practices, proxy measures of prosperity including land and livestock holdings, marketed surpluses of both crops and livestock, education level, and extent of household income diversification. However, the approach is still a long way off from field-level validation.

Similarly, the recent reports by 2AgSolutions (2019) and Palladium et el. (2020) suggest that subsidies could be targeted to farmers who are potentially profitable and able to shift into surplus production with the use of modern inputs. In some cases, these potentially profitable farmers can be readily identified by their landholding sizes (e.g., medium to large-scale farmers operating >2 ha). But in other cases these farmers may be identifiable by the crop (or mix of crops) they cultivate, the potential of their agro-ecology and geography, their proximity to markets and market infrastructure, or their individual entrepreneurial prowess. Again, operationalizing this approach seems extremely challenging.

Another typology-based criteria set might combine multiple, relatively observable attributes. These attributes might include (1) land quality (e.g., hillsides or marshland, terraced vs. non-terraced land, irrigated vs. non-irrigated land, or soil quality), (2) the choice of crops grown on the land, the landholding size, and (3) a credible measure of a household's income, wealth, or poverty status. To a certain extent, this was the intention of focusing subsidized inputs in LUC sites where intensive cropping, crop management, and input use were promoted. However, LUCs remain limited in scale and scope, suggesting that these criteria could be expanded to qualify other areas. The success of such a targeting approach based on this combination of attributes requires that both landholdings and the households operating them can be credibly characterized in a transparent, data-driven manner and considered in conjunction with landholdings, they might constitute useful targeting criteria. But, as is discussed in the next section, there are significant unintended consequences of implementing this—or any—targeting approach.

Consider the following example. The government chooses to direct subsidies only to small-scale farmers, making farmers with landholdings of less than 10 ha eligible to receive subsidized fertilizer, thereby excluding large-scale farmers (farmers with landholdings of 10 ha or more). Depending on assumptions made about large-scale farmers' sensitivity to changes in fertilizer price, one would expect a reduction in demand for fertilizer as the price of fertilizer increases. As a result, large-scale farmers may apply less fertilizer, leading to decreases in output.

Our simulation results indicate that this targeting approach would result in negligible decreases in maize and Irish potato production, and a 1-9 percent decrease in rice production. he associated reduction in the fertilizer subsidy bill would total RWF 0.94 to 1.03 billion.

Despite the encouraging nature of these simulated outcomes, the unintended consequences of targeted subsidies also need to be fully recognized. These include leakages from the subsidy system and development of a secondary market, crowding out or displacement of purchased and other inputs, and discrimination. We describe each one below.

1. *Leakages, rent seeking behavior, and secondary markets.* Any targeting of subsidies implies that some farmers will receive inputs at a discounted price while others do not. This creates opportunities for subsidy recipients to sell their subsidy access or the subsidized inputs to non-recipients at a premium in a “secondary” market. Jayne et al. (2013) find that about 33 percent of subsidized fertilizer does not reach the actual intended beneficiaries in some African countries because of leakages and diversions of fertilizer. Elite capture in these programs is also well documented (Ricker-Gilbert et al. 2011; Pan and Christiaensen 2012). Such leakages can be limited with anti-corruption practices and technologies, e.g., non-transferable electronic vouchers or radio frequency identification of bulky inputs, and input movement controls. Rwanda has pursued elements of this approach, as have Malawi, Mozambique, Nigeria, Zambia, and Zimbabwe. However, these monitoring systems can be costly to design and implement, are dependent on political will and institutional context, and require continuous evaluation of their impact (Jayne et al. 2018). For example, Mason et al. (2020) find that Zambia’s e-voucher pilot introduced to improve the national Farm Input Support Programme (FISP) showed very little promise due to implementation failures and lack of political will.
2. *Crowding out and displacement effects.* There also is evidence from other countries that input subsidies may have unintended crowding out effect. In Malawi, for example, there is evidence that the universal fertilizer input subsidy program displaced purchases of commercial fertilizer that farmers would have otherwise made in the absence of a subsidy (Mather and Jayne 2018; Ricker-Gilbert et al. 2013). There is also evidence from Malawi suggesting the same program slightly displaced the use of manure (Holden and Lunduka 2012).
3. *Discrimination.* Finally, targeting—especially data-driven targeting—can be a powerful means of discriminating against groups. Targeting approaches rely on the collection of proxy data on farmers and farm-households to determine whether the farmer qualifies for a subsidy. But if those proxies are poorly chosen or poorly understood, they can also become a mechanism to discriminate against specific groups in unplanned or unintended ways.

## Transition to an open market for fertilizer

There is strong evidence to suggest that demand for fertilizer is strongest among those producing commercial surpluses. 2AGSolutions (2020) find that a 1 percent increase in the share of harvest sold by a household is associated with a 2 percent increase in inorganic fertilizer expenditures per hectare. This suggests that strong demand for fertilizer among commercial farmers can, to some degree, be the basis for higher levels of fertilizer use at market prices. Yet at present, there is no explicit channel for farmers to purchase fertilizer at market rates—the majority of fertilizer supplied to the farmers is channeled through the input subsidy system. But in geographies and markets where farmer demand exceeds available fertilizer supplies at subsidized rates, there should be an option for farmers to purchase at market rates. This means allowing the farmer him or herself to determine the profitability of fertilizer use. It also means investing in the creation of a competitive market for fertilizer outside the subsidy channel requires a level playing field at the most local level, i.e., one in which no single dealer or group of dealers have the power to set fertilizer prices.

## Managing the current fertilizer price shock in global markets

In the short-term, many of the options discussed above will be eclipsed by the current shock to fertilizer prices in the global market, partly resulting from the crisis in Ukraine. In this context, it is important to consider the options facing MINAGRI.

First, it is important to recognize that MINAGRI’s efforts to increase the subsidy rate on fertilizers or increase the subsidy budget will likely have limited impact on farmer demand and crop output. Quite simply, MINAGRI will have to subsidize and spend massively to simply maintain progress in the face of rising international fertilizer prices. The opportunity costs of this option are significant, especially if the current fiscal situation limits public spending on agriculture.

Alternatively, if MINAGRI caps the subsidy bill as a share of its budget at, say 10 percent or so, then it will have to closely manage both the subsidy rate and the quantity of subsidized fertilizer provided to farmers. This would require frequent analysis of market data to calibrate the subsidy rate to market demand. It would also require some degree of rationing of subsidized fertilizer under a targeting system. Both have non-trivial costs of design, implementation, and monitoring, only some of which may be offset by the fiscal space that MINAGRI buys itself with a cap on the subsidy bill.

Ultimately, MINAGRI will have to determine whether a return to the original subsidy levels and rates is desirable and under what conditions. If production losses are small under most price regimes—as shown in the simulations above—there may be considerable room to maneuver in terms of economic policy in the medium term. With that in mind, the immediate course of action in 2022/23 may be as follows.

- In the short term, if international fertilizer prices are expected to continue rising (e.g., as a result of global market factors including those related to the conflict in Ukraine), it may be necessary to maintain the current subsidy regime irrespective of the budgetary implications. This may send an encouraging signal to farmers that MINAGRI is making efforts to manage the increase in fertilizer prices as best possible.

- If and when international fertilizer prices return to their pre-shock levels, then it may be desirable to *at least* return to the original, pre-shock subsidy rates and levels (DAP subsidized at 35 percent; urea at 30 percent; and NPK at 15 percent). A concerted effort by the government to demonstrate that fertilizer subsidies are a flexible instrument to support agricultural production will ultimately give MINAGRI the ability to respond to future changes as and when needed, rather than letting subsidies at higher rates become a permanent policy fixture.

- Even if fertilizer prices remain high into Q2 2022 when new procurement begins for Season A 2022/23, it may still be desirable MINAGRI to consider reducing the subsidy so that the rates (albeit, not the subsidy levels themselves) remain in line with pre-shock subsidy rates.

Lastly, moving towards market prices in the medium term is feasible, and may have insignificant consequences on production, yet positive implications for MINAGRI's budget and the fiscal space needed to pursue other priorities. But given where fertilizer prices are at present, it may be difficult to move in that direction quickly; a slow easing if and when international prices return to their 2019/20 levels may be advisable.

With all of this said, we recognize that decisions on subsidy rates and levels are not made in a vacuum. The interests of Rwanda's farmers and consumers are at stake, and factors beyond crop production and fiscal effects need to be considered. And keep in mind that the distributional impacts of these fertilizer subsidies—how they affect farmers in different income groups or *Ubudehe* categories—cannot be determined within the context of this exercise.

# POLICY RECOMMENDATIONS AND CONCLUDING REMARKS

In summary, there are several medium-term options going forward on fertilizer subsidies once fertilizers return to lower, more stable, prices in the international market. These options assume continued subsidies for seed sector development and improved management of the overall subsidy system.

- *Option 1: Decrease fertilizer subsidy rates and decrease the overall budget allocation for fertilizer subsidies.* This option may negatively affect the growth in fertilizer use, use intensity, and thus yields, output, and food prices. In reality, this is not a possibility for Rwanda given the current economic situation.
- *Option 2: Maintain fertilizer subsidies at their current rates and maintain the overall budget allocation for fertilizer subsidies.* Given current trends in fertilizer use and use intensity, total demand for fertilizer will continue to increase in Rwanda. This option may lead to a tradeoff between (a) rationing of subsidized fertilizer distributed to farmers, and (b) continued accumulation of arrears as district-level distribution of fertilizers exceeds MINAGRI's budget allocation. Outcome (a) may prevent Rwanda from accelerating the growth in fertilizer use and use intensity, thereby reducing growth in yields and output and limiting realization of the PSTA 4 targets. Outcome (b) is more likely to achieve the PSTA 4 targets through the growth of fertilizer use on the extensive and intensive margins, leading to growth in yields and output, but will be accompanied by the continued accumulation of arrears.
- *Option 3: Maintain fertilizer subsidies at their current rates (or decrease the subsidy rate on NPK only) and increase the overall budget allocation for fertilizer subsidies.* This option may reduce (or fully eliminate) the accumulation of arrears by increasing the budget, and will continue to fuel growth in fertilizer use and use intensity with an increase in MINAGRI's budget that better reflects farmers' needs and the situation facing the agricultural sector.
- *Option 4: Target fertilizer subsidies more precisely.* This is a likely second-best option to reducing subsidy rates as proposed above. And in the absence of perfect information and foresight, a farm/farmer typology-based approach may be a third-best approach to targeting those farmers more likely able to use inputs in an efficient and productive manner, but who might otherwise not use them due to resource constraints. The success of this targeting approach will rest on political will, smooth implementation, and a credible data collection and analysis tool used to determine whether a farmer qualifies for a subsidy or not. However, past experience from other countries suggests that the unintended consequences of targeting may be an insurmountable challenge to the successful implementation of reforms to the subsidy system.

Note that the analysis provided here highlights the need for cautious, time-bound continuation of input subsidies accompanied by strategic reductions in subsidy rates, an increase in the budget allocated to subsidies, and extensive changes to subsidy management, credit provision, targeting, and the open market for inputs.

A final note. It is important to state that there is scope for continued analysis of these issues using additional data sources, with supplementary statistical, econometric, and computational models, to be validated by additional expert insight and review. In this context, it is important to recognize that while the NISR SAS data are useful for the analysis presented in this paper, there are several important limitations. As noted earlier, the analysis does not address the individual, household, and farm characteristics that are key to understanding drivers and correlates of improved seed and fertilizer use. This includes estimating the relationship between use and price: accurate estimates of fertilizer price elasticities require much more data. It also includes estimating the income, poverty, and other distributional effects. Alternate data sources exist, namely the EICV and CFSVA datasets produced by NISR. However, they lack the high-resolution data on fertilizer use (by product, and with price and quantities). The 2020 AHS may be a more viable alternative, but will only be useful for a replication and extension of the simulation model developed here.

Finally, it is worth highlighting the fact that there is an opportunity to address this data disconnect by integrating an agricultural survey into future EICVs, as has been done successfully in a number of countries in sub-Saharan Africa (see Sheahan and Barrett 2017). A global effort to scale up this approach—the 50x2030 Initiative—aims to provide expertise and resources to support an integrated survey on agriculture in living standards measurement surveys such as the EICV.

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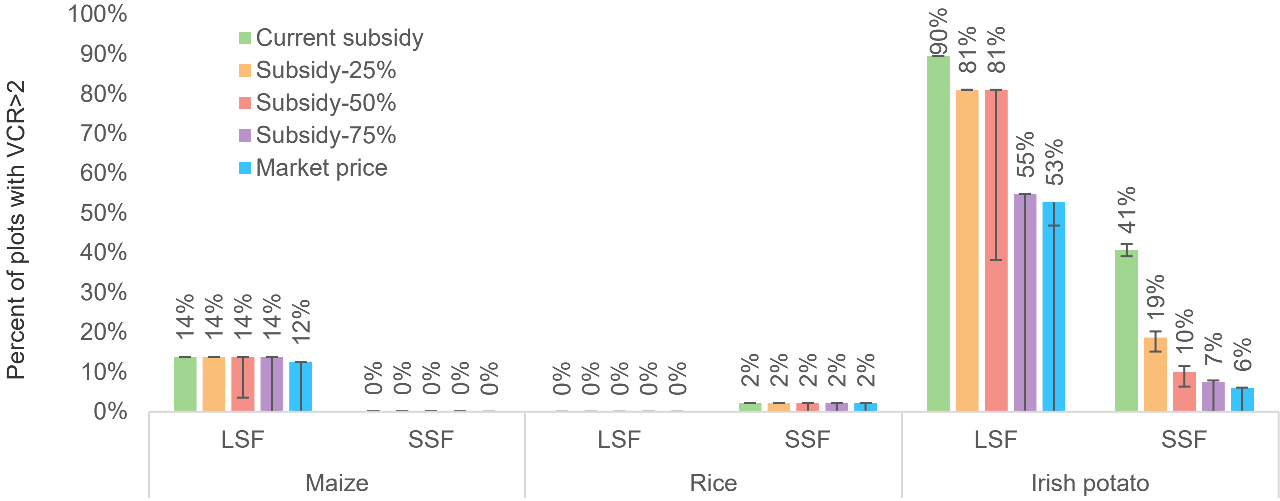
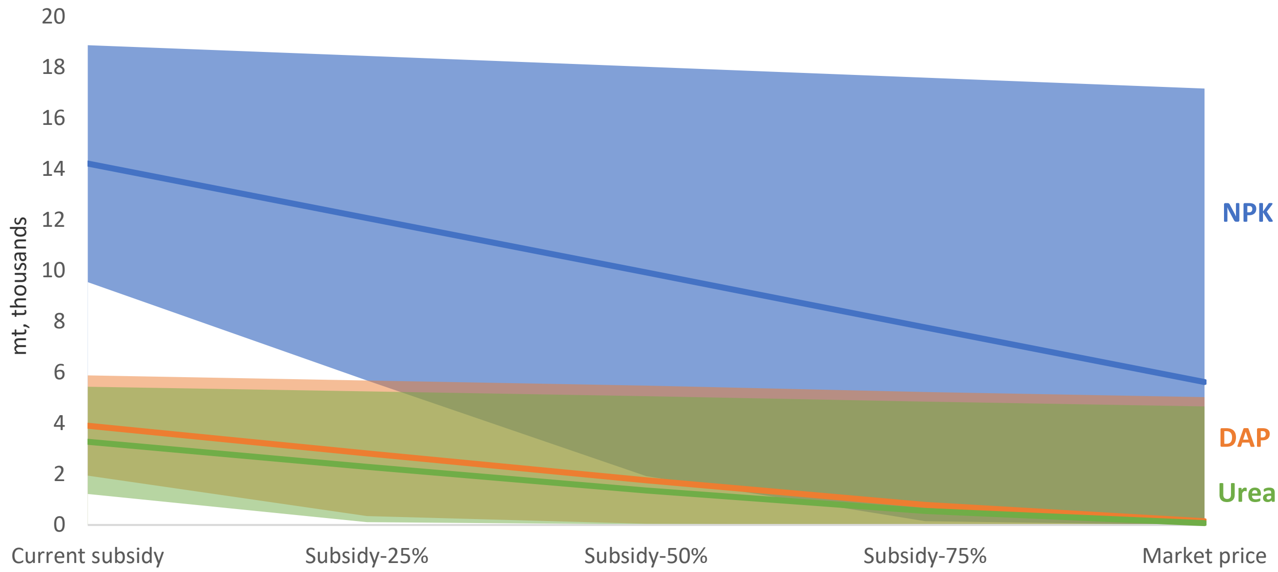
# ANNEXES

## Annex Figure A1: Simulated share of plots with value-cost ratios greater than 2 in Season A, by farm size and crop (2019)



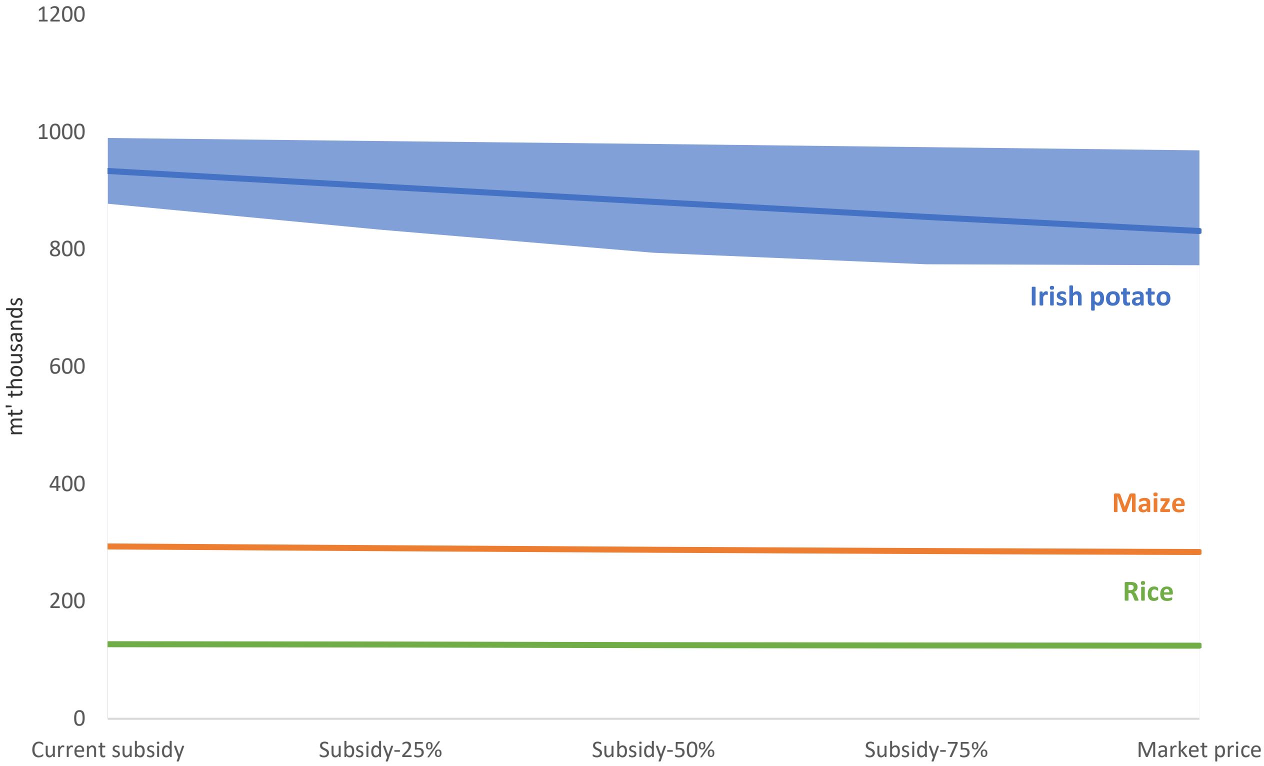

Source: Authors' calculations using 2019 Seasonal Agriculture Survey (NISR).
Note: Error bars indicate the range of simulated fertilizer demand based on varying assumptions about farmers' sensitivity to fertilizer prices. LSF=large-scale farmers (>10ha plots); SSF=small-scale farmers (<10ha plots); VCR=value-cost ratio.

## Annex Figure A2: Simulated yearly national fertilizer quantities demanded, in thousands of metric tons (2019)



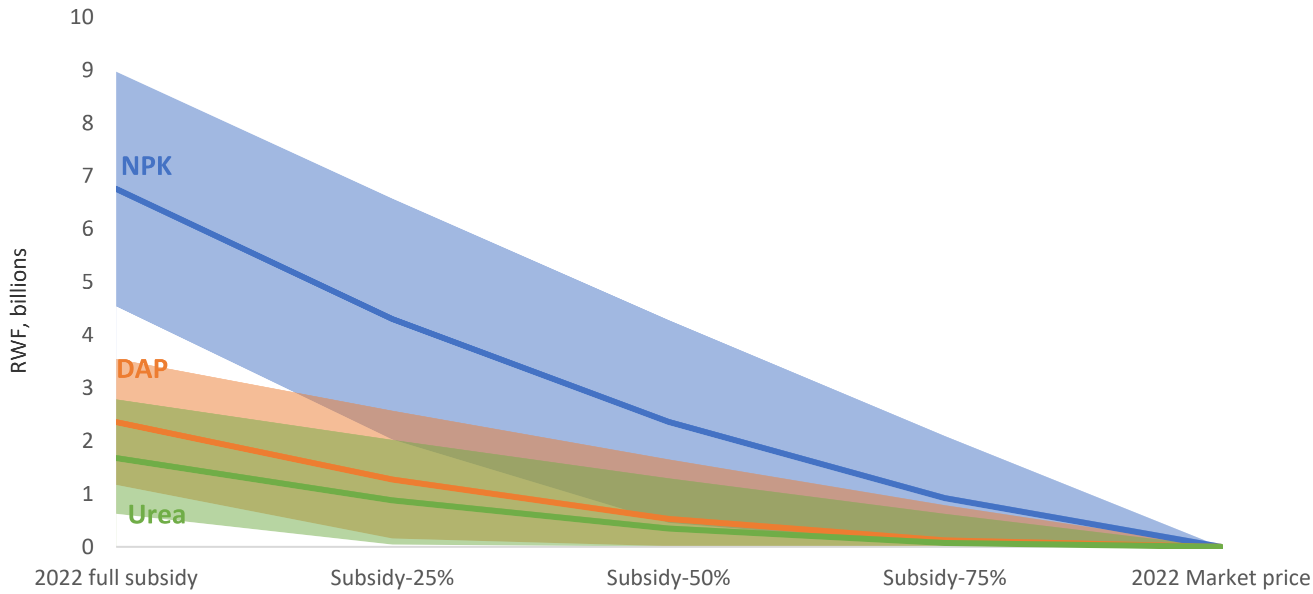

Source: Authors' calculations using 2019 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated fertilizer demand based on varying assumptions about farmers' sensitivity to fertilizer prices.

### Annex Figure A3: Simulated yearly national production, in thousands of metric tons (2019)




Source: Authors' calculations using 2019 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated national production based on varying assumptions about farmers' sensitivity to fertilizer prices; mt=metric tons.

### Annex Figure A4: Simulated yearly national fertilizer subsidy bill, billions RWF(2019)




Source: Authors' calculations using 2019 Seasonal Agriculture Survey (NISR).
Note: Shaded areas indicate the range of simulated national production based on varying assumptions about farmers' sensitivity to fertilizer prices.

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