Inorganic Fertiliser Use Among Smallholder Farmers in Sub-Saharan Africa: Implications for Input Subsidy Policies

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Abstract In recent years, use of inorganic fertiliser among smallholder farm households in Sub-Saharan Africa (SSA) has increased, in large part due to the scale-up of input subsidy programmes (ISPs). However, fertiliser use efficiency for maize remains low, so the benefits of ISPs are often less than their costs. In order to make ISPs more cost-effective, sustainable and beneficial to smallholders, governments who implement ISPs should move towards implementing self-targeting mechanisms where more productive farmers opt into participation and relatively less productive farmers opt out. Such mechanisms include (i) increasing the amount of money that beneficiaries are required to contribute to acquire subsidised inputs and (ii) making receipt of subsidised inputs conditional on a household's willingness to implement soil fertility management practices that can increase the amount of maize produced per kilogram of fertiliser in future. Limited resource farmers who cannot provide complementary inputs to subsidised fertiliser would likely be better served by a cash transfer programme rather than an input subsidy.

1 Smallholder Access to Inorganic Fertiliser

Nutrients such as nitrogen, phosphorous and potassium are key inputs into the production of cereals, including maize which is the most widely produced and consumed cereal in SSA. The most effective mechanism to deliver these nutrients to crops is through the application of inorganic fertiliser (Vanlauwe et al. 2011). However, there is a common perception that farmers in SSA use significantly less fertiliser than is economically optimal. This belief has spurred significant research into the constraints

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that inhibit and limit smallholders from using fertiliser. Reasons commonly given include supply-side problems such as poor infrastructure, late delivery of fertiliser, few input suppliers and inappropriate fertiliser blending and application rate recommendations that do not conform to local soil qualities (Gregory and Bumb 2006). Demand-side constraints include lack of credit at planting as a major inhibitor to using fertiliser, as identified by a number of studies (Coady 1995; Dorward et al. 2004; Duflo et al. 2011). Other studies point to unfavourable fertiliser/maize price ratios (Croppenstedt et al. 2003; Duflo et al. 2008) and poor soil quality leading to low maize to fertiliser response rates (Marenya and Barrett 2009), as reasons for low uptake of fertiliser.

With these considerations in mind, this chapter presents what is currently known about access to and use of inorganic fertiliser among smallholder farm households in SSA. I first discuss the common perceptions of low level of inorganic fertiliser use in SSA, and how recent data suggest that this may no longer be the case in many parts of the region. A substantial portion of the report is then devoted to discussing the challenges associated with input subsidy programmes (ISPs) that are currently being promoted by numerous governments in SSA to encourage inorganic fertiliser use among smallholders.[1] Evidence indicates that by lowering the price of fertiliser for smallholders, ISPs have contributed to increased fertiliser application per hectare among smallholders. However, low maize to nitrogen response rates are a major challenge for the cost-effectiveness of these programmes. I discuss the problem of low maize to fertiliser response rates and factors that explain why this occurs. I conclude with policy recommendations for making ISPs more cost-effective, sustainable and beneficial to smallholder farm households in SSA.

1.1 Background: Common Perception of Low Inorganic Fertiliser Use in SSA

There remains a common perception that inorganic fertiliser use among smallholder farm households in SSA is extremely low. Aggregate, national-level data from FAOSTAT suggest that on average, farmers across the region use only 13 kg of fertiliser nutrients per hectare of arable land, which is far below the developing-country average of 94 kg/ha (Minot and Benson 2009). Low fertiliser use, low yields, persistent poverty, along with several food price spikes over the past ten years have increased awareness of the need to increase smallholder staple crop production in SSA.

As a result, numerous African policymakers met in Abuja, Nigeria in 2006 at the African Fertilizer Summit, where they vowed to help smallholder farmers to access inorganic fertiliser as the primary mechanism for increasing agricultural productivity. The main policy mechanism advocated was through targeted ISPs. In targeted

[1] According to Jayne and Rashid (2013), seven countries in SSA spent the equivalent of USD 1.05 billion in 2011 subsidising inputs. This is equivalent to 28.6% of public spending on agriculture (Jayne and Rashid 2013).

subsidy programmes, a sub-sample of farm households who meet certain criteria is able to acquire a limited quantity of inorganic fertiliser at a price below the market price (subsidy). These targeted programmes in theory are supposed to overcome the problems with universal fertiliser subsidies that were common across SSA in the 1970s and 1980s. Under universal subsidy programmes, the government controls the price of fertiliser and makes it available to all farmers at a below-market rate. Evidence suggests that most of the benefits from universal subsidies go to wealthier households who are better able to access the fertiliser and to input suppliers who do not fully pass the cost savings back to farmers (Brooks et al. 2008). In addition, due to their high costs, universal subsidy programmes became financially untenable for many countries and were phased out in the late 1980s and 1990s under structural adjustment.

Recent evidence from nationally representative household-level panel survey data from six countries in SSA, collected by the World Bank in the years following input subsidy scale-up in many countries, indicates that inorganic fertiliser use may not be as low as commonly perceived. Table 1 (Sheahan and Barrett 2014) shows that the average rate of inorganic fertiliser nutrients is 26 kg/ha, double the 13 kg/ha from FAOSTAT data. In addition, several countries have nutrient use rates for inorganic fertiliser that are significantly higher than 26 kg/ha. It is also not surprising that the countries with the highest rates of inorganic fertiliser use—Malawi, Nigeria and Ethiopia—have all funded large fertiliser subsidy programmes in recent years. Malawi and Nigeria administer a targeted ISP, while Ethiopia uses a universal subsidy programme where the government imports fertiliser and distributes it at below-market price to farmers across the country, through its network of cooperative unions.

Higher fertiliser use than commonly perceived is also seen in Malawi (Ricker-Gilbert and Jayne 2017). This study follows 462 smallholder Malawian farm households over eight years. Fertiliser use patterns for these households are presented in Fig. 1. The figure demonstrates that the ISP in Malawi has contributed to raising fertiliser use since it was first scaled up during the 2005/06 season. Average fertiliser use

Table 1 Average household-level organic and inorganic fertiliser use trends

Country	% of cultivating households using inorganic fertiliser	Use (kg/ha) of inorganic fertiliser across all households (includes zeros)	
		Mean total	Mean nutrients
Ethiopia	55.5	45.0	25.2
Malawi	77.3	146.0	56.3
Niger	17.0	4.5	1.7
Nigeria	41.4	128.2	64.3
Tanzania	16.9	16.2	7.7
Uganda	3.2	1.2	0.7
Average	35.2	56.9	26.0

Source Sheahan and Barrett (2014)

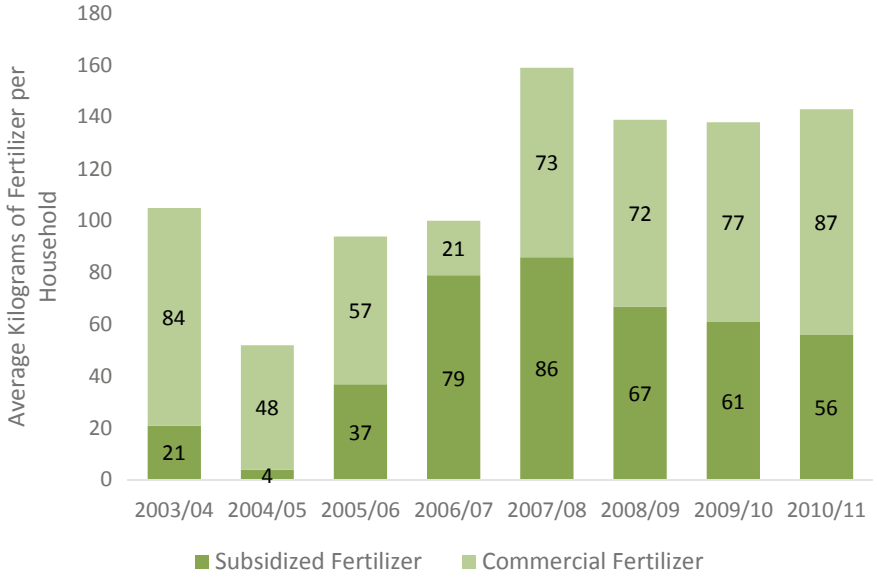

Fig. 1 Average fertiliser use (kg) by households in Malawi, by year and by source. $N = 462$ households in each year. *Source* Ricker-Gilbert and Jayne (2017)

per household stood at slightly more than 100 kg in 2003/04 but increased to nearly 150 kg in 2010/11. The figure also shows that commercial fertiliser use declined during the initial years when the subsidy was scaled up but has since rebounded to its pre-subsidy level.

1.2 Challenge of Low Maize to Fertiliser Response Rates

Although the evidence suggests that input subsidies have contributed to increasing fertiliser use among smallholders in SSA in recent years, fertiliser acquisition and use are just one component for raising yields and productivity. The first major challenge facing ISPs is making sure that recipients are using fertiliser efficiently so that the marginal benefits of using fertiliser are greater than the marginal costs.

The marginal product of fertiliser (kilograms of maize produced per kilogram of nitrogen) is a key factor determining whether or not the benefit/cost ratios for ISPs are greater than 1 and thus break even, or do better than that. Jayne and Rashid (2013) review the literature on ISPs in SSA and compile a table of studies across the region that estimate the marginal product of maize to nitrogen and benefit/cost ratios. Results from these studies are presented in Table 2. The main conclusion that can be drawn from this table is that the marginal product of fertiliser is quite low, and thus, the benefit/cost ratios hover around 1 or are below 1 in many contexts.

Table 2 Recent estimates of maize response to nitrogen applications in SSA

Study	Country	Agronomic response rate (kg maize per kg nitrogen)	Benefit/cost ratio
Minten et al. (2013)	Ethiopia	10–14	1.0–1.4
Sheahan et al. (2013)	Kenya	14–21	1.3–3.7
Marenya and Barrett (2009)	Kenya	17.6	1.76
Matsumoto and Yamano (2011)	Uganda	8.0	0.75–1.05
Burke (2012)	Zambia	9.6	0.3–1.2
Ricker-Gilbert and Jayne (2012)	Malawi	8.1	0.6–1.6
Pan and Christiaensen (2012)	Tanzania	11.7	–

Source Adapted from Jayne and Rashid (2013) and Burke et al. (2015)

This consistent finding raises questions about whether or not subsidies for fertiliser can by themselves be a cost-effective strategy for raising smallholder agricultural productivity.

1.3 Reasons for Low Maize to Fertiliser Response Rates

The next logical question to ask is why are response rates to fertiliser so low and what can be done to improve them, so that inorganic fertiliser is more profitable for smallholder farmers in SSA to use? The first potential challenge is, as mentioned earlier, that many farmers in SSA are dependent on rainfed agriculture and lack access to water control through irrigation. Water control is crucial for plant growth and for the economic returns on using fertiliser. Dependence on rainfall raises the risk associated with purchasing inorganic fertiliser, as climate trends suggest that most of SSA has been receiving less and more sporadic rainfall, and will continue to do so in future under most climate change scenarios (Niang et al. 2014). Access to irrigation affords more reliable water control and more stable yield response to fertiliser, compared to rainfed cultivation. Unfortunately, only 4% of arable land is under irrigation in SSA, compared to 45% in South Asia (Jayne and Rashid 2013). This difference helps to explain why fertiliser application rates and maize to fertiliser response rates are much lower in SSA than in South Asia.

The second reason for low maize to fertiliser response rates in SSA is poor and degrading soil quality. Rapid population growth in many parts of SSA leads to smaller and smaller farms that continuously cultivate cereals year after year with little nutrient replenishment, leading to worsening soil quality which in turn leads to lower yields. Marenya and Barrett (2009) demonstrate that, in western Kenya, soil organic matter (SOM) is an important indicator of soil degradation that has a strong effect on maize

to fertiliser response rates. The authors conclude that, given low levels of SOM, it is not profitable for many smallholders to purchase inorganic fertiliser.

Intercropping maize with legumes is one relatively low-cost way for soil fertility to be maintained or perhaps restored. Legumes have the ability to fix nitrogen at a higher rate than cereals do, so their presence in a cropping system can help build nitrogen and organic matter over time (Snapp 1998). Unfortunately, the percentage of maize fields intercropped with legume is not as high as it could be, and there is some evidence that the rate of intercropping may be declining over time. For example, Snapp et al. (2014) show that in Malawi, 50.1% of maize plots were intercropped with legumes in 2002/03; this percentage declined to 46.1% in 2006/07, 45.4% in 2008/09 and 37.9% in 2009/10—a worrying trend.

The third reason for low response rates is late delivery and application of fertiliser. Proper timing of fertiliser application is important to prevent nutrient loss, increase nutrient use efficiency and prevent damage to the environment through nutrient run-off (Jones and Jacobsen 2003; Snapp et al. 2014). Xu et al. (2009) find that timely application of fertiliser is one of the major factors that has a positive impact on maize response to fertiliser in Zambia. However, it is unfortunately not the case that farmers always acquire and apply fertiliser at the appropriate time. Snapp et al. (2014) find that more than half of all smallholders in Malawi apply their first dosage of fertiliser more than three weeks after planting, which is generally later than optimal for yield maximisation. There could be various explanations for late application of fertiliser, such as late delivery to fertiliser retailers, smallholders lacking sufficient labour to apply the fertiliser and not having the management ability and knowledge to appropriately apply fertiliser.

The fourth reason for low response rates is appropriate management and timely weeding. Weeding is essential to improve the ability of plants to access and use nitrogen and phosphorous effectively. Repeated weeding of maize during a growing season is essential to maximise yields, and farmers who weed their maize only once during the growing season can experience a 26–34% decline in yields due to the build-up of weeds (FAO 2000). Pests such as the parasitic weed *striga* are a major challenge for many smallholders in SSA; they can cause major yield losses if not removed through weeding or herbicide application. Snapp et al. (2014) find that in Malawi only 65–70% of plots are weeded twice as recommended, while 25–27% of maize plots are weeded only once or not at all. Furthermore, the authors find that 13.7–17.3% of households say that they have experienced yield reductions due to crop diseases or pests over the past two to three years.

2 Implications for Input Subsidy Policy

Dependence on rainfed agriculture, poor and worsening soil quality, late delivery and application of fertiliser and insufficient weeding all help to explain the low maize to fertiliser response rates observed in the studies presented in Table 2. Low response rates are a major challenge for input subsidies and undermine their cost-effectiveness

and sustainability in the long run. The issues highlighted above demonstrate that inorganic fertiliser is just one input into the production of cereals, which also depends on land, seed, water, labour, soil fertility and management ability. Therefore, there is a need for countries in SSA to move from a development strategy where substantial shares of national agricultural budgets are devoted to subsidising nitrogen and phosphorous, to a more holistic agricultural development strategy that focuses on soil fertility as a complement to inorganic fertiliser.

Unfortunately, in the past, focusing on soil fertility has sometimes been viewed as 'low input' or 'alternative' agriculture. However, research in the agronomy and soil science literature increasingly indicates that holistic soil fertility management (SFM) will be required to enable smallholders to use inorganic fertiliser more intensively and profitably. In this light, SFM and inorganic fertiliser can be viewed as complements that are necessary for one another, rather than substitutes that should take the place of each other. Elements of a holistic strategy would include (i) developing improved seeds that have the characteristics that farmers desire—accomplishing this would require more support for national agricultural research systems and (ii) increasing funding and support for extension programmes to help limited resource farmers to improve maize to fertiliser response rates. This could occur through better training in weeding and improved fertiliser management, along with programmes to restore soil fertility (Snapp et al. 2014).

2.1 Need to Clarify ISP Goals and Objectives

As mentioned previously, the need for complementary investments to raise maize to fertiliser response rates is the first challenge to making ISPs cost-effective and sustainable. The second challenge is ambiguity and expectations concerning the goal of these programmes. Take, for example, the goals of Malawi's Farm Input Subsidy Program (FISP), which are to increase productivity and reduce poverty by targeting the 'productive poor', who are broadly defined as full-time smallholder farmers who can contribute to increasing national-level production, but cannot afford to purchase one or two 50 kg bags of fertiliser at commercial prices (Dorward et al. 2008). This definition can be compared to the official targeting criteria for beneficiary selection under FISP, as of 2007/2008: (i) households headed by a Malawian who owns and currently cultivates land, (ii) vulnerable households, including guardians of physically challenged persons, and households headed by females, orphans or children. There is clear inconsistency between targeting the 'productive poor' and targeting vulnerable households because vulnerable households often do not have the land, labour and skills necessary to use inputs effectively. This inconsistency complicates both the evaluation of how well ISPs target the intended beneficiaries, and how effectively the FISP meets its stated objectives of increasing maize productivity, promoting household food security and reducing poverty.

As mentioned, fertiliser and seed subsidies require complementary inputs such as land, labour and management practices, so it makes sense for their goals to focus on

helping smallholders to boost food production. However, due in part to their high cost and substantial budget share, many people expect that ISPs should be able to both increase food production and reduce household vulnerability to poverty and hunger. There may be some overlap between households who can increase maize production through input subsidies and households who have their vulnerability reduced through input subsidies.

2.2 Improving Beneficiary Targeting

Two inter-related challenges with ISPs are (i) what are the characteristics of intended beneficiaries? and (ii) how can they be effectively targeted? The following subsection identifies three different potential targeting methods for reaching intended ISP beneficiaries.

2.2.1 Community-Based Targeting

At the local level, many countries including Malawi, Zambia, Nigeria and Kenya rely on a decentralised targeting system where local chiefs determine who should receive coupons for subsidised seed and fertiliser. Community-based targeting programmes have the benefit of using local knowledge to identify beneficiaries at a relatively low cost to the government. However, community-based targeting schemes are more likely to suffer from elite capture, where those with social connections and resources obtain a disproportionate share of the benefits (Pan and Christiaensen 2012). The majority of evidence from Malawi's ISP indicates that over the programme's duration, Malawi's rural poor have not been specifically targeted to receive subsidised fertiliser and seed (Ricker-Gilbert et al. 2011; Holden and Lunduka 2012; Chibwana et al. 2011; Kilic et al. 2015). Kilic et al. recently found that on average relatively well-off households, who are connected to community leadership and reside in agro-ecologically favourable locations, are more likely to be ISP beneficiaries. However, Fisher and Kandiwa (2014) find evidence that, in recent years, female-headed households are significantly more likely to be targeted by the ISP.

The difficulty in determining whether or not ISPs effectively target intended beneficiaries relates back to the problem of clarifying the programme's goals, which affects who the intended beneficiaries should be. The fact that relatively better-off households in areas with favourable agro-ecology are more likely to obtain subsidised fertiliser in Malawi, suggests that the community-based system may target inputs towards more productive households. A recent working paper by Basurto et al. (2015) finds support for the notion that chiefs take productive efficiency into account when identifying beneficiaries. However, they find that chiefs are more likely to offer the inputs to relatives rather than non-relatives, consistent with the idea of elite capture in community-based targeting programmes.

In order to deal with this ambiguity in community-based targeting, it is important that programme goals and targeting guidelines are clarified and communicated with communities so that they understand the following households should be the primary beneficiaries of ISP: (i) households who are credit constrained and may lack cash at planting to purchase inorganic fertiliser at commercial prices, (ii) households who have sufficient land and labour to make use of the inorganic fertiliser and seed. It should also be made clear that village leaders and relatives of chiefs should not receive any preferential treatment for receiving subsidised inputs. Clarifying and communicating goals to communities will likely not solve all of the targeting challenges, but it can remove confusion about who beneficiaries should be and help create accountability within the communities.

2.2.2 Proxy-Means Targeting Based on Observables

Proxy-means (PM)-based targeting systems, where households are selected to participate in the programme based on observable characteristics that proxy for household need, are one potential alternative to a decentralised, community-based targeting system. The advantage of a PM system is that, in theory, the criteria for beneficiary selection are clear and observable to all parties involved in the programme, thus providing transparency and potentially reducing elite capture problems that exist in community-based systems. The challenge with PM targeting is that it can be difficult to find observable proxies that accurately represent beneficiary need. In addition, potential beneficiaries have the incentive to make observable proxies appear unobservable to government officials who distribute the benefits of the programme, once they understand that eligibility depends on observing or not observing these proxies.

To my knowledge, the only study to directly compare PM targeting with community-based targeting in Malawi is the working paper by Basurto et al. (2015). The authors find that FISP's community-based targeting system performs almost as well as an ideal PM system based on observable proxies for household consumption. The authors point out that the consumption information in their study is a more reliable predictor of need than household assets, which is what the government would have to rely on if the FISP moves to a large-scale PM-based system. This suggests that the current community-based targeting system may distribute FISP inputs more effectively than an asset-based PM system. In total, the results from Basurto, Dupas and Robinson indicate that the current community-based targeting system should not be replaced with a PM system. It is possible that an improved FISP targeting system could incorporate some combination of community-based and PM targeting schemes, but this would require further investigation and piloting.

2.2.3 Self-targeting Mechanisms

Given the challenges associated with identifying intended beneficiaries to be targeted by ISP using either community-based, PM or geographic targeting, serious consideration should be given to programme modifications that induce self-targeting of beneficiaries. With self-targeting, appropriate beneficiaries self-select into ISP participation, and inappropriate beneficiaries self-select out of participating. Since this report argues that ISP goals should be to increase maize yields and maize output, the programme should be modified to encourage self-selection among relatively more productive smallholders who can contribute to these goals.

The first and perhaps the most straightforward method for encouraging self-targeting for ISP participation is to increase the contribution that beneficiaries are required to make to redeem subsidised fertiliser. For example, in Malawi the government increased the required farmer contribution in 2015/16 to about 30% of the total cost of fertiliser, from the 5% that beneficiaries were paying in previous years. This price increase serves as a self-targeting mechanism since smallholders will only purchase fertiliser if they believe that the marginal benefits of using it will outweigh the marginal costs. Therefore, raising the effective price that beneficiaries pay for subsidised fertiliser will induce more productive smallholders to self-select into participation as they can obtain high enough returns to cover the increased costs of acquiring the input.[2] At the same time, less productive farmers who can cover their costs at a 95% subsidy rate will find it increasingly less profitable to participate as the rate of subsidy decreases, and their costs increase.

Furthermore, as the size of the required beneficiary contribution increases, the arbitrage opportunities for subsidy beneficiaries to re-sell subsidised fertilizer are reduced. Resale of subsidised fertiliser on a secondary market has been identified in several studies as a major problem with Malawi's subsidy programme in recent years (Holden and Lunduka 2010; Lunduka et al. 2013). Therefore, governments who currently subsidise fertiliser should consider increasing the required farmer contribution to the ISP by 10 percentage points per year, as a strategy for gradually graduating from the programme. Increasing the required farmer contribution to subsidised fertiliser would also relieve budgetary pressure from the programme. Savings from input subsidies could be channelled into programmes that can complement the inorganic seed and fertiliser use, by helping farmers to restore and improve soil fertility over time.

With this consideration in mind, the second self-targeting mechanism advocated in this report is for a conditional subsidy programme, where receiving subsidised fertiliser would be conditional on beneficiary smallholders making some form of investment in their long-term soil fertility. These investments could take the form of (i) planting nitrogen-fixing trees, such as *Faidherbia*; (ii) using contour ridging on their fields to prevent erosion; (iii) using organic manure to improve soil fertility

[2]This is consistent with a policy simulation that was recently conducted by the International Monetary Fund (IMF) (Nsengiyumva et al. 2015).

and soil structure and (iv) using pit planting to reduce nutrient run-off, and increase nutrient uptake by maize plants.

Adoption of these practices requires some labour and incurs monetary costs on the part of smallholders. A recent study in Malawi by Jack (2013) finds that farmers self-select into and out of a programme that encourages tree planting based on the individual smallholder's perception of future costs and benefits associated with planting and maintaining their trees. Therefore, if input subsidies change towards a conditional subsidy, then smallholders who are willing to incur the cost of this type of soil fertility investment can select into the programme in order to obtain subsidised fertiliser and seed. Conversely, smallholders who do not want to or are unable to make this investment will select out of the programme and choose to not receive the subsidised inputs.

A conditional subsidy would require some verification by extension officers or another third party, but tree planting is relatively easy to observe, so it may be a desirable intervention from a cost-effective oversight standpoint. In addition, the government will likely need to invest some resources in training farmers and providing extension advice on these proposed soil fertility improving practices. The additional costs of verification and farmer training could be paid in part by the savings incurred from increasing the required farmer contribution to the ISP.

2.3 ISPs Versus Other Social Protection Programmes

The following sub-section compares the ISP to other similar programmes that can be targeted or are targeted towards smallholders in SSA. This sub-section discusses what is known about cash transfers and flexible input voucher (FIV) programmes—two possible alternative mechanisms to ISPs.

2.3.1 Cash Transfer Programmes

Cash transfer programmes provide money directly to recipients. Unlike ISPs, cash transfers do not require beneficiaries to have complementary land and labour input to make use of them. In terms of effectiveness, targeted cash transfers share many of the problems that one finds with targeted ISPs. These problems include greater participation by individuals who have connections to local leaders and households 'gaming the system' to appear more needy than they actually are (Ellis and Maliro 2013). However, one would expect that the administrative burden of distributing a cash transfer would be lower than the burden for distributing subsidised inputs. Cash transfer programmes would likely be a more effective mechanism than ISPs for directly reaching limited resource beneficiaries to provide them with direct resources to reduce their vulnerability to hunger and poverty.

2.3.2 Flexible Input Voucher Programmes

Flexible input vouchers (FIVs) have a certain cash value associated with them and allow recipients to redeem them at an input supplier for whatever combination of inputs best suits their needs. In addition, the FIV is a potential way of supporting and strengthening the private network for input distribution, wholesale and retail in SSA countries. Unfortunately, there is little evidence on the household-level impacts of FIV programmes. To my knowledge, the only study to date to evaluate FIVs is based on a pilot programme in Zimbabwe. The study measures FIV impacts on input suppliers and how effectively the programme reaches recipient farmers (Mazvimavi et al. 2013). The authors find that FIVs help retailers to boost sales and revenue, and help to link farmers to input suppliers. They find that FIVs work better in areas with good infrastructure and good mobile phone reception. The authors also identify challenges associated with FIVs, such as getting retailers to stock the full complements of inputs that farmers may want. In addition, wholesalers face financial risks if not all agro-inputs are purchased.

There is currently insufficient evidence to recommend that countries in SSA move fully towards an FIV system. However, it may be worth piloting an FIV programme in a few districts to compare its impact against current systems. An evaluation of the e-voucher programme in Malawi by Tsoka et al. (2015) reveals that the electronic system removes the problem of fraudulent printing of counterfeit paper vouchers, lowers the administrative costs compared to paper vouchers and makes it easier and faster for the government to reimburse input suppliers, which helps suppliers to keep inputs in stock. Combining an FIV pilot with an e-voucher could help to ensure accountability and swift repayment for inputs from the government to private retailers. As mobile phone use increases among smallholders in SSA and coverage improves, e-voucher options will likely become more cost-effective and viable in future. Such a system could be a step towards graduating from input subsidies in Malawi.

3 Recommendations for Improving ISPs

There are a number of ways in which ISPs can be modified and improved to better target smallholders who can effectively use the inputs while relieving pressure on the government's budget and moving towards eventual graduation from the programme. Given the challenges associated with effectively targeting programme beneficiaries, steps should be taken to encourage self-targeting as much as possible. The following four recommendations are potential ways of improving ISPs throughout SSA.

3.1 Governments Should Clearly Communicate that the Main Goal of ISPs Is to Increase Maize Yields and Maize Production

Poverty reduction *should not* be thought of as a primary objective of the ISP. Clarifying programme goals and communicating them to local communities will help to remove ambiguity in the targeting guidelines and lower the expectations on ISPs to be successful in multiple dimensions. Clarifying programme objectives will also help communities to understand that the following households should be the primary beneficiaries of ISP: (i) households who are credit constrained and may lack cash at planting to purchase inorganic fertiliser and seed at commercial prices; and (ii) households who have sufficient land and labour to make use of the inorganic fertiliser and seed. Given evidence that ISPs have been prone to elite capture where better connected households are more likely to receive subsidised inputs, it should be clearly communicated to the village that kin of the village chief and other leaders in the community should not be any more likely to receive ISP benefits than other households. Clarification of this issue may help to create some self-enforcement within the community, but oversight by agricultural extension personnel may be needed for auditing purposes.

3.2 Self-targeting Option No 1: Further Increase the Required Farmer Contribution to ISP Fertiliser

Increasing the farmer contribution as a percentage of the total cost of the ISP is a strategy for gradually graduating from the programme. Increasing the required farmer contribution to receive subsidised inputs has three main programmatic benefits. (1) It lowers the cost of the ISP for the government and relieves pressure on the budget and balance of payments. In doing so, money that went to paying for ISP can be transferred to other complementary programmes. (2) It reduces the gains from reselling subsidised fertiliser on the secondary market. (3) It serves as a self-targeting mechanism. Since we assume that farmers will only purchase fertiliser if they believe that the marginal benefits of using it will outweigh the marginal costs, raising the effective price that farmers pay for subsidised fertiliser will induce more productive farmers, who can obtain a high enough return to cover the increased costs, to self-select into ISP participation. At the same time, less productive farmers who can cover their costs at a 95% subsidy rate will find it increasingly less profitable to participate as the rate of subsidy decreases.

3.3 Self-targeting Option No 2: Pilot a Conditional Subsidy

As discussed earlier, inorganic fertiliser is just one input into the production of maize. Fertile soils that maintain sufficient nitrogen, phosphorous and other nutrients are crucial to increasing nitrogen use efficiency (NUE) from inorganic fertiliser, thus increasing the cost-effectiveness of ISPs. Therefore, it would be advantageous to make receiving subsidised fertiliser and seed conditional on smallholders making some form of investment in their long-term soil fertility. A conditional subsidy would require some third-party verification, so planting trees would be an option that is relatively easy for extension agents or others to verify. Under a conditional subsidy, smallholders who are willing to make these investments in soil fertility can select into the programme in order to obtain subsidised fertiliser and seed, while smallholders who do not want to or are unable to make this investment will select out of the programme.

3.4 Pilot Flexible Input Voucher (FIV) Programme

FIVs have a certain cash value associated with them that allows recipient smallholders to redeem the value at an input supplier for whatever combination of inputs best suits their needs. FIVs allow the government to recognise that the 100 kg of fertiliser and 5–8 kg of maize seed distributed under FISP may not be the best for everyone. The FIV has two main programmatic benefits over the current FISP: (1) FIVs offer a level of empowerment where households get to choose what input or combination of inputs they want; (2) FIVs provide a potential mechanism for supporting and strengthening the private network for input distribution, wholesale and retail in the countries where they operate. By providing empowerment and flexibility for smallholder households and support to the private sector, a move to an FIV system could be a step towards graduating from input subsidies. Use of an e-voucher with FIV could help to ensure accountability and swift repayment for products from the government to private sector retailers.

4 Conclusions

The present chapter reviews the recent literature on smallholder access to and use of inorganic fertiliser in SSA and draws implications for input subsidy programmes (ISPs). It seems clear, as demonstrated in Sheahan and Barrett (2014) and Ricker-Gilbert and Jayne (2017), that ISPs have helped to increase inorganic fertiliser use among smallholders in SSA. However, there are two major challenges that threaten the cost-effectiveness and sustainability of these programmes. The first is that low response rates of maize to fertiliser and relatively high costs of implementing these

programmes make it difficult for their marginal benefits to exceed their marginal costs. The second challenge is the need for ISPs to clarify their objectives and goals. Because fertiliser and seed subsidies require complementary inputs such as land and labour, these should be viewed primarily as productivity enhancing programmes. However, in part due to their high cost and the substantial share of national budgets allocated to them, they are often expected to also reduce poverty and vulnerability. This double burden puts tremendous pressure on ISPs.

These challenges make it necessary to find ways to make ISPs more effective and sustainable. In order to do so, this report makes the following set of recommendations. First, the goals of ISPs should be clarified, with a primary focus on enhancing productivity. Second, it is very difficult to determine, identify and target appropriate beneficiaries for the ISP using community-based targeting or proxy-means-based targeting schemes. Therefore, ISPs should be scaled down, and the government should move to implement self-targeting mechanisms where more productive farmers opt in and less productive farmers select opt of participating. One example of a self-targeting mechanism that is fairly easy to implement is to increase the required farmer contribution to the ISP. This would increase the marginal cost of acquiring subsidised fertiliser relative to the marginal benefit of using it. Therefore, as the cost to recipients increases, those who cannot make a profit at higher effective prices will likely self-select out. The second self-targeting mechanism that should be considered is making the receipt of subsidised inputs conditional on households who are willing to make longer-run investments in soil fertility. This means that if smallholders are willing to plant a tree or use organic manure or create contour ridging on their fields, they could be eligible to acquire subsidised fertiliser. Those who do not want to or are unable to make such investments will opt out of the programme. Requiring ISP recipients to make soil fertility investments will help to improve the soil fertility and the maize response to fertiliser over time on smallholder fields. Doing so will make ISPs more cost-effective and sustainable in the longer term.

While the ISP should focus on increasing maize productivity and production, cash transfer programmes to households should be scaled up, to provide income support that directly increases consumption for poorer households who cannot make effective use of subsidised inputs because they are land or labour constrained. Depending on availability of funds, a cash transfer could be scaled up as ISPs are scaled down.

References

Basurto, P., Dupas, P., & Robinson, J. (2015). *Decentralization and efficiency of subsidy targeting: Evidence from chiefs in rural Malawi* (Working Paper). Department of Economics, UC-Santa Cruz.

Brooks, J., Dyer, G., & Taylor, E. (2008). *Modelling agricultural trade and policy impacts in less developed countries* (OECD Food, Agriculture and Fisheries Working Papers 11).

Burke, W. (2012). Determinants of maize yield response to fertilizer application in Zambia: In Implications for strategies to promote smallholder productivity. (PhD Thesis), East Lansing, MI: Michigan State University.

Burke, W. J., Frossard, E., Kabwe, S., & Jayne, T. S. (2015). Soil management and crop response to fertilizer use in Sub-Saharan Africa: Methodological and policy issues: Examples from Zambia. In *Organized Symposia as Part of the International Conference of Agricultural Economists*, Milan, Italy, August 9–14.

Chibwana, V., Fisher, M., & Shively, G. (2011). Land allocation effects of agricultural input subsidies in Malawi. *World Development, 40*(1), 124–133.

Coady, D. P. (1995). An empirical analysis of fertilizer use in Pakistan. *Econometrica, 62*(246), 213–224.

Croppenstedt, A., Demeke, M., & Meschi, M. M. (2003). Technology adoption in the presence of constraints: The case of fertilizer demand in Ethiopia. *Review of Development Economics, 7,* 58–70.

Dorward, A., Kydd, J., Morrison, J., & Urey, I. (2004). A policy agenda for pro-poor agricultural growth. *World Development, 32*(1), 73–89.

Dorward, A., Chirwa, E., Kelly, V., Jayne, T. S., Slater, R., & Boughton, D. (2008). *Evaluation of the 2006/07 agricultural input subsidy programme, Malawi* (Final Report). Lilongwe, Malawi.

Duflo, E., Kremer, M., & Robinson, J. (2008). How high are rates of return to fertilizer? Evidence from field experiments in Kenya. *American Economic Review, 98*(2), 482–488.

Duflo, E., Kremer, M., & Robinson, J. (2011). Nudging farmers to use fertilizer: Theory and experimental evidence from Kenya. *American Economic Review, 101*(6), 2350–2390.

Ellis, F., & Maliro, D. (2013). Fertiliser subsidies and social cash transfers as complementary or competing instruments for reducing vulnerability to hunger: The case of Malawi. *Development Policy Review, 31*(5), 575–596.

FAO (Food and Agriculture Organization). (2000). *Fertilizers and their use: A pocket guide for extension officers* (4th ed.). Rome and Paris: Food and Agriculture Organization of the United Nations and International Fertilizer Association.

Fisher, M., & Kandiwa, V. (2014). Can agricultural input subsidies reduce the gender gap in modern maize adoption? Evidence from Malawi. *Food Policy, 45,* 101–111.

Gregory, D. I., & Bumb, B. L. (2006). *Factors affecting supply of fertilizer in Sub-Saharan Africa* (Agriculture and Rural Development Discussion Paper 24). Washington, DC: World Bank.

Holden, S., & Lunduka, R. (2010). *Too poor to be efficient? Impacts of the targeted fertilizer subsidy program in Malawi on farm plot level input use, crop choice and land productivity*. Unpublished manuscript. Ås, Norway: Department of Economics and Resource Management, Norwegian University of Life Sciences.

Holden, S., & Lunduka, R. (2012). Do fertilizer subsidies crowd out organic manures? The case of Malawi. *Agricultural Economics, 43*(3), 303–314.

Jack, B. K. (2013). Private information and the allocation of land use subsidies in Malawi. *American Economic Journal: Applied Economics, 5,* 113–135.

Jayne, T. S., & Rashid, S. (2013). Input subsidy programs in Sub-Saharan Africa: A synthesis of recent evidence. *Agricultural Economics, 44,* 547–562.

Jones, C., & Jacobsen, J. (2003). Fertilizer placement and timing. MSU extension service. In *Nutrient management module 11*. East Lansing, MI: Michigan State University.

Kilic, T., Whitney, E., & Winters, P. (2015). Decentralized beneficiary targeting in large-scale development programs: Insights from the Malawi farm input subsidy program. *Journal of African Economies, 24*(1), 26–56.

Lunduka, R., Ricker-Gilbert, J., & Fisher, M. (2013). The consistent and contrasting results of research examining the economic impacts of Malawi's fertilizer subsidy program. *Agricultural Economics, 44*(6), 563–579.

Marenya, P., & Barrett, C. B. (2009). State-conditional fertilizer yield response on western Kenyan farms. *American Journal of Agricultural Economics, 91*(4), 991–1006.

Matsumoto, T., & Yamano, T. (2011). Optimal fertilizer use on maize production in East Africa. In T. Yamano, K. Otsuka, & F. Place (Eds.), *Emerging development of agriculture in East Africa: Markets, soil, and innovations*. The Netherlands: Springer.

Mazvimavi, K., Murendo, C., Minde, I., & Kunzekweguta, M. (2013). *Assessing the impacts of Zimbabwe's agricultural vouchers input program*. Paper presented at the African Association of Agricultural Economists Meeting in Hammemet, Tunisia, September 22–25.

Minot, N., & Benson, T. (2009). *Fertilizer subsidies in Africa: Are vouchers the answer?* (Issue Brief 60). Washington, DC: International Food Policy Research Institute.

Minten, B., Koru, B., & Stifel, D. (2013). The last mile(s) in modern input distribution: Pricing, profitability, and adoption. *Agricultural Economics, 44*(6), 629–646.

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, et al. (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 1199–1265). Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Nsengiyumva, F., Peralta-Alva, A., Maehle, N., Ruiz, S. L., Wu, F., Banda, S., et al. (2015). *Malawi selected issues* (International Monetary Fund Country Report No. 15/346). Washington, DC.

Pan, L., & Christiaensen, L. (2012). Who is vouching for the input voucher? Decentralized targeting and elite capture in Tanzania. *World Development, 40*(8), 1619–1633.

Ricker-Gilbert, J., & Jayne, T. S. (2012). *Do fertilizer subsidies boost staple crop production and reduce poverty across the distribution of smallholders in Africa? Quantile regression results from Malawi*. Selected paper for the Triennial Meeting of the International Association of Agricultural Economists, Foz Do Iguacu, Brazil, August 18–24, 2012.

Ricker-Gilbert, J., & Jayne, T. S. (2017). Estimating the enduring effects of fertilizer subsidy programs on recipient farm households. Evidence from Malawi. *Journal of Agricultural Economics* (Forthcoming).

Ricker-Gilbert, J., Jayne, T. S., & Chirwa, E. (2011). Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. *American Journal of Agricultural Economics, 93*(1), 26–42.

Sheahan, M., & Barrett, C. B. (2014). *Understanding the agricultural input landscape in Sub-Saharan Africa. Recent plot, household, and community-level evidence* (World Bank Policy Research Working Paper 7014). Washington, DC.

Sheahan, M., Black, R., & Jayne, T. (2013). Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research. *Food Policy, 41,* 39–52.

Snapp, S. S. (1998). Soil nutrient status of smallholder farms in Malawi. *Communications in Soil Science and Plant Analysis, 29*(17 and 18), 2571–2588.

Snapp, S., Jayne, T. S., Mhango, W., Benson, T., & Ricker-Gilbert, J. (2014). *Maize yield response to nitrogen in Malawi's smallholder production system* (Malawi Strategy Support Program. Working Paper 9). Washington, DC: International Food Policy Research Institute.

Tsoka, M. G., Mezuwa, H., Mbendera, M., & Nyirongo, I. (2015). *Evaluation of FISP E-voucher pilot programme 2013/14*. Report prepared by the Centre for Social Research University of Malawi, Zomba.

Vanlauwe, B., Kihara, J., Chivenge, P., Pypers, P., Coe, R., & Six, J. (2011). Agronomic use efficiency of N fertilizer in maize-based systems in Sub-Saharan Africa within the context of integrated soil fertility management. *Plant and Soil, 339,* 35–50.

Xu, Z., Guan, Z., Jayne, T. S., & Black, R. (2009). Factors influencing the profitability of fertilizer use on maize in Zambia. *Agricultural Economics, 40*(4), 437–446.

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